UNIVERSITY OF EDUCATION, WINNEBA

USING CONCEPT MAPPING STRATEGY TO IMPROVE THE TEACHING AND LEARNING OF MOLE CONCEPT IN KETA BUSINESS COLLEGE

ROBERT PAVLOV KWADWO DOGBEY

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ROBERT PAVLOV KWADWO DOGBEY
200000384

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of the requirements for the award of the degree of Master of Philosophy (Science Education) in the University of Education, Winneba

NOVEMBER, 2021

DECLARATION

Student's Declaration

I, Robert Pavlov Kwadwo Dogbey, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: ……………………..……………

Date: ………………………..………………

Supervisor's Declaration

I, hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

Name of Supervisor: Professor K. D. Taale

Signature: ……………………..……………

Date: ………………………..………………

DEDICATION

This work is dedicated to my beloved wife Eunice Enyonam Gbortsyo-Dogbey and children Ethel, Egbert, Elsie and Egberta Dogbey as well as my beloved parents for their sacrifice throughout my studies.

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To God be the glory, honour and adoration for preserving my life and more still for His special grace, wisdom, guidance and strength showered on me right from the beginning to a successful end.

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To those whose names have not been mentioned, I owe it a Christian duty to duly acknowledge and appreciate your help and God richly bless you. To you all I say Bravo.

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ABBREVIATIONS

CK	Curricular Knowledge
CRDD	Curriculum Research and Development Division
GAST	Ghana Association of Science Teachers
IUPAC	International Union of Pure and Applied Chemistry
KETABUSCO	Keta Business College
MCAT	Mole Concept Achievement Test
MCCT	Mole Concept Construction Test
MOE	Ministry of Education
NaCCA	National Council for Curriculum and Assessment
NIST	National Institutes of Science and Technology
PCK	Pedagogical Content Knowledge
S.H.S	Senior High Schools
S.I	Syste,me Internationale (International System of Unit)
SMCK	Subject Matter Content Knowledge
SPSS	Statistical Package for Social Science
WASSCE	West African Senior School Certificate Examination

ABSTRACT

The study investigated the Use of Concept Mapping Strategy to Improve the Teaching of Mole Concept in Keta Business College**.** This study adopted action research design in the form of pre-intervention, intervention and post-intervention stages. The study focused on the academic achievement and retention in mole concept among Senior High School Integrated Science students in Keta Business College, Keta. A total of 30 form two students of General Arts 2B from the school was intactly selected from a population of 673 students of seventeen classes of the form two using balloting technique. The students were taught Mole concept using concept mapping strategy at the intervention stage. The instruments used for data collection were semi-structured interview, Mole Concept Achievement Test (MCAT), Questionnaire and Mole Concept Construction Test (MCCT). The instruments were validated by both Chemistry teachers in the Keta Business College and lecturers in Science Education Department. The Reliability coefficient of MCAT was 0.92. Students‟ scores from these halves were then correlated using the Spearman-Brown formula used in reliability testing. Based on the objectives, this study was guided by four research questions and answered using descriptive statistics. The results of the pre-intervention and post-intervention tests were compared and tested at 0.05 level of significance using statistical paired t-test. The results obtained from data analysis showed that students performed significantly better in both academic achievement and retention in mole concept. The study recommended among others that Integrated Science teachers should be trained and encouraged by GAST in the country to use concept mapping strategy in teaching Integrated Science.

CHAPTER ONE

INTRODUCTION

1.0 Overview

Chapter one presents the background to the study. It also includes statement of the problem that informed the study, purpose of the study, objectives of the study, research questions, educational significance of the study, delimitation and limitations of the study, organisation of the study, definition of terms and abbreviations.

1.1 Background to the Study

As a philosophy, Ghana provides education for national development based on principles and doctrines of self-reliance. In view of achieving this goal, the Curriculum Research and Development Division (CRDD), now National Council for Curriculum and Assessment (NaCCA) (2019) has come out with a number of subjects to be taught and learnt in schools of which Integrated Science is one of them. The Mission of NaCCA is to raise the quality of education at the pre-tertiary level, with emphasis on Science and Mathematics as fundamental building blocks for accelerated national development and to instill in young Ghanaians a heightened sense of cultural identity and nationalism. The study of Science helps us to understand the natural world and secondly helps us to approach challenges in life and in the workplace in a systematic and logical manner (NaCCA, 2019).

Development in the current world is knowledge, based on Science and Technology. Knowledge is gain faster through the use of Science and Technology. More knowledge helps nations to advance faster on the road to increased development and progress. For the country to develop faster, it is important for students to be trained in the processes of seeking answers to problems through scientific investigations and experimentation.

According to (Safo-Adu, Ngman-Wara & Quansah, 2018), the inclusion of Integrated Science into Ghanaian school curriculum is to promote national development and make the country achieve its strategic programme of scientific and technological literacy. Integrated Science solicits the perspectives of the individual science disciplines, and integrates them during all phases of the approach to solve scientific and resource management problems. The Integrated Science syllabus is a conscious effort to raise the level of scientific literacy of all students and equip them with the relevant basic scientific knowledge needed for their own living and secondly, needed for making valuable contributions to production in the country. Education in Science also provides excellent opportunities for the development of positive attitudes and values in our youth. These include: Curiosity to explore their environment and question what they find; Keenness to identify and answer questions through scientific investigations; Creativity in suggesting new and relevant ways to solve problems; Open-mindedness to accept all knowledge as tentative and to change their view if the evidence is convincing; Perseverance and patience in pursuing a problem until a satisfying solution is found; Concern for living things and awareness of their responsibility toward maintaining the quality of the environment; Honesty, truthfulness and accuracy in recording and reporting scientific information and Love, respect and appreciation for nature and desire to conserve natural balance, CRDD (2010).

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 teacher‟s role in fostering students‟ active involvement in teaching and learning of Science, is seen as crucial for students‟ achievement and retention in Science. As a result of the relevance of Science and Technology in nation building, the National Policy on Education emphasises on the teaching of Science and Technology in all institutions.

The acquisition of Science and Technology at all levels of education depends on the teaching effectiveness measured in terms of the knowledge of what to teach, how to teach it and when to teach it (Archibong, 2009). Researchers such as Eriba (2007) and Oyegun (2013) said Science and Technology is a basic tool for industrial and national development. Science and Technology is the backbone of social, economic, political and physical development of a country. These if properly harnessed could bring about economic and social happiness by providing and improving the welfare of the citizenry.

Teaching and learning Integrated Science in Senior High Schools (SHSs) appears to be very challenging to both teachers and learners. The learners of Keta Business College (KETABUSCO) are of no exception. In fact, if Integrated Science were only a set of explanations and a collection of facts, it could be taught with whiteboard and marker. Students could be assigned to read chapters and answer questions that follow. Good students would just take notes, read the text, turn in assignments then give all this information back again on the examination (Sunday, 2013). Because of that, these research works focused on using concept mapping strategy to improve the academic achievement and retention of Senior High School Integrated Science students in mole concept.

Quality teaching in Integrated Science is crucial for developing scientifically literate citizens and improving economic productivity for sustainable development. It enhances student‟s achievements, strengthens public confidence in schools and helps students attain conceptual understanding (Safo-Adu, Ngman-Wara & Esi-Quansah, 2018). Quality teaching is characterized by teacher‟s adequate knowledge of subject matter; encouraging inquiry and hands-on approach to learning for students; and recognizing individual students as learners as the teacher builds on learner‟s strengths rather than trying to stamp out their weaknesses. It helps teachers to focus on educational improvement of learners through the integration of adequate knowledge of the curriculum content areas, functional pedagogical skills, critical reflective teaching, empathy commitment to the educational process and acquisition of managerial competences within and outside the school context (Safo-Adu, Ngman-Wara & Esi-Quansah, 2018).

Science is a process which demands a dynamic interaction of rational inquiry and creative play. This enables scientists to probe, poke handle, observe, question, think up theories, test ideas, jump to conclusion, make mistakes, revise, synthesise, communicate, disagree and discover. Really, students can understand Science as a process only if they are free to think and act like scientists in a classroom that recognises and honours individual differences (Sunday, 2013).

Integrated Science as a holistic subject comprises the various Science subjects such as Biology, Chemistry, Physics, Agricultural Science and Earth Science. Chemistry has been the foundation stone to all science related subjects in the educational reform up to date, (Ngman-Wara, 2005). Chemistry is the science that deals with the composition and properties of substances and the reactions by which one substance is converted to the other. Chemistry is commonly regarded as the Central science or the Mother of all science, (Sunday, 2013). Chemistry is a science that deals with chemical changes involving the mole, molecule and particle concepts as well as mathematical computations.

In the various aspects of chemistry (physical, organic, inorganic and analytical), the concept of mole is needed (Ameyibor & Wiredu, 1991). The mole is a central concept in Chemistry and it is a fundamental basis for such complex topics as stoichiometry, the gas laws, solution concentration, solubility product, equilibrium constant and P^H, (Ameyibor & Wiredu, 1991). It is therefore essential that students understand the mole concept and what it entails. Chemistry by its very nature is a quantitative and qualitative, hence it is crucial for students to learn to work out calculations correctly and to be able to express their findings and results properly. Chang (2010) describes Chemistry as a core science subject needed as a pre-requisite for the study of any Science or Technological related discipline such as medicine, pharmacy, engineering, agriculture and all other science related disciplines.

Chemistry is needed for sustainable development as its knowledge is important in manufacturing of fertiliser, insecticides, food processing and storage, management of our natural resources, provision of food and health facilities as well as favourable living environment. It provides a natural link between home and school and the means through which students understand the world around them and explore the wider implications of Science in relation to man. The classification of any Nation into developed, developing and under-developed could be measured accurately by the number of Science Educators, Chemists, Physicists, Engineers, Pharmacists, Doctors and Agriculturist the Nation could produce, (Sunday, 2013).

A close look at the SHS syllabus revealed that most appropriate concept that links many aspect of chemistry is the mole. The mole concept is defined as the amount of substance of a system which contains as many elementary entities (atoms, molecules, ions, electrons, quanta, or other entities) as there are carbon atoms in 0.012kg of C-12 isotope, (Fang, Hart & Clarke, 2014 & 2016; Furio, C., Azcon, R., Guisasola, J., & Ratclife, M., 2000).

Mole is a unit of measurement used in chemistry to express amounts of a chemical substance, defined as the amount of any substance that contains as many elementary entities, for example, atoms, molecules, ions and electrons as there are atoms in 12 grams of pure carbon-12 (12C), the isotope of carbon with relative atomic mass of exactly 12 by definition, Goldberg (1998).This corresponds to the Avogadro constant, which has a value of 6.022×10^{23} elementary entities of the substance. It is one of the base units in the International System of Units, and has the unit symbol **mol** and corresponds with the dimension symbol **n**. In honour of the unit, some chemists celebrate October 23 (a reference to the 10^{23} part of the Avogadro constant) as "Mole Day".

The mole concept was introduced by Ostwald at the beginning of the 20th century with a meaning of weight (mass), in a context of skepticism towards Dalton‟s atomic hypothesis, (Furio, 2000). Since then the mole concept has evolved in meaning and context over time, (Brousseau & Vázquez-Abad, 2017).

The main reason that led the scientific community to adopt amount of substance as a fundamental quantity and to define the mole as its unit, stems from the acceptance, from the 20^{th} century of the atomic-molecular theory of matter to interpret chemical changes (Brock, 1967; Rocke, 1984; Thuillier, 1990; Furió *et al.*, 2000).

Brown-Aquaye (2001) disclosed that students always complained that mole concept is among the topics they find difficult to understand. Brown-Aquaye indicated however that this should not be so because the mastery of the mole concept is vital to achieve sound reasoning in chemistry. This indicates that students inability to understand the mole concept fully leads to the difficulties in learning Chemistry. Students dislike topics in chemistry that require the use or application of Mole Concept to solve problems. The concept makes it possible to count the microscopic entities taking part in chemical processes by carrying out chemical reactions at macroscopic level using volumes and masses of reacting substances, (Furio et al., 2000; Furio, Azcon & Guisasola, 2002). Thus, an understanding of the mole concept is key in laying learners' strong foundation in Chemistry. However, research findings in various studies globally indicated that teachers find it difficult to teach the concept (Furio et al., 2000). This implies that teachers don"t have adequate knowledge to transform the mole concept Content Knowledge in the form that could be easily be understood by learners. Shulman (1986, 1987) identified this knowledge as Pedagogical Content Knowledge (PCK). Shulman described PCK as the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented to the learners.

According to Silberg (1996), Chemistry deals with the changes we observe in the world around us and within the atomic scale and the events that cause them. In the context of this definition, the learning of mole concept in Chemistry requires sound knowledge as well as practical skill that link various concept and so extends their understanding of the real world around them. It is therefore important for students to be exposed to the knowledge and skills they need to understand the mole concept in order to link with the other concepts in Chemistry. In view of this, the teacher can achieve this by placing students in a situation where they are actively involved in the lesson.

Many students studying Integrated Science have often complained of the difficulty involved in solving problems related to the mole concept. Indeed, the mole concept is broad and as a matter of fact presents Chemistry in Integrated Science as Mathematics related subject, as it involves the use of formulae to do calculations. With the persistence of these problems, attempts have been made by other researchers to intervene but to no avail. It is for this reason that I also realized during my six years of teaching Integrated Science at Keta Business College and Deltas Remedial College at Keta that students studying Integrated Science have some misconceptions such as: *"the mole is a certain mass and not a certain number"* (the mole is seen as a mass and not as amount) or *"the mole is a property of a molecule"* and difficulties like basic mathematical principles, scientific notation used in the problems, the Avogadro constant and difficulties in students‟ abilities to solve two-step problems versus one-step problems about the mole concept.

Students generally were not familiar with the use of the mole as a unit of the amount of substance. They chose the wrong answer for the "mole" definition, identifying it with the weight in grams. These problems could be attributed to the fact that, teachers placed too much emphasis on the discussion method of teaching due to the voluminous nature of the Integrated Science syllabus, almost all teachers teaching the subject were not trained as Integrated Science teachers, mole concept seemed to be a challenging topic for teachers and lack of laboratory for experiments. Also, some Integrated Science teachers resort to the use of the formula in solving problems in mole concept without learners‟ full understanding due to the mastery and competency of the concept.

Learning difficulties and consequently their poor performance in mole concept can be to larger extent attributed to the teachers' difficulties in presenting the concept. These explained the reason why learners performed poorly in mole concept questions in WASSCE. Candidates were not able to carry out the calculation of the molar mass of compounds, calculate the number of moles of the substance and molarity of solutions, (Chief Examiner‟ report 2005, 2009, 2011, 2012, 2014, 2015, 2016, 2017, 2018 and 2019 both regular and private candidates) The aim of this study is to investigate the use of concept map to enhance academic achievement/performance and retention of students in mole concept at Keta Business College (KETABUSCO)

The teaching methods employed for the teaching and learning of Integrated Science at the Senior High School level has little or no positive effect on Students‟ academic achievement in Integrated Science particularly Mole Concept. This is because majority of Integrated Science teachers still teach students using the lecture method. Science educators reported that about 80-90% of the scientific information or principles students received from their teachers are through lecture method. Chief Examiner also pointed out that the use of concrete materials facilitates better and proper understanding of Integrated Science concepts. This is because Integrated Science or Chemistry concepts are abstract and can best be taught using activity base method which is “Hands on” “minds on”. A number of activity-oriented instructional strategies have been advocated for by curriculum designers and Science educators to facilitate meaningful learning and preventing misconception and also to help improve on the failure rate among Senior High School Science Students. Examples of these strategies include guided discovery approach, demonstration method, discussion method, concept mapping and problem-solving for teaching Integrated Science at Senior High Schools, (Danjuma & Aishatu, 2010).

Therefore, Integrated Science concepts must be conveyed to the receiver (student) accurately and well-arranged. For the successful learning, teaching strategies, methods, techniques and tools should transform knowledge from short-term memory to long-term memory. Ausubels‟ theory of meaningful learning is one of the most important expository theories which explain how to transform information from short-term memory to long-term memory. According to this theory Meaningful learning occurs when complex ideas and information are combined with students‟ own experiences and prior knowledge to form personal and unique understandings. In this process, it can be said that concept maps are one of the most important teaching and learning tool that promote meaningful learning in Integrated Science or Chemistry (Ausubel, 1960 & 1962). Ausubel projected meaningful learning to the disadvantage of rote learning by indicating that meaningful learning requires three conditions:

1. The material to be learned must be conceptually clear and presented in a language and relatable to the learner‟s prior knowledge.
2. The learner must possess relevant prior knowledge, and
3. The learner must choose to learn meaningfully.

Concept maps are helpful in meeting the above conditions by identifying general concepts prior to instruction in more specific concepts. It assists in sequencing learning tasks through progressively more explicit knowledge that anchors developing conceptual frameworks by incorporating new meanings into prior knowledge.

Concept maps are graphical teaching and learning tools that are convenient for representing and organising knowledge, with strong psychological and epistemological background. This background is based on Ausubel (2000) and Novak‟s (2002) theories. Using Ausubel‟s ideas of how learners construct meaning, and relying on the main distinction between the meaningful and rote learning, Novak has developed a concept map as a tool to represent concept/propositional framework for domain-specific knowledge (Lagowski, 2009). Concept mapping is an educational tool that is used to facilitate and demonstrate students‟ comprehension through the use of visual medium. Concept Map is a graphical tool that organises, connect, and synthesise information. Concept maps show concepts in circles or boxes and one can indicate relationships between concepts by connecting lines or linking words. Concept maps are two or three-dimensional spatial or graphical displays that make use of labelled 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 organise their thinking and summarising subjects of study (Canas, Hill, Granados & Perez, 2003).

Concept mapping is a teaching and learning strategy that establishes a bridge between how people learn knowledge and sensible learning. Concept mapping promises to be useful in enhancing meaningful learning and students‟ conceptual understanding. Concept mapping helps meaningful learning in several ways. It is an activity that provides the student with an opportunity to organize, summarize, analyse and evaluate many different ideas. Thus, it promotes the development of critical thinking skills, which can then be used for other meaningful learning activities (Sharma, 2012; Kumar, Manoj & Rizwaan, 2013; Brinkerhoff & Booth, 2013). It is believed that, one of the reasons Concept Mapping is so powerful for the facilitation of meaningful learning is that it serves as a kind of template or scaffold to help organise knowledge and to structure it, even though the structure must be built up piece by piece with small units of interacting concept and propositional frameworks. Teachers can use concept maps for obtaining information on what students know, how their conceptions are related to each other, and how they reorganise their cognitive structure after a specific training activity. They also serve as metacognitive tools for improving students' learning. In this way, teachers have the opportunity to identify some misconceptions that prevent construction of meaningful knowledge and check the effects of teaching on students' cognitive structure. Concept maps allow students to think deeply about the concepts by helping them to understand better and organize what they learn, and to store and retrieve information more smoothly and efficiently, (Novak, 1990b).

All concept maps have three components, (Hay, Kinchin & Lygo-Baker, 2008; Emmanuel, 2013) asserted that concept maps components are nodes that represent concepts; lines represent relations between concepts, arrowheads indicate direction and labels on the lines describe the nature of the relationship. Combined, these three components create propositions or meaningful statements

From an educational perspective, a growing body of research indicated that the use of concept maps could facilitate meaningful learning (Canas, Hill, Craft, Suri, & Lott, 2004). Concepts 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, De-Leij & Hay, 2005). (Novak & Gowin 1983) 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 and retention. Concept maps can be used for many purposes in Integrated Science education; as a method of learning, as a teaching method, as a curriculum and lesson planning method, as an evaluation method of students" performance. In addition, it helps to identify misconceptions held by students.

Since 1990, concept maps have been used in many ways as a research topic in science stream such as, Barenholz and Tamir (1992), Trowbridge and Wandersee (1998), Hegarty-Hazel and Prosser (1991). All of these researches have been proved under the validity, reliability and practicality of concept map as a method of teaching. Today instructors and educators are looking for more active and interactive teaching techniques. At this point, concept map work better in the field of education and take another step forward to instructional technique. The important thing is my contribution for the usage of effective teaching technique. With each passing day, the effective use and the effective implementation of concept map is explored and it makes learning of mole concept easier for learners.

Adepoju (2012) describes retention as the level at which an individual is capable to re-call an acquired knowledge at any given time. The author adds that, retention is measured in collaboration with achievement. This means that achievement is a function of retention. Hornby (2002) in Tyopav (2013) describes retention as the ability to remember experiences and things learnt. Similarly, Kundu and Tutoo (2002) in Olom (2010) posit that, retention is the preservation of mind. These imply that the amount of knowledge learnt and kept, skill maintained or problem-solving behaviours manifested consistently reflects what is retained. By implication, retention in Mole Concept knowledge is the ability of a learner to keep and remember as well as recall or reproduce the acquired knowledge or some parts of the knowledge after some period of time have elapsed. Therefore, to improve students‟ achievement level in Mole Concept, implies to improve the level at which they retain the Concepts of Mole learnt. Bichi (2007) reported that, anything that aids learning should improve retention while things that lead to confusion or interference among learned material decrease the speed and efficiency of learning and accelerates forgetting. Hence the researcher sees the need to find out if concept mapping could improve retention of male and female students in Mole Concept.

Gender inequality in Science and Education in general has remained a perennial problem of global scope. The differences between boys and girls in relation to Integrated Science achievement have received a lot of attention. Some studies indicated that, boys achieve better, either no difference or girls outperform boys have been demonstrated. Studies on gender differences in Integrated Science achievement continue to yield inconsistent results and it has usually been attributed to unequal exposure of males and females to learning instructions relevant to Integrated Science learning. Therefore, it is of interest to determine the relationship changes in sex of students could predict their achievement and retention in Mole Concept using Concept Mapping. Other effect of Concept Mapping still exist which can either positively or negatively have effect on Integrated Science students‟ achievement and retention.

It is on this note that this study is set out to examine the role of Concept Mapping strategy in teaching Senior High School Integrated Science and how it improved students‟ academic achievement and retention in Mole Concept and also whether concept mapping teaching strategy is gender related or not.

1.2 Statement of the Problem

The researcher‟s handling of mole concept at Keta Business College and Deltas Remedial College in Keta for the past six years, found out that most students have difficulty handling questions involving the mole concept. Students find working with the mole concept difficult and frustrating to understand. With enough practice, they can memorize a pattern to complete the calculations, but have a difficult time understanding the concept, quickly losing their enthusiasm to work with these calculations. This led to high rates of failure recorded by students in Integrated Science in external examinations such as West African Senior Secondary Certificate Examination (WASSCE) conducted by West African Examinations Council (Chief Examiner‟s report, 1993; 2004; 2006; 2009; 2010; 2012; 2013; 2016; 2017; 2018; 2019 & 2020) Integrated Science being a core science subject at the Senior High School level of education is expected to serve as a base for scientific and technological knowledge that enable the "learner" to fit into the scientifically and technologically progressive society.

A good number of students that offer Science and Science related courses in higher institutions are expected to pass Integrated Science at credit level. Despite this expectation, low achievement in Integrated Science by students appears to have persisted which is often blamed on poor teaching methods adopted. Poor method of teaching invariably translates to students‟ poor achievement and inability to retain and to put into practice what is learnt in reality has become a hydra-headed problem. In most cases what is taught in the classroom cannot be transferred to real life situation by students. Assessment of their work books and exam scripts revealed that, most of the students avoid answering questions involving mole concept and those who attempted it, got it wrong. Also the problem was evident in low scores on tests and quizzes, missing and incomplete assignments, lack of student participation, low self-esteem, reduced time on task, and minimal student performance.

After teaching for the past six years in the school and interacting with the learners through unstructured interview, it was realised that the students have the following difficulties and misconceptions;

1. the perception that mole concept is very difficult and confusing;
2. difficulties with the basic mathematical principles;
3. the misapplication of formulae in calculations whenever mole concept questions are raised;
4. unawareness of relationship between 'mole‟ and 'concentration in mol/dm^3'.
5. difficulties with the Avogadro constant and solving concentration problems;
6. students assigning wrong S.I units to particular measurement or calculations done;
7. how to properly analyze and answer mole concept questions;
8. difficulties with understanding the mole as a unit of the quantity of substance, as a concept and as a defined quantity;
9. difficulties with tasks that are changed by adding some scientific notation;
10. lack of practice in problem solving.

The nation‟s quest for science and technological advancement become a mirage, if effective modality is not put in place to incorporate innovative methods that promote active learning and considering the importance of Integrated Science in all round development (Sunday, 2013). There is need to make sure that Integrated Science is properly taught most especially the difficult concepts such as mole concept using innovative methods such as concept mapping. Therefore, this study examined the role of concept mapping strategy in teaching and learning mole concept in Senior High School Integrated Science; focused on how it improve the academic achievement and retention of students in Keta Business College (KETABUSCO).

1.3 Purpose of the study

The main purpose of the study was to introduce concept maps as a tool for meaningful learning, student centered, active, new learning and teaching of mole concept. The study examined the use of concept mapping on students‟ achievement and retention in mole concept in Keta Business College.

1.4 Objectives of the Study

According to Cooney, Davis and Henderson (1975), objectives should be stated in terms of observable student‟s behaviour. The study aims to determine:

1. the factors that affect students‟ academic achievement and retention in mole concept.
2. the effect of concept mapping strategy on students‟ academic achievement in mole concept.
3. gender difference in academic achievement when taught mole concept using concept mapping.
4. gender difference in concept map construction.

1.5 Research Questions

The study was guided by the following research questions:

1. What are the factors that affect students" academic achievement and retention in mole concept?
2. What is the effect of concept mapping strategy on mole concept?
3. What is the difference in academic achievement mean scores of males and females students when taught mole concept using concept mapping?
4. What is the difference between male and female students" ability to construct a concept map?

1.6 Significance of the Study

Improvements of teaching methods, strategies and techniques have been the concern of Integrated Science teachers and educators since time immemorial. These desires have motivated Integrated Science teachers to carry out research work in various aspects of the subject that interest them. These in effect serve as a guide to teaching and learning of the subject. The mole concept plays a vital role in the study of Chemistry and Integrated Science as a whole. It would serve as source of guide to do effective teaching and learning of the mole concept. It is hoped that the findings of this study could encourage the use of concept mapping during teaching and learning process to enhance students" achievement and retention in Mole Concept. Specifically, school authorities, teachers, students, educational administrators, prospective researchers and curriculum developers may stand to benefit from the findings of this study. The findings of this study would help in improving Integrated Science education in the following ways;

1. The findings of the study would facilitate the improvement of Science teaching and learning particularly Integrated Science in senior high schools, by using suitable teaching methods that require students to brainstorm.
2. The findings of this study would be of benefit to the students as it would make them to have a better understanding of the way to solve mole concept problems thereby improving their achievement and retention in mole concept.
3. The concept mapping strategy employed as intervention would help the students analyze and solve mole concept questions without just memorizing formulas because of examination.
4. The results of this study would serve as guides for teachers to vary their approach and methodology to enable students understand the mole concept.
5. Findings of this study would encourage the use of concept mapping during teaching and learning process to enhance students‟ achievement and retention of science concepts.
6. It served as a resource material for all stakeholders and others who would like to research further into this area of national interest.
7. The findings of this study would also create confidence in the teachers that the use of concept mapping in the form of hands-on activities is capable of improving the achievement and retention level of students.
8. To the researchers, the findings of this study may be a framework for further studies in related studies in Integrated Science or other fields. Curriculum developer at the other end, it gives further evidence for or against the use of concept mapping and would therefore provide basis for future work in curriculum development. This lead to the writing of books that may assist teachers have adequate information on the use of concept mapping and popularize its use in Ghanaian schools.

