UNIVERSITY OF EDUCATION, WINNEBA

IMPROVING THE PERFORMANCE OF STUDENTS IN VOLUMETRIC ANALYSIS THROUGH CONCEPT MAPPING IN WENCHI SENIOR HIGH SCHOOL

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JULY, 2017

DECLARATION

Candidate's Declaration

I, **Asantewaa Ruth Okrah** hereby declare that this dissertation, with the exception of quotations and references contained in published works which have all been identified and acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

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ASANTEWAA RUTH OKRAH **DATE:**

Supervisor's Declaration

This thesis has been approved as meeting the requirements of the School of Research and Graduate Studies, University of Education, Winneba.

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Victus Samlafo (Ph.D) **DATE:**

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I wish to express my deepest gratitude to the Almighty God. I would have never ventured down this path had it not been His grace and mercy. A thesis of this kind would not have been completed without His help.

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Finally, I thank my course mates: Charity Ofosu and Bernice Acheampong for their assistance during this research. I am deeply grateful for the help they have offered.

DEDICATION

This dissertation is dedicated to my loving HEAVENLY FATHER whose amazing grace and mercy has brought me this far.

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ABSTRACT

The study investigated the use of concept mapping teaching method on Senior high school students' academic achievement in chemistry. The design of the study was quasi-experimental design with 54 elective science Senior High students selected purposively from Wenchi Senior High School in Brong – Ahafo Region. Twenty – seven (27) students were used for both the control and experimental groups. Experimental groups were taught using concept mapping teaching strategy while Control groups were taught using the Traditional Teaching Method .The study was conducted within six weeks period and the topic covered was volumetric analysis.

The students were pre-tested and post-tested using a Tutor Constructed Chemistry Achievement Test (TCCAT). Instrument used for data collection was an achievement test tagged Tutor Constructed Chemistry Achievement Test (TCCAT). The content of the instrument was validated by three experts and Cronbach alpha formula was used to test its reliability. The reliability coefficient of 0.82 and 0.75 for pre- test and post- test respectively. The data from both pre and post tests were analyzed using methods of descriptive and inferential statistics. The statistical procedures employed were: student t-test analysis as well as descriptive statistical tool such as the mean, standard deviation etc. to determine the impact of concept mapping on students' performance in volumetric analysis.

The responses from the questionnaire items were analyzed through the use of descriptive explanation making use of averages, percentages and descriptive statistics such as means, and percentage scores were calculated for participants' responses.

The result from questionnaire revealed that, concept mapping method enhanced students' academic achievement in volumetric analysis concepts.

It was recommended that, concept mapping method should be incorporated in the teaching of chemistry for meaningful learning and that workshops should be organized for in-service and practicing teachers on how to use concept mapping strategy.

CHAPTER ONE

INTRODUCTION

1.0 OVERVIEW

This chapter includes the background to the study, statement of the problem, purpose of the study, research objectives, research questions, research hypothesis, and significance of the study, limitations and delimitations of the study.

1.1.Background of the study

One of the aims of Senior High education is to equip students to live practically in this modern age of science and technology. To this end, science students at the Senior High School level of education are required to study all the basic science subjects (Biology, Chemistry and Physics) as core subject (Arokoyu & Obunwo, 2014).

Chemistry is a pre-requisite to the study of courses such as Medicine, Engineering, pharmacy etc. Chemistry as a subject helps to develop in the learners such process skills as critical observations, analysis, experimentation, manipulation of variables and equipment which are very important in scientific investigation (Arokoyu & Obunwo, 2014).

However Chemistry is always perceived as an unpopular subject among the new students because there is a large chunk of concepts to be learned. There are varieties of theories and concepts such as atomic theory, mole concept, acid and base, equilibria etc. Students tend to memorise these concepts and theories in chemistry as isolated concepts. Consequently, students are unable to learn meaningfully hence route learning occurs. This may lead to the basis of students' difficulties in forming concepts coherently and applying newly learned knowledge into their learning (Brandt *et al,* 2001).

Studies have shown that a number of factors are responsible for the poor performance of students in chemistry. One of such factors is the teachers' competence in his teaching methods and materials available (Pepple, 2010, Usman and Memeh, 2007, Nwagbo, 2001, Osokoya, 1998).

Studies on underachievement of students Senior High School subjects found inefficient teaching methods by school teachers as a major factor for the underachievement of the students (Pepple, 2010, Usman and Memeh, 2007, Nwagbo, 2001, Osokoya, 1998).

According to Ayodele (2002), obstacle to effective teaching and learning of Chemistry include negative attitudes of teachers and students, lack of requisite mathematical skills and the nature of curriculum. The loaded nature of the syllabus and the inadequate periods allotted to each subject and other factors impede on the teaching and learning strategies.

In the bid to cover syllabus, teachers resort to traditional lecture method which involves mostly the cognitive domain of learning to the detriment of the affective and psychomotor domains.

The West African examinations Council Chief Examiner's Report (2009, 2010, and 2012), indicated poor mathematical skills as one of the major reasons for the poor performance of students in Chemistry. This suggestion agrees with Krammer (2005) and Badru (2004), who found out that students with poor mathematics background could not solve problems in chemistry.

Yewande (2012) suggested that Chemistry is a subject that involves some quantitative aspect that seems to influence the overall achievement in Chemistry. Ahiakwo (1991) stated that students have difficulties in general Chemistry because they cannot handle their mathematics.

Students offering Chemistry in Senior High Schools are required by WAEC to take one compulsory questions in volumetric analysis (quantitative analysis), and qualitative analysis.

The first question in this paper is on volumetric analysis, candidates are given full instruction for carrying out the experiment which requires students to determine concentration of an unknown substance using standard solution. Volumetric analysis is a common practice in Senior High Schools to assess Chemistry students' practical aptitude.

Majority of students find volumetric analysis difficult to study and often fail to perform well in this paper organized by WAEC, due to prerequisite concepts identified by Demerouti, Kausathana & Tsaparlis (2004), to be necessary for solving volumetric analysis problem. These concepts are ; the mole, gram/mole conversion, balancing and interpreting equations, calculation of relative mass of reactants and products from equations, converting solution from one concentration to another, and calculation of concentrations of solutions from the mass of substances. These subsumed concepts are, therefore, integrally necessary to facilitate and analyze volumetric analysis problems. It is hypothesized that such problems cannot be understood if the subsumed concepts are not understood by the students.

Since the introduction of SSCE in 1993 and WASCE in 2006, by the Ministry of Education in Ghana, science students in Senior High Schools, particularly Wenchi Senior High School students have continuously performed poorly in the volumetric analysis aspect of the Chemistry practical organized by WAEC.

Feedback on students learning outcome in Senior High School Chemistry particularly Wenchi Senior School is not encouraging probably due to ineffective teaching and learning of the subject. Students' Performance in Senior High School Certificate Examination in Chemistry from 2002 to 2008 (Appendix E) shows that about 53% of the students who sat for the examination within this period could not attain a credit level pass.

The West African Examinations Council Chief Examiner's report in 2008 indicates that few (about 30%) candidates could not quote the correct units for the titre values, molar masses and concentrations for the acid and base solutions, some candidates could not use the mole concept to solve problems posed in the quantitative analysis.

Although no vigorous study has been conducted to identify factors contributing to students' difficulties in the performance of volumetric analysis, these difficulties have been attributed to the task component (content) or structure inherent in the task.

Anamuah Mensah (1981) in a study suggested that, if these task components or structures which contribute to the difficulties that students encounter in solving such task could be identified, then it may be possible to design teaching strategy which could help to alleviate these difficulties.

Research studies have indicated that concept mapping is an example of such strategies (Novak and Gowin, 1984, Novak and Canas, 2006). Concept maps are two or three dimensional spatial or graphic displays that make use of labeled nodes to represent relationships between pairs of concept. It has been suggested that, the concept map structure parallels the human cognitive structure, as it shows how learners organize concepts (Fisher *et al*, 1990, Clarke, 1991 and Ferry & Harper, 1998).

Concept mapping was first suggested by Joseph Novak in 1972 of Cornell University who has studied the educational field as an aid for learners to increase understanding (Richardson, 2005). It is based on Ausubel's theory of subsumption of new ideas or concepts into an organized structure, of a pre-existing knowledge. It is believed that the new concepts are given meaning through assimilation into existing framework. Construction of good concept mappings by students depends to a large extent, on effective planning and sequential teaching by the teacher (Ikeobi, 2010).

When concepts and linking words are carefully chosen, the maps have been found to be useful as classroom tools for observing variation of meaning, helping students organize their thinking and summarizing subjects of study (Canas, Hill, Granados and Perez, 2003).

Concept mapping helps students to learn meaningfully by making explicit links between the scientific concepts. The links constructed and the appropriate linking words selected in concept maps enable the learners to identify and address the gaps in knowledge and misunderstanding. The maps might later lead to alternative conceptions. It also facilitates collaborative learning and improved students' problem-solving ability.

Concept mapping appeared to enhance clarity of learning, integration and retention of knowledge *(*Novak and Heinze-fry, 1990*).* Concept mapping as an instructional tool had an effect on the achievements of students which also reflected a positive attitude towards concept mapping as an effective teaching strategy (Rao, 2003).

The notion that concept mapping enables students to remember information longer and be able to use it more effectively, because the information, is moved into the long term memory, makes it possible as alternative teaching method.

The use of concept mapping is therefore appropriate in promoting its effectiveness on students' motivation – interest and conceptual understanding towards improvement of performance in volumetric analysis.

It is against this background of students' poor performance which could be a result of poor presentation strategies (though coupled with other factors), that conscious efforts are being continuously made to determine suitable teaching strategies that will facilitate effective learning and teaching of volumetric analysis concepts.

1.2. Statement of the Problem

Students' performance and interest in science are declining (Markow & Lonning, 1998). Senior High school and college students' knowledge of science is often characterized by lack of coherence and the majority of students engage in essentially rote learning (BouJaoude & Barakat, 2000, Brandt et al., 2001; Nakhleh, 1992). The problem is twofold: The abstract and highly conceptual nature of science seems to be particularly difficult for students. Teaching methods do not seem to make the learning process sufficiently easy for students (Gabel, 1999; Schmid & Telaro, 1990).

These problems are quite serious in chemistry, hence it is widely perceived as a difficult subject because of its specialized language, mathematical and abstract conceptual nature, and the amount of content to be learned (Gabel, 1999). The prevailing teaching practices do not actively involve students in the learning process and seem to deprive them from taking charge of their learning (Francisco, Nicoll, & Trautmann, 1998). Novak (1998) accentuated the need for educators to take advantage of the available knowledge base of learning, learners' knowledge construction, and instructional tools to improve teaching and learning.

The topic volumetric analysis is important component of the Senior High School Chemistry course in Ghana. To carry out volumetric analysis experiments successfully, students need to be proficient in handling apparatus and reagents, know how to carry out the experiment and what to look out for in the experiment. Students also need to record their results properly and interpret their results appropriately. Volumetric analysis involves manipulation, observation, recording and computational skills. To understand the experiment that students carry out, and the results obtain, students need to understand and apply concepts from other chemistry topics such as mole concept, acids, bases and salts, oxidation reduction, concentration of solution and balancing of chemical equations.

Many teachers perceive that students do not understand volumetric analysis. Teachers frequently complain that students adopt to a recipe-approach, and do not understand the purpose of the experimental procedure. Teachers noticed that students seldom think for themselves hence often resort to asking teachers for help in practical class, recording results and making sense of their observations.

Volumetric analysis is also chosen due to the direct response to the deteriorating performance of students in volumetric analysis in Senior High School Certificate Examinations. Chief examiners report (May/June, 2008) noted that students failed to provide units or give wrong unit to titre values, molar masses and concentrations for the acid and base solutions, some students could not use the mole concept to solve problems posed in the quantitative analysis, cancelled and altered the table of titre values to make another table to be within the range of obtaining maximum marks which made their work untidy and suspicious.

Some students wrongly put the alkali in burette rather than in the conical flask which can affect their results. The common mistake most students make is leaving the funnel on the burette while titrating. Drops of the solution from the funnel could affect the final burette reading.

The deteriorating performance of students could also be due to students putting down titre values without showing how the values are arrived at (initial and final burette readings not recorded), and consistently reading burette to the nearest whole number, lowers the final mark scored by the student.

This situation therefore calls for a search, for alternative teaching strategies that will supplement the use of laboratories to enhanced effective teaching and learning of volumetric analysis by teachers and students. From educational perspective, a growing body of research indicates that the use of concept maps could facilitate meaningful learning (Schmid and Telaro, 1990, Okebukola and Jegede, 1998, Nicoll, Francisco and Nakhleh, 2001) and performance support system (Canas, Hill & Lott, 2003).

This research was also motivated in part by the growing incidence of failure in chemistry at the senior high school certificate examination as a clear manifestation of poor teaching and learning strategy (Wachanga & Mwangi, 2004).

It is against this background that this study uses concept mapping to teach volumetric analysis at Wenchi Senior High School.

1.3.Purpose of the Study

The purpose of the study was to improve teaching of volumetric analysis in Wenchi Senior High School through concept mapping.

The study also aimed at finding out the impact of concept mapping as an instructional strategy on students' performance in volumetric analysis.

1.4. Research Objectives

The major objectives of the study were to;

1. Find out the impact of concept mapping instruction as a teaching strategy on the academic achievement of students in volumetric analysis.
2. Establish any statistical difference between experimental and control subjects.
3. Find out how the experimental students perceive the effectiveness of Concept mapping integration in enhancing Chemistry instruction?

1.5. Research Questions

The research questions guiding the study were;

1. Would there be any significant difference in the performance between students taught with concept mapping method in contrast to those taught with lecture method?

2. To what extent do the experimental students perceive the effectiveness of Concept mapping integration in enhancing chemistry instruction?

1.6. Research Hypothesis

1. There is no significant statistical difference in performances of students taught by concept mapping to those taught without concept mapping method.

1.7.Significance of the study

Much of the learning in schools is rote learning and examination oriented. There is the need for a new teaching strategy to see how it can better develop the critical and creative thinking and learning skills which are required for the future generation, if Ghana is to develop.

The educational importance of this research is to gather appropriate teaching strategies and methodology to help solve the problem of poor performance among Chemistry students in Wenchi Senior High.

This study also tried to make teachers and students to be more aware of what is required for the meaningful learning in volumetric analysis. With this, Students also would be exposed to concepts and skills in the laboratory and to better understand the experiments. The study highlights the critical factors in volumetric analysis experiments, why certain procedures need to be carried out and what outcomes are expected in assessing students' performance in volumetric analysis concepts.

The study will also assist Chemistry teachers to assess their own views in totally developing new ways that can result in major reconstruction of their knowledge and their conviction of how this knowledge should be presented in class. As a result, the study would allow teachers to gain a greater insight in their own teaching methodology.

Curriculum developers, who would have access to this study, can use the information in the development of curriculum materials such as textbooks, workbooks and multimedia instructions, to enable students to better understand concepts. The teaching strategy used in this study is a step in the right direction as it emphasizes understanding.

1.8 Limitation of the study

The study was conducted in a single educational institution, namely Wenchi Senior High School, in which all form two elective science students were selected. The result cannot be generalised to all elective Science students in the country.

1.9 Delimitation of the study.

Brong – Ahafo of Ghana has a large number of Senior High Schools, however, this study was conducted in only one Senior High School in the region because of the researcher's involvement with the school as a Chemistry teacher.

Also, due to the limited duration of the programme, elective science class was used from Wenchi Senior High School.

CHAPTER TWO

LITERATURE REVIEW

2.0. Overview

This chapter discusses the available literature related to this study. It is grouped under the following headings: Theoretical framework of concept Maps and Meaningful Learning conceptual framework, Concept mapping, Kinds of concept map, Uses of concept map, Benefits of concept map, , Effectiveness of Concept Mapping in Science Education, Concept Maps and other Forms of Educational Intervention, Research Concept Mapping Tools, Methods of Scoring Concept Maps, other methods of scoring concept map, Standard Concept Map Construction Method, Relevance of Concept-Mapping in Assessing Chemistry Learning, The theory of volumetric analysis, as well as importance of volumetric analysis.

2.1. Theoretical framework of Concept Maps and Meaningful Learning

Concept Maps are graphical representations of knowledge that are comprised of concepts and the relationships between them (Cañas, Valerio, Lalinde-Pulido, Carvalho & Arguedas*,* 2003). Concept Mapping is grounded in a sound cognitive learning theory.

According to Ausubel's (1968) Assimilation Theory, 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. The idea of a concept is defined as a perceived regularity in events or objects, or a record of events or objects, designated by a label, symbols etc. (Cañas, Valerio, Lalinde-Pulido, Carvalho, & Arguedas*,* 2003).