1.7 Delimitations of the Study

This study addressed only the Mole Concept. The study was limited to only Second Year Students of General Arts 2B of Keta Business College in the Volta Region of Ghana; though this problem might exist in other Senior High Schools in the Keta Municipality as well as the Country, Ghana. The selected concepts that were taught included Mole as a concept and a unit, Molarity, Mass Concentration, Molar mass, Amount, Avogadro"s number, Atomic mass and Mass number. The hierarchical type of concept mapping was used in this study. The study also covered the following variables: the effect of concept mapping on male and female students" achievement and retention in Mole Concept.

1.8 Limitations of the Study

Best and Kahn (1989) explained that limitations are conditions beyond the control of the researcher that placed restrictions on the validity of the study. This study like all other research works is not without limitations. One of the major limitations of the study was that the study considered only the views of the General Arts 2B students and Integrated Science teachers in the Keta Business College and this might not reveal the general picture about how the mole concept is taught at the school and other Senior High Schools.

The study was intended to cover all the twelve Senior High Schools in the Keta Municipality but due to time constraints as well as observation of COVID-19 protocols, the study was limited to only one school in the municipality specifically. Some of the students sampled for the study were absent from lessons during the intervention stage and this equally affected the study.

Even though the interviews were intended to gain in depth understanding of respondents‟ understanding and experiences related to the teaching and learning of the mole concept, participants tend to give responses consistent with their perceptions of the researcher‟s experiences.

Another limitation of the study was the respondents‟ misunderstanding of questions or failure of the respondents to answer all the questions.

1.9 Operational Definition of Terms

For the purpose of the study, the following definitions are implied for the terms below.

Achievement: -This is the learning outcome or attainment of students taught Mole Concept using Concept Mapping as expressed in scores.

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

1.10 Organisation of the Study

This thesis is organised into five chapters. The first chapter is the introduction which outlines inspiration for undertaking this research, statement of the problem that informed the study, purpose of the study, objectives of the study, research questions, educational significance of the study, delimitation of the study, limitations of the study, organisation of the study, definition of terms and abbreviations. Chapter two looks at the review of the related literature that focused on the following themes: theoretical framework Bruner‟s 1960 theory of learning by discovery, Bruner (1960); Kolb‟s 1984 theory of learning by doing, Kolb (1984) and the Shulman‟s (1986) three knowledge domains in teaching grounded with the Constructivists views of teaching and learning), conceptual framework Shulman (1986): concept mapping including (teaching strategy, origin of concept mapping, types of concept mapping, Construction of Concept

Mapping, uses and benefits of concept mapping in Teaching and learning of science); students‟ achievement in mole concept, students‟ retention in Integrated Science and gender difference in Integrated Science. Literature is also reviewed on the following thematic areas: the fundamental Concept about the Mole; the Mole as a Unit; related Concepts like Relative Atomic Mass (A_r), Relative Molecular Mass (M_r), Molar Mass (M), Avogadro‟ constant(N_A or L), Amount, molarity and mass concentration and the rationale for the teaching of the mole concept.

Chapter three is the methodology under the themes: Research area, Research design, Population and Sample, Sampling Techniques, Research Instruments, Validity of the Instrument, Reliability of the Instrument, Data collection procedure (Pre-Intervention Activities, Intervention Design and Post-Intervention Activities) and Data Analysis Plan. Chapter four dwells on the analysis and discussion of results obtained from the research instruments and chapter five is dedicated to summary of findings, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

Relevant literatures are reviewed here. It is discussed under two major sub-headings: theoretical and conceptual frameworks. This section provides theoretical framework anchor for the method employed in this work. Similarly, concepts related to this study are explained in relation to the topic.

2.1 Theoretical Framework

The theoretical framework discusses the relevant theories that anchor this research work. The theories discussed include: Bruner‟s (1960) theory of learning by discovery; Kolb‟s (1984) theory of learning by doing and the Shulman‟s (1986) three knowledge domains in teaching grounded in the Constructivists views of teaching and learning.

2.1.1 Bruner's (1960) Theory of Learning by Discovery

A major theme in the theoretical framework of Bruner is that learning is an active process in which learners construct new ideas or concepts based upon their current or past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so. Cognitive structure (i.e., schema, mental models) provides meaning and organization to experiences and allows the individual to "go beyond the information given".

Bruner‟s theory of discovery learning emphasises the importance of discovery learning method of instruction. He maintained that learning is best promoted when one is able to figure out new ideas or concepts. One is able to do this either because his cognitive structure (that is the existing structure of knowledge) is already tuned to absorb new information in which case there is familiarity and the new set is simply assimilated or if the new learning material is incompatible to the existing structure of knowledge, a restructuring to accommodate the new learning material must take place.

Bruner proposes that learners‟ construct their own knowledge and do this by organising and categorising information using a coding system. Bruner believed that the most effective way to develop a coding system is to discover it rather than being told by the teacher. The concept of discovery learning implies that students construct their own knowledge for themselves (also known as a constructivist approach). The role of the teacher should not be to teach information by rote learning, but instead to facilitate the learning process. This means that a good teacher designs lessons that help students discover the relationship between bits of information. To do this a teacher must give students the information they need, but without organizing for them. The use of the spiral curriculum can aid the process of discovery learning.

The implication of this theory to mole concept teaching is that, teacher should create activities for the students in the process of instruction with a purpose that, they would learn the basics as they are engaged in the activity. A discovery activity is a learner-centred activity in which student utilize his new mental skills to find the answer to a problem. This technique when applied in mole concept teaching, according to Bruner, help to generate self-confidence, encourages autonomy and independent, promotes the development of creativity and problem-solving skills, intellectual excitement, retention, actively engages students learning process, motivation of students to participate and critical thinking which invariably enhance students‟ achievement and retention. Bruner‟s theory is relevant to this present study because it points out that learning occurs when one is able to discover a new idea by doing it personally for a greater achievement and retention.

2.1.2 Kolb's (1984) Theory of Learning by Doing or Experience

Kolb states that learning involves the acquisition of abstract concepts that can be applied flexibly in a range of situations. In Kolb"s theory, the impetus for the development of new concepts is provided by new experiences (Kolb, 1984).

Kolb"s theory upholds that, learning is the process whereby knowledge is created through the transformation of experience or activity. The theory presents a cyclical model of learning, consisting of four stages. One may begin at any stage, but must follow each other in the sequence. The first stage called the concrete experience, this is where the learner actively experiences an activity such as a lab session or field work. The second stage is called reflective observation, this is when the learner consciously reflects back on that activity. The third stage is called „abstract conceptualization, this is where the learner attempts to conceptualize a theory or model of what is observed. The final stage, active experimentation, this is where the learner is trying to plan how to test a model or theory or plan for a forthcoming activity (Kolb, 1984)

Kolb identified four learning styles which correspond to these stages. The styles highlight conditions under which learners learn better. The styles are: assimilators, who learn better when presented with sound logical theories to consider. Converges, who learn better when provided with practical application of concepts and theories. Accommodators, who learn better when provided with "hands-on" activities. Diverges, who learn better when allowed to observe and collect a wide range of information.

Kolb"s theory of learning by doing is relevant to this present study because, it emphasises the importance of active involvement of the learner in concrete experience or activity using concrete materials. It gives an insight on the manner as well as procedural steps involved in learning by activity through a series of sequential arrangement of those activities for effective learning. It also emphasised that learning from experience or activity must involve links between the doing and the thinking. By implication, learning Mole Concept by doing may enhance reflection towards such activities, therefore, enhancing retaining ability of such activities. It is from the feelings and thoughts emerging from this reflection that generalisations or concepts can be generated. Therefore, its generalizations would enable new situations to be tackled effectively. The theory supports this study as its emphasis on hands-on concrete activities and direct involvement of the learner in the learning processes. Presentation of the mole concepts ideas requires the use of hands-on activities and analogies that would help learners to have a conceptual understanding of the embedded multiple meanings of the associations of the amount of substance with other quantities. Ideally, activities and material should be developed in ways that draw on abilities from each stage of the experiential learning cycle and take the students through the whole process in sequence (Kolb, 1984). A typical presentation of Kolb's two continuums is that the east-west axis is called the Processing Continuum (how we approach a task), and the north-south axis is called the Perception Continuum (our emotional response, or how we think or feel about it) (Kolb, 1984).

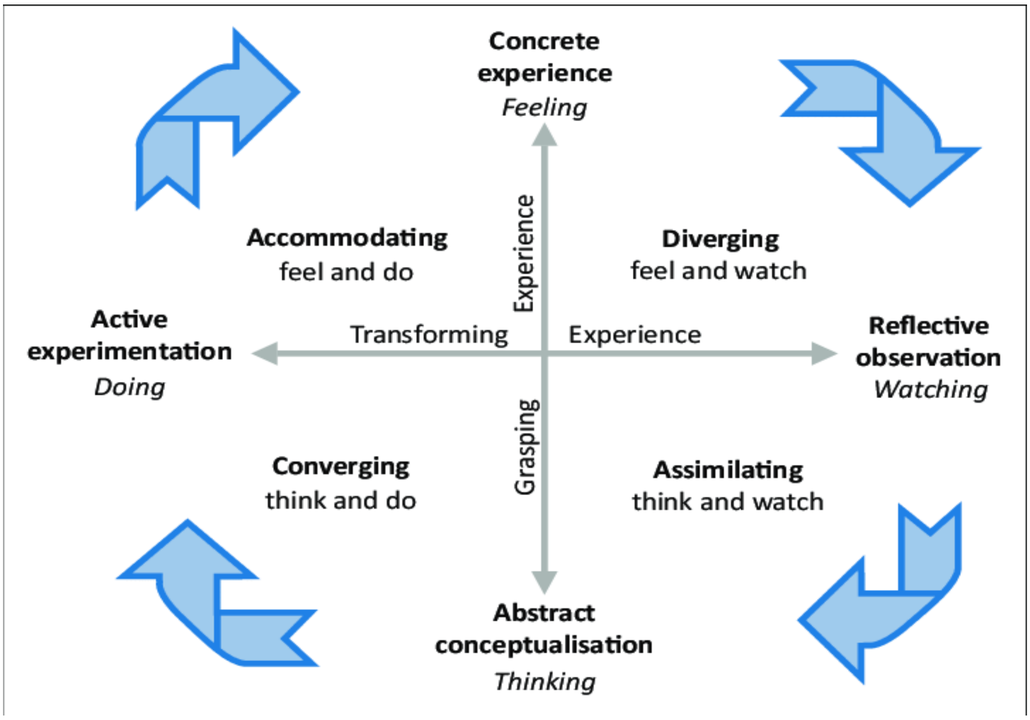


Figure 2.1: Kolb's learning cycle and experiential learning styles.

Source: simplypsychology.org

Kolb believed that both variables cannot be performed on a single axis at the same time (e.g., think and feel). Our learning style is a product of these two choice decisions. Effective learning only occurs when a learner can execute all four stages of the model. Therefore, no one stage of the cycle is effective as a learning procedure on its own.

2.1.3 Shulman‘s (1986) three knowledge domains in teaching

The theoretical framework for this study is also based on the Shulman‚s (1986) three knowledge domains in teaching; grounded with the Constructivist views of teaching and learning. These domains of Shulman (1986) encompass:

1. Subject Matter Content Knowledge (SMCK) of the teacher
2. Pedagogical Content Knowledge (PCK) of the teacher
3. Curricular Knowledge (CK) of the teacher

To teach all students according to today„s standards, teachers need to understand subject matter deeply and flexibly so that they, can help students create useful cognitive maps, relate one idea to another, and address misconceptions. Teachers need to see how ideas connect across fields and to everyday life. This kind of understanding provides a foundation for Pedagogical Content Knowledge that enables teachers to make ideas accessible to students (Shulman, 1987).

Teaching is not a matter of knowing something. It is far more than mere transmitting of concepts and ideas to learners. It involves bringing out the accumulated ideas and experiences that students come to class with and working on those ideas and experiences together with the students by way of refining, reorganizing, co-constructing and repairing these ideas and experiences into meaningful and compressible form for students to assimilate (Shulman, 2000). This forms the foundation on which teaching and learning Integrated Science through problem solving leans on.

According to Shulman (2000), teaching is about making the internal and external capabilities of an individual and can only be achieved if teachers engage students in the classroom discourse. It is only when students are engaged in an interactive classroom environment that their ideas, conceptions and experiences are made bare to the teacher to put them on truck.

2.1.3.1 Subject Matter Content Knowledge (SMCK) of the teacher

Shulman (1986) defined Subject Matter Content Knowledge as the amount and organization of knowledge intrinsically in the mind of the teacher. Shulman argues that teachers" subject matter content knowledge should not be limited to knowledge of facts and procedures; but also an understanding of both the substantive and syntactic structures of the subject matter.

The substantive structures are the various ways in which the basic concepts and principles of the discipline are organised to incorporate its facts. Teachers would therefore be able to use appropriate materials to teach Integrated Science well only when they comprehend the network of fundamental concepts and principles of problem solving in holistic manner (Shulman, 1986).

The syntactic structure of a discipline is the set of ways in which truth or falsehood, validity or invalidity are established (Shulman, 1986). The syntactic structure is used to establish the most appropriate claims about a particular phenomenon. Teachers" knowledge must therefore go beyond mere definitions of accepted truths in the subject matter domain.

In sum, to provide for effective teaching and learning of Mole Concept, Integrated Science teachers" Content Knowledge of concepts cannot be underplayed. The researcher believes that teacher,,s knowledge of mole concept is essential to their ability to teach effectively as Brophy (1991) cited in Asiedu-Addo and Yidana (2004). Teachers" knowledge is more explicit, better connected and more integrated, they would tend to teach the subject more dynamically, represent it in more varied ways, encourage and respond fully to students" comments and questions. Where their knowledge is limited, they would tend to depend on the text for content, de-emphasise interactive discourse in favour of assignments and in general portray the subject as a collection of static, factual knowledge.

This suggests that, the teacher uses mainly non provocative questions, and often selects only what to teach. Teachers found it difficult to deal with learners" wrong associations, conception and learning difficulties. This was because, to a larger extent, teachers were responsible for those misconceptions and learning difficulties. Teachers had the same conceptual challenges in understanding most of the concepts and hence they transmitted them to learners. Teachers‟ conceptual shortcomings limited their ability to identify learners‟ difficulties in understanding of key concepts. It also affected their creativity and innovativeness in addressing learners‟ misconceptions. This shows that without sound Content Knowledge it is very difficult to identify learners‟ misconception and learning difficulties. A teacher with sound mole concept Pedagogical Content Knowledge is likely to have knowledge about; the types of difficulties that learners experience, typical paths that learners‟ transverse to achieve understanding and potential strategies for helping learners overcome learning obstacles of the concept. This knowledge is critical for effective teaching and learning of the mole concepts, Shulman (1986)

2.1.3.2 Pedagogical Content Knowledge (PCK) of the Teacher

Pedagogical knowledge includes generic knowledge about how students learn, teaching approaches, methods of assessment and knowledge of different theories about learning (Harris, Mishra & Koehler, 2009), cited in Shulman, (1986). This knowledge alone though necessary; is insufficient for teaching purposes. According to Shulman (1986), pedagogical content knowledge is knowledge about how to combine pedagogy and content effectively. It includes, what approaches fit the content, knowing how elements of content can be arranged for better teaching. It also involves knowledge of teaching strategies that incorporate appropriate conceptual representations to address learner difficulties and misconceptions and foster meaningful understanding; and knowledge of what the students bring to the learning situation; knowledge that might be either facilitative or dysfunctional for the particular learning task at hand. Shulman (1986) lay emphasis on the pedagogical content knowledge as the combination of the most regular taught topics, the most useful forms of representations of those ideas, the most powerful analogies, examples, illustrations, explanations and demonstrations in the art of teaching. Shulman (1987) defined PCK as the ability of teachers to transform their content knowledge and pedagogical knowledge into an understanding of how some particular topics are organized, represented, adapted and presented for instruction to meet the diverse interests and abilities of students.

Pedagogical Content Knowledge also includes the ways of representing and formulating mole concept subject matter that makes it comprehensible to students with diverse views and understandings. In teaching Integrated Science through activity oriented base and problem solving techniques, teachers need to design and present the lesson using appropriate teaching learning materials (TLMs) that can enable the students construct their own knowledge of the concept. They need to know the pedagogical strategies and techniques most appropriate for reorganizing the understanding of learners who might appear before them as blank slates (Shulman, 2000); hence the knowledge of subject matter in the training of an Integrated Science teacher in particular and the classroom teacher in general is as important as the methodology aspect of it, and that the course outline in the Second Cycle Institutions should be reviewed in a more pragmatic approach by encouraging students to appreciate the need for both practical and content courses (Asiedu-Addo & Yidana, 2004).

2.1.3.3 Curriculum Knowledge (CK) of the Teacher

The word „curriculum" comes from a Latin root which originally meant a course to be run, that is, a course in the sense of race-course (Mereku & Agbemaka, 2009).

Curriculum has numerous definitions which can be slightly confusing; especially meeting it the first time. It refers to all the courses offered at a school; it is the prescribed course of studies which students must fulfil in order to pass a certain level of education. Curriculum is really more than just what is taught in the classroom. The term was once used to refer only to the content of educational provision. It was therefore barely distinguishable from terms like „syllabus" or even timetable, Mereku (2004). It is anything and everything that teaches a lesson planned or otherwise. Humans are born learners, thus the learned curriculum actually encompasses a combination of the hidden, null, written, political and societal etc. Since students learn all the times through exposure and modelled behaviours, it means that they learn important social and emotional lessons from everyone who inhabits the school.

According to Tanner and Tanner (1975) cited in Mereku and Agbemaka (2009), Curriculum is the planned and guided learning experiences and intended outcomes, formulated through the systematic reconstruction of knowledge and experience under the auspices of the school, for the learner‟s continuous and willful growth in personal-social competence. This definition according to Mereku and Agbemaka (2009) highlights the fact that the curriculum must take into account not only established knowledge but also emergent knowledge. This is because curriculum while transmitting the cumulative tradition of knowledge also concerns with the systematic reconstruction of knowledge in relation to the life experience, growth and development of the learner.

An interesting interpretation of the term „curriculum" by Costa and Liebmann (1997) cited in Mereku and Agbemaka (2009) is given as: Curriculum is the pulse of the school; it is the currency through which educators exchange thoughts and ideas with students and the school community. It is the passion that binds the organization together. Curriculum, in the broader sense, is everything that influences the learning of students both overtly and covertly, inside and outside the school.

Whereas, Young (1998) cited in Mereku and Agbemaka (2009) looks at the curriculum as socially organized knowledge; and said academic curricula are as much the products of people‟s actions in history as any other form of social organization. They are not given, nor, in today‟s language, do they represent an unchanging gold standard. They can therefore be transformed.

From the definitions above, it is possible to state that a curriculum has the following characteristics: It comprises the experiences of children for which the school is responsible, it has content, it is planned and it is a series of courses to be taken by students.

In addition, a curriculum considers the learners and their interaction with each other, the teacher and the materials. The output and outcomes of a curriculum are evaluated. Bringing all these points together, the curriculum is viewed as a composite whole including the learner, the teacher, teaching and learning methodologies, anticipated and unanticipated experiences, outputs and outcomes possible within a learning institution (Mereku & Agbemaka, 2009). The Integrated Science Curriculum therefore is represented by a full range of programmes designed for the teaching of Integrated Science topics at a given grade level. It covers a wide variety of instructional materials available in relation to the subject matter to be handled and the set of characteristics that guides the use of particular curriculum materials in particular circumstances (Shulman, 1986). Teachers need to think hard about students mole concept ideas, analyse textbooks presentations and judge the relative value of two different representations in the face of a particular mole concept issue (Ball & Bass, 2000).

Integrated Science teachers need to have thorough understanding of the curricular resources available for instruction so as to make them available to students when teaching mole concept for students to make their own meaning of terms and concepts.

2.2 Constructivist Idea of Learning or Approach To Learning

Constructivism is an epistemology, or a theory, used to explain how people know what they know. Fundamentally, constructivism says that people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences. Constructivist conceptions of learning have their historical roots in the work of Dewey (1929), Vygotsky (1962), and Piaget (1980). This theory hypothesizes that individuals try to make sense of all information that they perceive, and that each individual, therefore, "construct" their own meaning from that information. Driscoll (2000) explains that constructivist theory asserts that knowledge can only exist within the human mind, and that it does not have to match any real world reality.

According to Driscoll (2000), constructivism learning theory is a philosophy which enhances students' logical and conceptual growth. The underlying concept within the constructivist learning theory is the role which experiences-or connections with the adjoining atmosphere-play in student education. The constructivism learning theory argues that people produce knowledge and form meaning based upon their experiences. Two of the key concepts within the constructivism learning theory which create the construction of an individual's new knowledge are accommodation and assimilation. Assimilating causes an individual to incorporate new experiences into the old experiences. This causes the individual to develop new outlooks, rethink what were once misconceptions, and evaluate what is important, ultimately altering their perceptions. Accommodation, on the other hand, is reframing the world and new experiences into the mental capacity already present. Individuals conceive a particular fashion in which the world operates. When things do not operate within that context, they must accommodate and reframing the expectations with the outcomes. Learners constantly try to derive their own personal mental model of the real world from their perceptions of that world. As they perceive each new experience, learners continually update their own mental models to reflect the new information, and therefore, construct their own interpretation of reality. The basic idea is that problem solving is the core of learning, thinking, and development. As people solve problems and discover the consequences of their actions through reflection on past and immediate experiences – they construct their own understanding and deeply understand what they have constructed.

Constructivism is basically a theory based on observation and scientific study about how people learn. When we encounter something new, we have to reconcile it with our previous ideas and experience, by changing what we believe, or discarding the new information as irrelevant. In any case, learners are active creators of their own knowledge. To do this, we must ask questions, explore, and assess what we know, Driscoll (2000).

The constructivist learning is an active process where learners should learn to discover principles, concepts and facts for themselves. Knowledge is thus a product of humans and is socially and culturally constructed. Learning is not a process that only takes place inside our minds, it is a passive development of our behaviour that is shaped by external forces and that meaningful learning occurs when individuals are engaged in social activities. This means that the learning experience is both subjective and objective and requires that the culture, values and background become an essential part in the shaping of knowledge. Constructivism advocates learner-centred, activity-centred interactive pedagogical approach.

It is important to note that constructivism is not a particular pedagogy. In fact, constructivism is a theory describing how learning happens, regardless of whether learners are using their experiences to understand a lecture or following the instructions for building a model airplane. In both cases, the theory of constructivism suggests that learners construct knowledge out of their experiences. Constructivism is a philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates our own "rules" and "mental models," which we use to make sense of our experiences. Learning, therefore, is simply the process of adjusting our mental models to accommodate new experiences. Constructivism promotes a sense of personal agency as students have ownership of their learning and assessment. The following concepts are considered as central to the constructivist instructional design (Wilson & Cole, 1991):

1. Learning is embedded in a rich authentic problem-solving environment;
2. Authentic versus academic contexts for learning are provided;
3. Provisions for learner control are incorporated;
4. Errors are used as a mechanism to provide feedback on learners" understanding; and
5. Learning is embedded in social experience.

2.2.1 The 5 E's of Constructivist Approach to Learning

According to Bybee (2009), the 5E"s is an instructional model based on the constructivist approach to learning, which says that learners build or construct their own ideas. The 5E‵s can be used with students of all ages, including adult. Each of the 5E‵s describes a phase of learning and each phase begin with the letter "E" which are Engage, Explore, Explain, Elaborate and Evaluate. The 5E‵s allow students and teachers to experience common activities to use and build on prior knowledge and experience, to construct meaning and to continually assess their understanding of a concept.

1. **Engage:** This phase of 5E‵s start the process. An engage activity should do the following: Make connection between past and present learning experience. Anticipate activities and focus students‵‵ thinking on the learning outcomes of current activities. Students should become mentally engaged in the concept, process or skill to be learned.
2. **Explore:** This phase provide student with a common base of experience. They identify and develop concepts, processes and skills during this phase; students actively explore their environment or manipulate materials.
3. **Explain:** This phase of 5E‵s helps students explain the concepts they have been exploring. They have opportunities to verbalize their conceptual and understanding or to demonstrate new skills or behaviors. This phase also provides opportunities for teachers to introduce formal terms, definitions and explanations for concepts, process, skills or behavior.
4. **Elaborate:** This phase of 5E‵s extend students‵‵ conceptual understanding and allow them to practice skills and behaviors. Through new experiences, the learners develop deeper and broader understanding of major concepts, obtain more information about areas of interest and refine their skills.

5. **Evaluate:** This phase of the 5E"s encourages learners to assess their understanding and abilities and lets teachers evaluate student"s understanding of key concepts and skill development, Bybee (2009).

2.2.2 Principles of Constructivism Approach to Learning

The basic idea of constructivism is that knowledge is constructed in the mind of the learner. On the basis of the ideas underlying in the theory of constructivism, we can also formulate the following principles of learning based on constructivism

1. Learning is a constructive process of building new knowledge and not simply the collection of information from various sources. Each learner individually constructs his own knowledge as he or she learns.
2. Learning is a search for meaning. Therefore, learning must start with the issues around which students are actively trying to construct meaning.
3. Meaning requires understanding wholes as well as parts. Parts must be understood in the Context of wholes. Therefore, the learning process focuses on primary concepts, not isolated facts.
4. Learners build their new understanding by using their previous knowledge and experiences. They already have a repertoire of previously established knowledge which works as a foundation for developing new knowledge.
5. Learning is an interpretive process. Learners construct new knowledge by connecting the current information and experiences with their previous knowledge and interpreting the synthesis of the two, thus, it is the learner who provides meaning to the new synthesis.

6. Learning is an active process rather than passive. Learner is not passive recipient of the information alone. They remain active throughout the process of knowledge construction.
7. Learning is a social activity. In learning student interact with peers, teachers, family members and experts in the field. Though students construct their own knowledge but they also use other‟s experience for building final knowledge.
8. In constructivism approach the children learn in a variety of ways, through experience, making and in, doing things, experimentation, reading, discussions, asking, listening, thinking and reflection and expressing oneself in speech, movement or writing both individually and with other.
9. The purpose of learning is for an individual to construct his or her own meaning, not just memorize the "right" answers and regurgitate someone else‟s meaning. Since education is inherently interdisciplinary, the only valuable way to measure learning is to make the assessment part of the learning process, ensuring it provides students with information on the quality of their learning.
10. In order to teach well, we must understand the mental models that students use to perceive the world and the assumptions they make to support those models.
11. It provides strategies for promoting learning by all.

Jonassen (1991) notes that many educators and cognitive psychologists have applied constructivism to the development of learning environments. From these applications, he has isolated a number of design principles:

1. Create real-world environments that employ the context in which learning is relevant;
2. Focus on realistic approaches to solve real-world problems;
3. The instructor is a coach and analyser of the strategies used to solve these problems;

4. Stress conceptual interrelatedness, providing multiple representations or perspectives on the content;
5. Instructional goals and objectives should be negotiated and not imposed;
6. Evaluation should serve as a self-analysis tool;
7. Provide tools and environments that help learners interpret the multiple perspectives of the world;
8. Learning should be internally controlled and mediated by the learner.

Constructivist teaching is based on recent research about the human brain and what is known about how learning occurs. Caine and Caine (1991) suggest that brain-compatible teaching is based on 12 principles:

1. The brain is a parallel processor. It simultaneously processes many different types of information, including thoughts, emotions, and cultural knowledge. Effective teaching employs a variety of learning strategies.
2. Learning engages the entire physiology. Teachers can't address just the intellect.
3. The search for meaning is innate. Effective teaching recognizes that meaning is personal and unique, and that students' understandings are based on their own unique experiences.
4. The search for meaning occurs through 'patterning'. Effective teaching connects isolated ideas and information with global concepts and themes.
5. Emotions are critical to patterning. Learning is influenced by emotions, feelings, and attitudes.
6. The brain processes parts and wholes simultaneously. People have difficulty learning when either parts or wholes are overlooked.
7. Learning involves both focused attention and peripheral perception. Learning is influenced by the environment, culture, and climate.

8. Learning always involves conscious and unconscious processes. Students need time to process 'how' as well as 'what' they've learned.
9. We have at least two different types of memory: a spatial memory system, and a set of systems for rote learning. Teaching that heavily emphasizes rote learning does not promote spatial, experienced learning and can inhibit understanding.
10. We understand and remember best when facts and skills are embedded in natural, spatial memory. Experiential learning is most effective.
11. Learning is enhanced by challenge and inhibited by threat. The classroom climate should be challenging but not threatening to students.
12. Each brain is unique. Teaching must be multifaceted to allow students to express preferences.

Constructivist learning is inductive. Constructivist learning dictates that the concepts follow the action rather than precede it. The activity leads to the concepts; the concepts do not lead to the activity. Essentially, in constructive learning, the standard classroom procedure is turned upside down – no lectures, no demonstrations, and no presentations. From the beginning, students engage in activities through which they develop skills and acquire concepts. According to Good and Brophy (1994), constructivist learning includes:

1. ***Learners construct their own meaning:*** Students are not passive receptacles. They do not easily process or transfer what they passively receive. In order to make knowledge useful in a new situation, students must make a deliberate effort to make sense of the information that comes to them. They must own it. They must manipulate, discover, and create knowledge to fit their belief systems.
2. ***New learning builds on prior knowledge*:** In making an effort to make sense of information, students must make connections between old knowledge and new

information. They must compare and question, challenge and investigate, accept or discard old information and beliefs in order to progress.

3. ***Learning is enhanced by social interaction:*** The constructivist process works best in social settings as students have the opportunity to compare and share their ideas with others. Learning occurs as students attempt to resolve conflicting ideas. Although social interaction is frequently accomplished in small group activities, discussions within the entire class provide students the opportunity to vocalize their knowledge and to learn from others.
4. ***Meaningful learning develops through "authentic"*** *tasks:* This aspect of constructivism is frequently misinterpreted. Using authentic tasks mean that activities are chosen to simulate those that is encountered in real life or in an assignment.

2.2.3 Characteristics of Constructivist Learning

Brooks and Brooks (1993) in their book, "***In search of understanding: The case of constructivism classroom"***, define following characteristics for teachers adopting constructivist teaching:

1. Constructivist teacher encourage and accept student autonomy and initiatives.
2. Constructivist teacher uses raw data and primary resources, along with manipulative, interactive and physical materials.
3. When framing tasks, constructivist teachers use cognitive terminology such as classify, analyse, predict and create.
4. Constructivist teacher allow students response to derive lessons, shift instructional strategies and other contents.
5. Constructivist teacher inquire about students understanding of the concepts before sharing their own understanding of those concepts.

6. Constructivist teacher encourage students to engage in dialogue, both with the teachers and with other students.
7. Constructivist teacher encourage students enquiry by asking thoughtful, open minded questions and encouraging students to ask questions.
8. Constructivist teacher seek elaboration of students initial responses.
9. Constructivist teachers engaged students in experience that might engender contradictions to their initial hypotheses and then encourages discussion.
10. Constructivist teacher allow wait time after posing questions.
11. Constructivist teachers provide time for students to construct relationships and create metaphors.
12. The teacher should plan the teaching-learning processes to respond to the diverse need for the student.
13. Encouraging children to answer their own words and from their own experiences, rather than simply memorizing and getting answer right in just one way.
14. Intelligent guessing must be encouraged as a valid pedagogic tool.
15. Teacher should not scarify flexibility and creativity in the name of objectivity.

Other characteristics are given below by Jonassen, (1994).

1. Multiple perspectives and representations of concepts and content are presented and encouraged.
2. Goals and objectives are derived by the student or in negotiation with the teacher or system.
3. Teachers serve the role of guides, monitors, coaches, tutors and facilitators.
4. Activities, opportunities, tools and environments are provided to encourage Meta cognition, self-analysis -regulation, -reflection & -awareness.
5. The student plays a central role in mediating and controlling learning.

6. Learning situations, environments, skills, content and tasks are relevant, realistic, and authentic and represent the natural complexities of the 'real world'.
7. Primary sources of data are used in order to ensure authenticity and real-world complexity.
8. Knowledge construction and not reproduction is emphasized.
9. This construction takes place in individual contexts and through social negotiation, collaboration and experience.
10. The learner's previous knowledge constructions, beliefs and attitudes are considered in the knowledge construction process.
11. Problem-solving, higher-order thinking skills and deep understanding are emphasized.
12. Errors provide the opportunity for insight into students' previous knowledge constructions.
13. Exploration is a favoured approach in order to encourage students to seek knowledge independently and to manage the pursuit of their goals.
14. Learners are provided with the opportunity for apprenticeship learning in which there is an increasing complexity of tasks, skills and knowledge acquisition.
15. Knowledge complexity is reflected in an emphasis on conceptual interrelatedness and interdisciplinary learning.
16. Collaborative and cooperative learning are favoured in order to expose the learner to alternative viewpoints.
17. Scaffolding is facilitated to help students perform just beyond the limits of their ability.
18. Assessment is authentic and interwoven with teaching.

2.2.4 Pedagogical Goals of Constructivist Learning Environments

Honebein (1996) summarises what he describes as the seven pedagogical goals of constructivist learning environments as:

1. To provide experience with the knowledge construction process (students determine how they learn).
2. To provide experience in and appreciation for multiple perspectives (evaluation of alternative solutions).
3. To embed learning in realistic contexts (authentic tasks).
4. To encourage ownership and a voice in the learning process (student centered learning).
5. To embed learning in social experience (collaboration).
6. To encourage the use of multiple modes of representation, (video, audio text, etc.)
7. To encourage awareness of the knowledge construction process (reflection, metacognition).

2.2.5 Educational Implications of Constructivism for Teaching and Learning

Bednar, Cunningham, Duffy and Perry (1992) and Von Glasersfeld (1995) have proposed several implications of constructivist theory for instructional developers stressing that learning outcomes should focus on the knowledge construction process and that learning goals should be determined from authentic tasks with specific objectives. Constructivism believes that children never like to sit in a desk all day while the teacher lecture them on information, rather, they would like to learn of their own constructively. Therefore, education is about using knowledge to construct new knowledge rather than to acquire information. On the basis of the principles of learning are formulated and similarly educational implication of the theory of constructivism are as follows:

Jonassen (1994) summarises what he refers to as "the implications of constructivism for instructional design". The following principles illustrate how knowledge construction can be facilitated:

1. Provide multiple representations of reality;
2. Represent the natural complexity of the real world;
3. Focus on knowledge construction, not reproduction;
4. Present authentic tasks (contextualising rather than abstracting instruction);
5. Provide real-world, case-based learning environments, rather than pre-determined instructional sequences;
6. Foster reflective practice;
7. Enable context-and content dependent knowledge construction;
8. Support collaborative construction of knowledge through social negotiation.

Ernest (1994) in his description of the many schools of thought of constructivism suggests the following implications of constructivism which are derived from both the radical and social perspectives:

1. Sensitivity towards and attentiveness to the learner's previous constructions;
2. Diagnostic teaching attempting to remedy learner errors and misconceptions;
3. Attention to meta cognition and strategic self-regulation by learners;
4. The use of multiple representations of Integrated Science concepts;
5. Awareness of the importance of goals for the learner, and the dichotomy between learner and teacher goals;
6. Awareness of the importance of social contexts, such as the difference between folk or street Integrated Science and school Integrated Science (and an attempt to exploit the former for the latter).

Honebein (1996) describes seven goals for the design of constructivist learning environments:

1. Provide experience with the knowledge construction process;
2. Provide experience in and appreciation for multiple perspectives;
3. Embed learning in realistic and relevant contexts;
4. Encourage ownership and voice in the learning process;
5. Embed learning in social experience;
6. Encourage the use of multiple modes of representation;
7. Encourage self-awareness in the knowledge construction process.

Some other implications of constructivism for teaching and learning are mentioned below:

1. Teachers act as facilitators, supports, guides and models of learning.
2. Learning concerns in adjusting our mental models to accommodate new experiences.
3. Learning concerns with making connections between information.
4. Instruction should be built around more complex problems, not problems with clear, correct answers.
5. Context and personal knowledge have high significance.
6. Students should help in establishing the criteria on which their work is assessed.
7. Teachers know more and shouldn"t let students muddle around.
8. Student learning depends on background knowledge – that"s why teaching facts is so necessary (reversed).
9. Student interest and effort are more important than textbook content.
10. It is sometimes better for teachers, not students, to decide what activities are to be done.

11. Sense making and thinking are most important, not knowing content.
12. Experimentation replaces rote learning.
13. Teaching utilizes both skill-based and open-ended approaches.
14. Motivation to learn is intrinsic rather than extrinsic (done for its own sake rather than for grades, test scores or rewards).
15. Learners often produce unique and personal knowledge.
16. Naïve beliefs are used as the starting point for further discussion, exploration and evaluation for development, rather than being discounted as "wrong".
17. Learning for transfer is important.
18. Learners learn best through finding and generating their own knowledge.
19. Discovery and guided discovery learning are important.
20. Exploration and active learning are important.
21. Learning is collaborative and cooperative, not just individual.
22. Higher order thinking is significant.
23. Classrooms become multidimensional, with different activities at different levels taking place simultaneously.

Constructivism requires a teacher to act as a facilitator whose main function is to help students become active participants in their learning and make meaningful connections between prior knowledge, new knowledge, and the processes involved in learning. Brooks and Brooks (1993) summarise a large segment of the literature on descriptions of "constructivist teachers". They conceive of a constructivist teacher as someone who

1. encourages and accepts student autonomy and initiative;
2. use a wide variety of materials, including raw data, primary sources, and interactive materials and encourage students to use them;

3. inquire about students" understandings of concepts before sharing his/her own understanding of those concepts;
4. encourage students to engage in dialogue with the teacher and with one another;
5. encourage student inquiry by asking thoughtful, open-ended questions and encourage students to ask questions to each other and seek elaboration of students" initial responses;
6. engage students in experiences that show contradictions to initial understandings and then encourage discussion;
7. provide time for students to construct relationships and create metaphors;
8. assess students" understanding through application and performance of open-structured tasks.

Hence, from a constructivist perspective, the primary responsibility of the teacher is to create and maintain a collaborative problem-solving environment, where students are allowed to construct their own knowledge, and the teacher acts as a facilitator and guide.

2.2.6 Benefits of Constructivism

Von Glasersfeld, (1995) summarises the benefits of constructivist theory as:

1. Children learn more, and enjoy learning more when they are actively involved, rather than passive listeners.
2. Education works best when it concentrates on thinking and understanding, rather than on rote memorisation. Constructivism concentrates on learning how to think and understand.
3. Constructivist learning is transferable. In constructivist classrooms, students create organizing principles that they can take with them to other learning settings.

4. Constructivism gives students ownership of what they learn, since learning is based on students' questions and explorations, and often the students have a hand in designing the assessments as well. Constructivist assessment engages the students' initiatives and personal investments in their journals, research reports, physical models, and artistic representations. Engaging the creative instincts develops students' abilities to express knowledge through a variety of ways. The students are also more likely to retain and transfer the new knowledge to real life.
5. By grounding learning activities in an authentic, real-world context, constructivism stimulates and engages students. Students in constructivist classrooms learn to question things and to apply their natural curiosity to the world.
6. Constructivism promotes social and communication skills by creating a classroom environment that emphasizes collaboration and exchange of ideas. Students must learn how to articulate their ideas clearly as well as to collaborate on tasks effectively by sharing group projects. Students must therefore exchange ideas and so must learn to "negotiate" with others and to evaluate their contributions in a socially acceptable manner. This is essential to success in the real world, since they are always exposed to a variety of experiences in which they have to cooperate and navigate among the ideas of others.

2.3 Conceptual Framework

2.3.1 Concept Mapping Teaching Strategy

Today all countries aim to reach modernized education system. Above all, Integrated Science education is one of the pioneers of our educational system. Therefore, Integrated Science concepts must be conveyed to the receiver (student) accurately and well-arranged. For the successful learning, teaching strategies, methods, techniques and tools should transform knowledge from short-term memory to long-term memory. Ausubels" theory of meaningful learning is one of the most important expository theories which explain how to transform information from short-term memory to long-term memory. According to this theory meaningful learning occurs when complex ideas and information are combined with students" own experiences and prior knowledge to form personal and unique understandings. In this process, it can be said that, concept maps are one of the most important teaching and learning tool that promote meaningful learning, Ausubel (1962).

Concept mapping is the technique used by individuals and groups to organise, represent, and visualise 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 description of topics within one concept and/or relationships found among different concepts (Novak & Canas, 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 organising 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 Map is a graphical tool that organises, connect, and synthesize information. Concept maps show concepts in circles or boxes and one can indicate relationships between concepts by connecting lines or linking words. Figure 2 shows a concept mapping model, Novak and Gowin (1984). According to Oxford (1990), a concept map is the arrangement of words into a picture, with a key concept at the top or at the center and related concepts linked with the key concept by means of lines or arrows. In the words of Lafrancois (1997), a concept map is a verbal or graphic presentation designed to assist the learner in developing a clear and useful mental representation of whatever is being studied.

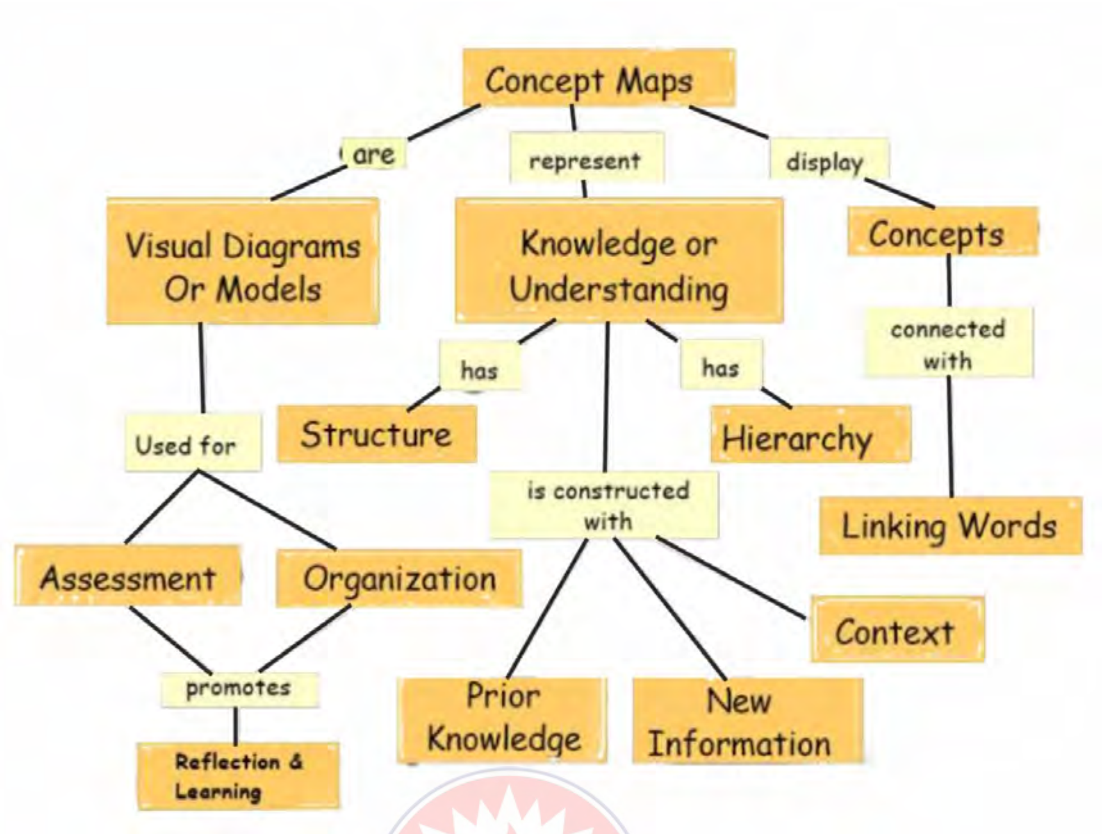


Figure 2.2: Conceptual mapping model

Source: Novak and Gowin, 1984

Concept maps were developed on the basis of Ausubels" theory of meaningful learning. According to Ausubel learning is meaningful when the student comprehends the relationship of what is being learned to other knowledge. When students imbibed the information completely, only then that the students are able to remember it better. Therefore, meaningful learning is necessary for successful learning, Ausubel (1962).

According to Weiss and Levison (2000), Concepts Maps involve:

1. Active, collaborative learning (creating a graphic representation)
2. Higher-order thinking (apply, analyze, synthesize, evaluate)
3. Visual information organization (Integrates relevant information)
4. General to specific information (hierarchal relationships of ideas)
5. Easy comparison of groups

6. Self-directed learning encouraged
7. Missing information identified
8. Critical thinking assessed

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, 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; 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 et al. (2005).

Why Concept Mapping is Superior to Other Methods? According to Novak and Canas (2008), there are several reasons why concept mapping is superior to other methods. These are as follows:

1. The 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 same subject 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-centred, active teaching method. It can encourage student-teacher interaction when 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 recalling concepts 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 examinations.
11. It is suitable for many different topics, instructional stage and grade level
12. It is easy to use for teaching and learning.
13. It helps visual learners grasp the material; however all learners benefit from the activity).
14. It helps students see relationships between ideas, concepts.
15. It utilizes the full range of the left and right hemispheres of the brain.
16. It helps memory recall.
17. It helps to clarify and structure ideas.
18. It aids in developing higher-level thinking skills (create, analyze, evaluate).
19. It helps students synthesize and integrate information, ideas and concepts.

20. Concept map encourages students to think creatively about the subject.
21. Concept map helps students do self-evaluation of beliefs, values, socialization, etc.
22. Concept map helps students evaluate assumptions.
23. Concept map helps develop an understanding of a body of knowledge.
24. Concept map helps explore new information and relationships.
25. Concept map helps access prior knowledge.
26. Concept map helps gather new knowledge and information.
27. Concept map helps share knowledge and information generated.
28. Concept map helps design structures or processes such as written documents, constructions, web sites, web search and multimedia presentations.

Mapping is an active learning strategy that moves you beyond rote memorization to critical thinking and helps you to learn about how you learn. This gets you beyond just knowing to reflecting on what you know and how you know it. Concept Mapping requires that you break down component parts to see how things are put together. This promotes a richer construction of knowledge because you must organize, select, relate and interpret data. It provides an explicit, encapsulated representation of important ideas on one page which is great for review. It also helps you to see gaps in knowledge and areas of oversimplification, contradiction, or misinterpretation.

Concept mapping is rooted in Ausubel"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 are graphical teaching and learning tools that are convenient for representing and organizing knowledge, with strong psychological and epistemological background. 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 organizers that modify the learner‟s cognitive structure. Ausubel stressed that if existing cognitive structure is clear, stable and suitably organized, it facilitates the learning and retention of new subject matter. Using Ausubel‟s ideas of how learners construct meaning, and relying on the main distinction between the meaningful and rote learning, Novak (2002) has developed a concept map as a tool to represent concept/propositional framework for domain-specific knowledge, Lagowski (2009).

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 needs to know before he can meaningfully learn the task at hand. Concept maps are usually introduced in advance learning materials to facilitate the establishment of meaningful learning set. The central propositions in Ausubel‟s cognitive assimilation 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.

Ausubel described how meaningful learning requires three conditions:

1. "The material presented to the learners be capable of being related in some sensible fashion" (Ausubel & Robinson, 1969). The material presented must be clear and related to the learners‟ prior knowledge.
2. "The learners must possess relevant ideas to which the new idea can be related or anchored" (Ausubel & Robinson, 1969). The learners must have some relevant prior knowledge about the domain of subject matter on which to build a concept framework for the present knowledge to be learned. Therefore, conditions (1) and (2) are interrelated (Canas, et al., 2003).
3. "Finally, the learners must actually attempt to relate, in some sensible way, the new ideas to those which they presently possess" (Ausubel & Robinson, 1969), i.e. the learners must willingly engage in the relevant meaningful learning activities.

If any of these conditions is missing, any learning that takes place is likely be rote learning. Concept mapping activities can satisfy these three conditions; the characteristic features of concept mapping should be related to the learners‟ prior knowledge to create links among the concepts that are already known and recently learned.

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.

Several problems are associated with the implementation of concept mapping in a classroom setting. Historically, assessment using concept maps has been difficult. Concept maps are difficult for many teachers to score because they are unfamiliar with them (Kinchin, et al., 2001). Some researchers began using the maps as an assessment tool, but ended up discontinuing its use for assessment because of these difficulties (Regis et al., 1996). Concept maps often lack reliability and validity. A call for research in these areas has been made, with minor attempts to answer (Mintzes & Wallace, 1990). Because of these and other reasons, the studies examined often lacked statistical significance (Heinze-Fry & Novak, 1990; Markow & Lonning, 1998).

The time and effort required to implement concept mapping in a classroom is seen by many teachers as excessive. For a pedagogy that is generally unfamiliar, implementation can be problematic and the benefits appear small (Santhanam et al., 1998). Regis et al. (1996) effectively used concept mapping and implemented it over a four year period of study; the amount of time invested was sufficient to make the mapping experience successful for the students.

Training in concept mapping for students, instructors, and teaching assistants is also seen as a difficulty. The time and effort involved in training is considered, by some instructors, not worth the effort. Studies that were successful in implementing concept mapping were careful in their training (Regis et al., 1996).

2.3.2 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 (1990) while at Cornell University, in Ithaca, New York. During that 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 (1990) 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. Novak (1990) 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.

2.3.3 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, (Novak, 1977).

Nodes are joined together with *connecting lines*, or links, which represent a particular relationship between two concepts. Nodes and links are usually labelled. Links can be non-directional (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.

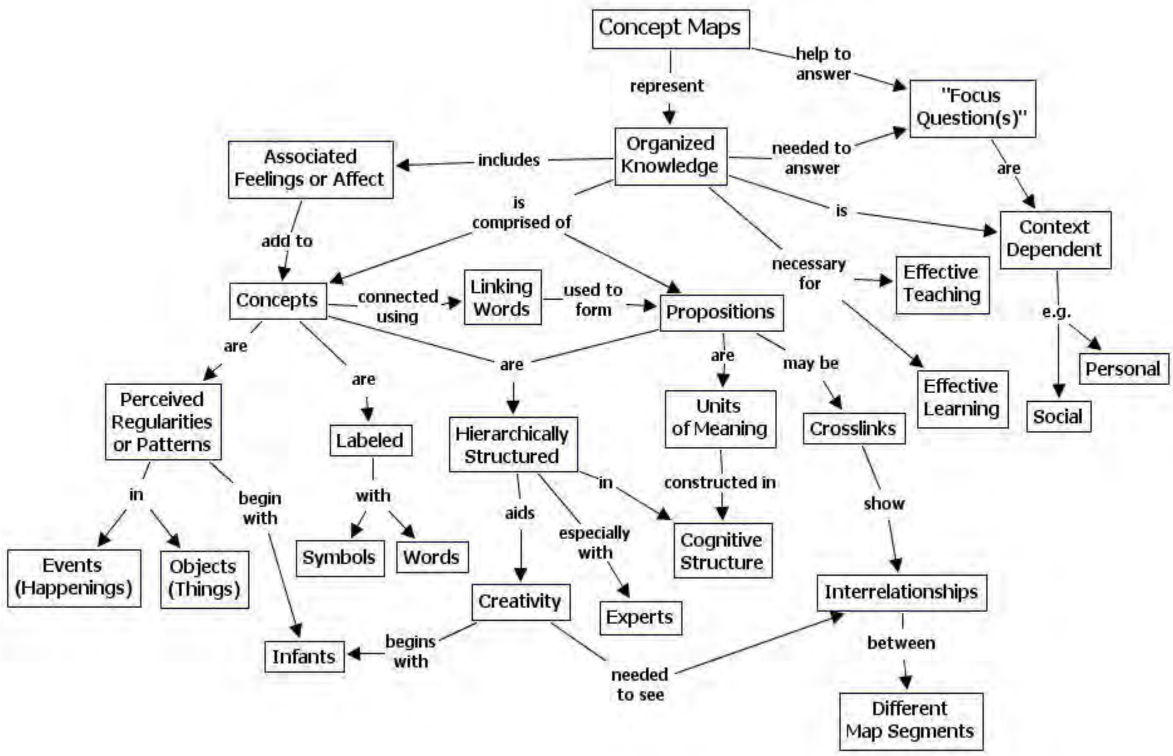


Figure 2.3: A concept map showing the key features of concept maps

Source: Novak & Canas, 2008, p.2

2.3.4 Types of Concept Mapping

According to the University of Illinois, US (2002), cited in Kilic and Cakmak (2013), there are seven kinds of concept map. The most commonly used five kinds of concept maps in Chemistry/Integrated Science are mentioned below with examples.

1. **A Spider concept map:** It is a kind of concept 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 centre of the map. It looks a bit like a spider's web, as its name suggests.

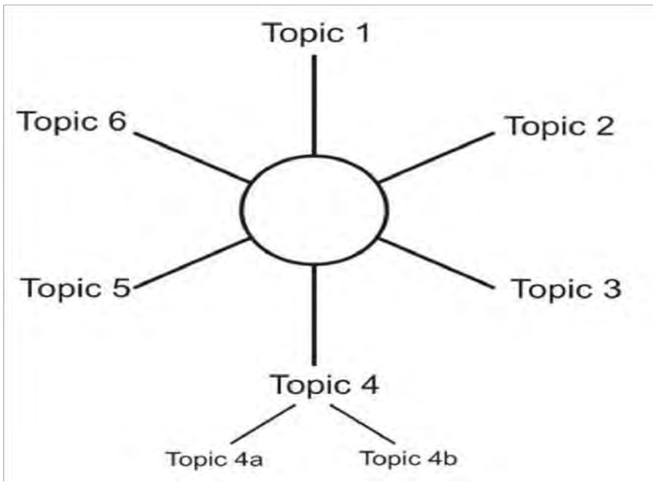


Figure 2.4a: Spider Concept Map,

Source: Novak and Gowin (1984)

Example: The figure 2.4b is an example of a spider type of concept map

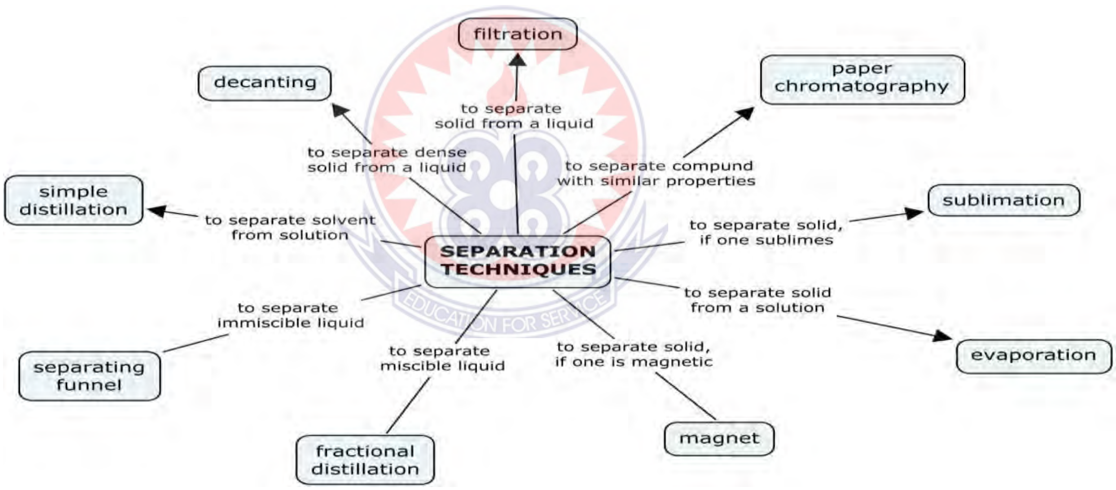


Figure 2.4b: Separation Techniques

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 2.6a shows an example to the hierarchy concept map.