In principle, Concepts are usually enclosed in circles or boxes, and relationships between concepts are indicated by connecting lines that link them together. Words on the linking line specify the relationship between the concepts. Another characteristic of Concept Maps is that, the concepts are represented in a hierarchical fashion with the most inclusive and most general concepts at the top of the map. The more specific, less general concepts are arranged below. The hierarchical structure for a particular domain of knowledge also depends on the context in which that knowledge is being applied or considered. Therefore, it is best to construct Concept Maps with reference to some particular question that seeks to answer, what is termed a focus question. The Concept Map may pertain to some situation or event that is understand through the organization of relevant knowledge, thus providing the context for the Concept Map.

Also important and characteristic of Concept Maps is the inclusion of "cross-links." These make explicit relationships between or among concepts in different regions or domains within the Concept Map. Cross-links show how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown on the map. In the creation of new knowledge, cross-links often represent creative leaps on the part of the knowledge producer. A final aspect of the structure of Concept Maps is the inclusion of specific examples of events or objects on the links towards nodes, as these can help to clarify the meaning of a given concept (Cañas, Valerio, Lalinde-Pulido, Carvalho, & Arguedas, 2003).

The fundamental idea in Ausubel's (1968) cognitive psychology is that learning takes place by the assimilation of new concepts and propositions into existing concept and propositional frameworks held by the learner. This knowledge structure as held by a learner is also referred to as the individual's cognitive structure.

One of the most fundamental goals in the use of Concept Maps is to foster meaningful learning. Ausubel made the very important distinction between rote learning and meaningful learning, and stated that meaningful learning requires three conditions:

- The material to be learned must be conceptually clear and presented in a clear language and examples related to the learner's prior knowledge. Concept Maps can be helpful to meet this condition, both by identifying general concepts prior to instruction. The more specific concepts are sequenced according to the learning tasks through progressively more explicit knowledge that can be anchored into conceptual frameworks.
- The learner must possess relevant prior knowledge. This condition can be met after age 3 for virtually any domain of subject matter. However it is necessary to be careful and explicit in building concept frameworks if one hope to present detailed specific knowledge in any field in subsequent lessons, hence first two conditions are interrelated and are important.
- The learner must choose to learn meaningfully. The condition under which the teacher or mentor has an indirect control is the motivation of students to choose to learn by attempting to incorporate new meanings into their prior knowledge.

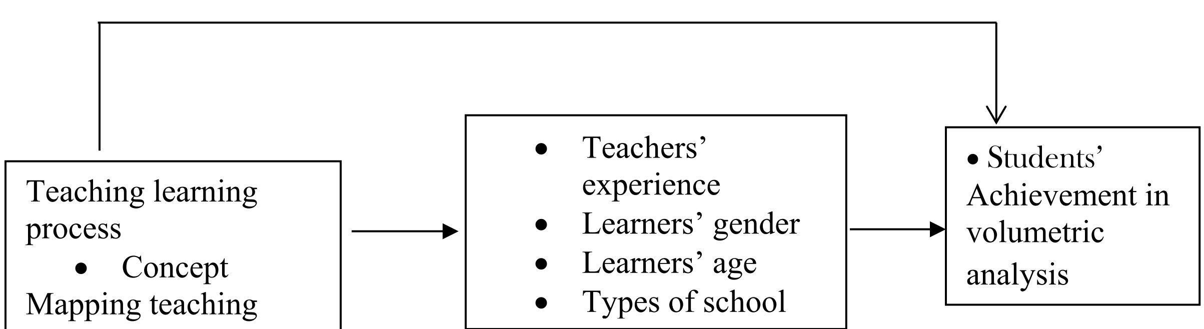
Another very powerful use of Concept Maps is as an evaluation tool, thus encouraging students to use meaningful-mode learning patterns (Novak & Gowin, 1984; Novak, 1998; Mintzes, Wandersee & Novak, 2000).

There is an important relationship among the different psychologies of learning, as we understand it today. The growing consensus among philosophers and epistemologists that new knowledge creation is a constructive process involving both our knowledge and our emotions. Learners struggling to create good Concept Maps are themselves engaged in a creative process, and this can be challenging to many, especially to learners who have spent most of their life learning by rote. Rote learning contributes very little at best to our knowledge structures, and therefore cannot underlie creative thinking or novel problem solving.

Concept Mapping is an excellent studying-exercise for the promotion of creative thinking and identification of new problem-solving methods.

2.2. Conceptual framework of the study

The conceptual framework used in this study was based on the constructivist theory of learning. This theory holds that, learning is an active process where students are actively involved in construction of meaning rather than having a teacher to serve as a dispenser of facts (Duit & Treagust, 1998). The study was based on the assumption that a teaching method that involves students in concept mapping is more likely to lead to meaningful learning as compared to regular teaching methods.



Independent Variable Intervening Variables Dependent Variable

Figure 1.Conceptual Framework for effects of Concept Mapping Teaching Strategy on students' achievement.

2.3. Concept mapping

Concept mapping is a graphical tool for organizing and representing knowledge in networks of concepts and linking statements about a problem or subject (Novak & Canas, 2006). Concepts are graphical or pictorial arrangements that deal with a specific subject matter. They are useful tools in representing the structure of knowledge in a form that is psychologically compatible with the way human beings construct meaning. Mouton (1996) defines a concept as the most elementary symbolic construction by means of which people classify or categorize reality or make sense and attribute meaning to their world. Novak and Gowin (1994) demonstrated that, the label for most concepts is a single word, although sometimes symbols such as plus (+) or percentage (%) are used. The core element of a concept mapping is a proposition, which consists of two or more concepts connected by a labeled link.

Propositions according to Novak (2010) are meaningful statements about some object or event.

One of the important characteristic of Concept Mapping is the inclusion of "crosslink." Cross-links show how a concept in one domain of knowledge represented on the mapping is related to a concept in another domain shown on the mapping. In the creation of new knowledge, cross-links often represent creative leaps on the part of the knowledge producer (Novak, 2000). A final aspect of the structure of Concept Mapping is the inclusion of specific examples of events or objects. These can help to clarify the meaning of a given concept.

2.4. Kinds of Concept Mapping

According to Novak & Canas (2006), there are seven kinds of concept map. The most commonly used five are as follows.

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

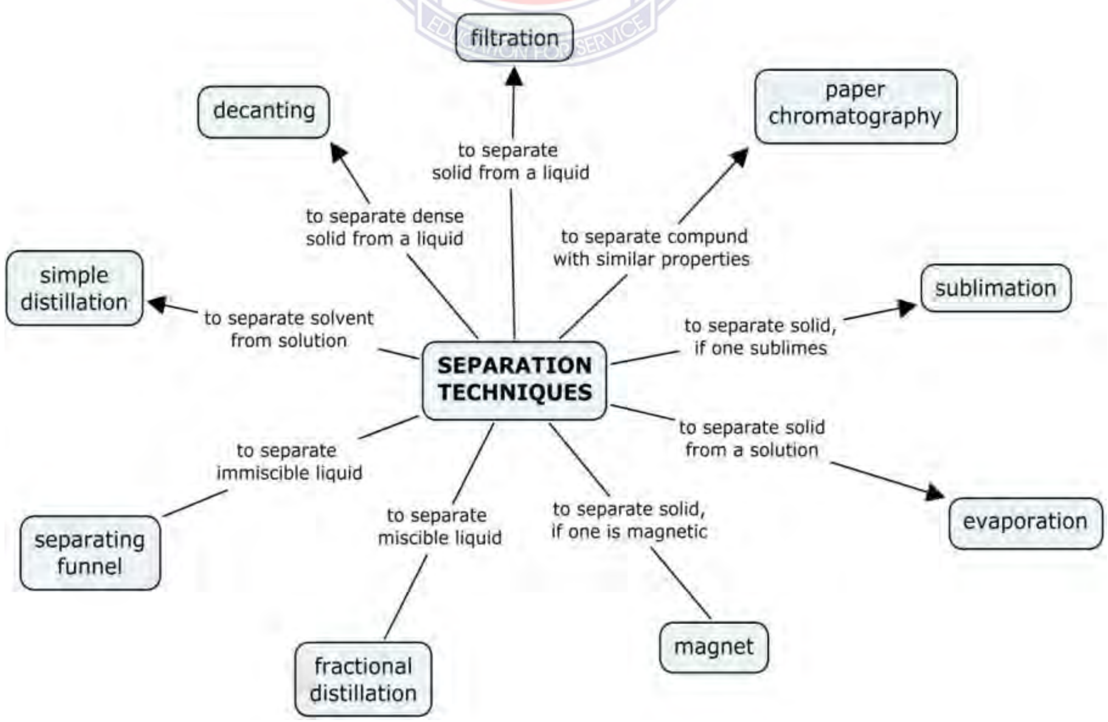


Figure (2) A Spider concept map of separation techniques

The hierarchy concept map: It 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.

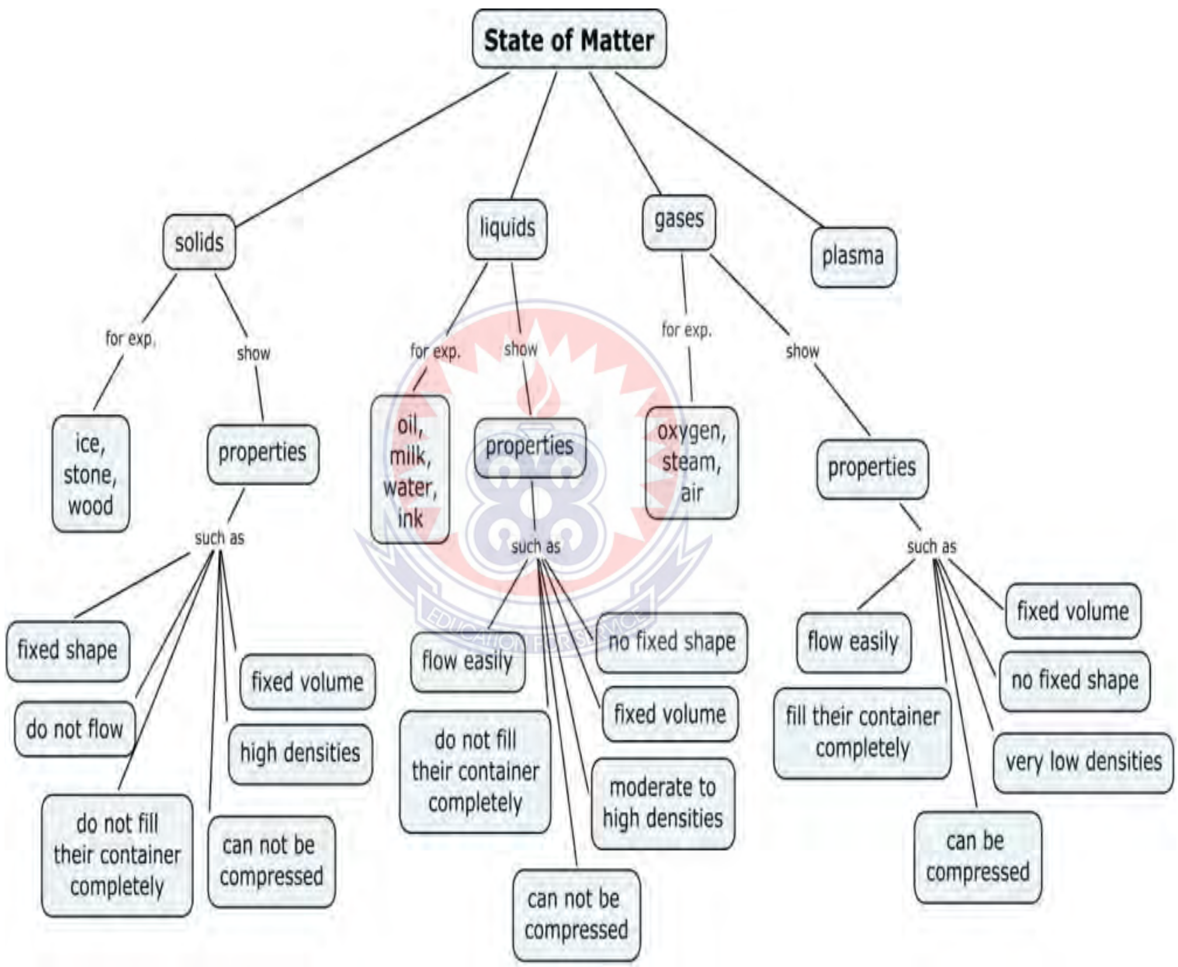


Figure (3) A hierarchy concept map of state of matter

The flowchart concept map: It organizes information in a linear format.

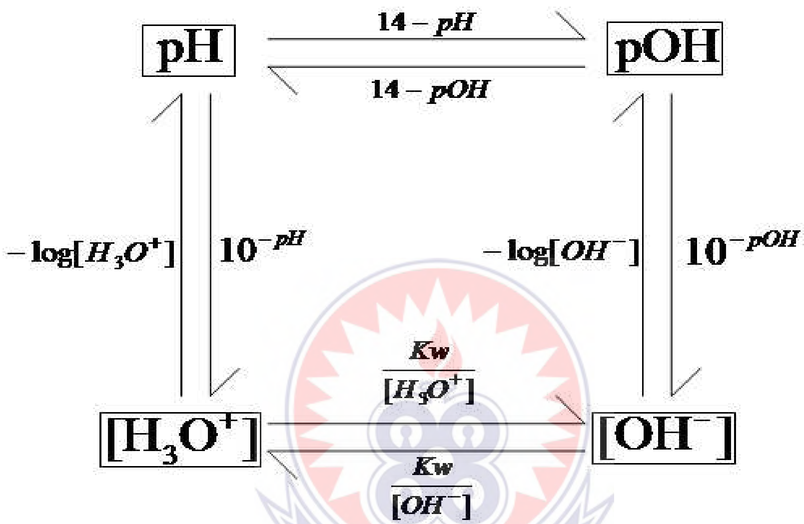


Figure (4) Flow chart concept map of pH and pOH

The systems concept map: It organizes information in a format. It includes all data on the map and shows many relationships among the data. It uses critical thinking skills along with problem solving skills.

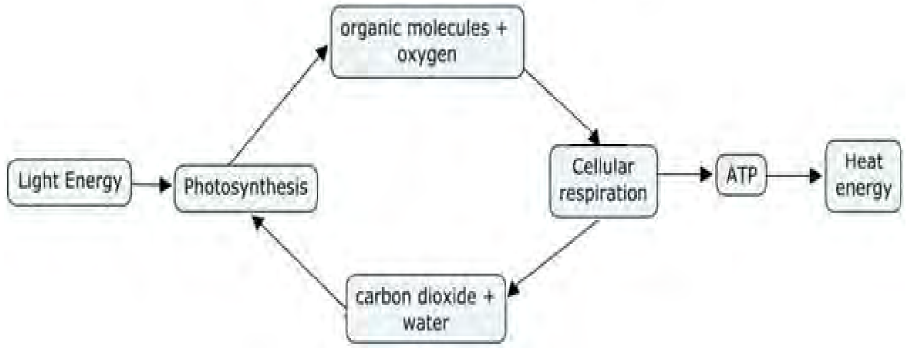


Figure (5): Systems concept map of photosynthesis and cellular respiration

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

Figure (6) Multi-dimensional (3D dimensional) concept map of the atom

2.5. Uses of Concept Maps

According to Collette and Chiappetta (1989), concept learning is an active process that is fundamental to understanding science concepts, principles, rules, hypotheses, and theories. It is the responsibility of the teacher to organize learning experiences in a way that will facilitate learning of students. As students are introduced to new science concepts, they embark on a cognitive process of constructing meaning and making sense by consciously or subconsciously integrating these new ideas with their existing knowledge. This is best facilitated by Concept Maps. In the views of Safdar (2010), “If teachers learn how to construct concept maps and use them for planning and assessing lessons, they will be able to teach students better how to make concept maps to organize their thoughts and ideas.” Science teacher can use concept maps to determine the nature of students’ existing ideas, and make evident the key concepts to be learned and suggest linkages between the new information to be learned and what the student already knows. Concept maps can be used for; knowledge construction: how students construct their knowledge, learning, assessment: used as a pre and post assessment of students’ prior knowledge and what they have learned (Mintzes, Wandersee & Novak, 2000 & Mintzes, et al.1998).

Concept maps are useful tools to help students learn about their knowledge structure and the process of knowledge construction. In this way, concept maps also help the student learn, how to learn (meta-learning). Concept mapping requires the learner to operate at all six levels of; knowledge, comprehension, application, analysis, evaluation, and creation (synthesis) of Bloom’s educational objectives of cognitive domain. The conceptual understandings students achieve in a new learning activity is highly dependent on what they already know. Concept Maps have been used to examine students’ prior knowledge, track student’s progression of knowledge throughout a course, compare students at different levels of knowledge etc. (Hoz, Bowman & Kozminsky, 2001; Pearsall, Skipper & Mintzes, 1997).