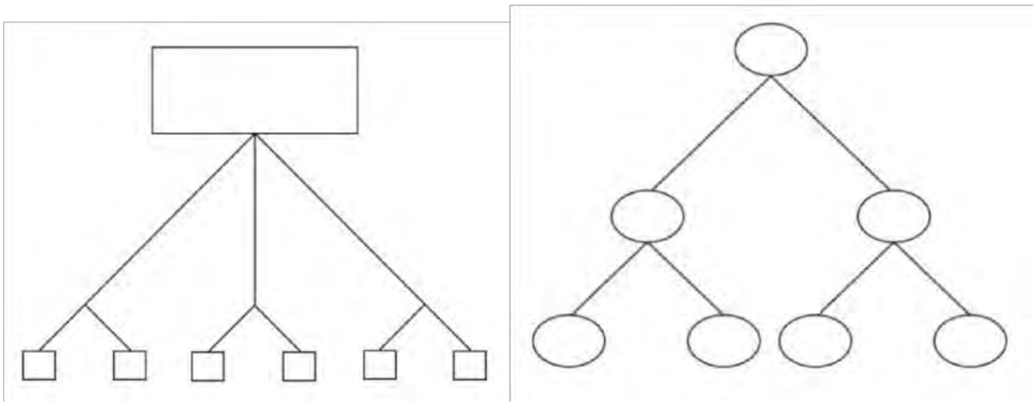


Figure 2.5a: The hierarchy Concept Map,

Source: Novak (1977)

Example: Figure 2.5b is an example of the hierarchy concept map

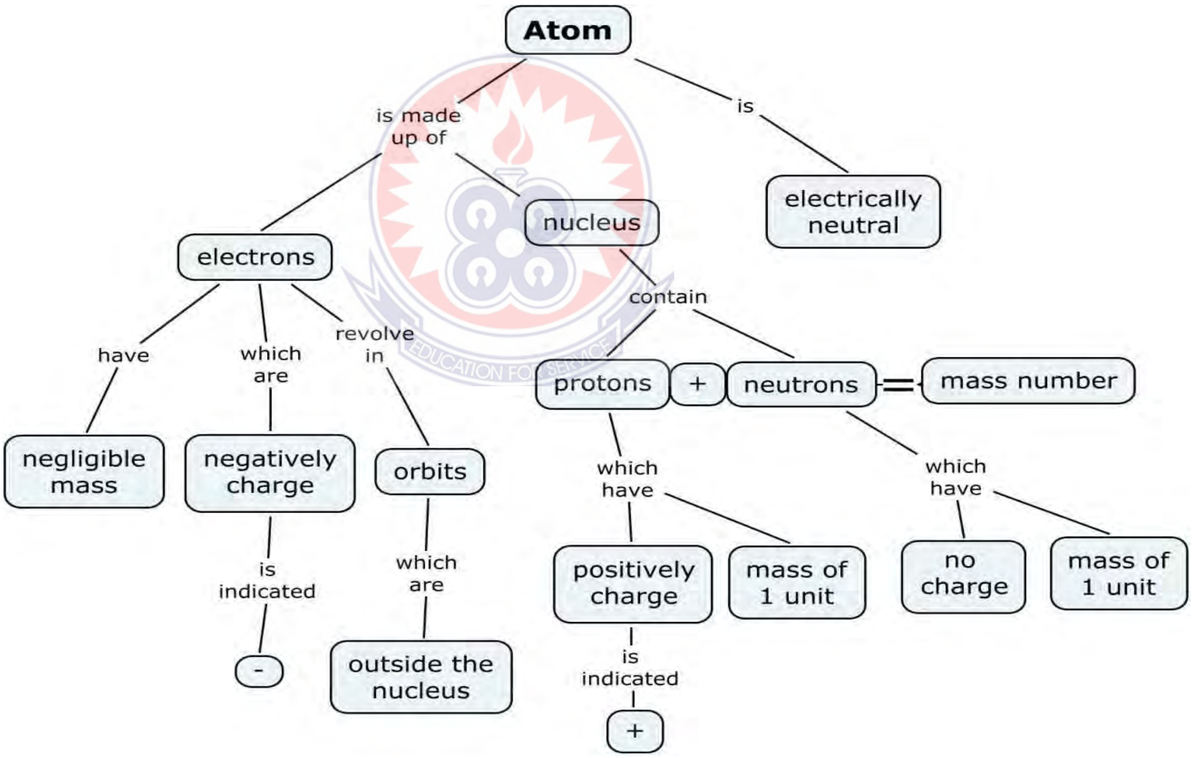


Figure 2.5b: A Concept Map of Structure of Atom

Source: Kilic and Cakmak (2013)

3. **The flowchart concept map** organizes information in a linear format.

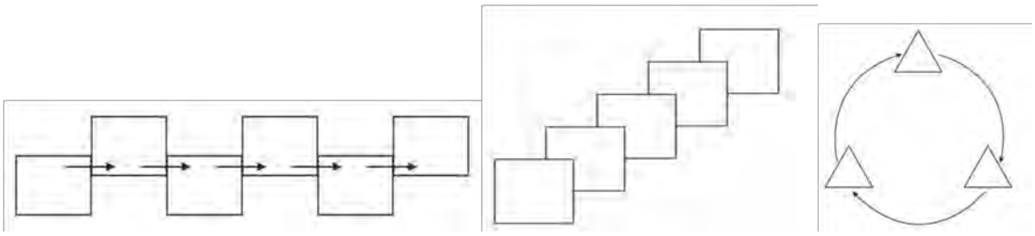


Figure 2.6a: The flowchart Concept Map

Source: Wandersee (1990)

Example: Figure 2.6b is an example of a flowchart type of concept map.

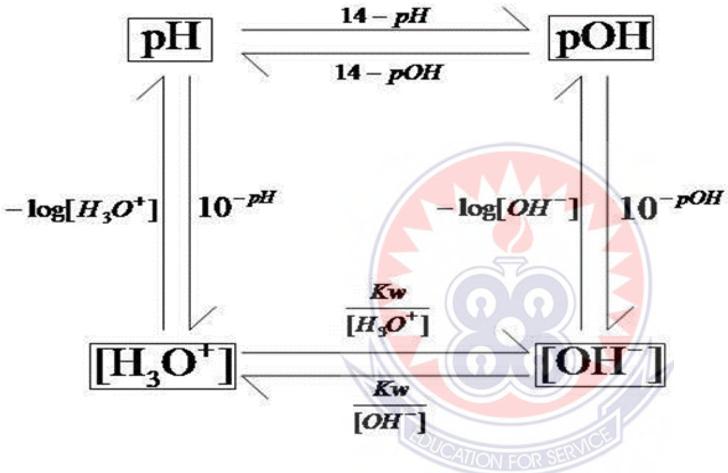


Figure 2.6b: pH and pOH

4. **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.

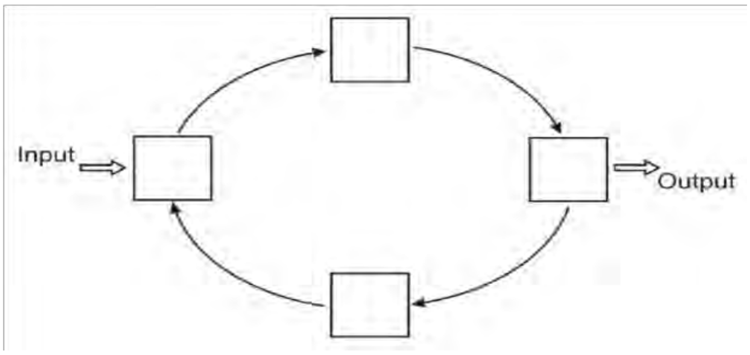


Figure 2.7a: The systems Concept Map

Source: Anderson (1993)

Example: The figure 2.7b is an example of the system concept map

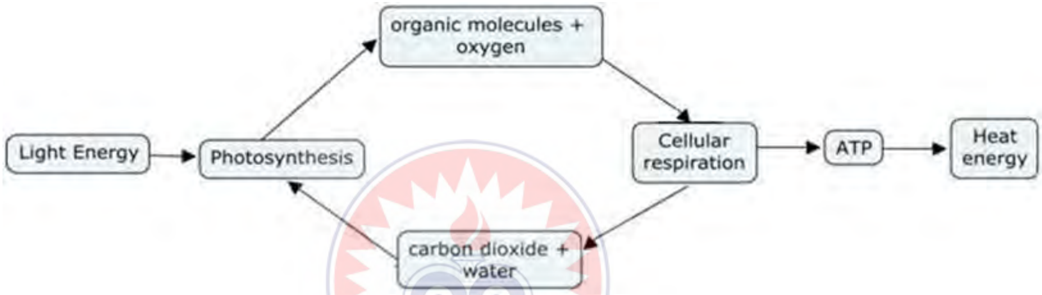


Figure 2.7b: Photosynthesis and Cellular Respiration

Source: Larbi (2011)

5. **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.

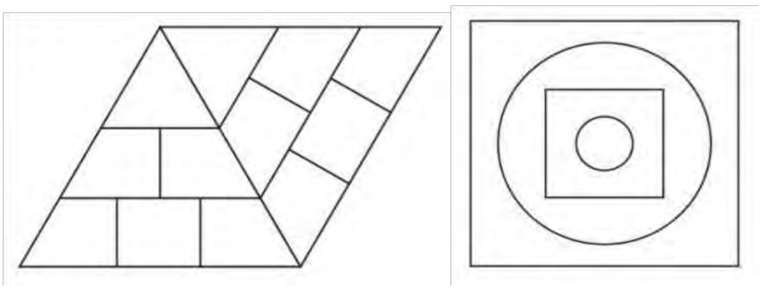


Figure 2.8a: Multi-dimensional concept map

Source: Kilic and Cakmak (2013)

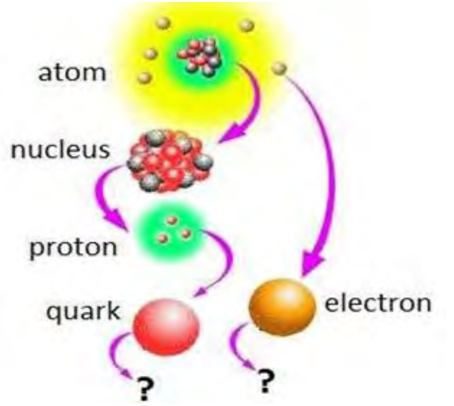


Figure 2.8b: Atom,

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, spider or flow chart concept mapping.

2.3.5 Objectives of Concept Mapping

According to Bello and Abimbola (1997) concept mapping can be done for several purposes, some of which are:

1. to generate ideas through brainstorming
2. to design a complex structure
3. to communicate complex ideas
4. to aid learning by explicitly integrating new and old knowledge
5. to represent information visually
6. to help students clarify thinking
7. to reinforce understanding
8. to integrate new knowledge and
9. to identify misconceptions.

2.4 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

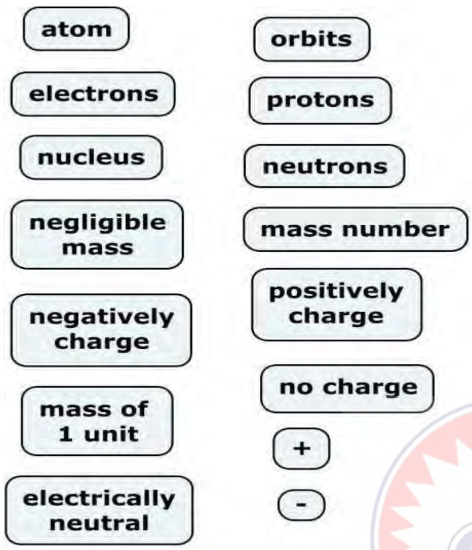
6. Make crosslink. These are links between concepts in different segment or domain of knowledge on the map to illustrate how these domains are related to one another. Cross links are important to show the learner understands the relationship between the sub-domains in the map.
7. Revise the map by repositioning 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.

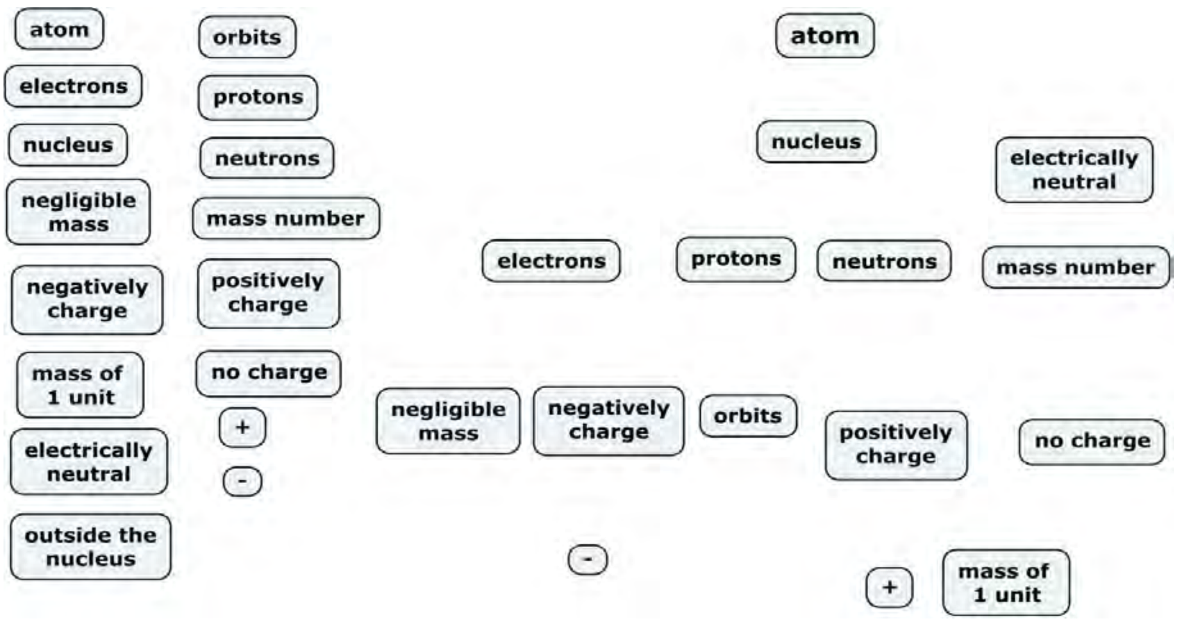
2.4.1 Steps of Constructing a Concept Map

Step 1: To construct a concept map, first, define the context. A good way to define the context for a concept map is to construct a focus question, which means, a question that clearly specifies the problem or issue the concept map should help to resolve. Every concept map responds to a focus question and a good focus question can lead to a much richer concept map. Assume that our focus question is "what is an atom?" OR Identify a main theme and then brainstorm for all related key words or phrases.

Step 2: Identify the key concepts in a paragraph, laboratory activity or in a chapter; or simply think of the concepts of a subject area and list them. It is better to write the concept labels on separate cards or small pieces of paper, in order that they can be moved around. Cluster concepts that function at similar level of abstraction and those that are closely related.

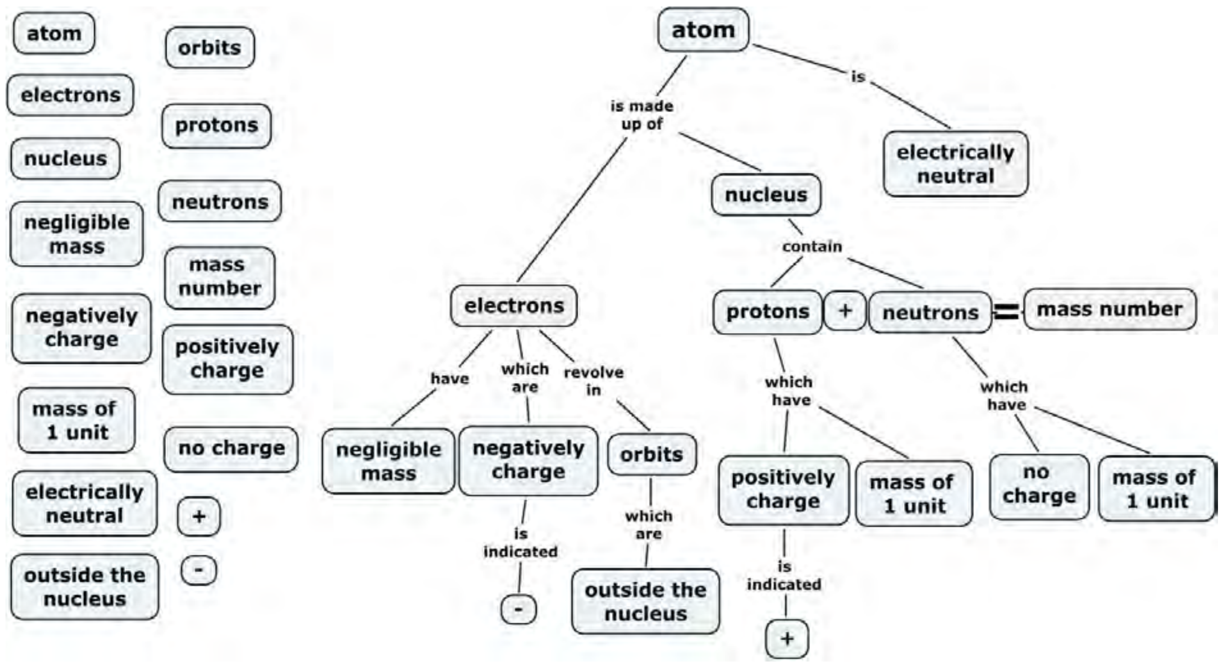


Step 3: From the listed concepts, rank the concepts by placing the broadest and the most inclusive idea at the top of the map. It might be difficult to identify the broadest, the most inclusive concept. It should be kept in mind that this rank order might be only approximate. It is helpful to be aware of the context of the concepts we are dealing with or to have some idea of the situation for which these concepts are arranged. Organize the major points and rank the key words from the most abstract and inclusive to the most concrete and specific.



Step 4: Work down the paper and add more specific concepts and do hierarchical arrangement of concepts. OR arrange concepts on a map, working from the core concept, to major points, to significant details.

Step 5: Connect the concepts by lines. Label the lines with action or linking words. These links between different domains of knowledge on the concept map can help to illustrate how these domains are related to one another. When you hold together a large number of related ideas, you can see the structure of meaning for a given subject area. OR Use branches, arrows, and other symbols like stop signs or yield signs to indicate the nature of the relationships between ideas. Write in phrases and propositions that link the ideas. Include detailed explanations, definitions, rules, formulae or equations as appropriate.



Step 6: Specific examples of concepts can be added below the concept labels. But these are not included in circles or boxes. They are specific events or objects; so they do not represent concepts.

Step 7: Analyze the resulting map by asking the following questions:

1. Is the core concept accurately defined and positioned?
2. How do the ideas fit together?
3. Have I considered all of the related information gathered from lectures, texts, labs?
4. Have I noted all relevant relationships, exceptions, and conditions?
5. Does the map have adequate validity, logic, complexity and detail?
6. What is the muddiest point and what can be done to clarify it?

Step 8: A concept map is never finished. After a preliminary map is constructed, it is always necessary to revise this map. Other concepts can be added by student under the guidance of teacher in classroom work. Good maps usually result from several revisions.

2.5 Benefits and Uses of Concept Mapping in Teaching and Learning of Science

The main benefit of concept mapping is achieving meaningful learning instead of rote learning, i.e., students understand the information they acquire and so remember it longer and can use it more successfully. Concept mapping is designed to help students and others clear up ambiguities and clarify misconceptions, along with strengthening the memory and retention process after the learning is accomplished (Canas & Novak 2008).

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.

1. **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 organisers 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 serve as a basis for discussion.

2. **Concept maps use by students**: Using concept maps reinforces students understanding and learning. This enables visualization of the concepts and summarises 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 ((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 map encourages students to think creatively about the subject and

also encourages critical thinking. Students with good visual recall remember concept maps better than text. Concept map encourages collaborative learning.

3. **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 essay, multiple-choice, and fill-in-the-blank questions, is a valuable way to test students. Such tests 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 summarise 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 used to evaluate student‟s achievement.
4. **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.

Starr and Krajcik (1990) 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. It is used for curriculum design, helping to achieve integration and continuity in the course. It can also increase awareness of the importance of the course.

5. **Concept mapping for capturing and archiving expert knowledge**: According to Novak and Canas (2008), one of the uses of concept maps which is 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

and 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 Novak (1990) 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 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 organisations 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.

2.6 The Fundamental Concept about the Mole

In Latin, mole means „massive heap" of material. In chemistry, it is a unit which is used 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 elementary entities as there are atoms in 0.012 kilogram of carbon-12. When the mole is used, the elementary entities must be specified as atoms, molecules, ions, electrons, other particles or specified group of such particles. Visualising a mole as a pile of particles, however, is just one way to understand this 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 litters at Standard Temperature and Pressure (STP) has a mass of 31.998 grams and contains about 6.022 x 10^{23} atoms of oxygen. Measuring one of these quantities helps in the calculation of the others and this is frequently done in stoichiometry (Ameyibor & Wiredu, 1991)

According to Hill and Holman (1989), John Dalton (1766-1844), suggested that all matter was composed of small particles which he named as „atom". He then identified certain substances as in nature as elements. Dalton, believed that atoms of different elements have differences. Dalton stated that it would be possible to compare the masses of different elements even though the atoms themselves could not be weighed.

In the 18th and 19th centuries, the idea of the mole was born and several Scientists devised various ways to ascertain the actual value for the relative masses of these elemental atoms. In the year 1919, mass spectrometer was devised by Aston. This invention created a big head way for scientists to reliably compare the masses of the atoms of different elements. It was realized that some elemental atoms were many times heavier than others, thus the mass of the element Hydrogen was considered as a standard for the comparison of the other elemental atoms.

Ameyibor and Wiredu (1991), hold the view that before the mass of one Hydrogen was chosen as the standard to which all masses of the other elements were compared, was due to the fact that Hydrogen was the smallest atom with an atomic mass of one (H=1),which conveniently facilitated their works. During the 1960,,s where more accurate relative atomic masses were obtained and the concept of isotope was discovered, Carbon-12 was chosen as the new standard to date. With reasons being that Carbon was in abundance and it could be stored or transported with less difficulty. The Carbon-12 scale was devised and the relative masses of all other atoms were obtained by comparing them with the mass of one Carbon-12 atom.

In addition, the history of the mole is intertwined with that of molecular mass, atomic mass unit, Avogadro's number and related concepts. The first table of relative atomic mass (atomic weight) was published by John Dalton (1766–1844) in 1805, based on a system in which the relative atomic mass of hydrogen was defined as 1. These relative atomic masses were based on the stoichiometric proportions of chemical reactions and compounds, a fact that greatly aided their acceptance: It was not necessary for a chemist to subscribe to atomic theory (an unproven hypothesis at the time) to make practical use of the tables. This would lead to some confusion between atomic masses (promoted by proponents of atomic theory) and equivalent weights (promoted by its opponents and which sometimes differed from relative atomic masses by an integer factor), which would last throughout much of the nineteenth century.

2.7 The Mole as a Unit

In everyday life, people are used to applying collective terms to describe a number of objects or entities. For example;

1. a dozen is a collective term used to describe a number of objects made up of 12 entities;
2. a score is made up of 20 objects;
3. a cent is made up of 100 entities;
4. a gross is made up of 144 items.

In Chemistry the term mole is used to describe a quantity of material made up of 6.022×10^{23} particles or entities. A mole of a substance contains 6.02 x 10^{23} of elementary particles that made up the substance. These could be molecules, ions, atoms, electrons or other subatomic particles. This large number (6.022×10^{23}) is called Avogadro,,s constant in honour of Italian Physicist Amedeo Avogadro (1776-1856). The mole is a unit in the metric system of measurement. An Avogadro number, 6.022×10^{23} of anything is called a mole. It is a chemist,,s way of counting. Usually is used to count atoms, molecules, electrons or other small particles. Thus, one mole of carbon consists of 6.022×10^{23} C atom; one mole of oxygen gas is 6.022×10^{23} O_2 molecules and one atom of carbon dioxide corresponds to 6.022×10^{23} CO_2 molecules (Schwartz, Bunce, Silberman, Stratton, Stanitski & Zippi, 1997). The symbol for the mole is n. The mass in gram of one mole of a substance is the number of atomic mass unit (amu) in one atom of that substance. One amu is 1/12 the mass of one atom of

Carbon-12. Carbon-12 is the isotope (form) of Carbon whose nucleus contains 6 protons and 6 neutrons. Thus one atom of the elementary entity of Carbon-12 has a mass of 12 amu and 1mole of Carbon-12 has a mass of 12 grams. Amedeo Avogadro was the first scientist who brought this idea to fore. The works of other scientists revealed that one mole of a substance has 6.022×10^{23} particles. It is symbolized by L or N_A, which is the Avogadro„s constant, (Goldberg, 1998).

Since its adoption into the International System of Units in 1971, there have been a number of criticisms of the concept of the mole as a unit like the metre or the second:

1. the number of molecules, etc. in a given lump of material is a fixed dimensionless quantity that can be expressed simply as a number, so does not require its own base unit;
2. the S.I thermodynamic mole is irrelevant to analytical chemistry and could cause avoidable costs to advanced economies;
3. the mole is not a true metric (i.e. measuring) unit, rather it is a parametric unit and amount of substance is a parametric base quantity;
4. the S.I defines numbers of entities as quantities of dimension one, and thus ignores the ontological distinction between entities and units of continuous quantities, (Goldberg, 1998).

2.8 Definition of Mole and Related Concepts

Ameyibor and Wiredu (1991) defined the mole as a unit of measurement of the amount of substance that contains as many particulate entities as there are atoms in 12g (or 0.012kg) mass of carbon-12 isotope. It is also defined as the amount of substance that contains as many entities (atoms, molecules, or other particles) as there are atoms in exactly 0.012 kg of pure carbon-12 atoms. According to this definition, the mole as a unit refers to a fixed number of items, the identities of which must be specified. Just as we speak of a dozen eggs or a pair of aces, we refer to a mole of atoms or a mole of molecules (or a mole of ions, electrons, or other particles). People could even think about a mole of eggs, although the size of the required carton staggers the imagination! Helium exists as discrete He atoms, so one mole of helium consists of 6.022 x 10^{23} particles of He atoms. Hydrogen commonly exists as diatomic (two atom) molecules, so one mole of hydrogen is 6.022 x10^{23} and H_2 molecules 2(6.022 x10^{23}) H atoms.