Teachers and students are often able to identify misconceptions within the context of a Concept Map. According to Novak and Gowin, (1984) “concept maps can make clearer to the student the number of important concepts learn.” The study further indicated that concept maps externalize a person’s knowledge structure and can point out any conceptual misconceptions the person may have concerning the knowledge structure. This explicit evaluation of knowledge and subsequent recognition of misconceptions allows for finely targeted remediation. Since concept maps are visual images, they therefore tend to be more easily remembered than text. Concept Maps have also been used to address specific misconceptions in knowledge (Gonzalez, 1997; Regis & Albertazzi, 1996). It also identifies alternative educational approaches to address misconceptions (Kinchin and Adams, 1998).

Another very powerful use of Concept Maps is as an evaluation tool, thus encouraging students to use meaningful-mode learning patterns (Novak & Gowin, 1984; Novak, 1998; Mintzes, Wandersee & Novak, 2000).

2.6. Benefits of Concept Maps

There are several benefits and uses of concept mapping for both students and teachers. Concept maps give students the opportunity to:

- Think about the connections between the concept being learned at the beginning
- Organize their thoughts and visualize the relationships between key concepts in a systematic way which can lead students to learn meaningfully.
- Reflect on their understanding.

When an expert creates a concept map, it is typically an elaborate, highly integrated framework of related concepts. Highly sophisticated maps show highly integrated knowledge structures, which are important in facilitating cognitive activities such as problem solving.

2.7. Effectiveness of Concept Mapping in Science Education

The concept and theory of Concept Mapping had its roots in education, and learning probably still constitute the bulk of its use (Cañas, Cañas, Valerio, Lalinde-Pulido, Carvalho & Arguedas, 2003). Like any other tool, the effectiveness of Concept Mapping depends on how it is used and the conditions under which it is applied. There is no doubt that Concept Mapping can enhance learning. An earlier review of the educational effectiveness of Concept Mapping (Horton *et al*., 1993) concluded that Concept Mapping can have educational benefits that range from what can be described as huge, all the way to having negative effects (i.e., when some alternative instructional intervention produced learning effects greater than Concept Mapping), although the great majority of the studies reviewed showed differing degrees of positive effect of Concept Mapping.

The development of learning strategy and knowledge tools such as concept mapping, semantic networks and others, are all efforts made to improve science education. Similarly, the large number of studies conducted on various aspects of science education is an indication of science educators' search for solutions to the problems facing meaningful learning of scientific concepts and theories.

More than two hundred studies in science education have employed concept mapping in one form or another (Novak, 1998; Mintzes, Wandersee & Novak, 1998). Several of these investigations have examined the reliability and validity of the technique as a way of representing knowledge in scientific disciplines (Markham & Mintzes , 1994; Ruiz-Primo

& Shavelson, 1994). For example, in one study (Markham & Mintzes, 1994) it was shown that the conceptual frameworks revealed by concept maps reflect essentially the same structure as seen in much more time-consuming techniques, such as interviews and picture sorting tasks.

The effectiveness of concept mapping has also been compared to several other learning techniques. For example, learners who used concept mapping as a learning strategy performed better than learners who used underlining (Amer, 1994), note-taking (Reader & Hammond, 1994), or outlining (Robinson & Kiewra, 1995).

There has been some research on worked-out concept maps. These are maps that have been constructed by a teacher or an expert and provided to students as a learning tool. In particular, students with low verbal abilities have been shown to benefit from studying such worked-out maps (O'Donnell, 2002; Rewey, Dansereau, Dees & Skaggs, 1998). In addition, learners with low prior knowledge of the content domain also benefit in particular from learning from worked-out concept maps (Lambiotte & Dancereau, 1991).

Schmid and Telaro (1990) tested the effectiveness of Concept Mapping on High School Biology Achievement and again assessed students' academic ability levels. The study was conducted in Montreal, Canada and involved students at levels "4 and 5" of the Canadian system. The subject matter was on the nervous system. The experimental design combined treatment and control crossed with three levels of Academic Ability (high, medium, and low). The results indicated that the helpfulness of Concept Mapping increased as groups went from high to medium and then to low ability. The authors concluded that Concept Mapping helps low ability students to a greater degree because it requires them to take an organized and deliberative approach to learning, which higher ability students are likely to do anyway.

The effectiveness of concept maps as advance organizer in improving Science achievement of students was also assessed by Willerman & Harg in 1991 on 82 eighth-grade students in four physical science classes at a middle school in North Chicago suburb. The experimental group had 40 students and the control group had 42 students. The social background of the students ranged from the poverty level to upper class and the ethnic breakdown of the sample was 42 black, 33 white, 4 Hispanic, and 3 Asian. The experimental group completed the concept map at the beginning of the science period under the teacher's supervision while the control group was given an introductory lesson with questions. At the end of the two- week period a science test was administered to the experimental and the control group. The results of a one-tailed t- test indicated that there was a significant difference between the two groups. The effect of class size was 0.40. The effect size of 0.40 in this study was well within the range of other advance-organizer studies. The study confirmed the hypothesis that students who are presented with a concept map that is used as an advance organizer at the beginning of a physical science period scored higher on a unit test than students who are not presented with the concept map.

On the other hand, Schau and Mattern (1997) found that post-test scores on maps drawn by graduate students in introductory statistics correlated significantly with final course grades. The interpretation from this study is that traditional evaluation tools (quizzes, tests, final grades) capture some aspects of conceptual structure, and concept maps capture other aspects.

A study by BouJaoude and May Attieh (2007) examined whether or not the construction of concept maps by students improves their achievement and ability to solve higher order questions in chemistry. It also investigated the differential effect of the treatment by gender and achievement level, and explored the relationships between performance on concept maps and chemistry achievement. Participants in this study were sixty Grade 10 chemistry students from private high school in Lebanon who were randomly divided into two groups.

At the end of the treatment period, both the experimental and control group students took the post-test at the same time. Results showed that while there were no significant differences on the achievement of total score, there were significant differences favouring the experimental group for scores on the knowledge level questions. Moreover, there were sex-achievement interactions at the knowledge and comprehension level questions favouring females and achievement level – achievement interactions favouring low achievers. Finally, there were significant correlations between students' scores on high level questions and total concept map scores.

Nicoll, Francisco and Nakhleh (2001) investigated the value of using Concept Mapping in general chemistry and, more particularly, to see if Concept mapping could produce a more interconnected knowledge compared to ordinary instruction. The results showed that students taught with Concept mapping knew more concepts, more linking relationships, more "useful" linking relationships, and had no erroneous linking relationships than the non-Concept Mapping students. Despite some design flaws (e.g., non-random assignment, and more high school chemistry experience among the treatment group) the findings were very impressive for Concept Mapping, as it relates to the development of an interconnected knowledge base and meaningful learning.

Trowbridge and Wandersee (1993) conducted a study to describe how concept mapping could be used as an integral instructional strategy for teaching evolution course in college. The study sought to evaluate the usefulness of incorporating concept mapping in a college evolution course, and its effects on students' understanding of evolution. It also sought to determine if students' concept maps revealed critical points in learning. The students were taught how to construct concept maps and were made to submit concept maps after each course lecture. Results of the study indicated that critical points in learning evolution could be identified by checking the degree of concordance of super ordinate evolutionary concepts appearing on the students' concept maps. The use of seed concepts, micro mapping, a standard format and standard concept map checklist were to make the use of concept-mapping strategy feasible for the instructor to implement and for students to adopt.

In a related study, Pankratius (1990) sought to test if Concept Mapping, and especially the amount of Concept Mapping, would affect achievement in physics problem solving. The main variable was the amount of Concept Mapping practice/experience the students were engaged in. One treatment group created Concept maps at the beginning of a period and continued to improve upon them throughout the period, a second treatment group made Concept Maps once at the end of a period. A control group did not make Concept Maps. The results showed statistically significant differences, with both treatments groups performing better than the control, and the periodic Concept Mapping being more effective than Concept Mapping just at the end of the unit.

According to Esiobu and Soyibo (1995), in the same field of study among 808 final year Senior High School students to determine the effectiveness of concept mapping strategies in enhancing meaningful learning of biology concepts, it was found out that appropriate class interaction pattern helped to tackle the problem of large classes in biology. A questionnaire, a paper and pencil test, and an attitudinal test were employed to gather data by the researchers. The experimental group was given instruction on ecology and genetics using concept mapping instructional strategies. Students in the group were also made to construct their own individual concept maps on the topic of every lesson. The control groups of students were not asked to construct concept maps. Data gathered in the study were analyzed using ANOVA and ANCOVA statistical techniques. Results of the study indicated that the experimental group performed better than the control group in the achievement test and developed favourable attitudes to ecology and genetics.

Stensvold and Wilson (1992) investigated the effect of students' construction of concept mapping in high school chemistry laboratories on their comprehension of chemical concepts. No statistical differences were found between the experimental and control groups.

A study by Willerman and Harg (2006) which aimed at determining if concept map used as an advanced organizer can improve the science achievement of eighth-grade students, Eighty two (82) students in four science classes participated in this study with two classes as experimental. The result showed that concept map can provide the classroom teacher with meaningful and practical structured approach to teaching.

Candan (2006) investigated the effect of concept mapping on primary school students' understanding of the concepts of force and motion, the result showed that there was significant difference between the means scores of experimental and control group but no difference between genders.

Qais (2006) examined the effect of concept mapping on the science achievement of sixth grade students. Research findings revealed that there were statistically significant differences between the scores of the experimental group and those of control group regarding the use of concept maps.

Horton, *et al*. (1993) carried out a meta-analysis of studies that employed concept mapping as an instructional strategy. A total of 133 potentially acceptable concept-mapping studies were obtained from various sources. Only 19 studies met the required criteria for acceptance for the analysis. Results of the study revealed that concept mapping had positive effects on students' achievement. The study, however, failed to provide answers to two of the research questions posed in the study. The questions were:

(a) What was the effectiveness of concept-mapping instructional strategy for improving students' attitude towards learning?

(b) Was there any gender effect when concept mapping was used as an instructional strategy?

Insufficient data was the main reason given for the failure to provide answers to these questions according to the investigators.

Bello (1997) conducted a related study among over 400 Senior High School students to determine the comparative effects of' two forms of concept-mapping instructional strategies on students' achievement in evolution at University of Ilorin. A combination of clinical interview protocol, essay and multiple-choice tests were employed as data gathering instruments. Analysis of Variance and t-test statistical techniques were employed to analyze the data gathered in the study. Results of the study indicated that the two forms of concept-mapping instructional strategies improved students' achievement and reduced students' misconceptions and alternative conceptions of the theory of evolution.

A study by Czerniak and Haney (1998) was designed to test if the addition of a structured concept mapping to instruction in a physical science course would improve achievement, reduce anxiety toward physical science, and reduce anxiety about teaching physical science at the elementary school level. The results showed that concept mapping increased achievement, decreased anxiety for learning physical science, and decreased general (trait) anxiety. Results did not indicate an increase in self-efficacy for teaching physical science.

The reviewed studies clearly revealed that concept mapping enhanced students' achievement. Most of the studies are quasi-experimental in design while paper, pencil test and clinical interviews are common data gathering instruments. Analysis of Variance and t-test were the common statistical techniques employed for data analysis.

2.8. Concept Maps and other Forms of Educational Intervention

A study by Chang, Sung and Chen (2001) sought to test the benefits for learning three different kinds of Concept Maps. The design involved four conditions, one control and three experimental. Pre-test and post- test were used to collect data. For two contact hours per week for four weeks, students read one of the science articles and studied it under one of the four conditions. The Map Generation group of students constructed a Concept Map for the material from scratch. The Map Correction groups of students also were given an "expert-generated" Concept Map for the material, in which some errors had been introduced. Students were to find and correct these errors. In the Scaffold-Fading group, students were progressively weaned from pre-constructed Concept Maps. The control group received no adjuncts at all, just the original text to read and study. The results showed that "the map-correction group did better on the (comprehension) post-test than the map-generation and control group. The differences among the scaffold-fading, map-generation, and control group were not significant".

Zittle (2002) set out to determine the relative effectiveness in producing analogical transfer of studying text, studying a completed Concept Map, or filling in a blank, but structured Concept Map. The study involved three groups: one that studied text; a second that studied Concept Maps; and a third that selected concepts to fill in Concept Maps. The dependent variable was the number of hints required for solving a set of problems. The text and Concept Map groups were nearly identical (requiring 7.3 versus. 6.2 hints respectively). The group that filled in the Concept Maps required only half as many hints (3.4).

Moreland, Dansereau and Chmielewski (1997) tested the effect of Concept mapping on learning versus using text annotations, which are learner-generated enhancements of learning materials, including underlining, marginal notes, etc. There was no statistically significant difference on recall between the mapping condition and the text condition, although a difference in favour of the mapping group was significant.

A study by Spaulding (1989) addressed the effects of Concept Mapping versus "concept defining" on learning achievement in biology and chemistry. The results showed no differences between Concept Mappers and Definers. There was also no differential effect for chemistry versus biology. The statistical interactions indicated that lower ability students performed better with Concept Mapping, and higher ability students performed better when just defining the concepts.

Katcha (2010) investigated the effects of Vee-mapping (which is a simpler form of concept mapping) instructional strategy on students' achievements in biology. He found out that students exposed to Vee-mapping performed better than those taught with the conventional lecture method; his result shows a mean score of 48.14 for the experimental group and a mean score of 39.48 for the control group.

2.9. Concept Mapping Tools

Webster is not currently a commercial tool, but may become one at some point (Gaines & Shaw 1995a). Currently, prototype versions are available for educators to test. Webster allows the incorporation of images and other media directly into the Concept Maps, as well as the attachment of resources. Webster also permits the development of sub maps, easy transition of a map section to a sub map, and conversion between map and outline format.

Researchers at the Knowledge Science Institute (KSI) at Calgary had an early interest in the use of Concept Maps and multimedia (Gaines & Shaw 1995b). They have developed a number of demonstration programmes, such as Knowledge Science Institute (KSI) Mapper and Concept Map (CMap). These programmes are not available for purchase, and some of the capabilities have been integrated into Smart Ideas from Smart Technologies. The Calgary group is interested in the use of Concept Maps in multimedia, for education, collaboration, and for the capture of expert knowledge. The primary contribution to date appears to be the development of a Concept library that will assist developers (CMap) and a demonstration programmes (KSI Mapper) (Kremer & Gaines, 1996; Gaines &Shaw, 1989).

Concept map Tools has been extended to aid the user in the construction of Concept Maps. A search feature (Carvalho, Hewett & Cañas, 2001) allows the user to locate resources (including Concept Maps) and Web pages that are related to a Map, facilitating the addition of explanatory resources to the Map (all Concepts map servers in the network are automatically indexed making the search feature very fast). A Word Net server allows users to navigate through definitions, synonyms, antonyms, etc. for any word in a Concept Map (Cañas, Valerio, Lalinde-Pulido, Carvalho & Arguedas, 2003). Research is being done on "suggester" additions to the software that take advantage of the topology and semantics of Concept Maps to mine the Web and index servers to propose concepts (Cañas, Valerio, Lalinde-Pulido, Carvalho & Arguedas, 2003), propositions, resources and other Concept Maps (Leake, Maguitman & Cañas, 2002), and topics for related Concept Maps (Leake *et al.,* 2003), that will help the user improve their Concept Map. A new recorder feature allows the recording and step-by step playback of the whole Concept Map construction process which will greatly facilitate the analysis of Concept Map building techniques and allow teachers and instructors to carefully re-examine the Map construction process of their students. Further information on the software tools is available at http://cmap.coginst.uwf.edu.

Luckie Concept Connector is a software suite developed at Michigan State University. This system allows students to build Concept Maps online, and to receive immediate feedback about their maps based on automatic scoring systems that are derived from scoring methods suggested by Novak and Gowin, (1984). The Concept Mapping system is based upon a pre-defined set of concepts and linking phrases. The system is currently being used for online homework and assignments. Team Performance Lab – Knowledge Assessment Tool

Suite (TPL-KATS) includes modules for both Concept Mapping and card sorting (Hoeft, *et al.,* 2003). The suite is designed to assist with the assessment of what the developers call "structural knowledge." The system computerizes the administration of tasks such as the logging of user actions and the scoring of completed maps. The system provides concepts, and requires that all concepts be used, and all linking lines should be labelled. The software includes an administrator mode in which task characteristics such as arrow types, whether or not participants can add concepts, and the maximum number of concepts, can be specified. The system can also be used to make fill-in maps, to attach multimedia and comments to maps, to prompt the user to specify the strength of a relationship, etc.

Several different methods of scoring are provided. The system can produce output files based on mapping tasks and completed Concept Map and characteristics that can be analyzed with standard statistics packages.

Chung, Baker and Cheak (2002) describe the most recent version of their knowledge mapping software, called the Knowledge Mapper Prototype system. Research with their system suggests that users take some time to become proficient. The authoring system allows instructors to define tasks for students by specifying concepts and linking terms, to designate an existing Concept Map as the "expert map" to be used as a scoring criterion, and to assign groups of users and associated group privileges. Their system is a relatively constrained Concept Mapping system, with predefined concepts and linking terms, although they describe some exploration of user-generated links.

2.10. Methods of Scoring Concept Maps

Although it has been over thirty years since Novak proposed the idea of a concept map, researchers are still impressed by its versatility in curriculum design (Edmondson, 1995), teaching strategy (Schmid & Telaro, 1990), and evaluation of teaching (Beyerbach and Smith, 1990; Goldsmith, Johnson, & Acton, 1991; Novak & Gowin, 1984; Ruiz-Primo & Shavelson, 1996). A concept map consists of a set of propositions, which are made up of a pair of concepts (nodes) and a relation (link) connecting them. Although many researchers have reported that concept mapping is a useful tool for learning and instruction, constructing concept maps using pencil and paper has some obvious disadvantages (Chang, Sung, & Chen, 2001). These include the following:

- ❖ It is an inconvenient for a teacher to provide appropriate feedback to students during concept mapping.
- ❖ The construction of a concept map is complex and difficult for students, especially among novice students.
- ❖ Concept maps constructed using pencil and paper are difficult to revise.
- ❖ The ‘pencil-and-paper’ concept map is not an efficient tool for evaluation.

Because of the above difficulties, researchers have built computer-based concept mapping systems to help students construct concept maps more easily (Chang, Sung, and Chen, 2001). Generally speaking, there are three major approaches (Ruiz-Primo & Shavelson, 1996) for the scoring of the concept mapping in science. The first one is scoring a student’s map component, like propositions, hierarchy, cross links and examples in Novak and Gowin (1984) scheme. The second approach is using a criterion map and comparing students map with that criterion map. The closeness index use in Goldsmith, Acton, and Johnson, (1991) is a typical example. The third approach combines both the component of a generated map and a criterion map.

Although scholars have proposed various scoring schemes for assessing and scoring concept maps, closeness index is the type of the weighted scheme of scoring that takes into account a number of students and teachers instructional needs. Teachers need to determine the importance of each proposition based on their professional knowledge, and each proposition is given a weight ranging from 0 to 1. A concept map which uses weighted propositions is term a "weighted concept map." The higher a proposition ranks in importance, the higher the weight it is assigned. The quantitative analysis is a similarity value found in the comparison of concept maps drawn by students and an expert concept map drawn by a teacher.

The traditional method of concept map scoring was proposed by Novak and Gowin (1984), and is based on the components and structure of the Concept Map. Novak and Gowin's (1984) system assigns points for valid propositions (1 point each), levels of hierarchy (1 point for each level), branchings (1 point for the first branching where two or more concepts are connected to the main concept and 3 points for any subsequent branching where there are two or more concepts connected to the preceeding concept), pattern (maximum 5 points if the map shows general to specific pattern), crosslinks (1 point for each valid cross-link), and specific examples (1 point for each example). The number of hierarchical levels addresses the degree of subsumption, the number of branchings indicates progressive differentiation, and the number of cross-links indicates the degree of integration of knowledge. This scoring technique has proven to be time-consuming, but it does give a great deal of information about the creator's knowledge structure.

Although Liu & Hinchey (1996), found relatively low correlations among different component scores in Novak and Gowin's (1984) scoring system, the component scores for propositions, levels of hierarchy, cross-links, and examples may actually be measurements of different aspects of the structure and organization of knowledge. Studies on reliability and validity measures indicate that Concept Maps fall within acceptable ranges from the viewpoint of psychometrics (West & Pomeroy ; 200).

Some researchers are pursuing the possibility of providing automated assessment of the structural components of concept maps designed by students (Abimbola, 1996). Ruiz-Primo and Shavelson (1996) describe methods to compare a student's map to that of an expert. Expert maps may be constructed by a teacher, a domain expert or a group of teachers or domain experts. A comparison procedure must also be defined, and range from propositional comparisons to holistic comparisons of structure.

A computerized technique can be used to simplify the comparison of maps, and this possibility has been explored by researchers at Centre for Research on Evaluation, Standards, and Student Testing (CRESST) and at other places (Chung, Herl, Klein, O'Neil & Schachter, 1997; Herl, O'Neil, Chung, Dennis & Lee, 1997). These automated scoring systems are typically based on propositional matching within limited sets of concepts and linking phrases. Holistic or structural comparisons are more difficult to automate, as they often require human judgment.

Some researchers have experimented with the combination of methods based on components, and methods in comparison to a criterion (e.g., "expert") map. One example of this approach is to use traditional component-based scoring combined with some comparison to a criterion map, by assigning more weight to propositions that were considered to be critical by experts. Rye & Rubba (2002) reported such a concept map scoring system that was based on components, but which used an expert map to weigh propositions in the students' maps.

2.11. Standard Concept Map Construction Method

The Concept mapping method defined by Novak & Gowin (1984) involves a series of steps as listed below:

- Define the topic or focus question. Concept maps that attempt to cover more than one question may become difficult to manage and read.
- Once the key topic has been defined, the next step is to identify and list the most important or "general" concepts that are associated with that topic.
- Next, those concepts are ordered from top to bottom in the mapping field, going from most general and inclusive to the most specific, and an action that fosters the explicit representation of subsumption relationships (i.e., a hierarchical arrangement or morphology).
- Once the key concepts have been identified and ordered, links are added to form a preliminary concept map.
- Linking phrases are added to describe the relationships among concepts.
- Once the preliminary concept map has been built, a next step is to look for cross

links, which link together concepts that are in different areas or sub-domains on the map. Cross-links help to elaborate how concepts are interrelated.

❖ Finally, the map is reviewed and any changes to the structure or content are made.

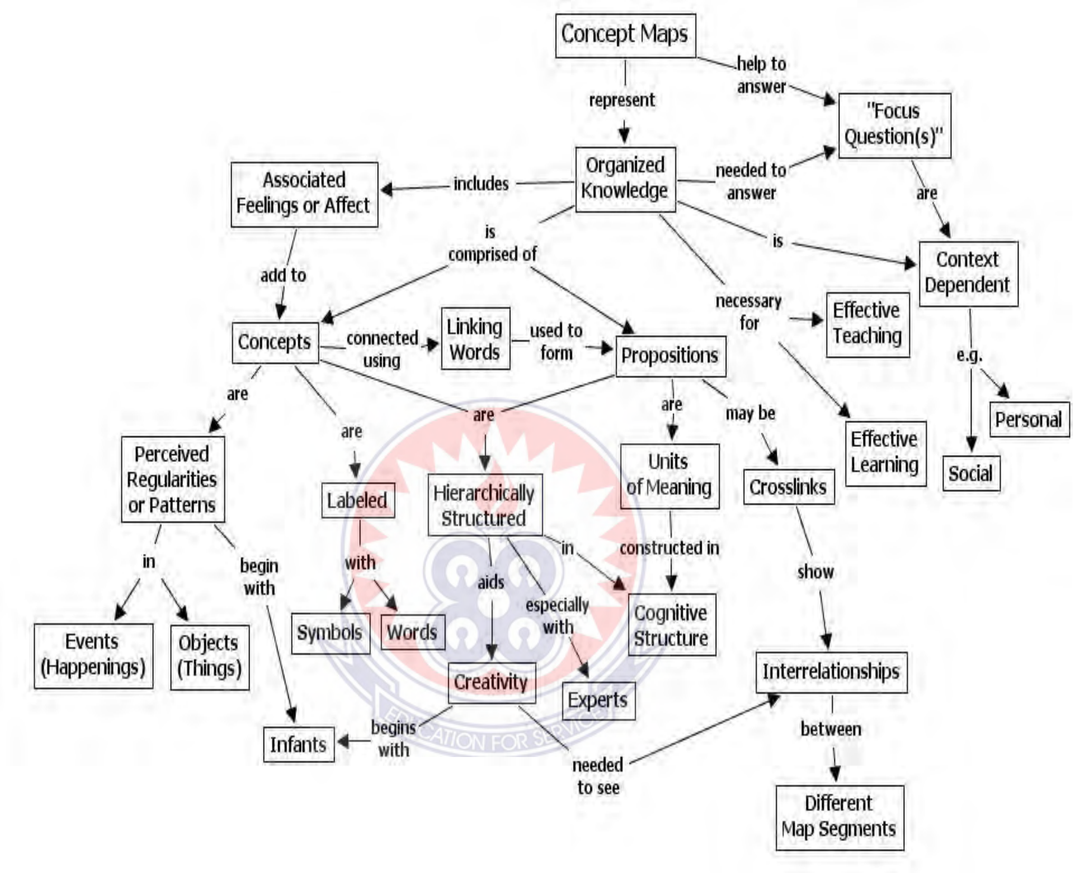


Figure (7): A pictorial presentation of a concept map (Cañas, Hill, & Lott, (2003).

2.12. Relevance of Concept-Mapping in Assessing Learning in Chemistry

Chemistry learning is perceived as tedious for a majority of Senior High school students (De Vos, Bulte, & Pilot, 2002; Osborne & Collins, 2001). There are indications that the student's difficulty is increasing as the student moves up the educational ladder. For instance, the interest towards chemistry is declining in students as they move from upper primary classes to high school and then to higher secondary classes (Gafoor & Shilna, 2013). Student's difficulties in chemistry are due to the abstract and particulate nature of the subject (Johnstone, 1991). In particular, organic chemistry has symbolic aspects and it relies on the use of two dimensional structures and figures to represent three-dimensional molecules. To learn organic chemistry effectively, the student must have the ability to perceive and manipulate the pictorially presented stimuli (Pribyl & Bodner, 1995). While factors that impede learning include content variables like abstract nature of the subject, the fault is not always with nature of the subject matter and the limitations of the learner. Students' learning difficulties with chemistry are associated with the content representations, and, pedagogical, classroom and assessment practices too. Effective learning takes place only if the students feel comfortable with the learning and testing situation.

The use of concept mapping as an effective teaching strategy is well established in the literature. Lopez *et al* (2011) studied the use of concept mapping as a diagnostic assessment tool in organic chemistry. The results showed that concept maps could inform instructors of potential gaps in conceptual understanding that might be overlooked by traditional, lecture-method instruction and problem-set activities. Concept-mapping tests to assess student teachers' understanding of physics was found informative, engaging, reinforcing and providing immediate feedback, thus serving the real purpose of evaluation in Indian context (Gafoor & Shareeja, 2011).

As the concept-map permits, turning the assessment process itself as an activity of learning in accordance with extant constructivist educational practices in India's schools, the student may turn to be more interested in the learning-assessing process better than conventional test-formats like multiple-choice items or true/false items. Further, concept-mapping permits higher order cognitive skills like application, analysis, and synthesis to be incorporated in testing. In this study the concept-mapping technique is used as an assessment tool along with the traditional measures of assessment like true/false items and multiple-choice items.

Moreover, there are disagreements between researchers on the effectiveness of concept mapping in chemistry teaching. Zoller (1990), for example, questioned the effectiveness of concept mapping in chemistry because many chemistry concepts are abstract, non-intuitive, and not directly interrelated. In contrast, Novak (1998) argues that the problems are not due to the nature of chemistry; problems rather arise from the fact that students learn chemistry by rote and do not recognize key concepts and their relationships. Moreover, Novak (1998) contends that instruction fails to stress chemical concepts and relationships. Differing results could arise also from the fact that studies have focused on the use of concept maps an instructional, curriculum development, and homework assignments. Many students struggle to learn chemistry, but are often unsuccessful. It seems that many of them do not construct appropriate understandings of fundamental chemical concepts throughout their educational experiences (Nakhleh, 1992). Instead of having well-structured and integrated domain-specific knowledge structures, students consider the different chemical concepts as isolated elements of knowledge. This lack of integration may be the main reason for difficulties in concept formation and application of acquired knowledge (Brandt et al., 2001). Thus, concept mapping as a method to build explicit links and relations between concepts, as a study tool is used as personal learning tool (Johnstone & Otis, 2006), and as an opportunity for students to construct maps using their own terms. According to Horton, et al., (1993), it is expected to stimulate the construction of integrated knowledge structures leading students to achieve higher in tests that measure high cognitive levels.

2.13. Volumetric Analysis

Volumetric analysis is the quantitative analysis of an unknown chemical solution by determining the amount of reagent of known concentration necessary to completely react in a known volume of the solution. Much of the quantitative analysis (that is, analyzing the amount of substance present) is performed using reactions between two substances in solution. The volume and concentration of one solution is known and a titration method is used to find the exact volume of the second solution necessary to react completely with the first. The concentration of the second solution can then be determined if the equation for the reaction is known (Strauss and Corbin, 1990).

Volumetric analysis is a method of quantitative analysis using measurement of volumes. For gases, the main technique is in reacting or absorbing gases in graduated containers over mercury, and measuring the volume changes. For liquids, it involves titration. It can also be said to be a method of determining principles of redox (reduction-oxidation) reactions between molecules. Chemicals under this topic are classified based on the results obtained from titration.

The process of creating a balance chemical equation 'in vitro' is called titration. There are three types of volumetric titration, which are classified based on the rate of their reaction. Direct titration method (DTM) is a one-step titration process. Indirect titration method (ITM) involves a two-step titration process. Back titration method (BTM) uses a three-step titration process.

In a general term, the volumetric analysis of acid-base reaction can be represented as:

$HA + OH^- \longrightarrow H_2O + A^-$

$H^+ + OH^- \longrightarrow H_2O$

$H_3O^+ + OH^- \longrightarrow 2H_2O$

Acid-base reaction in volumetric analysis is the commonest one in Senior High School syllabus. This and other types are indicated in the Table 1.

Table 1. Type of reactions used in volumetric analysis.

Reaction type	**Description**	**Examples**
Acid-Base	H^+ donor (acid) reacts with H^+ acceptor (base). Indicator can be colored dye sensitive to acid/base or pH electrode	a) Strong acid + strong base $HCl_{(aq)} + NaOH_{(aq)} \longrightarrow H_2O + NaCl_{(aq)}$ b) Weak acid + strong base $CH_3COOH_{(aq)} + NaOH_{(aq)} \longrightarrow CH_3COONa_{(aq)} + H_2O$ c) Weak base + strong acid $CH_3NH_{2(aq)} + HCl_{(aq)} \longrightarrow CH_3NH_3 + Cl^-_{(aq)} + H_2O$
Precipitation	Reagent and analyte combine to form insoluble compound. Indicator can be colored reagent or electrode of some type.	soluble ionic compound 1 + soluble ionic compound 2 $\longrightarrow$ insoluble ionic compound 3

Complexation	Reagent and analyte form a coordination compound. Indicator can be a colored dye or electrode.	$NaCl_{(aq)} + AgNO_{3(aq)} \longrightarrow AgCl_{(s)} + NaNO_{3\,(aq)}$ Complexation agent (ligand with multiple electron pairs to donate) + metal cation. $(^{-}O_2C\text{-}CH_2)_2N\text{-}CH_2CH_2\text{-}N(CH_2CO_2^{-})_2$ [called $EDTA^{4-}$] $EDTA^{4-} + Ca^{2+} \longrightarrow [Ca(EDTA)]^{2-}$
Redox	Oxidation-Reduction (electron transfer). Indicator can be a colored dye or electrode.	Many types are possible. Some examples include: a) $Ce^{4+} + Fe^{2+} \longrightarrow Ce^{3+} + Fe^{3+}$ b) $2MnO_4^{-} + 5C_2O_4^{\,2-} + 16H^{+} \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

2.14. Theory of Volumetric Analysis

Volumetric analysis was first introduced by Jean Baptiste Andre Dumas, a French chemist (Ackerman, 2005). He used it to determine the composition of nitrogen combined with other elements in organic compounds. Dumas burned a sample of a compound with known weight in a furnace under conditions that ensured the conversion of all nitrogen into elemental nitrogen gas. The nitrogen was carried from the furnace in a stream of carbon dioxide that was passed into a strong alkali solution, which absorbed the carbon dioxide and allowed the nitrogen to accumulate in a graduated tube. The mass of the nitrogen was then calculated from the volume it occupies under known conditions of temperature and pressure, and therefore, the proportion of nitrogen in the sample was determined. From then volumetric analysis has been used widely in chemistry and industrial laboratories.

2.15. The importance of volumetric analysis

The quantitative relationship between two reacting solutions is important to the chemists. The technique is called gravimetric analysis. It is used in quantitative experiments to determine mass relationships. The technique is useful but it is not always practically efficient. Volumetric analysis looks a better and faster technique, especially if the substances involved are acids and bases. They can be titrated against one another for better quantitative results.

Volumetric analysis is used in high school and college chemistry laboratories to determine concentrations of unknown substances.