Every kind of atom, molecule, or ion has a definite characteristic mass. It follows that one mole of a given pure substance also has a definite mass, regardless of the source of the sample.

Brown-Aquaye (2001) conducted a study and indicated that the difficulties students face may be attributed to the fact that mole as a unit relates to a certain mass of a given substance to the Avogadro„s number. Thus, according to the mole concept the actual mass of a mole varies from different substance, but the numbers of entities or particles remain the same. He explained that the mole in a layman„s language could be viewed as ream of reams of paper in every case contain the same number of sheets (that is 500) so does a group consisting the Avogadro„s number of entities valued as 6.02×10^{23} could be called a mole. Hence, a mole of any substance contains the Avogadro„s number of entities.

Another research study conducted using Scottish school children by Duncan and Johnstone, (1973) indicated that many students above the age of sixteen face a lot of problems in the mastery of the mole concept.

1. Overcoming the misunderstanding that one mole of a substance will always react with one mole of another regardless of the reaction

2. Balancing equation.
3. Manipulation of calculation involving molarity of solution.

Atkins (1989) also explains the mole as the unit chemist use for expressing large numbers of atoms, ions and molecules. Atkins (1989) said one mole is the number of atoms in exactly 12g of carbon-12. Although, 1 mole is defined in terms of carbon atoms, the limit applies to any object, just as dozen means 12 of anything. The mass of the one ^{12}C atom is exactly 12amu or $12\times1.6605\times10^{-24}$g and so the number of atoms in 12g of carbon-12 is the number of ^{12}C atoms

$$= \frac{\text{Mass of sample}}{\text{Mass of 12C atom}}$$

$$= \frac{12g\ of\ 12_{C\ atom}}{12 \times 1.6605 \times 10^{-24}}$$

$$= \mathbf{6.02 \times 10^{23}\ atoms}.$$

That is one mole of any element is 6.02×10^{23} atoms of the element. The same is true for 1mol of any object (atoms, ions and molecules). The number 6.02×10^{23} is called the Avogadro number. Atkins also explains Molar mass (M) as the mass per mole of atoms of an element. The word molar is often used to mean per mole.

Avogadro reasoned that elements are bonded with each other in definite amount according to their relative atomic masses. Avogadro concluded that there must be in the same number of each element in each gram atomic mass. It was finally established that in every gram-atomic of an element, there are $6.02\text{x}10^{23}$ atoms called the Avogadro"s number.

Thus, it could be inferred that one Avogadro‟s number of eggs contain 6.02 $x10^{23}$ eggs. Example; Hydrogen has a gram-atomic mass of one (1) and carbon has 12 but all contain equal number of atoms.

However, although one gram atom of hydrogen contains the same number of atoms as one gram atom of carbon is 6.02 $x10^{23}$. They do not have the same weight; Hydrogen weighs one gram while carbon weighs twelve grams. Thus, a group consisting of $6.02x10^{23}$ identical objects such as elements, atoms, compounds, molecules, is called the mole as a dozen consists of twelve identical objects.

This implies that the greater the number of entities or particles, the greater the amount of substance or mole. This means that the amount of substance is directly proportional to the number of specified entities (N). 1 mole = Avogadro‟s number (L) is $6.02x10^{23}$ entities.

X mole = X multiplied by L entities

Mathematically, N ∞n, N= n x L; where n=amount of substance

Mole as the amount of substances containing the same number of atoms or molecules or these are atoms in 12g of Carbon-12 isotopes. They go on to say that, if relative atomic mass or formula mass of a substance is worked out and then that number of grams of the substance is weighed out, it will be possible to know how many atoms or molecules the substance contains. For example the Relative Atomic Mass of Carbon-12 is 12. The 12g of Carbon containing 6.02 x 10^{23} single atoms of Carbon. This huge number of atoms was called a mole of atoms, molecules, ions or electrons.

Furthermore, Moore (1972) explains that, Chemists have found it convenient to choose a unit much larger than a single atom or molecule for comparing amounts of different materials. This unit called the mole contains a huge number of particles 6.02 x 10^{23}. For example, a mole of Oxygen atoms, Hydrogen atoms etc contain 6.02 x 10^{23} atoms of the specific kind.

Although a Chemist can calculate the mass of a single Oxygen atom as 2.67 x 10^{23} g, it is much more convenient to know that a mole of Oxygen atoms has a mass of 16.0g and that a mole of Oxygen molecules has a mass of 32.0g. This amount can be easily weighed in the laboratory. The mass of one mole of a substance is a useful number known as molar mass. The molar mass of a compound or an element in the molecular state is the mass in grams of 6.02 x 10^{23} molecules. If the molecular formula for a substance is known, its molecular mass can be calculated. This mass contains 6.02 x 10^{23} molecules.

The reasons why Chemists choose to count in mole is that, Chemists prefer a definition in terms of a quantity that can be measured readily and with high precision. Weighing is much easier than counting when the number of particles is so huge.

2.8.1 Relative Atomic Mass (A_r)

Majority of elements are found in nature as mixture of isotopes. For example a sample of Bromine contains two isotopes: Bromine-79 (^{79}Br) and Bromine-81 (^{81}Br). The mass spectrometer is used to find out the masses of these isotopes. Using the Carbon-12 scale, their relative isotopic masses are 78.919 and 80.917 respectively. The word is used to emphasize that we are taking their masses relative to an atom of Carbon-12. Thus the average mass of a Bromine atom woud be 79.919 x $\frac{50.52}{100}$ + 80.917 x $\frac{49.48}{100}$ = 79.908. This is the value of the relative atomic mass of Bromine. Thus $A_r(Br)$ = 79.91, Moore (1972).

The relative atomic mass of an element, A_r, is the average mass of one atom of the element compared to 1/12 of the mass of one atom of ^{12}C. Or $A_r =$

$$\frac{Average\ mass\ of\ one\ atom\ of\ element}{\frac{1}{2}\ of\ one\ atom\ of\ carbon-12}$$

The relative atomic mass of an element tells that on the average, how the mass of one atom of the element compares with 1/12 the mass of an atom of ^{12}C. It is the ratio of two masses which both have the same units. Therefore, the units cancel out and A_r itself has no units; it is a pure number (Ameyibor & Wiredu, 1991).

2.8.2 Relative Molecular Mass (M_r)

Molecules are very tiny particles of matter whose masses can be compared in similar manner to the masses of atoms. The relative molecular mass of a molecule is defined as the average mass of one molecule compared with 1/12 the mass of one atom of ^{12}C. Thus $M_r(H_2O) = 18$ tells that the relative molecular mass of water is equal to 18. This means that the water molecules is 18 times as 1/12 the mass of the ^{12}C atom. Taken Bromine atom as an example, the relative molecular mass of a Bromine molecule Br_2 is 2x $A_r(Br_2)$, that is $M_r(Br_2) = 2 \times 79.908 = 159.816$ or $M_r(Br) = 160$.

Calculate the relative molecular mass of the following molecules: (i) $C_6H_{12}O_6$ (ii) H_2SO_4. (Relative atomic masses, A_r, are S = 32, C = 12, H = 1, O = 16), Ameyibor and Wiredu (1991).

Solution

(i)$M_r(C_6H_{12}O_6) = 6 \times A_r(C) + 12 \times Ar(H) + 6 \times A_r(O)$

$M_r(C_6H_{12}O_6) = (6 \times 12) + (12 \times 1) + (6 \times 16)$

$= 72 + 12 + 96$

= 180.

(ii) $M_r(H_2SO_4) = 2 \text{ x } A_r(H) + 1 \text{ x } A_r(S) + 4 + A_r(O)$

$= (2 \text{ x } 1) + (1 \text{ x } 32) + (4 \text{ x } 16) \quad = \mathbf{98}$.

2.8.3 Molar Mass (M)

There are (L) entities in one mole of every substance, where the L is the Avogadro‟s constant. The masses of different types of entities differ from substance to substance, hence the mass of one mole of different substance also differ (Ameyibor & Wiredu 1991).

Thus the mass of one mole of any substance is called its molar mass (M). Molar mass is the mass in gram per mole of an element and has the symbol (M) and has a unit $gmol^{-1}$. For example 1mole of atom of Hydrogen (H), Oxygen (O) and Sodium (Na) has masses of 1g, 16g and 23g respectively. The relative atomic mass (A_r) and the relative molecular mass (M_r) are numerically equal to their molar mass but molar mass has a unit whilst relative molecular mass and relative atomic mass has no unit. It could be inferred that the molar mass of any substance contains Avogadro‟s constant $6.022 \text{x} 10^{23}$ entities, Ameyibor and Wiredu (1991). From the definition of molar mass:

1 mole of any substance has mass Mg

X mole of any substance has mass X x Mg.

Therefore; $m = n \text{ x } M$;

$$\text{Molar mass (M)} = \frac{\text{mass (g) of asubstance (m)}}{\text{amount of substance (n)}}$$

$$\mathbf{M = \frac{m}{n}};$$

Where m = mass of substance, M = molar mass, n = amount of substance.

2.8.4 Amount of Substance (Chemical amount)

Chemical amount is a term that IUPAC has recognized as an alternative to amount of substance for over 20 years. In everyday life, various physical quantities have their units of measurements. For instance, mass is measured in kilogram (kg), volume in cubic decimetre (m^3) and length is measured in metres (m). In Chemistry, the unit of measurements for the quantity of matter is the mole (the amount of a substance is measured in moles) though the mass quantity (kg or g) may be used. Amount of substance is the most important of all the physical quantities to a chemist (Ameyibor & Wiredu, 1991).

According to Ameyibor and Wiredu, (1991), amount of substance (n) is the quantity that measures the number of entities of (atoms, molecules, ions, electrons etc) present in a substance, expressed in moles. It is a quantity that measures the size of an ensemble of entities. „The amount of substance, symbol n, of a system is a measure of the number of specified elementary entities.

An important application of the quantity of amount of substance in Chemistry is the way in which the particles react in any chemical reaction. When the amount of substance is measured in moles then the particulate entities must be specified-atoms, ions, molecules or other specified groups. Amount of substance is not a number, therefore the old way of referring to it as "the number of moles" should be discontinued as recommended by the IUPAC rules. The term „number of moles" should be replaced with „the amount of substance". The greater the number of entities the greater the amount of substance. This means the amount of substance is directly proportional to the number of specified entities, *N.* The amount of substance can be calculated if the relevant number of entities or moles is given respectively. The amount of substance according to Ameyibor and Wiredu, (1991) could be calculated as:

$$\text{Amount of substance, n} = \frac{\text{mass of substance in grams}}{\text{mass of 1 mole of substance}}$$

$$\text{Amount of substance, n} = \frac{\text{mass of substance in grams (m)}}{\text{Molar mass of substance (M)}}$$

$$\mathbf{n} = \frac{\text{m}}{\text{M}}$$

2.8.5 Amount of Substance Concentration or Molarity

The concentration of a solution is defined as the amount of solute present in a given amount of solution. Concentration is generally expressed as the quantity of solute in a unit volume of solution. In current practice, concentration is most often expressed as molarity. Molarity (symbol *M*), or molar concentration, is a common unit for expressing the concentrations of solutions. Molarity is defined as the number of moles of solute per litre of solution. If *n* is the number of moles of solute and *V* litres the volume of solution, Molarity = $\frac{\textbf{Moles of solute}}{\textbf{Volume in litres}}$

$$M = \frac{n}{V(\text{in litres})} \text{---------------} \textbf{(1)}$$

As evident from expression (1), unit of molarity is mol/litre.

According to Abbey, et al, (2001), the term concentration expresses certain amount of substance (moles) present in a specified volume of solution. The concentration of a solution is defined as the amount of substance, *n*, (in moles) per unit volume, *v* (in 1dm^3 or 1000 cm^3) of a solution. The symbol for concentration is **c**. The relation between concentration, amount of substance and the volume of solution is obtained as follows:

From the definition, **concentration, (c)** = $\frac{number\ of\ moles\ (n)}{Volume\ in\ dm^3\ (V)}$

$$\mathbf{c} = \frac{\mathbf{n}}{\mathbf{V}} \text{ ------------- } \mathbf{(2)}$$

Other useful relations can be derived from relation $\mathbf{c} = \frac{\mathbf{n}}{\mathbf{V}}$. Substituting $n = \frac{m}{M}$ into $\mathbf{c} = \frac{\mathbf{n}}{\mathbf{V}}$ gives $\mathbf{c} = \frac{\mathbf{m}}{\mathbf{Mx\ V}}$ and **m = c x V x M**.

Therefore $\mathbf{c} = \frac{\mathbf{m}}{\mathbf{MV}dm^3}$ -------------- **(3)**

The SI unit of amount of substance concentration is mole per cubic decimetre (**$moldm^{-3}$** or **mol/dm^3**) or sometimes abbreviated as **M**, that is molar.

According to Asiedu and Amoako (2005), to find out the concentration of a solution in moles per cubic decimeter ($mol\ dm^{-3}$) one needs to know: the formula of the compound, the molar mass and the volume of the solution. Guides to calculations of quantities are as follow:

1. List all given information on quantities
2. Think about the appropriate relation to use
3. If possible, calculate any other quantity that would be required in order to use the relation chosen
4. Substitute into the chosen relation the know quantities to obtain your answer, noting the units used.

2.8.6 Mass Concentration

Mass concentration is the mass, in grams of the substance dissolved in one cubic decimetre ($1dm^3$) of solution. It is expressed in grams per dm^3 (g/dm^3 or gdm^{-3}). Mass concentration is also called mass density and can be expressed in units of g/cm^3 or gcm^-

^{3} and g/mol or gmol^{-1} which is commonly called density (Abbey, et al., 2001; Ameyibor & Wiredu, 1991).

From definition, mass concentration, $p = \frac{mass\ of\ substance\ (m)}{Volume\ in\ cubic\ decimetre\ (V/dm^3)}$

$$p = \frac{m}{V/dm^3}$$

2.9 The Rationale for the Teaching of Mole Concept

Nellist (1986), stated that students tend to forget what they hear, they remember what they see, and whatever they are able to do, they understand. As a result, it is important for teachers to make teaching and learning mole concept as real as possible to the student through experiments. This makes teaching and learning easy and simple, saves teachers from excessive use of words and formulae and enhances students understanding and recall. The various effective ways of teaching challenging concepts such as mole must be investigated to promote teaching and learning to enhance the understanding of the learners.

Knowledge of the concept of mole plays an important or significant role in our daily lives. For example with a knowledge in this concept one would be able to calculate the percentage or dosage of a particular medicine at any given time, identify the major ingredients that go into the preparation of drugs, soaps and even soup that is prepared and eat. Thus, the mole concept is applied in certain areas such as the industries for preparations of chemicals and medicines and many more. Mole concept also allows scientists to use the correct amount of substances in chemical equations.

Matthias in Nakayama (2011) discuss some applications of mole concept as follows:

1. Mole concept in medicine: Mole concept is applicable in medicine because it allows us to predict how much of reactant is consumed in a chemical reaction, how much unwanted product is generated. This is especially important in medicine, because we would want the amount of toxic side products formed from the biochemical processes acting on the consumed medicine in our body to be minimal. It is also important in determining the amount of the substance necessary and whether the medication might react with a metabolic process in the body;
2. Mole concept in Pharmaceutical industry: It is especially important in the manufacturing of drugs. Mole concept principles help pharmacist to prescribe proper drugs ratios to a patient that would function effectively without any potential harm to the patient. They use a person weight to determine dosage. Pharmaceutical manufacturing uses mole concept calculations all the time in creating drug products and intermediates from raw materials;
3. Mole concept in Engineering: Engineers use it to determine the proper amount of reactant to produce a certain product. Mole concept is applicable in the development of jet engines and propulsion mechanisms for missiles and other rockets. The rocket for example, uses mole concept principles to convert a dense liquid fuel into the correct amount of gas fuel in order to allow the engine to travel at supersonic speeds and for great distance. Mole concept is used by chemical engineers in the production of plastics. Common plastics including PVC, C_2H_3Cl, polyethylene, CH_2, and Nylon-6, $C_6H_{11}ON$, are produced through the use of combining different substances, including resins, salts and carbon-based substances. These reactants are bonded together in a chemical reaction by heat. Chemical engineers use mole concept to formulate the ratio of reactants to produce these

kinds of plastics and with the properties that they wish to attain. Also, chemical engineers use mole concept to calculate the quality of reactants to the quality of the product they would like to be produced;

4. Mole concept in Aircraft Engineering: Mole concept is used by aircraft engineering so they can determine the distance that a plane would travel before refueled. The distance that a fighter jet needs to be refueled and the distance that a commercial airliner needs to be refueled are different. Mole concept is used so that the commercial airliner can land in the airfield and be refueled, and then the fighter jet can be refueled in the air. Otherwise the pilots would not know when to refuel.

2.10 Students' Achievement in Integrated Science

Science as a process requires some measure of commitment, curiosity, and love for what scientists do; in order to be able to go through it successfully. A school of thoughts are of the opinion that males find it less worrisome to identify problem, gather facts about problems formulate hypotheses, experiment, observe and interpret, formulate generalizations and application, Tyopav (2013). A scientific attitude is an important aspect of a personality of someone who wants to be successful in the field of science. It requires rationality, inquisitiveness, and a need for creativity and flexibility (Wimsey, 1998).

Students‟ achievement in Integrated Science remains poor in many schools, so teachers need to consider the needs and abilities of their students if achievement in Integrated Science is to be improved. Many factors influence students‟ achievement in Integrated Science, including prior experiences in science as well as the qualifications and ability of the teachers. In addition, the science curriculum is weak in focus, depth, and rigour. Teachers‟ lack of content knowledge is another factor in poor students‟ achievement.

Teaching quality can influence students" achievement in Integrated Science (Lan & Tan2008).

Achievement refers to the students" present performance level or academic skills in studying or reading Integrated Science, (Usman (2009); Usman (2008)) The Longman Dictionary of Contemporary English (2003) defines achievement as something important that you succeed in doing by your own efforts. According to Central New Mexico (CNM) (2009), academic achievement is all about what students do when they have finished a course of study. Elliot and Zahn (2008) define achievement motive as a dispositional motivational tendency to energize competence-relevant behaviour and orient individuals towards success or failure possibilities. Those theorist have identified two primary achievement motives; the need for achievement which represents a desire to approach success, and fear of failure, which represents a desire to avoid failure.

Elliot and Zahn (2008) further added that achievement value is the degree to which competence is considered important or valued by the individual. Initially, theorists viewed achievement value in terms of effectively based incentives for success or failure. Later theorists have retained the motion that value is grounded in effect, but have emphasized a general effective commitment to competence valuation rather than anticipations of a specific effect upon success, Elliot & Zahn (2008). Achievement oriented behaviour may occur in any human endeavor that involves level of competence. Achievement situations typically contain cues pertaining to standard of excellence, which would indicate degree of competence or incompetence.

2.11 Effect of Concept Mapping Strategy on Students' Academic Achievement

Concept mapping is the visual representation of the relationships between concepts held by an individual, materials of a lecture, text book or laboratory exercise, Novak (1998). Thus concept mapping is not only a visual representation of the relationships between concepts but is a meta-cognition learning process. It engages the mental processes of the learner at a high level and makes them think about their thinking. In addition it helps to understand the concepts held by an individual on a topic and how that individual relates those concepts. The concepts on mole concept can be represented at each level, and it is the transition from one level to other that possess a challenge. For instance sodium chloride can be represented in terms of mass which is a macroscopic level, or in terms of mole which is a microscopic level or in terms of chemical formula which is symbolic. Concept mapping is seen as a means to facilitate the linking of concepts on macroscopic level to those on the microscopic level or help learners link underlying concepts on the microscopic level only, Markow and Lonning (1998).

Olorundare and Aderogba (2009), disclosed that students exposed to concept mapping performed better academically than those exposed to analogy that also performed better than those exposed to expository method of learning. Combining concept mapping with other methods or indeed the traditional or conventional way of teaching has synergistic effect as compared to its unilateral use. This was affirmed by Moono and Singh (2015) who found in their research that, concept mapping is an effective method of teaching Integrated Science and Chemistry and that its effect is even significantly higher in academic achievement and retention if it is combined with the traditional method of teaching. Concept mapping has the ability to improve student"s achievement on mole concept and consequently in Integrated Science and Chemistry because mole concept is applicable to many other topics in Integrated Science and Chemistry. Also, concept mapping makes students learn meaningfully to improve upon their capacity to answer high order cognitive level questions. 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 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 Integrated Science and subsequently enhance academic achievement or performance of students.

2.12 Factors that Affect Student's Academic Achievement and Retention

Many factors have been suggested as contributing to the poor performance of students in Integrated Science in particular and Science in general. Lack of understanding of mathematical principles is a real impediment to solving mole concept problems correctly using reasoning, Gabel and Sherwood (2005). Some of these factors include: inadequate laboratory infrastructure and equipment in chemistry laboratories (Eniayeju, 2001); poor teaching methods (Ayogu, 2001); psychosocial factors (Bankole, 2001); mathematical nature of chemistry among others.

Tella (2007), disclosed that the academic achievement and retention of students in Integrated Science teaching and learning could be affected by factors such as inappropriate and inadequate instructional materials, inappropriate instructional strategies used by teachers, poor teacher preparation before lessons and poor attitude and interest of students towards the subject. Other variables such as motivational orientation, self-esteem and learning approaches are important factors that affect teaching and learning. Opara and Etukudo (2014) posits that with adequate instructional materials and strategies, the teacher would be able to give students the chance to learn through their senses of hearing, smelling, tasting, seeing and feeling.

A study conducted by Azure (2015) in Ghanaian Senior High Schools revealed that students were not led to carry out activities as suggested by the Integrated Science curriculum; teachers taught without performing activities as suggested in the curriculum. It was also revealed that students were made to read textbooks while teachers explained some of the concepts.

Deci (1998) emphasized that interest is an important factor that supports learning, individual development and achievement. Gbamanja (1992) in Olatunde (2007), itemised problems that have to a great extent drastically reduced students‟ interest in Integrated Science hence their achievement in the subject; these problems/factors include;

1. Lack of understanding of what Science is all about.
2. Lack of well-equipped Science laboratory
3. Lack of funds for the supply and maintenance of necessary equipment.
4. Poor teaching strategies used by the teachers.
5. Lack of workshop centres.
6. Lack of textbooks, journals and materials needed for professional growth.

If a student shows a higher interest in a course, this would help him to put in more time, effort and energy in learning which would in turn lead to higher or better achievement and retention.

The researcher"s teaching of mole concept in Integrated Science and elective Chemistry for the past six years in the Senior High Schools and interacting with the learners, the researcher realised that the students learning Mole Concept have the following difficulties and misconceptions;

1. learners" perception that the mole concept is a very difficult and confusing topic;
2. difficulties with the basic mathematical principles/learners" poor mathematics background;
3. the misapplication of formulae in calculations whenever mole concept questions are raised;
4. difficulty in calculation involving more than one stage;
5. unawareness of relationship between mole and concentration in mol/dm^3;
6. difficulties with the Avogadro constant and solving concentration problems;
7. students assigning wrong S.I units to particular measurement or calculations done;
8. how to properly analyze and answer mole concept questions;
9. difficulties with understanding the mole as a unit of the quantity of substance, as a concept; and as a defined quantity;
10. difficulties with tasks that are changed by adding some scientific notation;
11. confusing mole concept vocabulary;
12. lack of practice in problem solving as well as lack a scientific conception of mole.

Most of these factors are learner related as opposed to the nature of the mole concept knowledge and didactic factors. This indicated that teachers did not consider their conceptual understanding and how they presented the ideas under the mole as some of the key factors that made the topic difficult to teach and understand. Teachers found it difficult to deal with learners" wrong associations, conception and learning difficulties. This was because, to a larger extent, some teachers were responsible for those misconceptions and learning difficulties. Teachers had the same conceptual challenges in understanding most of the concepts and hence they transmitted them to learners (Pekdag & Azizoglu, 2013).

Teachers" conceptual shortcomings limited their ability to identify learners" difficulties in understanding of key concepts. It also affected their creativity and innovativeness in addressing learners" misconceptions of mole concept. This shows that without sound conceptual knowledge, it is very difficult to identify learners" misconception and learning difficulties. That is why sound conceptual knowledge is a precursor for quality teaching and learning of mole concept. A teacher with sound mole concept pedagogical content knowledge is likely to have knowledge about; the types of difficulties that learners experience, typical paths that learners" transverse to achieve understanding and potential strategies for helping learners overcome learning obstacles of the concept (Schulman, 1987). This knowledge is critical for effective teaching and learning of the mole concepts.

In addition to mathematical difficulties, Gabel and Sherwood (1984) cited the following difficulties:

1. One-step test items were easier to solve than two-step items, even when the student was very familiar with the content. Gabel and Sherwood (1984) associated this problem with students" difficulties with division. Students found division more

difficult than multiplication, and as two-steps tasks always require both division and multiplication, students find them more difficult to solve;

2. Students showed significant difficulties in tasks that involve decimal numbers rather than the whole unit;

3. When scientific notation was used in the problems, students found them more difficult to solve;

4. Very simple changes in problems made them more difficult to solve. More precisely, if the task, which was done during the lesson (as a teaching example), contained changed data, generally students were not able to solve it.

2.13 Students' Retention in Integrated Science

The mind acquires the materials of knowledge through sensation and perceptions. These acquired materials used to be preserved or retained in the mind in the form of images for knowledge to develop. The ability to memorize difficult subjects by rote learning was considered a way of exercising the mind and developing the muscles of the mind and brain. Olorundare (2009) asserted that retention is a function of achievement (Eze & Egbo, 2007). Retention is a crucial construct that most classroom teachers strive to maximize among their pupils.

Retention is the preservative factor of mind. Whatever touches consciousness leaves trace or impression and is retained in the mind in the form of images. Whenever a stimulating situation occurs retained images are revived or reproduced to make memory possible. It means that Chemistry concepts should be presented to the students such that it touches their consciousness. It then implies that any pedagogical approach used in education to improve Integrated Science students" achievement should be able to improve students" retention ability.

To correctly and effectively use or apply whatever one had learnt, retention comes to play an important role. Ausubel and Robinson (2008) referred to retention as the process of maintaining the availability of a replica of the acquired new meaning or some part of them. One can then suggest that the amount of the original meaning that will be retained at any point in time is a variable of the quantity at hands.

Bala (2010) reports that studies conducted in Integrated Science in secondary schools in Nigeria showed that, there is a definite loss varying from 12% during long-term vacation to 35.11%. It was as well further revealed during a standardized Integrated Science test, some students even showed a loss of 100%. Physics and Chemistry were at the lowest retention as was in History, Biology, Mathematics and Government.

To be able to measure retention, a test has to be conducted on the learner to know if the material learnt are retained and can be remembered and reproduced. Integrated Science is not a subject which can be learnt by mere memorization through rote learning. It is a known fact that the ability to remember takes place more effectively when experiences are passed on to the learner via an appropriate instructional or teaching method.

2.14 Gender Difference in Integrated Science

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 in Samuel, 2012).