The titrant (the known solution) is added to a known quantity of analyte (unknown solution) and a reaction takes place. Knowing the volume of the titrant allows the student to determine the

concentration of the unknown substance (Nelson & Kemp, 1997). Medical laboratories and hospitals use automated titration equipment for basically the same purpose. Beside these, the method has found ample use in analytical laboratories and industries. Industries like ones that manufacture drugs, fine chemicals, petrochemicals, beverages and food processing benefit immensely by the application of this method. For example, in biodiesel industry, it is used to determine the acidity of a sample of vegetable oil. By knowing the precise amount of base that is needed to neutralize a sample of vegetable oil, scientists know how much base to add to neutralize the entire acid. Volumetric analysis has also been used in space science in determining the presence of volatile component in the ejecta flow of crater cavity volume (Ackerman, 2005). It is also used in ecological study to determine the relationship between brain structure and sensory ecology of aquatic animals (Lisney et al., 2007). It is an area of science that is indispensable to man.

CHAPTER THREE

METHODOLOGY

3.0. Overview

This chapter is devoted to the following; design of the study, population, sampling procedure. It continues with the instrumentation, reliability and validity, and data collection procedure.

3.1. Research design

The study was quasi experimental research design with mixed quantitative and qualitative data. It is pre-test-post-test control group design. This is because the researcher cannot randomly sample and assign the subjects to experimental groups. They are already in intact classes (Ali, 2006). According to Nworgu (2006) it is an experiment where it is not possible to assign the subjects to experimental and control groups. This research design made use of concept mapping as an intervention, and the use of pre-and post-treatment test as well as students' questionnaire items. The design helped the researcher to use questionnaire to objectively measure how students perceive the effectiveness of concept mapping.

The pre-intervention test was administered to all the seventy-nine second year elective science students of the Wenchi Senior High School, in the Brong Ahafo Region. The result of the pre-intervention test was used to classify the students into two groups namely the control and the experimental groups for those scoring above fifty percent (50%) and below fifty percent (50%) respectively.

3.2. Population

The target population of this study was all Senior High Schools in the district; however the accessible population was form two elective science students in Wenchi Senior High School. A sample of 54 male and female elective science students representing 72% of the total population of 75 was used for the study.

3.3. Sampling Procedure

In this study, all form two elective science students were used with a total population of seventy – five students but only sixty – two students took part in the pre – test. Purposive sampling technique with the help of the pre-intervention test was used to sample a total of thirty - five (35) participants to form the experimental group base on their performance from the pre-test results. The purpose was to get a sample size of thirty - five (35) within the lower scores limit in the pre-intervention test as the experimental group, and the remaining twenty-two (27) with the upper and higher scores limit as the control group.

Out of thirty - five (35) the experimental students, 71.44% (n =25) were male, and 28.56% (n =10) were female. Among the control group, 100% (n=27) were male. There were no females in the control group. The average age of the participants was 17.78 years. During the period of the intervention, 27 participants out of the 35 participants chosen as experimental group, participated in the study.

3.4. Instrumentation

The main instruments used included a set of pre and post-treatment test items as well as students' questionnaires. A set of Tutor Constructed Chemistry Achievement Test

(TCCAT) items were used as the main tool for collecting data. The pre- test items consisted of 25 objective test items on sub concept related to the topic. Each objective test item had four options lettered A to D, with one correct answer. The post- test items consisted of one structured question. The pre-test questions served to assess students' ability and the post-test determined the effect of the treatment on students' performance.

The scores of the pre- intervention and post -intervention test items were used in the analysis to answer the research questions. The student's questionnaire items were chosen to gather data and further buttress findings on the effectiveness of Concept mapping as instructional strategy integration in chemistry education.

Questionnaire was probably the most common data collection instrument used in educational research which was more familiar to respondents (Muijs, 2004). However, the disadvantages were that they often have low response rates and cannot probe deeply into respondents' opinions and feelings (Fraenkel & Wallen, 2000; Muijs, 2004; Alhassan, 2006).

Both open and closed ended items were used in the questionnaire because respondents were more inclined to answer close-ended items and open-ended items. It also provided a greater depth of responses since there was no standardized answer across responses (Nworgu, (2006).

3.4.1. Description of the questionnaire items

The items in the questionnaire consist of two (2) main parts (A and B). Part (A) contains four (4) items that elicited information on the demographic background of the participants. The variables in part (A) covered respondents' gender, age and entry qualification. These data were in tune with the purpose of this research since the respondents' gender, age might have significant influence on their perceptions about concept mapping integration.

The second part (B) of the questionnaire on students' perceptions about concept mapping integration consists of eleven (11) items (i.e. items 5 – 16) elicited information on respondents' perception of the effectiveness of concept mapping in teaching and learning of chemistry. In addition, there was an open ended item in the questionnaire that was used to get information on participants' views about concept mapping integration in chemistry instruction.

3.4.2. Scoring the questionnaire items on students' perceptions about concept mapping integration

A Likert scale with five options Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), and Strongly Disagree (SD) was used to score the questionnaire items on student perceptions about concept mapping integration. The items on the questionnaire were positively and negatively worded in order to minimize bias responses of participant

Response Intensity	Symbol	Score
Strongly Agree	SA	5
Agree	A	4
Neutral	N	3
Disagree	D	2

Strongly Disagree	SD	1

Likert scale was used to score the questionnaire items because it looks interesting to respondents and people often enjoy completing a scale of this type (Muijs, 2004). Again, Likert scale is easier to construct, interpret and also provide the opportunity to compute frequencies and percentages as well as statistics such as the mean and standard deviation of scores. This in turn, allows for a more sophisticated statistical analysis such as T-test (Fraenkel & Wallem, 2000; Muijs, 2004). Additionally, likert scales was often found to provide data with relatively high reliability (Fraenkel & Wallen, 2000).

Variable scores were obtained by averaging the numeric values of the responses for the related items on the variable. A mean score near 5 was considered a very high level of support, between 3 and 4 a high level of support, and a score between 1 and 2 was regarded as low level of support. For the Perception of the Effectiveness of concept mapping in the instructional process, a mean score of 3.0 represents a 'neutral position'. This value representing a neutral position was used in this study to indicate a position that respondents neither agree nor disagree with a statement. A mean value below 3.0 gave a general picture of disagreement while a mean value above 3.0 gave a general picture of agreement with a statement (Figure 8). However, it must be noted that, a mean value above or below 3 does not imply that all respondents agreed or disagreed with a statement, but the majority were. Agreement or disagreement to a statement was therefore considered on majority basis. The percentages of the participants' response to the Likert scale items were also used to indicate the extent to which participants agreed or disagreed with the items.

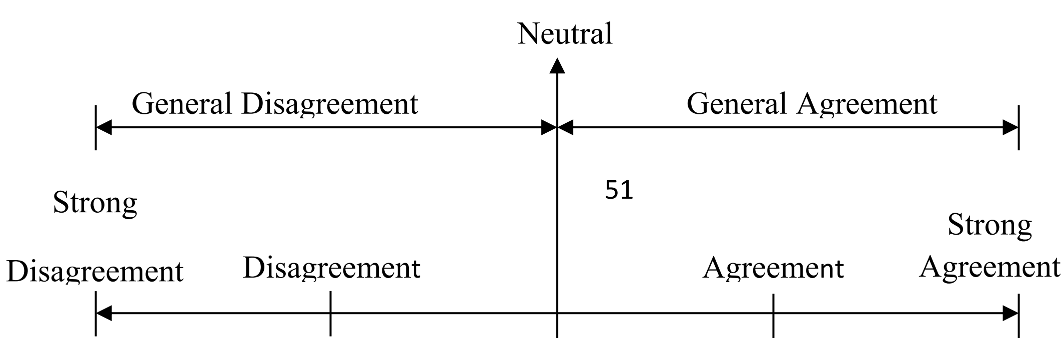


Fig. 8: The neutral position on the five-point Likert-type scale

3.5. Reliability and validity of Instrument

The issues of reliability and validity were vital in research because credibility of a research results depended on the reliability of the data, methods of data collection and also on the validity of the findings (Lecompte & Preissle, 1993; Cohen, Manion & Morrison, 2000). Fraenkel and Wallen (2000) cautioned that, it was possible to design a questionnaire that was reliable because the responses were consistent, but might be invalid because it might not measure the concept it intended to measure.

An expert who is senior lecture in the field of Chemistry Unit at the Department of Science Education in the UEW was consulted to evaluate the research instruments.

The West African Examinations Council syllabus for Chemistry and elective chemistry for Senior High Schools were used as a guide to ensure adequate reliability and validity of the research instruments. The required content materials for the volumetric analysis were extracted from the elective chemistry for Senior High Schools textbooks and other relevant advanced chemistry textbooks. The extracted content materials were used to prepare Student-and teacher-centred Concept-mapping Instructional Strategy Package. The research instruments consisted of lesson notes, students' test items and questionnaires, concept maps on volumetric analysis and other relevant instructional materials.

The validations of the content material as well as the Student-and-teacher-centred Concept-mapping Instructional Strategy Package were carried out through the assistance of two validators. The validators were asked to determine the appropriateness of the content material and to find out whether the instructional package can be used to achieve the objective of the lesson. The recommendations of the validators were used to revise the content material and the instructional package. The pre and post-test items internal consistency was determined by the use of test retest method of reliability co-efficiency. A high reliability values of (0.82) and (0.75) for the pre and post-test respectively were obtained with the use of cronbach's alpha computation relation,

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{K} \sigma_{Y_i}^2}{\sigma_X^2}\right)$$

where K is the number of components (*K-items* or *testlets*), σ_X^2 the variance of the observed total test scores, and $\sigma_{Y_i}^2$ the variance of component *i* for the current sample of persons.

3.6. Data Collection Procedure

An objective test items consisting of twenty-five test items on a treated sub-concept topics such as mole concept, balancing chemical equation, concentration of solution, etc. were administered to the sixty-two form two elective science students as a pre-intervention test with the assistance of science teachers. The questionnaire items on the effectiveness of concept maps in chemistry instruction was administered to the experimental group after the treatment.

3.6.1. Intervention Procedure

Two instructional strategies were used. The experimental group received the concept map instructional treatment, while the control group was taught using the traditional method.

The two study groups covered the same content material. Each group was met three times per week for six weeks. The content covered was extracted from the Senior High School chemistry curriculum. The units covered in volumetric analysis were, mole concept, chemical equation, and acid – base.

In the traditional teaching method, the main methods used were lecture- note-taking sessions, discussion and question and answer methods and laboratory sessions. The control group was given an introductory lesson on the first day, which included the unit objectives of the sub topics given above and some other questions which were designed to instill motivation. The succeeding days consisted of regular class discussions, paper and pencil activities, informal assessments, laboratory work and textbook exercises.

Secondly, the basic elements of concept mapping were introduced to the experimental groups.

The lesson on day one, started by defining what a concept map was and the actual steps that were followed in constructing concept maps. A concept map was defined as a tool that presents the relationships among a set of connected concepts and ideas. Concept maps were defined in terms of graphic organizers and other advance terms. The methods of Novak and Gowin (1984) were applied in preparing the lesson plan.

3.6.2. General procedure for constructing a concept map

The students were introduced to the following general approach to construct concept maps in relation to volumetric analysis.

Contextualization*:* Involved defining the context for the concept map. This was done by constructing a focus question for each of the topics. The focus question for acid – base titration was "what is an acid – base titration?" while that of mole concept was "what is mole concept? etc.

Brainstorming phase: In this phase, students were asked to write on small pieces of paper, the terms they knew in the topic "mole concept". Examples of concepts, students wrote included; Avogadro's constant, molar mass, mass number, e.tc.

The concepts were ranked according to how related they were hierarchically from general to specific. The more broader and inclusive concept was placed on top.

Lay out phase*:* In this phase students were asked to connect concepts with linking words by means of lines with arrows to show the relationship between concepts. These linking words in between concepts help to illustrate how the domains of knowledge were related to one another.

Finalizing the concept map**:** In this phase specific examples were given below each concept to consolidate meaning. Students during this stage were now asked to put their concept map into a permanent form.

It was important to recognize that a concept map is never finished. It depended on what domains of knowledge one was looking for. The steps that were stated above were just meant to serve as a guide to explore even more complex concept map structures.

In the second week, students in the experimental group were given the topic “mole concept. Students in groups were instructed to write the concepts as a matter of practicing how to construct concept maps. Lists of the written words were given by each group as a phrase bank. After the session, participants were instructed to list the words that they wrote.

In the same week, the experimental group received blank concept map with spaces assigned for the concepts in hierarchical fashion. Arrows showing the linkage between the concepts were included. The students completed their concept maps by copying from the example which was given.

The maps were also used as basis for discussion to emphasize the meaning of the concepts in the topics.

All concepts with equal importance or value were placed next to each other horizontally, guiding the students in relating concepts by positioning linking or connecting words on directional arrows.

These concepts were supported in some cases with examples to accrue meaning. For the rest of the week students in the experimental were given more time to practice the construction of concept maps using a concept list according to the subtopics outlined in acid – base and chemical equations. Students received feedback on their concept maps. concept map of each group was checked for accuracy and completeness at the end of the activity. To help self-check, a concept map rubric adopted from Novak and Gowin (1984) was used. Students were also told they could modify their concept maps and add more concepts if they wished so. The same procedure was done for the succeeding lessons. The students constructed the first concept map on mole concept using concept list provided.

On the third and fourth week, the students constructed concept maps on chemical equations, and acid – base titrations. The rest of the weeks were used for revision on construction of concept maps. The control groups were taught using lecture method.

The experiment lasted for six weeks after which the students in the control group (subjected to traditional teaching) and the experimental group (subjected to teaching using the concept map) took the same post- test. During the post test the students of the experimental group did not use the concept.

The scores for the post test were collected and marked to assess both group of students' progress and their understanding of the subject matter on the concept of volumetric analysis.

The participants' questionnaire items on participants' perceptions about concept mapping integration in chemistry teaching were administered to the experimental students after the post-treatment test for the analysis of the second research question.

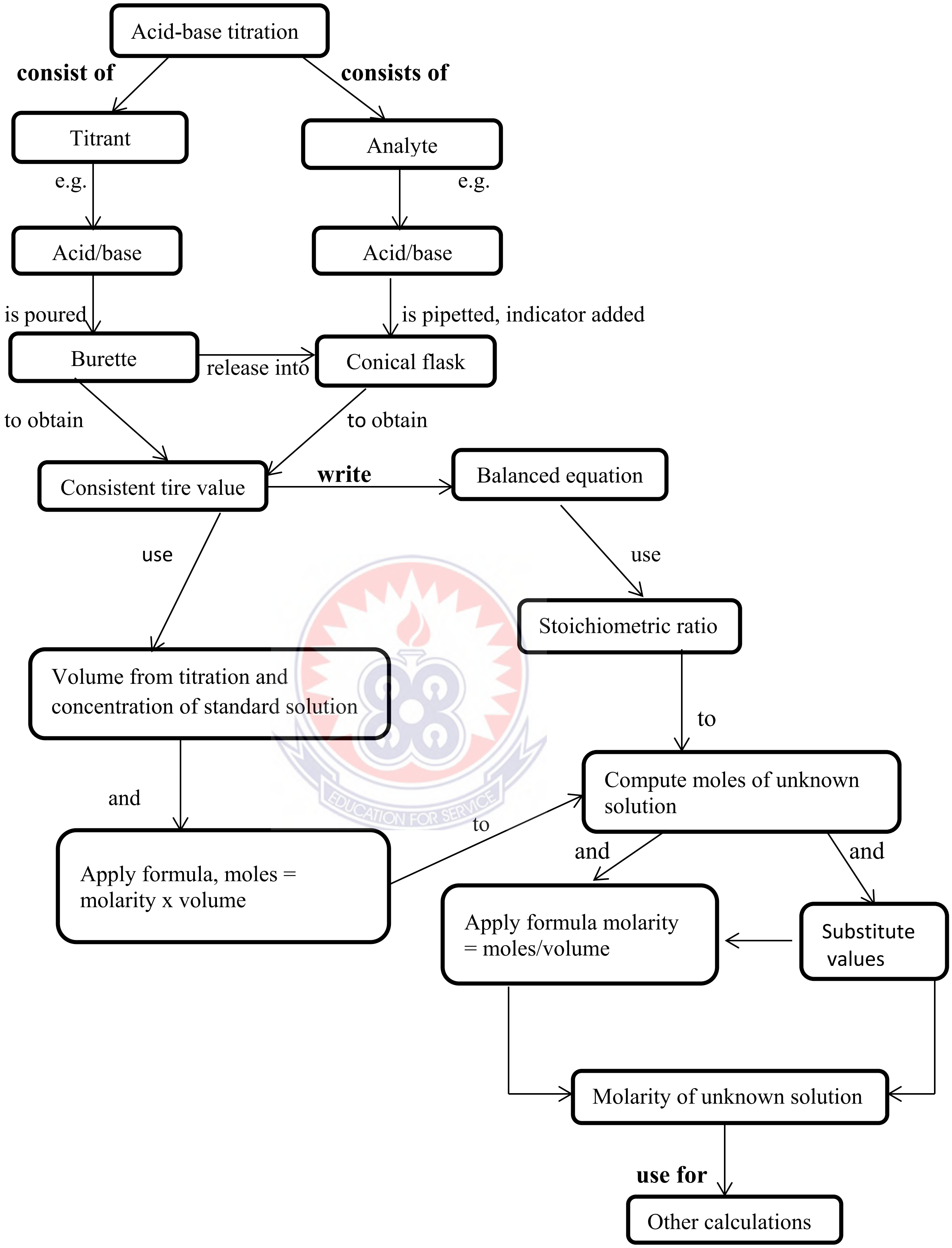


Fig. 9: Expert concept map for acid-base titration

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0. Overview

In this chapter, the findings from the investigation into the influence of concept mapping on students' performance in Chemistry, and their ability to construct concept mapping using volumetric analysis as concept were discussed in relation to the three research questions. The research questions are discussed with the use of quantitative t-test statistical tool and qualitative descriptive analysis of the pre-and post-test mean scores as well as the responses of questionnaire for the students. The findings of the study are discussed based on the research questions of the study.