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, 2009). In most societies, gender has relegated females to the sidelines, preventing them from participating in and benefiting from educational and development efforts.

Several studies have been carried out over the years to determine factors that influence students" achievement in Integrated Science. Integrated Science is a fundamental science subject that prepares students for the Senior High School Science subjects and subsequently for Science related courses in higher institutions. Abande (2010), opined that interest is a state of curiosity or concern about something or the attention given to something. Magnus (2008), further stated that interest encompasses the positive, pleasant feelings an individual has when trying to study a subject-matter. Gender has attracted the attention of many psychologists, Science educators and other researchers as a result of which a lot of literature exists on different aspects of the concept. For instance, numerous studies have been carried out on gender and social role; gender and work role; gender, Science and Technology, gender and achievement. Findings showed that gender has a significant influence on the interest of students in Integrated Science but does not have a significant influence on achievement of Integrated Science students (Bajah, 2007).

According to Wijesundera, and Ramakrishna (1986) the issue of gender differences in achievement in school Science is far from being resolved, and the inconclusiveness of studies conducted to date provides no solid basis on which changes can be made in teaching and learning. In many Science, Technology, Engineering, and Mathematics disciplines, women are outperformed by men in test scores, jeopardizing their success in science-oriented courses and careers. In studies held in advanced countries, New Zealand women were frustrated in trying to get promoted even with very good Curriculum vitae (Brooks, 1993).

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; Etukudo, 2002 & Kolawole, 2002). But, a few scholars have also found no significant difference in academic performance in Integrated Science and Mathematics between male and female students (Ogunkola, 2000; Owolabi, 2000; & Kurumeh, 2004). The controversy as to which of the sexes would have better academic performance therefore, continues.

In science education generally, there is concern that girls are not achieving as boys (Ericson & Ericson, 2010; Welch, 2008; Jegede & Inyang, 2007). The difference, they said, seem to be more pronounced in the Physical Science. Fernema and Shema (2011) in Okoroafo (2014) noted that fewer girls take advanced Sciences and Mathematics courses and select careers in Sciences. Bajah (2007) noted that boys were superior to girls to school achievement especially in the sciences. Some researchers have advanced some reasons for the difference in gender achievement in science subjects. Tracy (2006) postulates that, sex related differences might be related to social (that is, sex role model and orientation), educational and personal ability.

There are indications at all levels of education in Ghana that females are grossly under-represented in terms of enrolment, participation and achievement in Science, Technology and Mathematics education (Okeke, 2004; Maduabum, 2006; Anaekwu & Nnaka, 2006). Becker and Hall, (2013) discovered that, the teachers were friendlier with boys, which created a better rapport for better understanding for the boys. While some studies indicate that in general, boys achieve better (Gipps, 2004; Kingdon, 2009), either no difference (Ventura, 2008; Calsambis, 2007; Mohapatra & Mishra, 2008) or girls outperform boys (Chambers, 2008; Soyibo, 2009) has been demonstrated. As for the influence of gender on students‟ academic achievement, science educators differ in their findings. For instance, Aluko (2005), Nbina and Avwiri (2014) and Muhammad (2014) in separate studies, reported that gender has no effect on student achievement in science while Lawal (2009) found that female subjects were significantly better than their male counterparts and that there was a significant difference between the male and female subjects in their ability to evaluate science concepts. Also Omwirhiren (2013) and Daluba (2013) noted, that the males perform significantly better than their female counterparts in evaluating science concepts. The consensus among Science educators is that some instructional strategies are gender bias while some are gender friendly, however, the degree of gender related differences in learning vary from one method of instruction to the other as well as the concept being learnt. Therefore, it is of interest to find out if the relationship changes in sex of students could predict their achievement and retention in Mole Concept using Concept Mapping strategy as a method of instruction.

2.15 Review of Related Empirical 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. It was found out that the ability to construct good concept maps is not limited to any student gender. Bello and Abimbola (1997) 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. Bello and Abimbola (1997) also found no significant difference in achievement in evolution between male and female students who were taught using the concept mapping method. Bello and Abimbola (1997) 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. Otor (2013) 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 that, 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 the students 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 designs. The 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 (2012) in his work on effectiveness of using concept maps in improving the science achievement of thirty four 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) also determined the effects of concept mapping learning strategies on Secondary students‟ academic achievement in mole concept. Jack (2014) used 100 SS1 students in Taraba State, Nigeria. The findings indicated 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 mole concept. 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 mole concept 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 as an advance organizer can improve the science achievement of eighth-grade students, Eighty two students in four science classes participated in this study, two classes as experimental. The result showed that, concept map can provide the classroom teacher with meaningful and practical structured approach for using advance organizers in their classes.

Mahasneh (2013) examined the relationship between reflective thinking and learning styles among Jordanian university students. Participants of the study consisted of four hundred and seventy-six students (male and females) selected randomly from different faculties of Hashemite University. Regression and correlation analysis were used for data. Results indicated that there was 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.

The goal of a study by Nicoll, Francisco and Nakhleh (2001) was to investigate the value of using Concept Mapping in general chemistry and, more particularly, to see if Concept Mapping would produce a more interconnected knowledge base in students, compared to ordinary instruction. The results showed that, the Concept Mapping group knew more concepts (49 vs. 38), more linking relationships (69.9 vs. 46.2), more "useful" linking relationships (55 vs. 34.6), and had no more erroneous linking relationships than the non-Concept Mapping students

Ameyaw (2015) investigated the use of concept map to enhance academic performance of students in Glycolysis and Krebs cycle. Sixty-three second year students from Odorgonno Senior High School in the Greater Accra Region of Ghana were used for the study. A quasi-experimental design which combines both qualitative and quantitative with inclusion of participatory design was used to gather information from students" concept maps (interventional tool used) on Glycolysis and Krebs cycle. Closeness index technique designed by Goldsmith, Johnson and Acton (1991) was used to assess students" concept maps. The outcome of the study disclosed high performance of students" skills in concept map construction and a significant increase in students" understanding of Glycolysis and Krebs cycle; concepts in tissue respiration. The study portrayed a significant difference between the pre-test and post-test scores and this suggests that concept mapping is an effective tool that can enhance SHS students" academic performance in Glycolysis and Krebs cycle.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter describes the method and procedure that were used in carrying out the study. It is discussed under the following sub-headings: Research area, Research design, Population and Sample, Sampling Techniques, Research Instruments, Validity of the Instrument, Pilot Testing, Reliability of the Instrument, Data collection procedure (Pre-Intervention Activities, Intervention Design and Post-Intervention Activities) and Data Analysis Plan.

3.1 Area of the Study

The study was conducted in Keta Business College (KETABUSCO) in the Keta Municipality of the Volta Region of Ghana. The school is located in the Tegbi- Xekpa on the Anloga- Keta road, 15 minutes" drive away from the Anloga station. Keta Business College was established on 1st January, 1935 as a private evening school by the late Reverend Adolphus Egbetor Fiagbedzi with a single student. The school was first known as First Century Gospel Industrial School (FICEGO). The name was later changed to First Century Gospel Business College and later renamed Keta Business College. The school, like an Orthopteran, jumped from Vodza to Kedzikope to Dzelukope and finally to the present site Tegbi- Hekpa. The school was absorbed into the public education system in September 1965, and the students sat for the School Certificate/General Certificate of Education (SC/GCE) Ordinary Level Examinations for the first time in June, 1974.

The Education Reform that took off in the country in 1987 brought changes in the programmes run in the school. The school currently offers courses in five programmes namely: Business, General Arts, Home Economics, General Science and Visual Arts. The current student population is about 1895 comprising 987 girls and 908 boys. The school has a teaching staff population of 124 teachers.

3.2 Research Design

McMillan and Schumacher (2011) opined that, research design refers to the plan and structure of the investigation used to obtain evidence to answer research questions. The design describes the procedures for conducting the study, including when, from whom and under what conditions the data will be obtained.

According to Gay and Airasian (2000), a research design is used as the overall plan for obtaining answers to the research questions being investigated. Amedahe (2002) asserts that research design is a plan or blue-print that specifies how data relating to a given problem should be collected and analysed. The research design identifies the evidence needed to address the research purposes, objectives and questions, i.e., the logic that underpins the connections between purposes, objectives, questions, data and conclusions drawn. Seidu (2007) also discloses that, research design describes the procedures and methods used to gather data. He further explained that for every research study, the choice of design must be appropriate to the subject under investigation. According to Seidu (2007), there are various designs which are used in research, all with specific advantages and disadvantages. Which one the researcher uses, depends on the aims of the study and the nature of the phenomenon. Some examples of research designs are case study, action research, survey, quasi-experimental, longitudinal, cross-section, causal and correlational designs.

The purpose of research design is to provide the most valid, accurate answers possible to research questions. The research design is very important part of an investigation, since certain, limitations and cautions in interpreting the results are related to each design, also because the research design determines how the data should be analysed.

The design employed for this study was an Action Research in the form of pre-intervention activity, intervention activity and post-intervention activity which was structured to examine how the performance of students in mole concept can be improved using "Concept Mapping" at Keta Business College.

Action research according to Cannae (2004) involves the formal and systematic application of the scientific methods to solve classroom problems. Action research in education is any systematic inquiry conducted by teachers, principals, school counselors, or other stakeholders in the teaching-learning environment that involves gathering information about the ways in which their particular schools operate, the teachers teach, and the students learn. This information is gathered with the goals of gaining insight, developing reflective practice, effecting positive changes in the school environment (and on educational practices in general and their complexity), and improving student outcomes and the lives of those involved.

Action research significantly contributes to the professional stance that teachers adopt because it encourages them to examine the dynamics of their classrooms, ponder the actions and interactions of students, validate and challenge existing practices, and take risks in the process. When teachers gain new understandings about both their own and their students" behaviors through action research, they are empowered to make informed decisions about what to change and what not to change, link prior knowledge to new information, learn from experience (even failures), and ask questions and systematically find answers, Cannae (2004). Action research is a disciplined inquiry in which a personal attempt is made to understand, improve and reform practice, Jashim (2009). Action research is a way of assessing result while operating.

According to Cohen, Manion and Morrison (2018), action research can be used in a variety of areas, for example:

1. **teaching methods:** replacing a traditional method by a discovery method;
2. **learning strategies:** adopting an integrated approach to learning in preference to a single-subject style of teaching and learning;
3. **evaluative procedures:** improving one‟s methods of continuous assessment;
4. **attitudes and values:** encouraging more positive attitudes to work, or modifying pupils‟ value systems with regard to some aspect of life;
5. **continuing professional development of teachers:** improving teaching skills, developing new methods of learning, increasing powers of analysis of heightening self-awareness;
6. **management and control:** the gradual introduction of different techniques of class management;
7. **administration:** increasing the efficiency of some aspect of the administrative side of school life.

The purpose of action research is to provide teacher researchers with a method for solving everyday problems in schools so that they may improve both student learning and teacher effectiveness. The researcher has chosen this design because it helps to explore the problem with an aim toward developing a solution to a problem, to find out the learning difficulties of learners in the mole concept and put in an intervention to solve the problem, to improve practice and is a useful tool for change and improvement at the local level.

3.3 Population and Sample

Population is the total number of person inhabiting a country, city, or an area, (Jennifer, 2002). On the part of Polit and Hungler (1999), population is the sum totality or aggregate of phenomenon of interest to the researcher. According to Anamuah-Mensah, Asabere Ameyaw and Mereku (2004), the quality and integrity of any research depend on the validity and the efficiency of the samples used in the study. In this regard, the sample was carefully selected. Out of the target population of 673 Second Year Students of Keta Business College, a sample size of 30 students comprising 18 males and 12 females of General Arts 2B were selected and deemed appropriate for the study since action research focuses on designing an intervention to solve problem in a specific situation. Most of the students have their ages ranging from seventeen to twenty-five years.

3.4 Sampling Techniques

The sampling technique used was the cluster sampling techniques in the form of intact class to select the samples for the study. According to Borg and Gall (1996), cluster sampling is employed in situations in which a researcher study a number of intact classes that is already in existence and the use of individual unit might not be the best option. In cluster sampling, intact groups, not individuals are randomly selected from a population of clusters using balloting method to select the General Arts 2 G in the population. This was achieved by writing “ONE YES” and “SIXTEEN NO” on pieces of paper of equal size and texture, folded and poured them inside a container. A student from each of the seventeen classes of the form two was asked to hand-pick a paper. All members of the cluster selected were included in the sample. In cluster sampling a cluster is perceived as a sampling unit. Cluster sampling is used when it is more feasible or convenient to select groups of individuals than it is to select individual from a defined population.

The researcher has chosen this technique because the population of the Second Year Students is extremely large. Cluster sampling usually involves less time and expense and is generally more convenient, data accuracy, ease of implementation, more feasible and requires fewer resources than either simple random sampling or stratified sampling. Additionally, cluster sampling is advantageous for educational researchers because they frequently cannot select and assign individual participants. Also it is efficient; clusters are mostly used in school research; don"t need names of all population members; reduces travel to sites. The main purpose of cluster sampling is to decrease costs and increase operational efficiency.

3.5 Research Instruments

An **i**nstrument is a tool for measuring, observing, or documenting quantitative data. In this research, four instruments were used for data collection. These were semi-structured interview; tests-Mole Concept Achievement tests (MCAT), Mole Concept Construction Test (MCCT) and a set questionnaire. The MCATs were in two folds, pre-intervention test and post-intervention test. MCATs designed by the researcher was used by the researcher to measure students" academic performance and retention and MCCT was used to determine students" ability to construct a concept map.

The researcher also interacted with the learners through semi-structured interview to identify their difficulties and misconceptions about mole concept. As the name signifies, this instrument has no definite structure. It involves free-style discussion with the interviewees. Semi-structured interview as a research instrument has a weakness. It may be meaningless when the interviewer fails to establish cordial and friendly relationship. However, the researcher chose to use semi-structured interview because of its flexibility and freedom which would enable me to unearth detailed and relevant information as well as sensitive information through probing. This instrument was used to ascertain the problem understudy. The semi-structured interview also helped the researcher to determine the various causes of the inability of the students to understand the mole concept.

The questionnaire consisted of 30 items arranged in a seven column Likert scale which respondents responded to by ticking either "Strongly Disagree"(scoring 1), "Disagree"(scoring 2), "Somewhat Disagree" (scoring 3), "Neither Agree or Disagree"(scoring 4), "Somewhat Agree" (scoring 5), "Agree"(scoring 6) and "Strongly Agree"(scoring 7), (see Appendix C). These were given to respondents before the intervention activities to find out some factors that affect their participation in academic performance and retention of mole concept lessons. The questionnaires were also used to assess the students" conceptual understanding of mole concept.

3.5.1 Mole Concept Achievement Tests (MCAT)

According to Gay (1976), achievement test measures the current status of individuals with respect to proficiency in given areas of knowledge or skills. Standardised achievement tests are carefully developed to include measurement of objectives. They measure knowledge of facts, concepts, and principles.

The MCAT consisted of 30 multiple choice questions with four options constructed to serve as pre-intervention test to ascertain or measure students basic knowledge and understanding in the mole concept and post-intervention test to determine the effects of the intervention on ability to solve numerical problems in Integrated Science based on the Mole Concept. The items consisted of 15 calculations and 15 theories on mole concept. The content of MCAT was drawn based on the Integrated Science syllabus and past question papers of WAEC (Appendix A). The questions measured the meaningful learning domain (level of perception, application, analysis, evaluation and innovation or creativity according to the Bloom's classification of cognitive objectives). Monotonous scoring of 1 mark is awarded for each question. Table 3.1 Shows the Table of specification on Mole Concept Achievement Test questions for the pre-intervention.

Table 3.1: Item Specification for MCAT of pre-intervention Based on Sub- topics Selected

S/No	Sub-Topic	No. of Items	Total no. of Items
1	Molarity	10, 28, 20, 21, 22	5
2	Molar mass	5, 8, 9, 12,17	5
3	Mass Concentration	16, 6	2
4	Amount	7, 14, 18, 19	4
5	Units	1, 2, 3, 4, 13	5
6	Mass number And atomic number	15, 25, 26, 27, 29, 30	6
7	Mass	11, 23, 24	3
	Total		**30**

Table 3.2: Table of Specification Based on Blooms' Taxonomy in the Cognitive Domain

S/No.	Contents	Weight 100%	Knowl. 30.00%	Comp. 20.00%	Appl. 16.70%	Analy. 16.70%	Syn. 10.00%	Eval. 6.70%	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	1	0	1	2	0	0	4
5	Molarity	16.7	0	0	2	0	3	0	5
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	10.1	1	0	1	1	0	0	3
	Total	**100**	**9**	**6**	**5**	**5**	**3**	**2**	**30**

Source: Adapted from Bamidele et al (2013)

3.5.2 Mole Concept Construction Test (MCCT)

The MCCT was used to determine the student"s ability to construct a concept map after the intervention activities. The instrument was adapted from Novak (1977). The construction test items comprised 25 concepts, all on 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 F).

The Researcher used an expert/teacher made concept map (Appendix G) as a standard or reference material and a scoring rubric 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 (2005) 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 & 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 maps, they received a score of 3 that is, nothing was missing. The correctly labeled links with the directions clearly shown by an arrow is three points.

Convergence measures the extent to which the possible links are actualised 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 and Attieh, (2008). This result compares very favourably with those reported in the literature on scoring concept maps, Ruiz-Primo, Shultz, Li, & Shavelson, (2001).

3.6 Validation of the Instruments: MCAT, MCCT and Questionnaire

Validity of an instrument according to Taale and Ngman-Wara (2003), refers to whether the instrument truthfully does what it is constructed to do. In other words, when the instrument measures what it is intended to measure, then it is valid. Durrheim and Blanche (1999) suggests that the researcher approach others in the academic community to check the appropriateness of his or her measurement tools. Validity is an important key to effective research, as such, the test items in MCAT and MCCT were given for validation (Appendix A and Appendix D). The completed test items were given to one experienced chemistry teacher in the Senior High school who is a seasoned examiner of WAEC, two Science educators who were well experienced in concept map construction from Science Education Department of the University of Education, Winneba for comment on the validity and correctness of the questions. All of these educators were senior lecturers with the minimum qualification of PhD. The experts involved in the validation were requested to critically examine and assess all the items of the instrument paying attention to the following:

1. scope of coverage and content relevance,
2. whether the test conformed to the subject specification,
3. whether the questions are clear,
4. precise and free from ambiguity,
5. whether the questions match the ability of the students, and
6. whether the language of expression is simple and unambiguous for students understanding.

The experts were also expected to check whether the answers to MCAT and MCCT (Appendix B and Appendix E) were correct or not, the appropriateness of instructional package designed for the study was to be scrutinized. 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 were used for the study.

Content and construct validity for the students" questionnaire were obtained thorough analysis of the items by two experts including the supervisor in the Department of Science Education at the University of Education, Winneba. Based on their comments and suggestions, a number of alterations and corrections were made to the instruments.

3.7 Pilot Testing of the Instruments for Reliability

Reliability refers to how well the instrument provides a consistent set of results across similar test situation, time periods and examiners (Taale & Ngman-Wara, 2003). It means the degree of dependability of a measuring instrument. It is worth mentioning that it is possible to have an instrument which is reliable because the responses were consistent, but might be invalid because it fails to measure the concept it intends to measure (Fraenkel & Wallen, 2000).

The instrument MCAT for the pre-intervention test and post-intervention test were pilot tested on sample of 40 form three students in the National Science and Mathematics Quiz of the school and one intact class of General Arts 2G selected randomly 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 might affect the effective administration of the instrument during the actual research work. The reliability of the instruments was examined using test-retest reliability. 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 split-half method was used to check the reliability of the test items and questionnaire because it is a "more efficient way of testing reliability" and was less time consuming Durrheim and Blanche (1999). The split-half method requires the construction of a single test consisting of a number of items. These items are then divided or split into two parallel halves (usually, making use of the even-odd item criterion). Students" scores from these halves were then correlated using the Spearman-Brown formula used in reliability testing. The value of the coefficient was 0.92 for MCAT as shown below. Thus, the instruments were reliable to measure the academic achievement of the study subjects. This value 0.92, indicates a good degree of reliability of the instrument as asserted by Fraekel and Wallen (2000).

Table 3.3: Calculation for the reliability of MCAT

S/N	x	y	$x - x$	$y - y$	$(x - x)(y - y)$	$(x - x)^2$	$(y - y)^2$
1	12	14	-3	-3	9	9	9
2	12	13	-3	-4	12	9	12
3	12	14	-3	-3	9	9	9
4	10	14	-5	-3	15	25	9
5	14	14	-1	-3	3	1	9
6	14	23	-1	0	0	1	0
7	20	18	5	6	30	25	36
8	16	17	1	1	1	1	1
9	13	17	-2	0	0	4	0
10	12	15	-3	-2	6	9	4
11	17	19	2	2	4	4	4
12	16	15	1	-2	-2	1	4
13	19	21	4	4	16	16	16
14	13	16	-2	-1	2	4	1
15	13	16	-2	-1	2	4	1
16	14	15	-1	-2	2	1	4
17	18	20	3	3	9	9	9
18	20	20	5	3	15	25	9
19	14	16	-1	-1	1	1	1
20	21	23	6	6	36	36	36
21	12	15	-3	-2	6	9	4
22	13	17	-2	0	0	4	0
23	16	18	1	1	1	1	1
24	20	23	5	6	30	25	36
25	14	17	-1	0	0	1	0
26	14	14	-1	-3	3	1	9
27	10	14	-5	-3	15	25	9
28	12	14	-3	-3	9	9	9
29	12	13	-3	-4	12	9	16
30	12	14	-3	-3	9	9	9
31	20	20	5	3	15	25	9
32	14	16	-1	-1	1	1	1
33	21	23	6	6	36	36	36
34	18	20	3	3	9	9	9
35	14	15	-1	-2	2	1	4
36	13	16	-2	-1	2	4	1
37	13	16	-2	-1	2	4	1
38	19	21	4	4	16	16	16
39	16	15	1	-2	-2	1	4
40	17	19	2	2	4	4	4
Total	600	680			340	388	352

$$x = \frac{\sum x}{N} = \frac{600}{40} = 15$$

$$y = \frac{\sum y}{N} = \frac{680}{40} = 17$$

$N = 40$, $\sum x = 600$, $\sum y = 680$, $\sum(x - x)(y - y) = 340$, $\sum(x - x)^2 = 388$, $\sum(y - y)^2 =$ 352.

$r = reliability\ coeficient\ of$ MCAT

Substituting these values in mean score formula, we obtain

$$r = \frac{\sum(x - x)(y - y)}{\sqrt{\sum(x - x)^2(y - y)^2}}$$

$$r = \frac{340}{\sqrt{(388)(352)}}$$

$$r = \frac{340}{\sqrt{136576}}$$

$$r = \frac{340}{369.5619}$$

$$r = \mathbf{0.92}$$

3.8 Data Collection Procedures

Data were collected through tests (pre-intervention and post-intervention tests). The data collection which last for two weeks was divided into three stages. These are: pre-intervention stage, intervention stage and post-intervention. Firstly, the pre-intervention stage of the research was chosen in order that the researcher would be equipped with strengths and weaknesses of students in the concept under study. At this stage, a pre-intervention test was conducted for students" conceptual understanding in mole concept by the researcher. The essence of the written test was to obtain numerical values on students" performance and appropriate statistical approaches employed in judging their performance.

Secondly, at the intervention stage, researcher employed the use of concept mapping teaching strategy in guiding students develop in-depth understanding of the mole concept. The researcher designed an intervention for the process which was based on the difficulties found in students" understanding of the mole concept. The group was taught for four weeks and was meeting twice a week for 80 minutes per session.

Lastly, a post-intervention test of Mole Concept Achievement tests (MCAT and the Mole Concept Construction Test (MCCT) were conducted at the post-intervention stage. This stage also provided numerical values on students" achievement and retention of mole concept after implementation of interventions for which statistical measures were performed and interpretations drawn from the results. The scores of the pre and post-intervention tests were compared and result analysed. The MCCT was to compare the males and females in their ability to construct concept maps.

3.8.1 Pre-Intervention Activities

All the thirty students sampled for the study responded to the MCAT pre-intervention test administered to determine their previous knowledge of the mole concept. Mole Concept Achievement tests (MCAT) pre-intervention test was made up of 30 multiple choice objective questions. The test was conducted in line with the laid down regulations of the West African Examination Council. All the answered test scripts were marked using the marking scheme (Appendix B), recorded and the scores were collated for further processing. Questionnaire was also administered (Appendix C), analysed and the results were presented as in Appendix H.

The MCAT pre-intervention test and the questionnaire were given to respondents before the intervention activities to determine some factors that affect their participation, academic performance and retention of mole concept lessons. The questionnaires were also used to assess the students‟ conceptual understanding of mole concept.

3.8.2 Intervention Activities

The intact class sampled was taught mole concept with the integration of concept mapping strategy. This is the most effective and productive way of teaching and learning mole concept in Integrated Science. This strategy is based on the constructivist view of learning where learners take active role in learning to ensure meaningful learning. Concept mapping was integrated into group discussion, class discussion practical work and teacher exposition. It was also used to introduce the topic and highlight the expected outcomes and conceptual framework of the topic. The selected sub-topics taught to the sampled class on mole concepts were: Mole as a concept and a unit, Atomic mass, Mass number, Molar mass, Amount, Molarity, Mass concentration, Mass, and Avogadro‟s number.

Major sub concepts of the topics were written on the board. This was followed by explanation of the sub-concepts 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. Terms were explained to students using concept maps.

WEEK ONE

LESSON 1: Concept mapping strategy I (Definition of terms on Mole concept)

A. Teacher wrote the following quantities on the board:

Amount, Molarity, Molar mass, Mass concentration and Avogadro‟s number

B. Teacher explained each concepts to the students

Amount: Amount of substance (n) is the quantity that measures the number of entities of (atoms, molecules, ions, electrons etc.) present in a substance, expressed in moles. It is a quantity that measures the size of an ensemble of entities. The unit of amount of a chemical substance is the mole-abbreviated **mol**.

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 ($gmol^{-1}$ or g/mol). Molar mass is equivalent to the formula mass of a substance but formula mass has no unit.

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 Avogadro‟s constant.

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

Mass Concentration: Is the mass, in grams of the substance dissolved in 1dm3 of solution. It is expressed in grams per dm^3 (gdm^{-3} or g/dm^{-3})

C. The teacher led the students to put these terms in the concept map (amount, molar mass, molarity or molar concentration, mass concentration Avogadro‟s number, electron, molecule, atom, ion) by illustrating the concept map on the board.

Example:

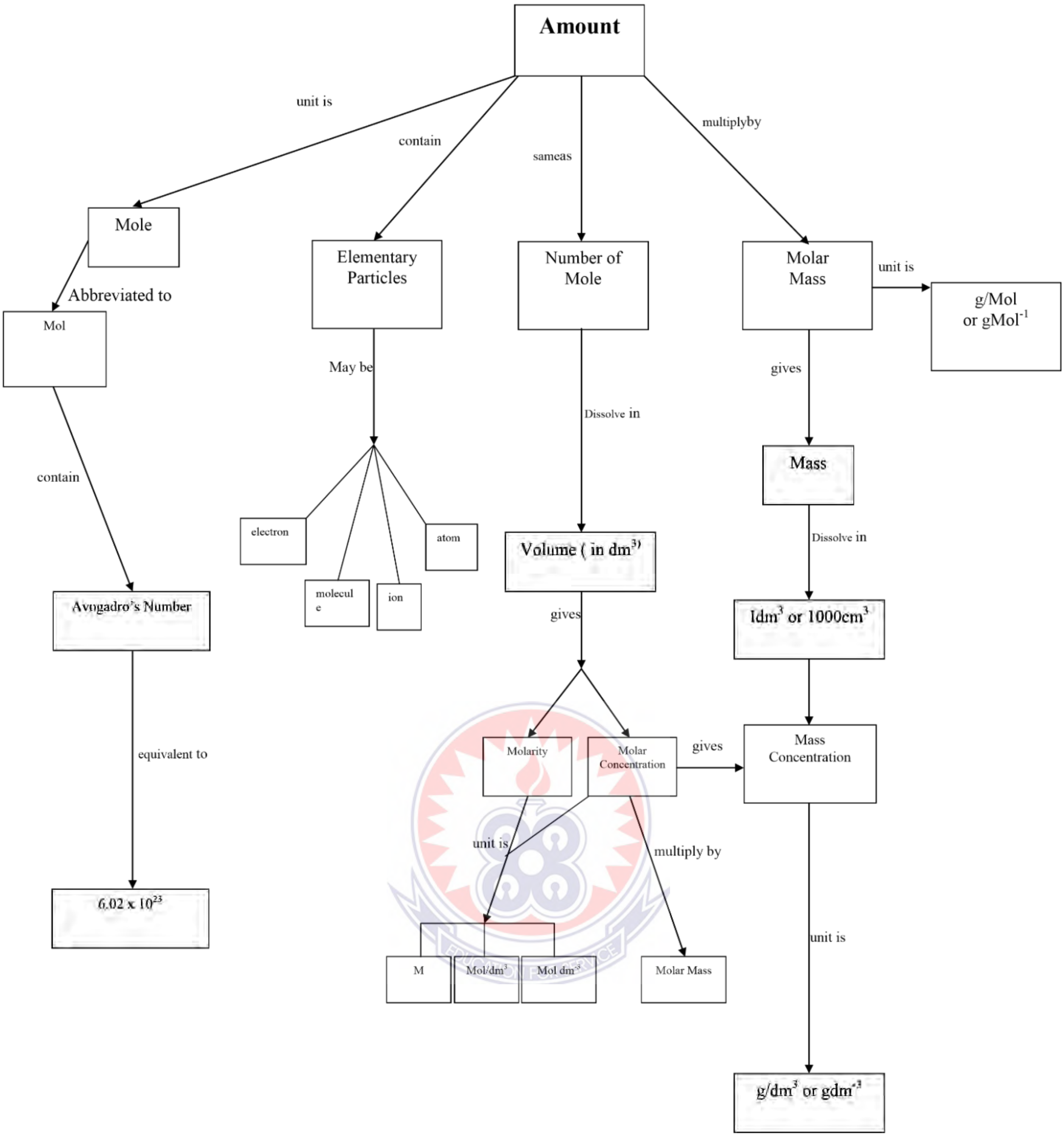


Figure 3.1: Teacher Made Concept Map on Mole Concept

D. Teacher gave summary of the lesson.

E. Student's activity: Students were provided with a sheet of paper to construct a concept map. The terms were as follow: amount, molar mass, molarity, mass concentration, Avogadro"s number, 6.02 x 10^{23} and mole.

Evaluation: Teacher evaluated the students by asking the following questions: Define the following; Amount, Molar mass, Mass concentration, Molar concentration and Avogadro"s number. Students constructed concept maps in groups and submitted at the end of the exercise.

LESSON 2: Concept mapping strategy II (Calculation on Mole Concept)

A. Students were familiar with molarity, amount, molar mass, mass concentration, Avogadro"s number. Teacher introduced the lesson by asking questions on their previous knowledge.

B. Teacher introduced the lesson by giving formulae to show relationship that exist between; Molar Mass, Mass Concentration and Molarity, Amount, Mass, Number of particle and Avogadro"s number as follow

- ✓ Molar mass, M = $\frac{mass(g) of\ substance (m)}{amount\ of\ substance (n)}$

$$\mathbf{M = \frac{m}{n}}$$

Where m = mass of substance, M = molar mass, n = amount of substance.

- ✓ Amount of substance (number of moles), n = $\frac{mass\ of\ substance\ in\ grams\ (m)}{molar\ mass\ of\ substance\ (M)}$,

$$\mathbf{n} = \frac{m}{M}$$

- ✓ Molarity, C = $\frac{Amount\ of\ substance\ (n)}{volume\ in\ dm^3\ (V)}$

$$\mathbf{C} = \frac{n}{V}$$

Also Molarity, C = $\frac{m}{MVdm^3}$ and Molarity, C = $\frac{Mass\ concentration}{Molar\ mass}$

Where m = mass, M = molar mass and v = volume in dm^3

- ✓ Mass concentration, $\rho = \frac{mass\ (g)}{volume\ in\ dm^3}$

$$\rho = \frac{m}{v}$$

Also mass concentration, ρ **= concentration (C) in moldm^{-3} x molar mass (M)**

- ✓ Number of entities, *N*, in a given amount of substance, *n*, is given by: ***N = n x L*** and

Amount of substance, $n = \frac{N}{L}$, where L = Avogadro‟s number, **6.02 x 10^{23} mol^{-1}**

C. Teacher worked molar masses of some compounds on the board. Teacher called some students to the board to solve molar mass of some compound examples: H_2O, HCl, CO_2 and Na_2CO_3.

[H = 1, O = 16, Cl = 35.5, C = 12, Na = 23], (Sapong, 2014).

1. Molar mass CO_2 = 12 + (2x16) = **44g/mol**
2. Molar mass of HCl = 1 + 35 = **36.5gmol^{-1}**
3. Molar mass of H_2O = (1x2) + 16 = **18g/mol**
4. Molar mass of = Na_2CO_3 = (2x23) + 12 + (3x16) **= 106gmol^{-1}**

D. Teacher led the students to solve problems on amount of substance and molar mass using the formula, example:

How many moles of Carbon dioxide molecules were present in 11g of Carbon dioxide (CO2)?

[C = 12, O = 16], (Sapong, 2014).

Mass (m) of CO_2 = **11g**

Molar mass (M) of CO_2 = Ar(C) + 2 x Ar(O) = 12 + (2 x 16) = **44g/mol**

Amount of substance (number of moles), n = $\frac{mass\ of\ CO_2\ in\ grams\ (m)}{molar\ mass\ of\ CO_2\ (M)}$

$$\mathbf{n} = \frac{11g}{44g/mol}$$

$$\mathbf{n} = \mathbf{\mathit{0.25\ mol.}}$$

E. Researcher wrote on the whiteboard the questions below and asked learners to work them out on the whiteboard. How many moles are there in;

i. 60g of $CaCO_3$, ii. 98g of NaCl, iii.45g of $CuSO_4$. , iv. 48.5g of $Ca(OH)_2$, v.5.8g of HNO_3,

[Take Ca = 40, C= 12, O= 16, Na = 23, S= 32, H= 1, Cl = 35.5, Cu =64]

F. Teacher gave exercise to the students to solve. The questions were;

a. Calculate molar mass of the following (a) HCl (b) Na_2CO_3

b. What is the amount, in moles, of each of the following substances present in:

i. 5.25g of NaOH ii. 5.45g of Na_2CO_3,

[H = 1, Cl = 35.5, Na = 23, C = 12, O = 16]

WEEK TWO

Series of numerical questions on mole concept were asked by the researcher. Both the researcher and the students solved the problems on 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 and Avogadro῾s number.

LESSON 1: Concept Mapping Strategy III (Calculation on Mole Concept continuation)

A. Teacher introduced the lesson by asking questions on their previous knowledge. Students solved problems on amount and molar mass using the formula.

B. Teacher together with learners solve problems on Avogadro‟s number using the formula, eg:

1. What would be the number of molecules in HF when given 4.20 moles of Hydrogen fluoride?

Using Number of particles, N = Number of moles, n *x* Avogadro„s number, L;

N = n x L

= 4.20 x 6.02 x 1023

= 2.53 x 10^{24} molecules of HF.

2. You are given 12.04 x 10^{23} molecules of ammonia gas, NH_3, calculate the amount of substances present in ammonia molecules. [L = 6.02 x 10^{23} mol^{-1}],

The number of molecules, N, of ammonia gas = 12.04 x 10^{23} molecules, L = 6.02 x 1023 mol^{-1}

Using N = n x L,

$$n\ (NH_3) = \frac{N}{L} = \frac{12.04 \times 10^{23}}{6.02 \times 10^{23}} = 2\text{mol}$$

C. Teacher and the students calculated molar concentration of substances using the formula. To determine the concentration of a solution in moles per cubic decimeter (mol dm^{-3}) one needs to know: The formula of the compound, the molar mass and the volume of the solution.

Find the concentration of 35g of Sodium chloride (NaCl) present in 1000cm^3 of solution.

[Na = 23, Cl = 35.5], (Sapong, 2014).

Moles, n = $\frac{mass\ (m) of\ NaCl}{molar\ mass\ (M) of\ NaCl}$

Molar mass of NaCl = 23 + 35.5

= 58.5g/mol,

mass of NaCl = 35g.

n = $\frac{35g}{58.5g/mol}$

= **0.598 mol**

Volume = 1000cm^3 = 1dm^3

Molarity, C = $\frac{Amount\ of\ substance\ (n)}{volume\ in\ dm^3\ (V)}$,

= $\frac{0.598\ mol}{1dm^3}$

= 0.598mol/dm^3

Alternative: Using C = $\frac{m}{MVdm^3}$

C = $\frac{35g}{58.5g/mol\ x\ 1dm^3}$

= **0.598moldm^{-3}**

D. Teacher led the students to solve problems on the board on mass concentration of a solution using the formula, Mass concentration, $\rho = \frac{mass\ (g)}{volume\ in\ dm^3}$

An aqueous solution of 2.0 dm^3 contains 53.0 g sodium trioxocarbonate (IV). Calculate the concentration in: (i) gdm^{-3} (ii) moldm^{-3} [Na_2CO_3 = 106 g/mol],

Calculation of concentration in gdm^{-3}

Mass concentration, $\rho = \frac{mass\ (g)}{volume\ in\ dm^3}$

$$\rho = \frac{53.0\ g}{2.0\ dm^3}$$

$$\rho = \mathbf{26.5\ gdm^{-3}}$$

(i) Calculation of concentration in $moldm^{-3}$

Molarity, $C = \frac{Mass\ concentration}{Molar\ mass}$

$$C = \frac{26.5\ gdm^{-3}}{106.0\ g/mol}$$

$$C = \mathbf{0.25\ moldm^{-3}}$$

E. Teacher led the students to solve problems on molarity, molar mass and mass concentration using the formula; Molar concentration, $C = \frac{Mass\ concentration}{Molar\ mass}$.

Example:

Determine the molar mass of Na_2CO_3 given that 0.75M Na_2CO_3 solution has a mass concentration of $79.5 g/dm^3$.

From Molar concentration, $C = \frac{Mass\ concentration}{Molar\ mass}$,

$$\text{Molar mass} = \frac{mass\ concentration}{molar\ concentration}$$

$$= \frac{79.5 g/dm^3}{0.75 mol/dm^3}$$

$$= 106 g/mol$$

Hence molar mass of $Na_2CO_3 = 106\ g/dm^3$

F. The teacher summarized the lesson all over. Teacher evaluated the students by giving class work. Eg. What is the molarity of Na_2CO_3 solution of concentration of $3.153 g/dm^3$? [Na = 23, C = 12, O = 16].

LESSON 2: Practical Stage: Construction of Concept Maps on Mole Concept by Students

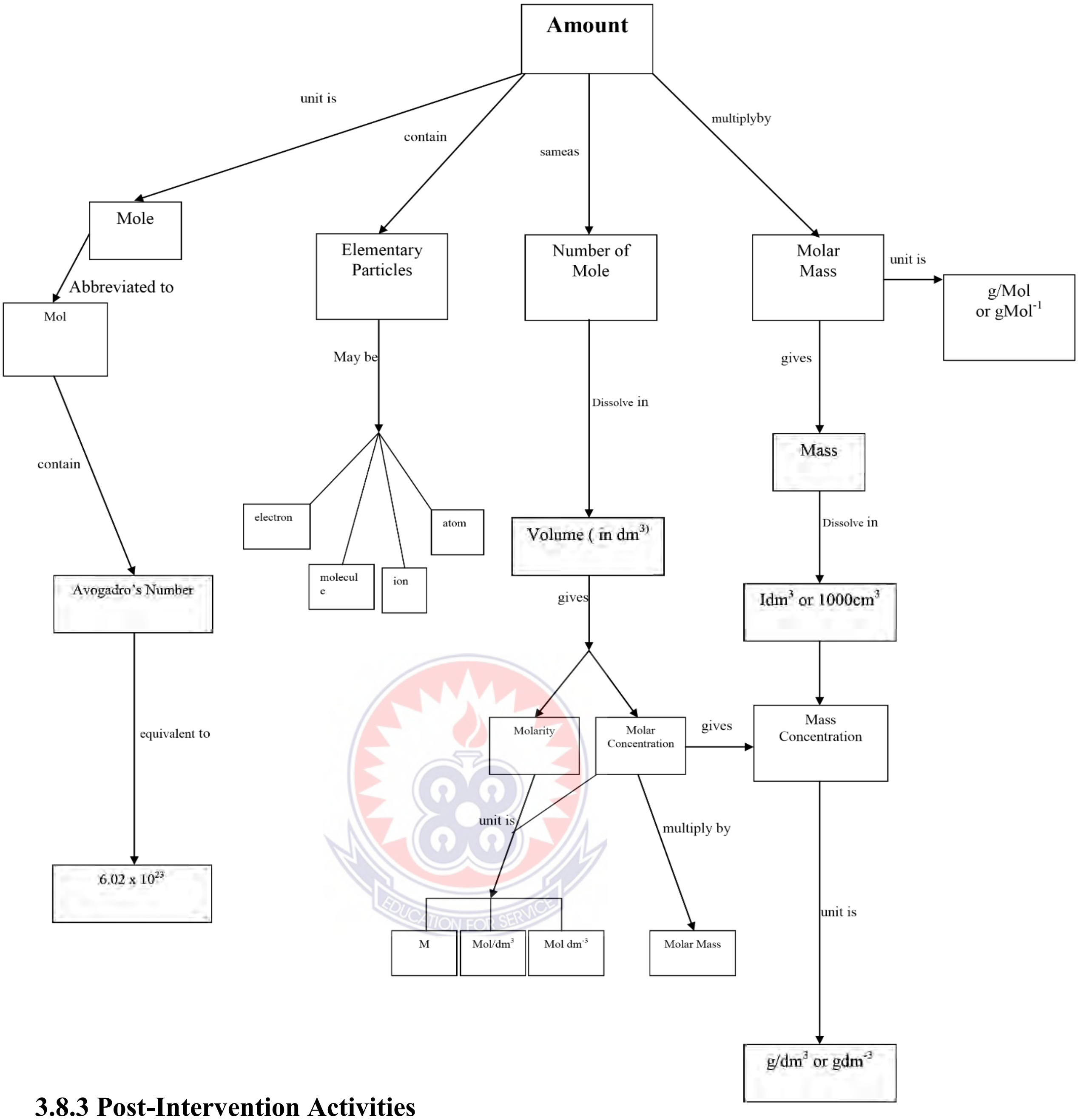
A. Students were familiar with molarity, amount, molar mass, mass concentration, Avogadro‛s constant, 6.02×10^{23}, mole and the relationship that exist between them using formula.

B. Students were provided with a sheet of paper to construct a concept map to show the relationship that exist between the concepts listed in (a) above individually.

C. With the use of a concept map students show the relationship that exists between the following terms/concepts step-by-step: *Amount, Mole, Molar Mass, Mass, Molar concentration, Molarity, Mass concentration, Avogadro's number,* 6.02×10^{23}*, Molecules, Number of mole, Ion, Atom, Mol,* g/dm^3*,* mol/dm^3*,* gdm^{-3}*,* $Moldm^{-3}$*, M, g/mol,* $gmol^{-1}$*, gram, volume,* $1000cm^3$*, Elementary particles*

D. Teacher went around to guide the students who might have some difficulties.

E. Students continuous to construct a concept map on the above terms until the last student master the concept as shown below.



3.8.3 Post-Intervention Activities

After the interventions, the summary of the general lesson was given by the researcher. After learning, learners were asked to draw their own concept maps. The learners were at liberty to expand the initial concept maps they had drawn as they expanded their knowledge. They were asked to draw specific concept maps based on the lessons covered (Appendix F and G). The concept maps were also used to consolidate the learnt concepts.

In the same week, the students were tested with reshuffled Mole Concept Achievement Tests (MCAT) administered in the pre-intervention test and a concept map construction using the Mole Concept Construction Test (MCCT), (Appendices D and F). The Mole Concept Construction Test was to compare the males and females" ability to construct concept maps. The scores of Mole Concept Achievement Test and Mole Concept Construction Test were collected and recorded for analysis. All the answered test scripts of post-intervention test were marked using the marking scheme (Appendix E)

3.9 Data Analysis Plan

The data collected was analyzed quantitatively and qualitatively. The results from the pre- intervention test and post-intervention test raw scores were analysed using both the descriptive and inferential statistics employed on the Statistical Package of Social Sciences (SPSS). The descriptive statistic was used to analyze the data projected the sample size, mean, standard deviation.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.0 Overview

In this chapter the results of data collected during the research and their discussions were presented. Descriptive and inferential statistics were used in analysing the data using alpha <0.05 level of significance. The data collected were analysed using the Statistical Package for Social Sciences (SPSS) version 22.0. A paired t-test with alpha value of (α = 0.05) was used to investigate whether there were any significant difference between the pre-intervention mean score and the post-intervention mean score after the administration of the intervention activities. A paired t-test was used because the researcher was interested in the difference between two variables (the pre- intervention test and post-intervention test) for the same subject or the same group; or comparing the same group at two different periods of time or the same group is measured on two occasions; or the researcher was interested in testing whether there was a significant increase or decrease in the test scores of the same group of students at two different times, Cohen, Manion and Morrison (2018). Often the two variables are separated by time and an intervention. The presentation of results followed the order in which the research questions were posed in chapter one as well as questionnaire and pre-intervention and post-intervention tests.

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

1. Performance/achievement scores from the pre-intervention test
2. Performance/achievement scores obtained from the post-intervention test
3. Students‟ scores from questionnaire before the intervention activities.
4. Students‟ scores from concept mapping construction after the intervention activities.

4.1 Data Analysis and Discussion of Results

Research Question One: *What are the factors that affect students' academic achievement and retention in mole concept?*

The questionnaire administered to students was analysed and the result presented in the Tables 4.1A and 4.1B (result of questionnaire and analysis of questionnaire) below.

Table 4.1A: Showing the result of questionnaire administered to students

	SD	D	SoD	NAD	SoA	A	SA	TOTAL
1. Do you have perception that mole concept is very difficult and confusing?	0	0	0	0	3	4	23	30
2. Do you have difficulties with the basic mathematical principles?	0	0	2	5	16	5	2	30
3. Misapplication of formulae in calculations whenever mole concept questions are raised	0	0	0	0	6	18	6	30
4. Do you find difficulty in calculations involving more than one stage of mole concept?	1	4	3	14	3	4	1	30
5. Lack of understanding of what mole and mole concept is all about	0	0	5	4	12	4	5	30
6. Do you have difficulties with the Avogadro constant and solving concentration problems?	0	0	0	0	7	16	7	30
7. I am always assigning wrong S.I units to particular measurement or calculations done	0	0	0	0	3	4	23	30
8. I find it difficult to properly analyze and answer mole concept questions	0	0	0	0	3	4	23	30
9. I have difficulties with understanding the mole as a unit of the quantity of substance, as a concept and as a defined quantity	0	0	0	0	7	16	7	30
10. I have difficulties with tasks that are changed by adding some scientific notation confusing mole concept vocabulary	0	0	5	4	12	4	5	30
11. I lack practice in problem solving involving mole concept	0	0	0	0	4	22	4	30
12. The sum of the atomic masses of all atoms in the formula unit of a compound is the formula mass	0	0	0	0	7	16	7	30
13. The mole represents the number 6.02×10^{23}	0	0	5	4	12	4	5	30
14. The quality of Integrated Science teaching and learning is affected by inappropriate and inadequate instructional materials	0	0	0	0	3	3	24	30
15. Poor instructional strategies used by teacher and lack of textbooks needed for professional growth	0	0	0	0	3	4	23	30
16. Poor teacher preparation before lessons and poor attitude and interest of students towards mole concept	0	0	0	0	4	22	4	30
17. Students were made to read available textbooks while teachers explained some of the concepts.	0	0	5	4	12	4	5	30

18. Teachers taught without performing activities as suggested in the curriculum	0	0	0	0	3	4	23	30
19. The teacher uses the lecture method only in teaching mole concept.	0	0	0	0	4	22	4	30
20. The teacher does not provide the most current information.	0	0	0	0	4	22	4	30
21. In teaching mole concept, the teacher follows what is in text books.	0	0	5	4	12	4	5	30
22. The teacher usually adopts teaching technique such as individual/group activities.	0	0	5	4	12	4	5	30
23. The teacher usually uses a combination of teaching methods in teaching mole concept.	5	20	5	0	0	0	0	30
24. The concept of the mole says that in a defined mass of an element there are precise number of atoms.	0	0	0	0	4	22	4	30
25. The teacher helps us solve adequate problems on mole concept.	0	0	5	4	12	4	5	30
26. The mass of one mole of any substance is called its molar mass.	0	0	0	0	3	4	23	30
27. The term mole is restricted to only atoms and molecules.	0	0	5	4	12	4	5	30
28. The number of atoms in one mole of a substance is equal to the Avogadro,s number.	0	0	0	0	4	22	4	30
29. Concentration, (c) = $\frac{number\ of\ moles\ (n)}{Volume\ in\ dm^3\ (V)}$	0	0	5	4	12	4	5	30
30. Molarity is the amount of substance dissolved in 1 dm^3 of solution.	0	0	0	0	2	5	23	30

Legend: SD = Strongly Disagree, D = Disagree, SoD = Somewhat Disagree, NAD = Neither Agree or Disagree, SoA = Somewhat Agree, A = Agree, SA = Strongly Agree.

Items numbered 1 to 13 in the Questionnaire were classified as students‟ difficulty since they elicited the various difficulties learners have as far as mole concept was concerned. The items from 14 to 23 tackled the pedagogical approaches used by teachers in delivering the concept of Mole. Items 24 to 30 dealt with some key concepts in mole. The above divisions were analysed using SPSS 22.0 which is indicated below in Table 4.1B.

The Likert scale used was a seven-response scale starting from strongly disagree to strongly agree. Thus from 1 to 7, a mean that shifted towards the 7 mark shows that students agreed strongly to the factor under consideration and the one towards the 1 mark indicated a strong disagreement with the issue under consideration.

Table 4.1B: Analysis of questionnaire to find out the factors that affect students' academic achievement and retention in mole concept

	N	Minimum	Maximum	Mean	Std. Deviation
STUDENTS DIFFICULTY	30	5.69	5.85	5.7692	.04040
PEDAGOGY	30	5.60	5.60	5.6000	.00000
CONCEPTS	30	1.14	2.14	1.5524	.21464
Valid N (list wise)	30				

Source: Statistical Package for the Social Sciences (SPSS) 22.0 output as in appendix H

From Table 4.1B above, the factors contributing to students‟ difficulty in the Mole Concept had a mean of 5.7692 which is greatly shifted towards the 7 mark of strongly agree. This means the students were of the view that one of the key factors that affect their academic achievement was due to one or more of the following personal situations: - spanning from their perception that the Mole Concept is a difficult concept to the difficulties with the basic mathematical principles, misapplication of formulae, assigning wrong S.I units to particular measurement and difficulty to properly analyse and answer mole concept questions.

Also, the students attribute their arguably poor performance in the Mole Concept to their teachers‟ pedagogical approaches. This was evident in the mean for pedagogy in Table 4.1B which was 5.60 which was towards the agreement mark. Some of the teachers attributed by the students to the teachers‟ causing their poor achievement include: Poor instructional strategies used by teacher during lesson delivery, poor teacher preparation before lessons, students being made to read available textbooks while teachers explained some of the concepts and teachers using the lecture method only in teaching mole concept makes learning of mole concept boring and affects their understanding and participation. This the respondents noted added to their difficulty in achieving results in most science concepts including the Mole Concept.

From the Table 4.1A, the respondents vehemently disagree that, they have some level of understanding of the Mole Concept. They noted through their responses that, they have close to little knowledge about the mole concept due to their personal difficulties, teachers‟ pedagogy and lack of relevant materials for their study. This is clearly demonstrated in the Table 4.1B where the mean for the conceptual understanding is 1.5524.

Yalcinalp, Geban and Ozkan (1995) who considered that the abstractness of knowledge has an influence on learning difficulty. Specifically, in problems involving chemical formulas and the mole concept students have to deal with very small and very large numbers. The Avogadro constant unavoidably additionally complicates the problem. Gabel and Sherwood (1984) stressed that some students did not understand the basic mathematical principles, which could be mathematical manipulations, such as proportional reasoning, changing orders of magnitude and converting units, Dori and Hameiri, (1998). That is a real impediment to solving mole concept problems correctly using the reasoning methods.

The analysis of the interview responses in the research conducted in Israel by Novick and Menis (1976) revealed some misconceptions such as: *the mole is a certain mass and not a certain number* (the mole is seen as a mass and not as amount) or *the mole is a property of a molecule*. They concluded that most 15-year-old pupils in Israel achieve neither a coherent understanding of the mole concept and its significance in the interpretation of chemical phenomena, nor the ability to use it effectively in solving problems. These difficulties in learning the *mole* are an important issue, not only because of the repercussions they may have on the teaching and learning of this concept as a unit of one of the seven fundamental physical quantities-*the amount of substance* Schmidt, (1990), but also because of their influence on the solving of stoichiometry problems (Dori & Hameiri, 1998; Schmidt, 1990; Furio, Azcona, Guisasola & Ratcliffe, 2000).

This is congruent with American Association for Advancement of Science (1989) that quality teaching is characterised by teacher‟s adequate knowledge of subject matter; encouraging inquiry and hands-on approach to learning for students; and recognizing individual students as learners as the teacher builds on learner‟s strengths rather than trying to stamp out their weaknesses. Opara and Etukudo (2014) posits that with adequate instructional materials and strategies, the teacher will be able to give students the chance to learn through their senses of hearing, smelling, tasting, seeing and feeling. The instructional materials used during teaching and learning Integrated Science for that matter mole concept in Keta Business College were inadequate. The study revealed that textbooks were the only instructional materials utilized during teaching and learning mole concept.

Research question Two: *What is the effect of concept mapping strategy on mole concept*?

To provide an answer to this research question, the mean standard deviation scores for the participants in the pre-intervention test and post-intervention test scores in the Mole Concept Achievement Test (MCAT) were analysed.

Table 4.2: Comparison of students' pre-intervention test and post-intervention test

	Mean	N	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
PRETEST	9.5667	30	2.82456	.51569	-28.279	29	0.000
POSTTEST	27.5000	30	1.73702	.31714			

Source: Statistical Package for the Social Sciences (SPSS) 22.0 output as in appendix I

Table 4.2 shows a mean difference of 17.933 between the Pre-intervention test and the Post-Intervention tests. In the Table, the mean score for the Pre-Intervention test was 9.5667 and that of the Post-Intervention test was 27.500 meaning the performance in the post-intervention test was far better than in the pre-intervention test. This is an indication that when students were taught Mole Concept with Concept Mapping students tend to grasp the concept better and most of their difficulties addressed.