4.1. Data Analysis

The Statistical Package of Social Sciences (SPSS) was used for data analysis.

The data from both pre and post tests were Analyzed using methods of descriptive and inferential statistics. The statistical procedures employed were: quantitative t-test analysis as well as descriptive statistical tool such as the mean, standard deviation etc. to determine the impact of concept mapping on students' performance in volumetric analysis.

The responses from the questionnaire items were analyzed through the use of descriptive explanation making use of averages, percentages and descriptive statistics such as means, and percentage scores were calculated for participants' responses. Some of the responses were exported to Microsoft Excel to plot Bar graphs and Pie charts.

4.2. Research Question One (1)

Would there be any significant difference in the performance between students taught with concept mapping method in contrast to those taught with lecture method?

Results of the post-test on students' achievement in volumetric analysis and other related chemistry topics have been answered by the use of both group students' mean scores in the post -intervention test when compared as shown in Appendix A2. The data collected were statistically calculated using the paired t-test as shown in the Table 2.

Table 2: Mean scores of the pre and post-test of the control and experimental groups.

Groups	Type of test	N	Mean scores	S. D	t-valve	p-valve
Experimental	Pre-test	27	40.56	5.96	15.17	9.857E-15
Control	Pre-test	27	58.52	7.65		
Experimental	Post-test	27	59.96	8.10	0.00	0.50
Control	Post-test	27	59.96	6.41		

The results in table 2 indicated that; mean test score from the control group (58.52) in the pre-test was higher than that of their experimental group (40.56). The computed p (9.857E-15< 0.05) value is less than the set alpha value (0.05). Therefore, the pre-test mean scores of the experimental and control groups were statistically significant different at 95% confidence level (t (52), at the beginning of the study. It again indicates that the two groups were not comparable on their initial understanding of the taught concepts in their subsumed concept. Hence the control group showed understanding of the topic under consideration.

However, the mean test scores of post-test of the Experimental group students had a high significant increased from 40.56 to 59.96 as compared to 58.52 to 59.96 for the control group (Table 2) with some slight increase in their test means scores. The control group did not record any major increase as shown by the post-test results.

From table (2) t-test analysis shows that the computed p-value for the post-test ($P = 0.5 > 0.05$) was greater than the set alpha value (0.05). Therefore the post-test mean scores of experimental and control groups were not statistically significant different at 0.05 alpha level ($t(52) = 0.00$, $p > 0.05$, after the introduction of concept mapping.

Therefore, there was no significant difference between the performances of both group students in their mean scores as can be seen in the table 2 above. However experimental groups demonstrated a better conceptual understanding of volumetric analysis with the use of concept mapping which reflected in their post-test mean score value after the intervention (concept mapping). The experimental group might be a group of students, who needed more time and more innovative teaching strategies to grasp concepts.

4.3. Null Hypotheses Testing

There is no significant difference between the performances of students who were taught volumetric analysis with concept mapping and those taught without concept mapping method.

The table below shows the mean scores of both experimental and control groups.

Table 3: Mean scores in volumetric analysis of control and experimental groups analyzed.

Groups	Type of Test	Mean score	Standard Deviation	Degree Freedom	t-value	p-value
Control	Post-test	59.96	6.41	26.00	0.00	0.50
Experimental	Post-test	59.96	8.10	26.00		

A two-tailed un-paired t-test was employed for the verification of the post -test mean scores of the experimental and the control groups. From table (3) t-test analysis shows that the computed p-value was greater than the set alpha value (0.05). Therefore the post-test mean scores of experimental and control groups were not statistically significant different at 0.05 alpha level (t (52) = 0.00, p>0.05, after the introduction of concept mapping.

It is therefore suggested statistically; that the null hypothesis is maintained or accepted at 95% confident level because concept mapping had only been able to raise the performance of experimental group.

In summary, this hypothesis rightly answers the research question one (1) posed in this study that "would there be any difference in volumetric analysis achievement test means scores between the students taught with concept mapping method of teaching and those taught by lecture method?"

4.4. Discussion of Results

From table 2, prior to the administration of the concept mapping instructional strategy, the experimental group was the sample within the lower and weak achievement range in the pre-intervention test. But from the analysed results in (Table 3), the experimental group though had the weakest mean scores in the pre-test, they were able to perform equally better as the control group after the introduction of the concept mapping instructional strategy.

This shows that with the use of concept mapping, both group of students' general performance had improved significantly and this indicates that concept mapping has a greater advantage of enhancing students understanding and retention of Chemistry concepts.

4.5. Research Question Two (2)

To what extent do the experimental students perceive the effectiveness of Concept mapping integration in enhancing chemistry instruction?

Table 4; indicates the ratings of experimental science students on the effectiveness of Concept mapping integration in chemistry as an instructional strategy and some of their responses were also illustrated using graphs and charts as shown below.

Table 4: The effectiveness of Concept mapping in the teaching and learning of chemistry.

ITEMS	SD n (%)	D n(%)	N n (%)	A n (%)	SA n(%)

5. I was more enthusiastic and motivated during the use of concept maps in the teaching and learning of volumetric analysis.	1(3.7)	1(3.7)	2(7.4)	4(14.8)	19(70.4)
6. The use of Concept maps as instructional techniques is an effective strategy for students of all abilities.	0(0.0)	2(7.4)	1(3.7)	4(14.8)	20(74.1)
7. The use of Concept maps in instruction reduces my personal interaction with my colleagues.	19(70.4)	3(11.1)	2(7.4)	2(7.4)	1(3.7)
8. The use of Concept maps provide aids for expanding what has been taught in class.	1(3.7)	3(11.1)	2(7.4)	3(11.1)	18(66.7)
9. The use of Concept map as instructional strategy would promote students understanding of concept and do away rote learning.	1(3.7)	1(3.7)	1(3.7)	2(7.4)	22(81.5)

ITEMS	**SD n(%)**	**D n(%)**	**N n(%)**	**A n(%)**	**SA n(%)**

10. Concept maps hinder students' Ability with learning tasks (e.g., writing, analyzing data, or solving problems).	12(54.4)	7(25.9)	1(3.7)	2(7.4)	5(18.5)
11. The use of concept mapping instruction is an effective means of helping students to understand the relationships among concepts.	1(3.7)	1(3.7)	1(3.7)	3(11.1)	21(77.8)
12. I find concept mapping method for learning chemistry easy to comprehend.	1(3.7)	2(7.4)	2(7.4)	4(14.8)	18(66.7)
13. The use of concept maps for learning almost always reduces the personal undue forgetfulness and recitation of mnemonics as well as acronyms during examinations.	1(3.7)	2(7.4)	4(14.8)	5(18.5)	15(55.6)
14. The use of concept maps for instruction would enable me to interact more with my colleague to promote group discussion.	2(7.4)	2(7.4)	1(3.7)	6(22.2)	16(59.3)
15. I feel the use of concept maps for instruction would affect my learning during my private time in a positive way.	1(3.7)	2(7.4)	2(7.4)	3(11.1)	19(70.4)

Majority of the participants (85.2 %,) strongly agreed with item 5, which indicated that the: "integration of Concept mapping in chemistry teaching would elicit student interest in Chemistry concepts. This is demonstrated graphically in a bar-chart shown in fig. 10.

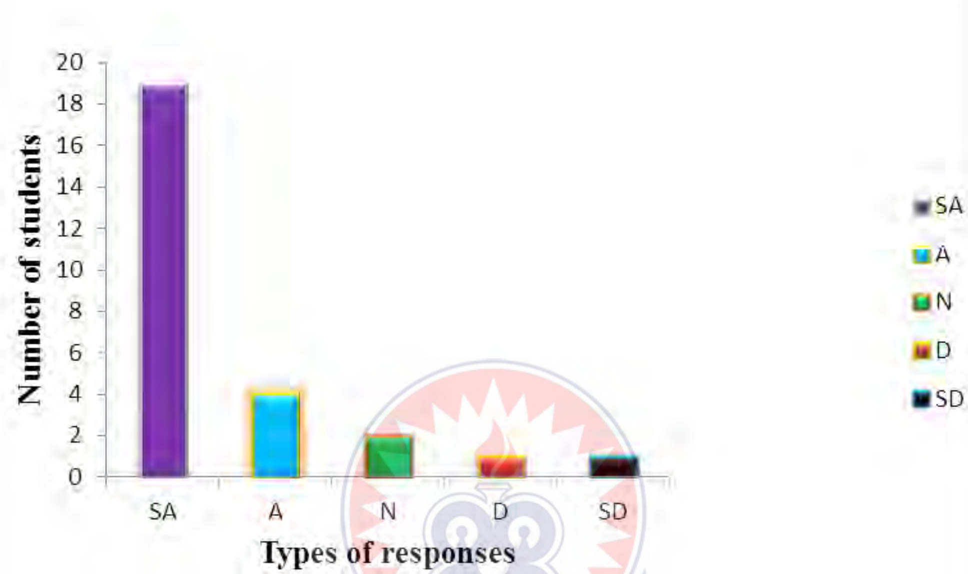


Fig. 10: Concept maps promote students interest in learning

For item 6, 88.9% representing (24) out of the 27 participants strongly agreed that Concept mapping was an effective tool for improving the ability and knowledge of students. This was confirmed by one of the participants who asserted that: "*Concept mapping can help improve the technical abilities of individual students*," and these responses are shown in Fig.11.

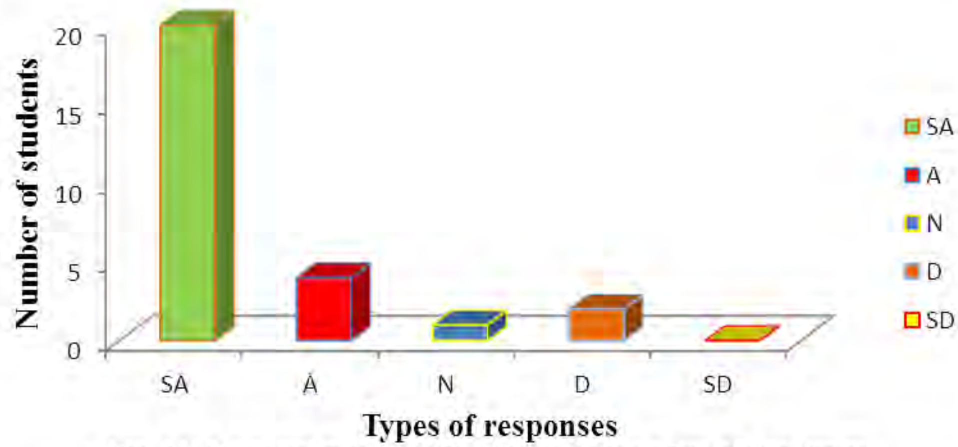


Fig. 11: Concept map is better for students of all ability levels

The item 7 was negatively coded, and 81.5% (n = 22) disagreed or strongly disagreed with the statement whiles 18.5% of the participants established that Concept mapping integration reduced their personal interaction with colleagues and the responses are presented Fig.12.

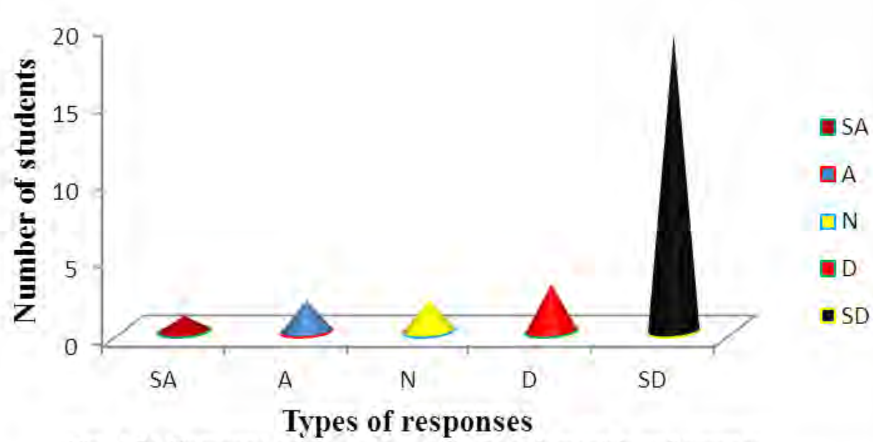


Fig. 12: Concept map reduces interaction with colleagues

Additionally, in item 8, 77.8% (n=21) of the participants strongly agreed that the use of concept mapping was an effective means of expanding what have been taught in class

(Table 4) as one of the participants indicated: *The enforcement and integration of concept mapping in science would go a long way to affect the subject positively even though there might be some lapses. It would help us to have an in-depth understanding of most topics in the teaching and learning of chemistry,* and the responses are presented Fig.13.

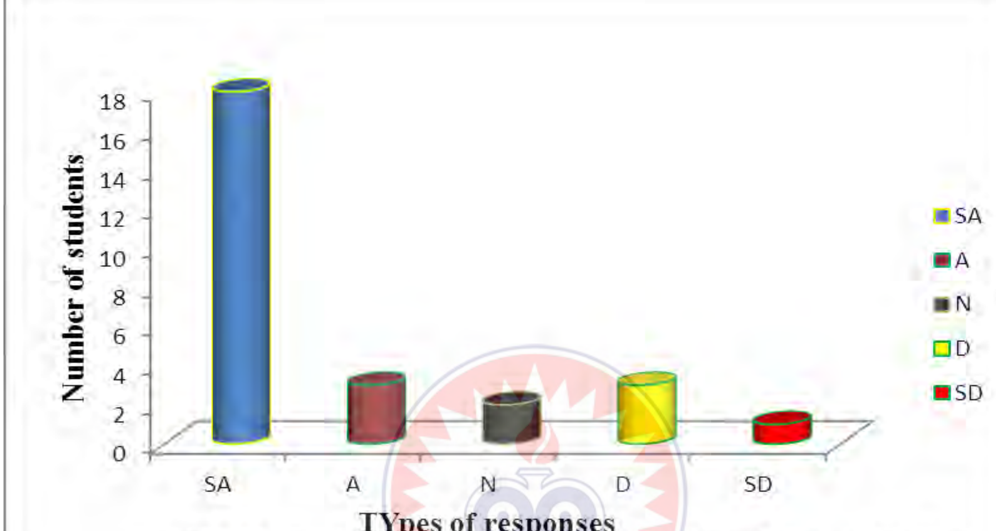


Fig. 13: Concept maps help with concept knowledge application.

For Item 9, 88.9% (n=24) of the participants strongly agreed that, Concept maps as instructional tool would promote the understanding of concepts and did eliminate rote learning and memorization of facts. This was indicated by one of the participant that: "*using Concept maps for instruction would promote our understanding of concepts and do away with rote learning and memorization of facts during examinations and tests in schools, this will arouse our cooperation and confidence in the study of chemistry in class*".

Item 10 was negatively coded with 48% of the respondents strongly disagreeing. This showed that less than half of the respondent perceived concept mapping to enhance students learning ability in chemistry instruction through writing, and analyzing of data for problem solving.

Notably with item 11, the significantly high number (n=24, 88.9%) of the participants strongly agreed that the use of concept mapping instruction is effective means of helping students to understand relationships among concepts and theories.

As indicated in table 4, 81.5% (n=22) of the participants for item 12, strongly agreed that they did find concept mapping method for learning chemistry easy to comprehend.