The Table also shows that there is a statistical significant difference value of 0.000 which is less than the alpha value of 0.05, hence there is a significant difference between the achievement of the students in the Post-intervention test and the pre-intervention test. This showed that the use of concept mapping strategy have a positive effect on the students‟ academic achievement and retention.

This finding is in conformity with that of Larbi (2011), Otor (2013) and Jack (2014) who reported that students exposed to Concept mapping strategy achieve better results. Students‟ improved achievement might be that the instructional strategy provides opportunity for students to link concepts learned. Olorundare and Aderogba (2009) added that students exposed to concept mapping performed better than those exposed to analogy that also performed better than those exposed to expository method of learning. Combining concept mapping with other methods or indeed the traditional or conventional way of teaching has synergistic effect as compared to its unilateral use. Concept mapping strategy enable students to establish a relationship between concepts learned thereby increasing performance. The students were able to see links among concepts and this boosted their comprehension on topics which they were taught. Students taught using concept mapping might have learnt meaningfully because of the hierarchical, logical and sequential presentation of concepts.

Research question Three: *What is the difference in academic achievement of males and females students when taught using concept mapping?*

In answering the Research question above the post-intervention scores of both the male and the female students were analysed using Statistical Package for the Social Sciences (SPSS) and presented in Table 4.3.

Table 4.3: Comparison between the post-intervention tests of male and female students

	GENDER	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	df	Sig. (2-tailed)
POSTTEST	MALE	12	27.5000	2.02260	.58387	.0000	28	1.000
	FEMALE	18	27.5000	1.58114	.37268			

Source: Statistical Package for the Social Sciences (SPSS) 22.0 output as in appendix J

From Table 4.3 the mean scores of the male and female students were (27.50 and 27.50) respectively with a mean difference of 0.00. This means that virtually there no difference between the achievement of the female students and the male students. A further look at the Table 4.3 shows a p-value of 1.000 which is greater than the alpha value of 0.05. This result indicates that there is no significant difference in the performance of male and female students when taught Integrated Science using concept mapping strategy. By implication male and female students performed equally the same when exposed to concept mapping strategy.

This finding is in line with the findings of Otor, (2013) 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 achievement. This shows that both male and female students benefited equally when exposed to Concept mapping strategy. Qarareh (2010) added that the method is beneficial irrespective of gender. The result from both males and females shows that students can be impacted positively by concept mapping. In one case the males performed better than female and in another the females performed better than males. These results agree with the findings of Chawla (2015) who found that concept mapping method of teaching and learning had a significant effect on achievement of leaners in Integrated Science.

Research question four: *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 four was analysed using descriptive statistics in form of mean and standard deviation as shown in Table 4.4. To provide an answer to this research question, the result in Mole Concept Construction Test (MCCT) was used, and the analysis is as shown in Table 4.4.

Table 4.4: Comparison between the male and female students ability to construct a concept map

	GENDER	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	df	Sig. (2-tailed)
POSTTEST	MALE	12	24.7500	3.30633	.95446	2.13889	28	0.059
	FEMALE	18	26.8889	2.63213	.62040			

Source: Statistical Package for the Social Sciences (SPSS) 22.0 output as in appendix K

From Table 4.4 the mean score of the male and female were (24.75and 26.89) respectively, with a mean difference of 2.14. The female achieved higher than the male in the construction test. This indicates that the means difference of (2.14) exists. However, to find how significant the difference is, paired t-test statistics was used. The p-value of 0.059 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 on mole concept. In other word, male and female students perform equally the same in the mole concept mapping construction test.

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 students" gender. As students construct concept maps, it helps them to summarise, organise 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 Integrated Science.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

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 suggestions for further studies and for curriculum development were also outlined.

5.1 Summary of Findings

1. Key factors that affect Student‟s academic achievement were due to the following personal situations spanning from their perception that the mole concept is a difficult concept to the difficulties with the basic mathematical principles, misapplication of formulae, assigning wrong S.I units to particular measurement and difficulty to properly analyse and answer mole concept questions.
2. Pedagogical approach of the teachers in teaching and learning mole concept such as poor instructional strategies used by teacher during lesson delivery, poor teacher preparation before lessons, students being made to read available textbooks while teachers explained some of the concepts and teachers using the lecture method only in teaching mole concept makes learning of mole concept boring and affects their understanding and participation.
3. There was a significant difference in the students‟ academic achievement when exposed to Concept mapping strategy.
4. There was no significant difference in the academic achievement of male and female when exposed to Concept mapping strategy because concept mapping strategy is gender friendly.

5. There was no significant difference in both sex ability to construct a concept map on mole concept.

5.2 Conclusion

The use of concept mapping strategy used as an intervention enhanced students‟ academic achievement and retention in mole concept and more effective in increasing the performance of Senior High School Students in Integrated Science. No gender disparity exists in the achievement and retention capacity of male and female Integrated Science students taught mole concept using concept mapping strategy. This implies that concept mapping strategy is very rewarding to students‟ in-terms of achievement and retention capacity regardless of gender. The results of the study showed that concept mapping was excellent for teaching mole concept. Concept mapping had the ability to improve student‟s achievement on mole concept. Also, concept mapping makes students learn meaningfully to improve upon their capacity to answer high order cognitive level questions, which underlies the constructive integration of thinking, feeling and acting, leading to empowerment for commitment and responsibility.

The use of concept maps brings about self-confidence and sense of responsibility. It provided learners with self-confidence and a positive feeling of learning through which new materials become related to prior knowledge and lead to knowledge transfer and development of learning skills. Moreover, a positive impact on students' achievement, self-regulation and self-efficacy is enhanced when students attended to tasks, focus on important features, organise material and maintain a productive psychological climate for learning.

The study also revealed that action research is one of the best ways a researcher could use to solve problems related to teaching and learning Integrated Science and Science in general, as it enabled the researcher to solve a problem of misunderstanding and misconception on mole concept among the second year students of Keta Business College.

5.3 Recommendations for Policy and Practice

Based on the findings and conclusion of this study, the following recommendations were made:

1. Teachers should familiarise themselves with the misconceptions of the students in mole concept and make practical efforts at ensuring that the misconceptions are addressed, for example by giving students more exercises in these areas both as homework and class activities.
2. Since concept mapping teaching method is found to be an effective method for improving students" achievement and retention, the Integrated Science teachers should accept and adapt it in teaching mole concept and other topics in our Senior High schools.
3. Since the integration of concept mapping in teaching and learning of mole concept has proved to be effective and since this strategy is relatively new, it should be included in the curriculum of pre-service teachers of Integrated Science. This would help popularise this technique and bring about more effective teaching and learning of Integrated Science.
4. During professional body meetings such as Ghana Association of Science Teachers (GAST) and government organised workshops, seminars and short courses, well informed Science educators should educate practicing Science teachers in general

on what concept mapping strategy is as well as how to use it in order to enhance students" achievement and retention.

5. Concept mapping teaching and learning method is not gender sensitive therefore both male and female students should be involved in concept mapping activities to enhance their achievement and retention in mole concept.
6. The concept mapping method should be encouraged in many Integrated Science classes since it gives students opportunity to see links between concepts, summarise and organise their works and thoughts logically and sequentially.
7. There is a need for curriculum planners and textbook publishers to take into cognisance concept mapping strategy in developing the curriculum and the textbooks as context for each unit of learning must be identified. This would simplify adoption of the method for use by Science teachers.
8. Ministry of Education and Science educators should design instructional strategies that tackle students" misconceptions: this involves planning and structuring curriculum materials and learning activities using the constructivist approach that aims at promoting conceptual changes and development, such as the use of examples and analogies, cognitive conflicts, concept maps and student activities.

Based on the findings of this research the following recommendations/suggestions have been made for further research/studies:

9. More research needs to be done to include other topics so that the effect of concept mapping on senior High School Integrated Science can be determined. This is because this research only focused on one topic, mole concept.
10. Another research to be done to include a large sample and a number of schools so that its results can be generalized to a wide population. The results of this study only apply to the sample involved in the study.

11. The study can be extended to other levels of education to see if level is a factor in the approach.
12. More study should be carried out in order to examine the efficacy of concept mapping strategy on students" interest, achievement and retention in other Science subjects.
13. To generalise the findings of the study it is recommended to replicate the study under other conditions, such as comparing the use of this strategy with other learning strategies, using larger samples, comparing its use across gender, proficiency level, different specialised subjects, age group, various educational environments (colleges, universities), different cultures or different foreign/second languages, regions of Ghana and other Science Subjects.

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APPENDICES

APPENDIX A: Mole Concept Achievement Test (MCAT)

PRE-INTERVENTION

KETA BUSINESS COLLEGE
TIME: 1 HOUR
GENDER……………… AGE………………… CLASS……………………………..

Instruction: Answer all the question by **circling** the appropriate options (Letters)

1. Mole is a unit for
(a) Mass (c) Amount of substance
(b) Molar mass (d) Molarity

2. The unit for Molarity is
(a) mol (c) $moldm^{-3}$
(b) $gmol^{-1}$ (d) gdm^{-3}

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

4. The unit for molar mass is
(a) $moldm^{-3}$ (c) $gmol^{-3}$
(b) gdm^{-3} (d) Mol

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

6. What is the mass concentration of 0.1M of $NaHCO_3$ [Na = 23, H = 1, C = 12, O = 16]
(a) 52.02 (c) 8.4
(b) 108.4 (d) 5.0

7. The number of moles represented by 252.06g of $NaHCO_3$ is [Na = 23, H = 1, C = 12, O = 16]
(a) 5.0 (b) 3.0
(c) 2.0 (d) 1.0

Calculate the molar mass for each of the following compounds

8. H_2SO_4 [H = 1, S = 32, O = 16]

(a) 98 (c) 56
(b) 48 (d) 104

9. $NaNO_3$ [Na = 23, N = 14, O = 16]

(a) 85 (c) 108
(b) 75 (d) 84

10. Given the mass concentration of NaOH as 4.0g, its molarity is [Na = 23, O = 16, H = 1]

(a) 59.8 (d) 8.4
(b) 95.2 (e) 0.1

11. The mass of 1.50×10^{23} molecules of cane sugar ($C_{12}H_{22}O_{11}$) is [C = 12, H = 1, O =16]

(a) 5.13g (d) 1370.00g
(b) 85.20g (e) 94.00g

12. The sum of the atomic masses of all atoms in the formula unit of a compound is the

(a) atomic density (d) formula mass
(b) molecular mass (e) isotopic mass

13. Which of the following unit is used to represent the chemical quantity of a substance as a number of particles?

(a) Kilogram (C) Mole
(b) Ampere (D) Gram

14. The number of moles represented by 23.0gram of nitrogen (IV) oxide NO_2 is [N = 14, O = 16]

(a) 0.5 (c) 2.0
(b) 1.5 (d) 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.

16. Given the molarity of Na_2SO_4 as 0.1M, what is the mass concentration [Na = 23, S = 32, O = 16]

(a) 14.20 (d) 70.90
(b) 36.50 (e) 138.40

17. The number of atoms of each element in a molecule is shown in

(a) empirical formula (c) mole
(b) molecular formula (d) mass

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

18. Fifteen (15.0)g of carbon (IV) oxide, CO_2 [C = 12, O = 16]

(a) 0.34 (c) 1.52
(b) 0.50 (d) 0.71

19. Fifty (50.0)g of Aluminum Sulphate, $Al_2(SO_4)_3$ [Al = 13, S = 32, O = 16]

(a) 0.22 (c) 0.82
(b) 0.15 (d) 10.4

20. The molarity of a solution prepared by dissolving 75.5 g of pure KOH in 540 cm^3 of solution is
    [K = 39, O = 16, H = 1]
    (a) 1.25 (c) 1.30
    (b) 0.25 (d) 2.50
21. Forty-nine (49)g of H_2SO_4 are dissolved in 250 cm^3 of the solution. Its molarity will be
    [H = 1, S = 32, O = 16]
    (a) 2.0 (c) 2.9
    (b) 2.5 (d) 2.2
22. The molarity of a solution containing 331g of HCl dissolved in sufficient water to makes 2 dm^3 of solution is [H = 1, Cl = 35.5]
    (a) 9.04 (c) 2.26
    (b) 4.52 (d) 1.45

Determine the mass of each substance present in the following:

23. 0.105 Moles of $Na_2C0_3.10H_2O$
    (a) 7.0g (c) 2.4g
    (b) 30.0g (d) 4.0g
24. 0.2 mole of KOH solution.
    (a) 10.5g (c) 11.2g
    (b) 7.6g (d) 10.4g
25. The atomic mass of sodium is
    (a) 11 (c) 14
    (b) 23 (d) 14

26. The atomic mass of chlorine is
    (a) 15.0 (c) 17.0
    (b) 12.0 (d) 35.5

27. Chlorine molecule contains……….atoms.
    (a) 6.02 x 10^{23} (c) 6.04 x 10^{23}
    (b) 6.50 x 10^{23} (d) 1.08 x 10^{23}
28. Molar Concentration is the same as…
    (a) mass concentration (c) amount
    (b) molarity (d) volume
29. The atomic number of Oxygen is…
    (a) 16 (c) 6
    (b) 8 (d) 104

30. The atomic number of Carbon is…
    (a) 4 (c) 23
    (b) 6 (d) 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 Mole Concept Achievement TesT (MCAT) PRE-INTERVENTION

1. C
2. C
3. B
4. C
5. B
6. C
7. C
8. A
9. A
10. D
11. A
12. C
13. C
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: Pre-Intervention Questionnaire For Students

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

GENDER………………………AGE……………… CLASS…………………………......

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 tick (√) the appropriate box to indicate the level of your agreement with the statements about some factors that affect your conceptual understanding of mole concept lesson so far. Matrix questionnaire type:

SD = Strongly Disagree,

D = Disagree,

SoD = Somewhat Disagree,

NAD = Neither Agree or Disagree,

SoA = Somewhat Agree,

A = Agree,

SA = Strongly Agree.

	SD	D	SoD	NAD	SoA	A	SA
1. Do you have perception that mole concept is very difficult and confusing?							
2. Do you have difficulties with the basic mathematical principles?							
3. Misapplication of formulae in calculations whenever mole concept questions are raised							
4. Do you find difficulty in calculations involving more than one stage of mole concept?							
5. Lack of understanding of what mole and mole concept is all about							
6. Do you have difficulties with the Avogadro constant and solving concentration problems?							
7. I am always assigning wrong S.I units to particular measurement or calculations done							
8. I find it difficult to properly analyze and answer mole concept questions							
9. I have difficulties with understanding the mole as a unit of the quantity of substance, as a concept and as a defined quantity							
10. I have difficulties with tasks that are changed by adding some scientific notation confusing mole concept vocabulary							

11. I lack practice in problem solving involving mole concept							
12. The sum of the atomic masses of all atoms in the formula unit of a compound is the formula mass							
13. The mole represents the number 6.02×10^{23}							
14. The quality of Integrated Science teaching and learning is affected by inappropriate and inadequate instructional materials							
15. Poor instructional strategies used by teacher and lack of textbooks needed for professional growth							
16. Poor teacher preparation before lessons and poor attitude and interest of students towards mole concept							
17. Students were made to read available textbooks while teachers explained some of the concepts.							
18. Teachers taught without performing activities as suggested in the curriculum							
19. The teacher uses the lecture method only in teaching mole concept.							
20. The teacher does not provide the most current information.							
21. In teaching mole concept, the teacher follows what is in text books.							
22. The teacher usually adopts teaching technique such as individual/group activities.							
23. The teacher usually uses a combination of teaching methods in teaching mole concept.							
24. The concept of the mole says that in a defined mass of an element there are precise number of atoms.							
25. The teacher helps us solve adequate problems on mole concept.							
26. The mass of one mole of any substance is called its molar mass.							
27. The term mole is restricted to **only** atoms and molecules.							
28. The number of atoms in one mole of a substance is equal to the Avogadro,s number.							
29. Concentration, (c) = $\frac{number\ of\ moles\ (n)}{Volume\ in\ dm^3\ (V)}$							
30. Molarity is the amount of substance dissolved in 1 dm^3 of solution.							

APPENDIX D: Mole Concept Achievement Test (MCAT)

POST-INTERVENTION TEST
KETA BUSINESS COLLEGE
TIME: 1 HOUR

GENDER……………………………AGE……………………CLASS………………………

Instruction: Answer all the question by **circling** the appropriate options (Letters)

9. What is the mass concentration of 0.1M of $NaHCO_3$ [Na = 23, H = 1, C = 12, O = 16]
(a) 52.02 (c) 8.4
(b) 108.4 (d) 5.0

10. The number of moles represented by 252.06g of $NaHCO_3$ is [Na = 23, H = 1, C = 12, O = 16]
(a) 5.0 (b) 3.0
(c) 2.0 (d) 1.0

Calculate the molar mass for each of the following compounds

11. H_2SO_4 [H = 1, S = 32, O = 16]
(a) 98 (c) 56
(b) 48 (d) 104

4. $NaNO_3$ [Na = 23, N = 14, O = 16]
(a) 85 (c) 108
(b) 75 (d) 84

5. Given the mass concentration of NaOH as 4.0g, its molarity is [Na = 23, O = 16, H = 1]
(a) 59.8 (d) 8.4
(b) 95.2 (e) 0.1

6. The mass of 1.50×10^{23} molecules of cane sugar ($C_{12}H_{22}O_{11}$) is [C = 12, H = 1, O =16]
(a) 5.13g (d) 1370.00g
(b) 85.20g (e) 94.00g

7. The sum of the atomic masses of all atoms in the formula unit of a compound is the
(a) atomic density (d) formula mass
(b) molecular mass (e) isotopic mass

8. Which of the following unit is used to represent the chemical quantity of a substance as a number of particles?
(a) Kilogram (C) Mole
(b) Ampere (D) Gram

9. The number of moles represented by 23.0gram of nitrogen (IV) oxide NO_2 is [N = 14, O = 16]
(a) 0.5 (c) 2.0
(b) 1.5 (d) 4.0

10. 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.

11. Given the molarity of Na_2SO_4 as 0.1M, what is the mass concentration [Na = 23, S = 32, O = 16]
(a) 14.20
(b) 36.50
(d) 70.90
(e) 138.40

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

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

13. Fifteen (15.0)g of carbon (IV) oxide, CO_2 [C = 12, O = 16]
(a) 0.34
(b) 0.50
(c) 1.52
(d) 0.71

14. Fifty (50.0)g of Aluminum Sulphate, $Al_2(SO_4)_3$ [Al = 13, S = 32, O = 16]
(a) 0.22
(b) 0.15
(c) 0.82
(d) 10.4

15. The molarity of a solution prepared by dissolving 75.5 g of pure KOH in 540 cm^3 of solution is
[K = 39, O = 16, H = 1]
(a) 1.25
(b) 0.25
(c) 1.30
(d) 2.50

16. Forty-nine (49)g of H_2SO_4 are dissolved in 250 cm^3 of the solution. Its molarity will be
[H = 1, S = 32, O = 16]
(a) 2.0
(b) 2.5
(c) 2.9
(d) 2.2

17. The molarity of a solution containing 331g of HCl dissolved in sufficient water to makes 2 dm^3 of solution is [H = 1, Cl = 35.5]
(a) 9.04
(b) 4.52
(c) 2.26
(d) 1.45

Determine the mass of each substance present in the following:

18. 0.105 Moles of $Na_2C0_3.10H_2O$
(a) 7.0g
(b) 30.0g
(c) 2.4g
(d) 4.0g

19. 0.2 mole of KOH solution.
(a) 10.5g
(b) 7.6g
(c) 11.2g
(d) 10.4g

20. The atomic mass of sodium is
(a) 11
(b) 23
(c) 14
(d) 14

21. The atomic mass of chlorine is
(a) 15.0
(b) 12.0
(c) 17.0
(d) 35.5

22. Chlorine molecule contains……….atoms.
(b) 6.02×10^{23}
(b) 6.50×10^{23}
(c) 6.04×10^{23}
(d) 1.08×10^{23}

23. Molar Concentration is the same as…
(b) mass concentration
(b) molarity
(c) amount
(d) volume

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

25. Mole is a unit for
(a) Mass
(b) Molar mass
(c) Amount of substance
(d) Molarity

26. The unit for Molarity is
(a) mol
(b) $gmol^{-1}$
(c) $moldm^{-3}$
(d) gdm^{-3}

27. The unit for Mass concentration is
(a) s
(b) gdm^{-3}
(c) mol
(d) $Moldm^{-3}$

28. The unit for molar mass is
(a) $moldm^{-3}$
(b) gdm^{-3}
(c) $gmol^{-3}$
(d) Mol

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

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

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

APPENDIX E: Marking Scheme for Mole Concept Achievement Test (MCAT) Post-Intervention

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

APPENDIX F: Mole Concept Construction Test (Post-Intervention Test)

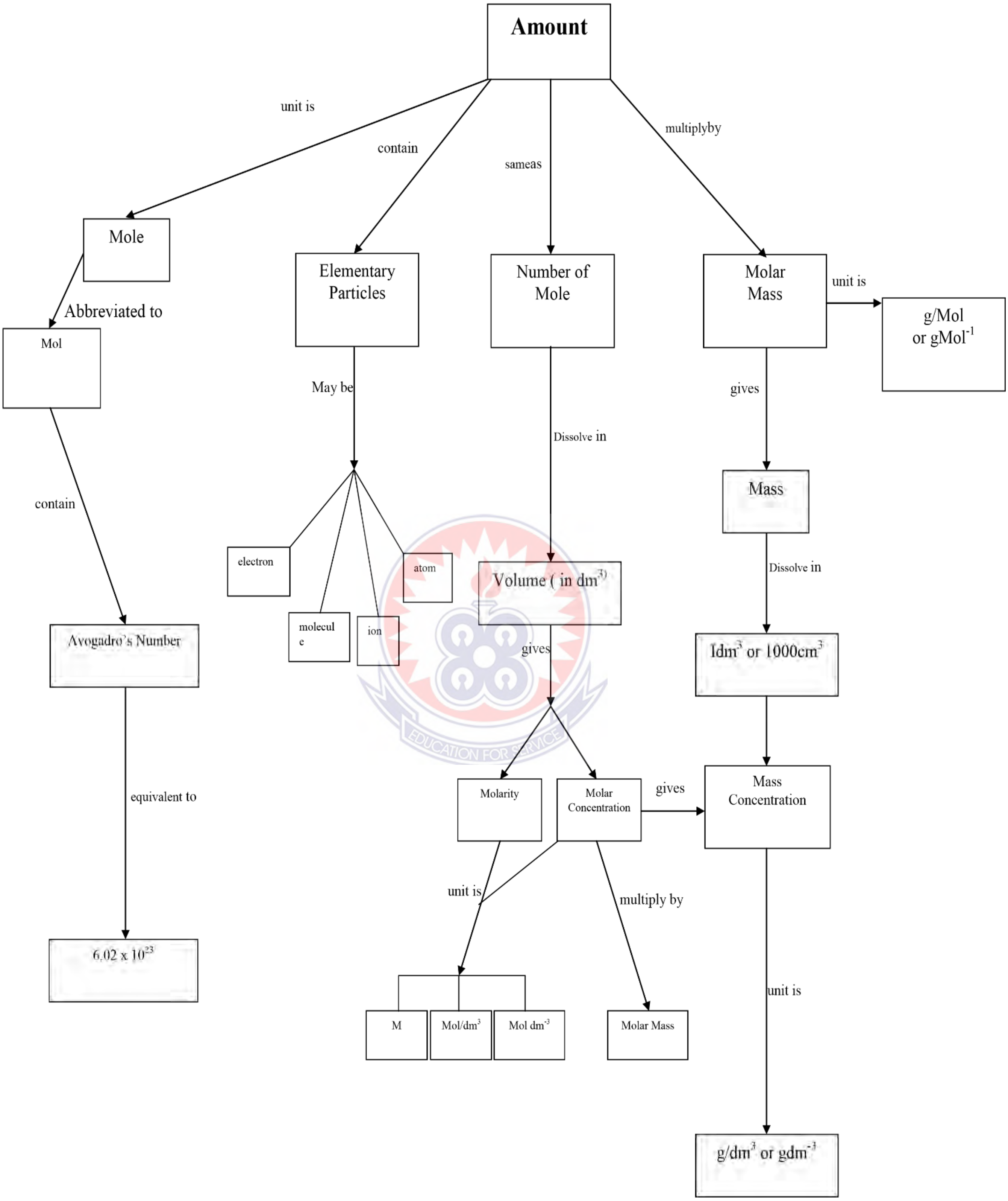
KETA BUSINESS COLLEGE

Gender………………… Age……………………   CLASS…………………………......

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. Avogadro"s no
9. 6.02×10^{23}
10. Molecules
11. No. of mole
12. Ion
13. Atom
14. mol
15. g/dm3
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 particle

Appendix G: Teacher Made Concept Map on Mole Concept



Appendix H: Analysis Of Questionnaire

Descriptives

[DataSet1] C:\Users\ROBERT_PAVLOV\Desktop\Untitled2.sav

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
STUDENTSDIFFICULTY	30	5.69	5.85	5.7692	.04040
PEDAGOGY	30	5.60	5.60	5.6000	.00000
CONCEPTS	30	1.14	2.14	1.5524	.21464
Valid N (listwise)	30				

Appendix I: Pre-Intervention Test And Post Intervention Test Analysis On Academic Achievement In Mole Concept

Pre-Intervention Test

	N	Minimum	Maximum	Mean	Std. Deviation
PRETEST	30	5.00	15.00	9.5667	2.82456
Valid N (listwise)	30				

Post-Intervetion

	N	Minimum	Maximum	Mean	Std. Deviation
POSTTEST	30	23.00	30.00	27.5000	1.73702
Valid N (listwise)	30				

Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
PRETEST	9.5667	30	2.82456	.51569
POSTTEST	27.5000	30	1.73702	.31714

Paired Samples Test

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PRETEST - POSTTEST	-17.93333	3.47338	.63415	-19.23031	-16.63635	-28.279	29	.000

Appendix J: Analysis of Male And Female Performance When Taught Mole Concept Using Concept Mapping

Group Statistics

	GENDER	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	df	Sig. (2-tailed)
POSTTEST	MALE	12	27.5000	2.02260	.58387		28	1.000
	FEMALE	18	27.5000	1.58114	.37268	.00000		

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
POSTTEST	Equal variances assumed	.622	.437	.000	28	1.000	.00000	.65881	-1.34951	1.34951
	Equal variances not assumed			.000	19.676	1.000	.00000	.69267	-1.44642	1.44642

APPENDIX K: Analysis Of Post Intervention Tests For Male And Female On Construction Of Concept Mapping

Group Statistics

	GENDER	N	Mean	Std. Deviation	Std. Error Mean		Mean Difference	df	Sig. (2-tailed)
POSTTEST	MALE	12	24.7500	3.30633	.95446		2.13889	28	0.059
	FEMALE	18	26.8889	2.63213	.62040				

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
POSTTEST	Equal variances assumed	.622	.437	.000	28	1.000	.00000	.65881	-1.34951	1.34951
	Equal variances not assumed			.000	19.676	1.000	.00000	.69267	-1.44642	1.44642