From table 4, 74.1% (n=20) of the participants for item 13, strongly agreed that the use of concept maps for learning almost always reduces the personal undue forgetfulness and recitation of mnemonics as well as acronyms during examinations, as one of the participants indicated*: that concept mapping is a tool for quick revision and remembrance.*

For item 14, 81.5% representing (20) participants strongly agreed, that concept mapping as a tool would enable them interact with their fellow students to promote group discussion.

Finally for item 15, 81.5% (n=22) of the respondents perceived that the use of concept mapping would capture their attention and, that the use of concept maps for instruction would affect their learning during their private revision time positively, as one of the participants indicated: *"Concept mapping enforcement and integration will enhance the teaching and learning of science as we are actively involved in the teaching and learning process. It will also enhance our analytical and critical thinking skills,"* and their responses.

The overall mean score on students' perception of the effectiveness of concept mapping integration in enhancing Chemistry instruction was 3.85(SD = 0.380) which shows that the participants of the study have a positive perception towards the integration and enforcement of concept mapping in chemistry instruction.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.0. Overview

This chapter of the study discusses the conclusion and educational implications of the study for Chemistry teaching and for further studies. It continues with the recommendations of the research study.

5.1 Conclusion

One important benefit of concept mapping, among others, to the learner is that it helps the learner about the structure of knowledge and the process of knowledge production. The usefulness of concept mapping to the teacher is that, it helps in promoting student understanding of concept. It also helps in the assessment of student learning, in particular, the diagnostic and formative aspects which enable the teacher to use the maps as starting points in building links between the prior knowledge and new knowledge that the teacher intends the students to learn as well as in addressing misconceptions or preconceptions that students may have at the beginning of learning period.

The findings of this study tend to suggest that concept mapping when efficiently used as a teaching strategy and study skill could enhance immediate improvement in post achievement test scores and retention of chemistry concept as compare to other study skills used by students. This will however, only be possible when the major limitations such as lack of appropriate knowledge on how to construct concept maps and lack of experience on the use of concept maps are eliminated. The use of concept maps in teaching is a very effective way of helping students to understand and relate topic to other areas of chemistry.

5.2. Educational Implications of the Study for chemistry Teaching

The use of concept-mapping to teach chemistry (science in general) has the potential to improve students' cognitive development. At the same time imparting positively on the affective and psychomotor domains because it enhances retention. The implication of this finding for science teaching and especially chemistry is that the strategy should be adopted in the teaching of science in general and chemistry in particular. This is because concept mapping involves head-on, heart-on and hands-on activities, which foster retention of knowledge. Hence, chemistry teaching and learning should involve the 3Hs (Head, Heart and Hands) are all at work.

5.3. Recommendations

In view of the conclusions drawn in this study, the following recommendations were posited:

- Chemistry teachers should learn and use concept-mapping instructional strategy as a means of assisting their students to improve their performance in chemistry in mixed gender and ability classes.
- Students should be taught how to construct concept maps on their own on various topics in Chemistry because this improves the cognitive structures of the students.
- Concept map teaching model should be incorporated in the new curriculum to supplement existing methodologies in order to enhance student understanding and linking of concepts. The traditional lecture method of teaching should be used together with the concept map teaching method in teaching Chemistry.
- In view of the immense versatility of concept mapping, it should be incorporated into teacher education programmes in order to equip chemistry student teachers with adequate instructional strategies that can make them effective teachers.
- It is recommended that: the Curriculum Research Development Division (CRDD) of the Ghana Education Service must as a matter of necessity re-examine the science curriculum and revise the existing syllabus to explicitly state what concept

mapping tools must be used and how it should be used in the teaching and learning process.

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APPENDICES

Appendice A1: <u>Pre-intervention (sub concept) test for the study.</u>

Name: ---

Age …………………

Date: ---

This is a multiple choice test of certain chemical concepts. Attempt all questions. Answer the questions by circling the appropriate lettered options from A – E.

Please use the following atomic masses.

Al = 27	**H = 1**	**K = 39**
Ca = 40	**Fe = 56**	
C = 12	**Mg = 24**	
Cs = 133	**N = 14**	
Cl = 35.5	**O = 16**	
Cu = 63.5	**Na = 23**	
S = 32	**Avogadro's constant = 6.02 x 10 ^{23}**	

Please do not spend too much time on any question which you have difficulty answering.

1. If 20.0g of NaOH is dissolved in 200cm^3 of water, what is the concentration of the solution?

   A. 0.5 mol per dm^3

   B. 1.0 mol per dm^3

   C. 2.0 mol per dm^3

   D. 2.5 mol per dm^3

   E. 3.0 mol per dm^3

2. How many moles of NaOH are in 500cm^3 of 4M NaOH solution?

A. $^1/_2$ mole

B. 1 *mole*

C. $1^1/_2$ moles

D. 2 moles

E. 3 moles

3. What mass of NaOH is contained in 500cm^3 of 1M NaOH solution?

A. 10g

B. 20g

C. 40g

D. 60g

E. 80g

4. Which of the following HCl solution is most concentrated?

A. 500mL of 2M HCl

B. 1000mL of 3M HCl

C. 300mL of4M HCl

D. 800mL of 5M HCl

E. 500mL of 6M HCl

5. What volume of 6M HCl solution is required to prepare 300cm^3 of 1M HCl?

   A. 50 cm^3

   B. 83cm^3

   C. 600cm^3

   D. 800cm^3

   E. 1800cm^3

6. 20cm^3 of 18M H_2SO_4 is diluted to a total volume of 1000cm^3. What is the molar concentration of this solution?

   A. 0.36M

   B. 0.72M

   C. 9M

   D. 12M

   E. 360M

7. What volume of 5M NaOH is needed to prepare 200mL of 2M NaOH solution?

   A. 15mL

   B. 20mL

   C. 40mL

   D. 80mL

E. None of the above.

8. How many moles of chloride ions are in200cm3 of 2M $CaCl_2$ 92cm^3

A. 0.036 mol of Cl^- ions

B. 0.3mol of Cl^- ions

C. 0.043 mol of Cl^- ions

D. 0.5 mol of Cl^- ions

E. 0.05 mol of Cl^- ions

9. Given this equation: $2SO_2 + O_2 \longrightarrow 2SO_3$

What mass of SO_2 would react with 32g of O_2?

A. 32g

B. 64g

C. 96g

D. 128g

E. 130g

10. $2NaOH + H_2SO_4 \longrightarrow 2H_2O + Na_2SO_4$

If 8.0g of NaOH reacts with 9.81g of H_2SO_4 to produce 3.60g of H_2O, then the mass of Na_2SO_4 produced is

A. 6.21

B. 8.31

C. 14.21

D. 17.81

E. 21.41

11. Assume sulphur was S_4. 3moles of sulphur would have a mass of

A. 24.0g

B. 96.0g

C. 128.0g

D. 256.0g

E. 384g

12. In the reaction: $C + O_2 \longrightarrow CO_2$

What mass of O_2 is required to react with 0.25mole of carbon?

A. 4.0g

B. 8.0g

C. 16.0g

D. 64.0g

E. 128g

13. The number of moles of NaCl in 908g of table salt is

A. 0.0644 mole

B. 15.5 mol

C. 585 mol

D. 72.0 mol

E. 5.31×10^4 mol

14. The mass of 6.02×10^{23} molecules of carbon tetrachloride (CCl_4) is

A. 1.0g

B. 30g

C. 47.5g

D. 6.02×10^{23}g

E. 154g

15. The number of moles of atom in 1.40g of copper is

A. 0.0013

B. 0.0220

C. 0.250

D. 0.50

E. 88.9

16. The number of moles of NaOH that would be equal in mass to 2.0 moles of $CaCO_3$ is

    A. 2.00

    B. 2.50

    C. 3.33

    D. 5.00

    E. None of the above.

17. How many moles of sodium contains the same number of atoms as 0.5 moles of calcium?

    A. 0.5 moles

    B. 1.0 moles

    C. 23 moles

    D. 40 moles

    E. None of the above.

18. Calculate the mass of ammonia (NH_3) containing twice as many molecules as 32g of oxygen (O_2).

    A. 17g

    B. 32g

C. 34g

D. 6.02×10^{23}g

E. None of the above.

19. In the reaction: $Cl_2 + C_{10}H_{16} \longrightarrow C + HCl$ (unbalanced)

The ratio of molecules of Chlorine (Cl_2) reacting with molecules of $C_{10}H_{16}$ is

A. 1:8

B. 8:1

C. 8:10

D. 16:1

E. None of the above.

20. Sulphuric acid + Aluminium hydroxide $\longrightarrow$ water + Aluminium sulphate

The balanced equation for the above equation is

A. $H_2SO_4 + Al(OH)_2 \longrightarrow 2H_2O + AlSO_4$

B. $HSO_4 + AlOH \longrightarrow H_2O + AlSO_4$

C. $3H_2SO_4 + AlH_3 \longrightarrow 6H_2 + Al_2(SO_4)_3$

D. $3H_2SO_4 + 2Al(OH)_3 \longrightarrow 6H_2O + Al_2(SO_4)_3$

E. None of the above.

21. The volume occupied by 0.02 moles of a gas at S.t.p. is

A. $0.112dm^3$

B. $0.224dm^3$

C. $0.24dm^3$

D. $0.448dm^3$

E. $0.422dm^3$

22. Calculate the number of moles of sodium hydroxide in $25cm^3$ of 0.5 $moldm^{-3}$ of its solution.

A. 0.0125 mol

B. 0.025 mol

C. 0.125 mol

D. 0.250 mol

E. 0.00250 mol

23. The molarity of a given solution is the same as

A. Mole of solute in a given volume of solution.

B. Mass of solute in a given volume of solution.

C. Mass of solute in 1 dm^3 of solution

D. Mole of solute in 1 dm^3 of solution.

E. Fraction of solute in a given volume of solution.

24. A $250cm^3$ solution contains 14.63g of a salt. Calculate the concentration of the solution in mole dm^{-3} if the formula mass of the salt is 58.5g mol^{-1}.

A. 0.063 mol dm^{-3}

B. 0.63 mol dm^{-3}

C. 0.25 mol dm^{-3}

D. 1.0 mol dm^{-3}

E. 0.2 mol dm^{-3}

25. Which of the following groups of substances has the same number of moles?

A. 8g of Mg, 8g of Al, 8g of K

B. 12g of Mg, 24g of Al, 36g of K

C. 2.4g of Mg, 2.7g of Al, 3.9g of K

D. 1.6g of Mg, 0.9g of Al, 1.3g K

E. 2.4g of Mg, 2.7g of Al, 39g of K

Appendice A2

Post-intervention test for the study

Time: 1 hour

Please answer each of the following questions to the best of your knowledge giving orderly representation of your work. These are questions on volumetric analysis.

1. D is a solution containing 2g of NaOH per 500cm^3 of solution.

   E is a solution of dilute tetreoxosulphate (VI) acid of unknown concentration.

   (a) Put E into the burette and titrate it against 25cm^3 portions of D using methyl orange as indicator. Repeat the experiment to obtain two consistent burette readings. Tabulate your burette readings and find the average volume of acid used.

   (b) Write a balanced chemical equation for the reaction.

   (c) From your results and information given, calculate the concentration of

   (i) NaOH in moldm^{-3}

   (i) Tetraoxosulphate (VI) acid in

   ($\propto$) moldm^{-3}

   (β) gdm^{-3}

   [Na = 23, O = 16, H = 1, S = 32]

2. Give one reason for each of the following during the titration.

   (i) Using an indicator during the titration.

(ii) Obtaining two consistent or concordant values.

(iii) Placing a white title on the retort stand.

STUDENTS' QUESTIONNAIRE

APPENDIX B: TEACHING WITH CONCEPT MAPPING STRATEGY

INSTRUCTIONS

Thank you for taking time to complete this questionnaire. Please answer each question to the best of your ability. Your thoughtful and truthful responses will be greatly appreciated. **Your individual name or any identification number is <u>not required</u> and will not at any time be associated with your responses.** Your responses will be kept completely **<u>confidential</u>** and will not influence your course grade and any of your examination results anywhere.

Please read the following statements and kindly provide the information required.

A. Background information

Please tick [✓] in the appropriate space provided below and supply answers where required.

1. Gender [ ] Female [ ] Male

2. Age ………………years

3. What is your pre-entry qualification?

[ ] BECE

Please other, specify…………………………………………………………………………

4. At what level were you taught the use of concept mapping? Please, tick [✓] only one level.

Nursery Level	
Kindergarten Level	
Junior High School level	
Senior High School level	
Other, please specify	

B. Perceptions of the effectiveness of Concept mapping on teaching and learning.

Please, tick [✓] the option that best reflects how you associate with each of the following statements.

Rating Scale: Strongly Agree (SA = 5), Agree (A = 4), Neutral (N = 3), Disagree (D = 2), Strongly Disagree (SD = 1).

Statement	SA	A	N	D	SD
5. I was more enthusiastic and motivated during the use of concept maps in the teaching and learning of volumetric analysis.					
6. The use of concept maps as instructional techniques is an effective strategy for students of all abilities.					
7. The use of concept maps strategy in instruction reduces my personal interaction with my colleagues.					
8. The use of concept maps provides a means of expanding and applying what has been taught in class.					
9. The use of Concept mapping instruction would promote the student understanding of concepts and do away rote. learning.					

10. Concept maps hinder students' ability with learning tasks.					
11. The use of Concept mapping instruction is an effective means of helping students to understand relationships among concepts.					
12.I find concept mapping method for learning chemistry easy to comprehend.					
13. The use of Concept maps for learning almost reduces the personal undue forgetfulness and recitation of mnemonics as well as acronyms during examinations.					
14. Concept maps for instruction would enable me to interact more with other students to promote group discussion.					
15. The use of concept maps for instruction would affects my learning during my private time in a positive way.					

(16) Please, give your general view(s) about the Perceptions of the effectiveness of Concept mapping integration in the teaching and learning of science as a practice to enhance students' performance in science in the space below:

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

…………………………………………………………………Thank you very much for your assistance and time.

APPENDIX C1

Sample of Lesson plan Instructions 1

Concept Mapping Technique 1 Instructions

Name……………………………………………………………..

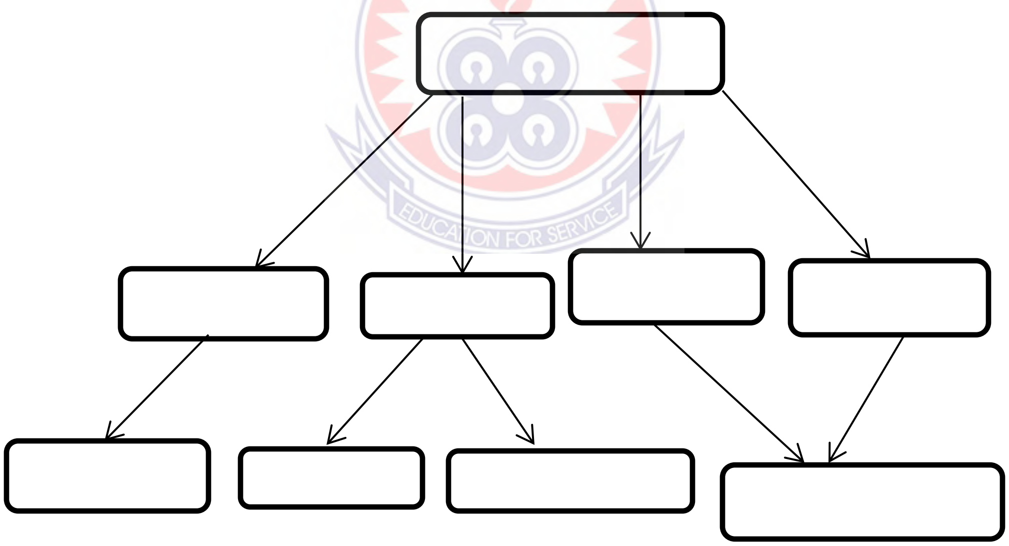
Week………………………

Examine the concepts listed below. They were selected from the chapter on mole concept that you recently studied. Fill the concept map using the terms provided below. Label the line using phrases or only one or two words.

When you finish your map check that: (1) you have all the concepts on the list in your map; (2) all the lines have labels; (3) your map is explaining mole concept.

LIST OF CONCEPTS

Mole	Molecular formula
Avogadro's number	Molar mass conversion
% composition	6.02×10^{23}
Empirical formula	Balancing chemical equation
Basic maths skills	



APPENDIX C2

Sample of Lesson plan Instructions 2

Concept Mapping Technique 2 Instructions

Name ……………………………………………………

Week………………………

Examine the map concepts listed below. They were selected from the chapter on chemical equation that you recently studied. Fill the concept map using the terms provided below. Label the line using phrases or only one or two words.

When you finish your map check that: (1) you have all the concepts on the list in your map; (2) all the lines have labels; (3) your map is explaining chemical equation.

LIST OF CONCEPTS

Chemical equation

Reactant

Products

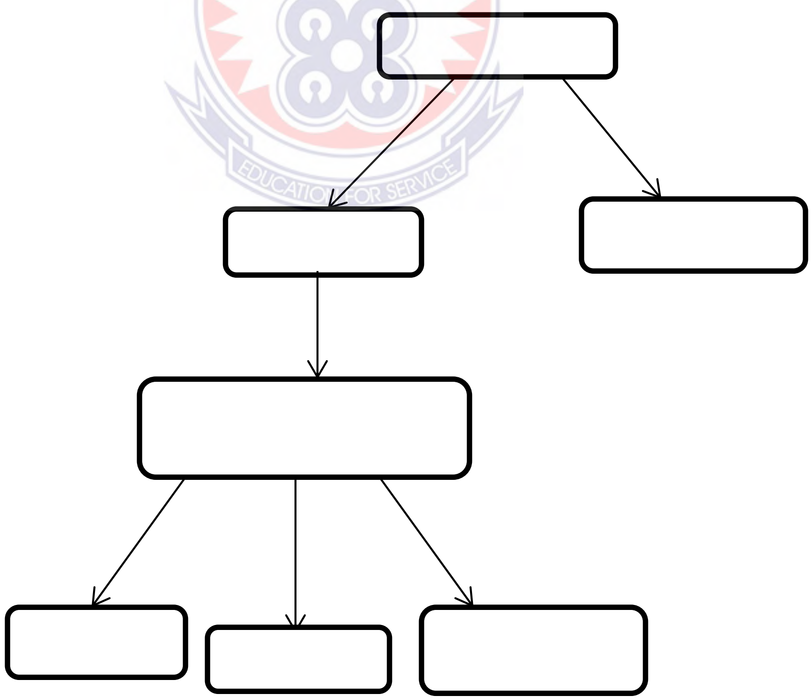
Avogadro's number – NA

Molar volume

Amount of substance – n = N/NA

Molar mass

Mass of substance



APPENDIX C3

Sample of Lesson plan Instructions 3

Concept Mapping Technique 3 Instructions

Name ………………………………………………….

Week………………………

Examine the map concepts listed below. They were selected from the chapter on acid – base titration that you recently studied. Fill the concept map using the terms provided below. Label the line using phrases or only one or two words.

When you finish your map check that: (1) you have all the concepts on the list in your map; (2) all the lines have labels; (3) your map is explaining acid – base titration.

LIST OF CONCEPTS

Acid-base titration

Acid/base

Consistent tire value

Apply formula, moles = molarity x volume

Compute moles of unknown solution

Volume from titration and concentration of standard solution

Apply formula, moles/volume

titrant

conical flask

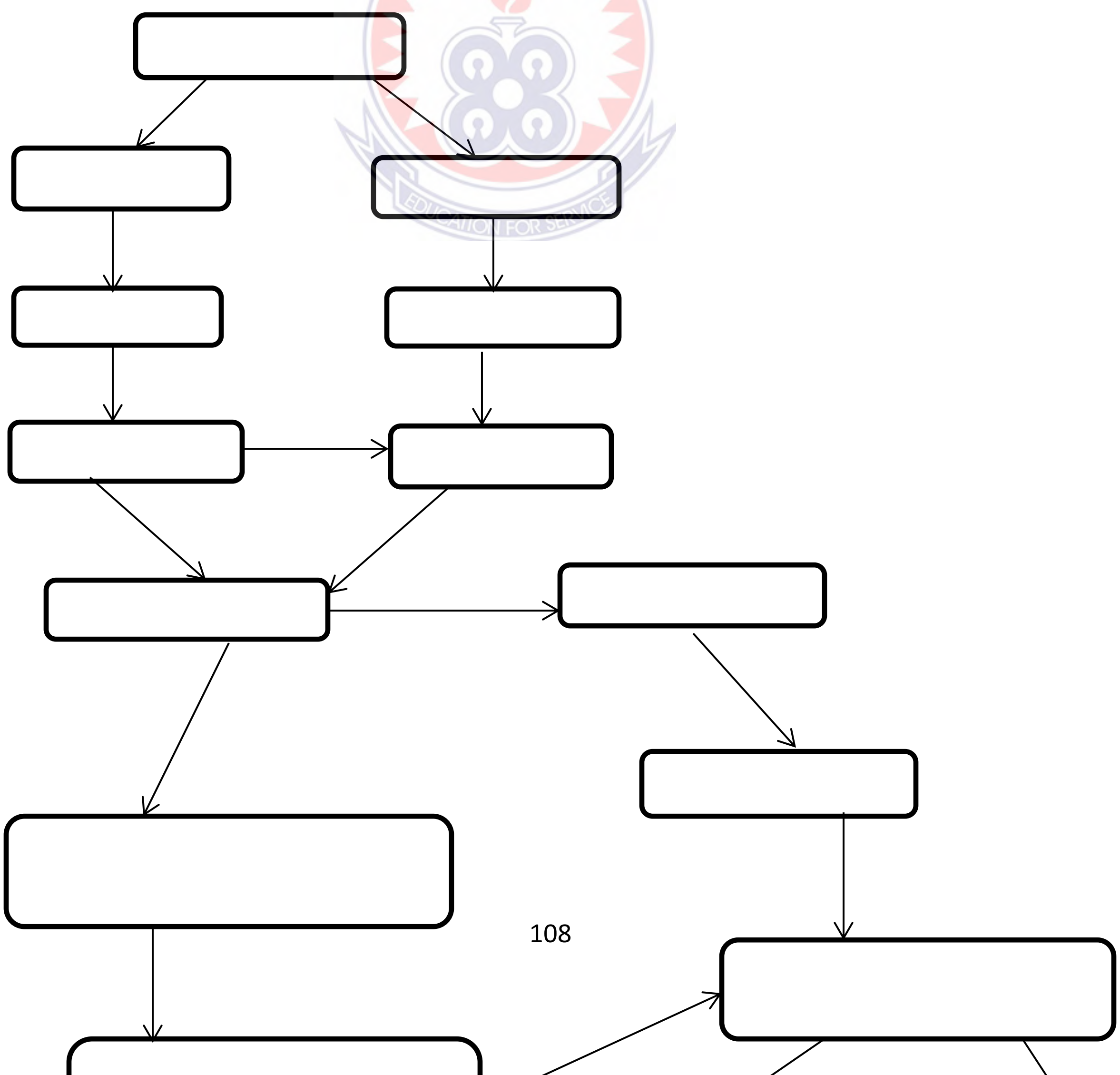
balanced equation

Stoichiometric ratio

substitute values

other calculations

Concentration /molarity of unknown solution



APPENDIX D

EXPERT AND STUDENTS CONCEPT MAPS

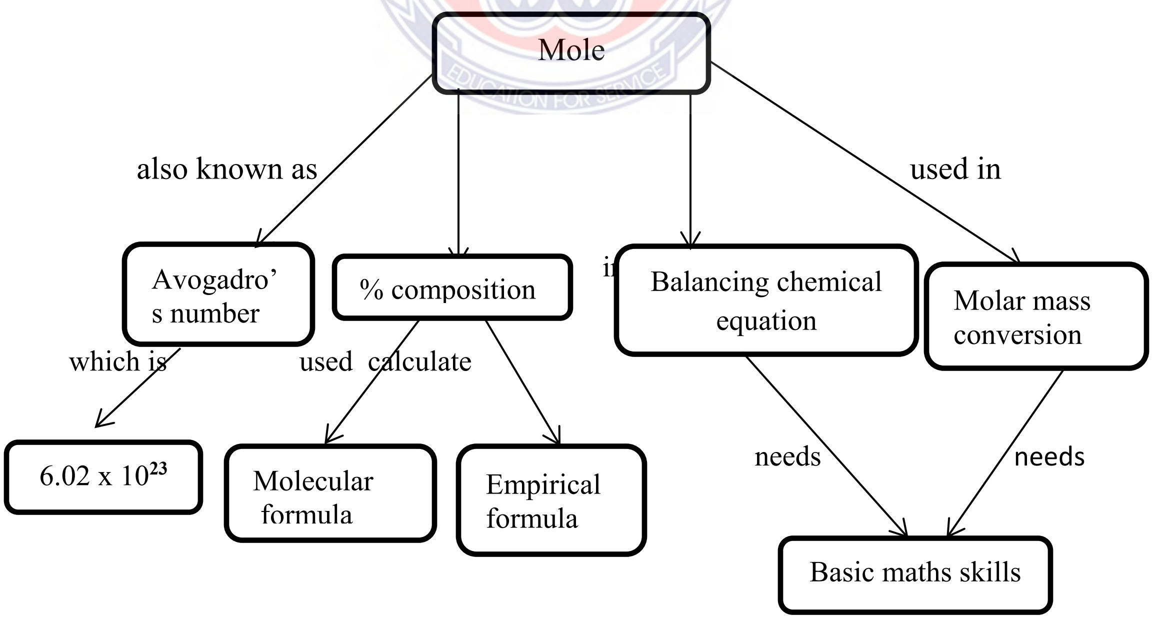


Fig. 14: Expert concept map on mole concept

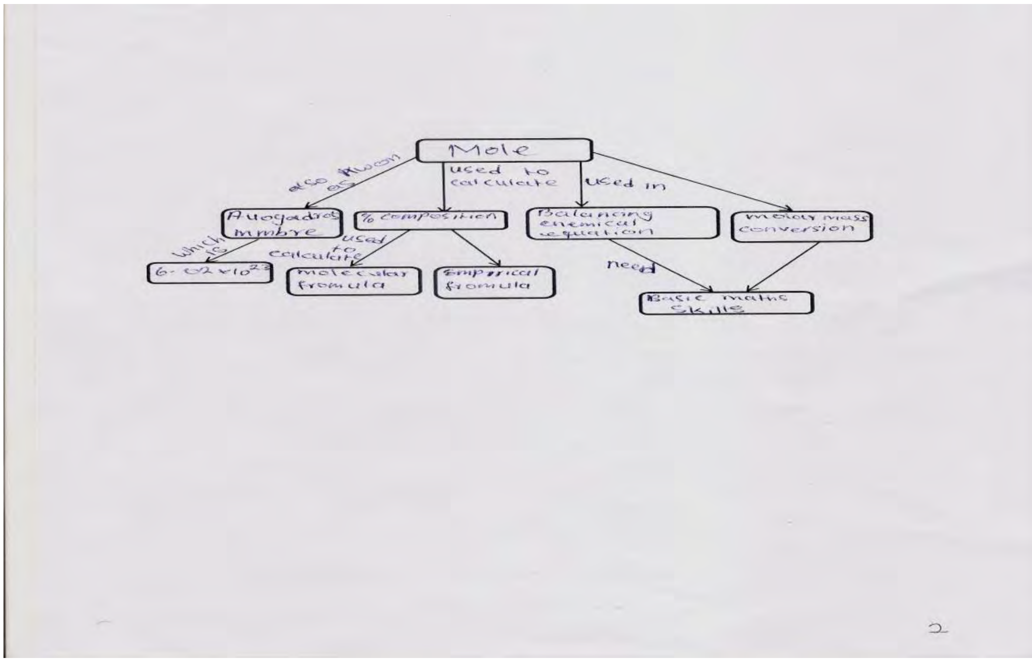


Fig. 15: A student concept map on mole concept

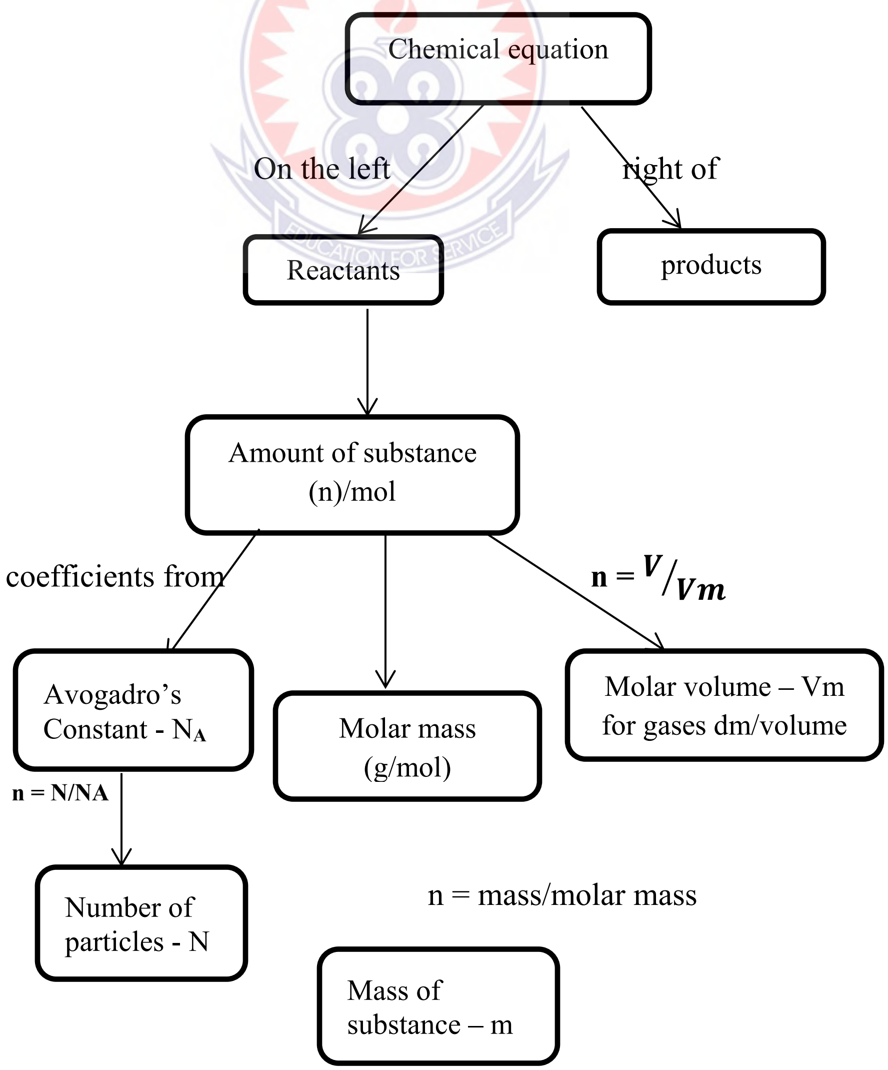


Fig. 16: Expert concept map on chemical equation

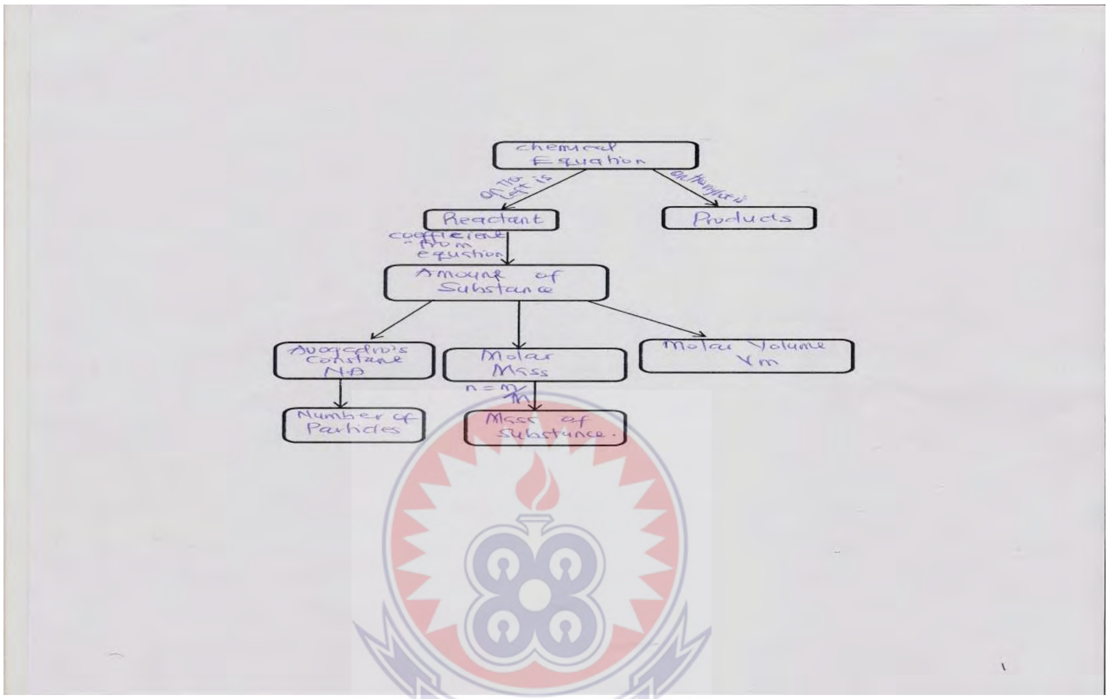


Fig. 17: A student concept map on chemical equation

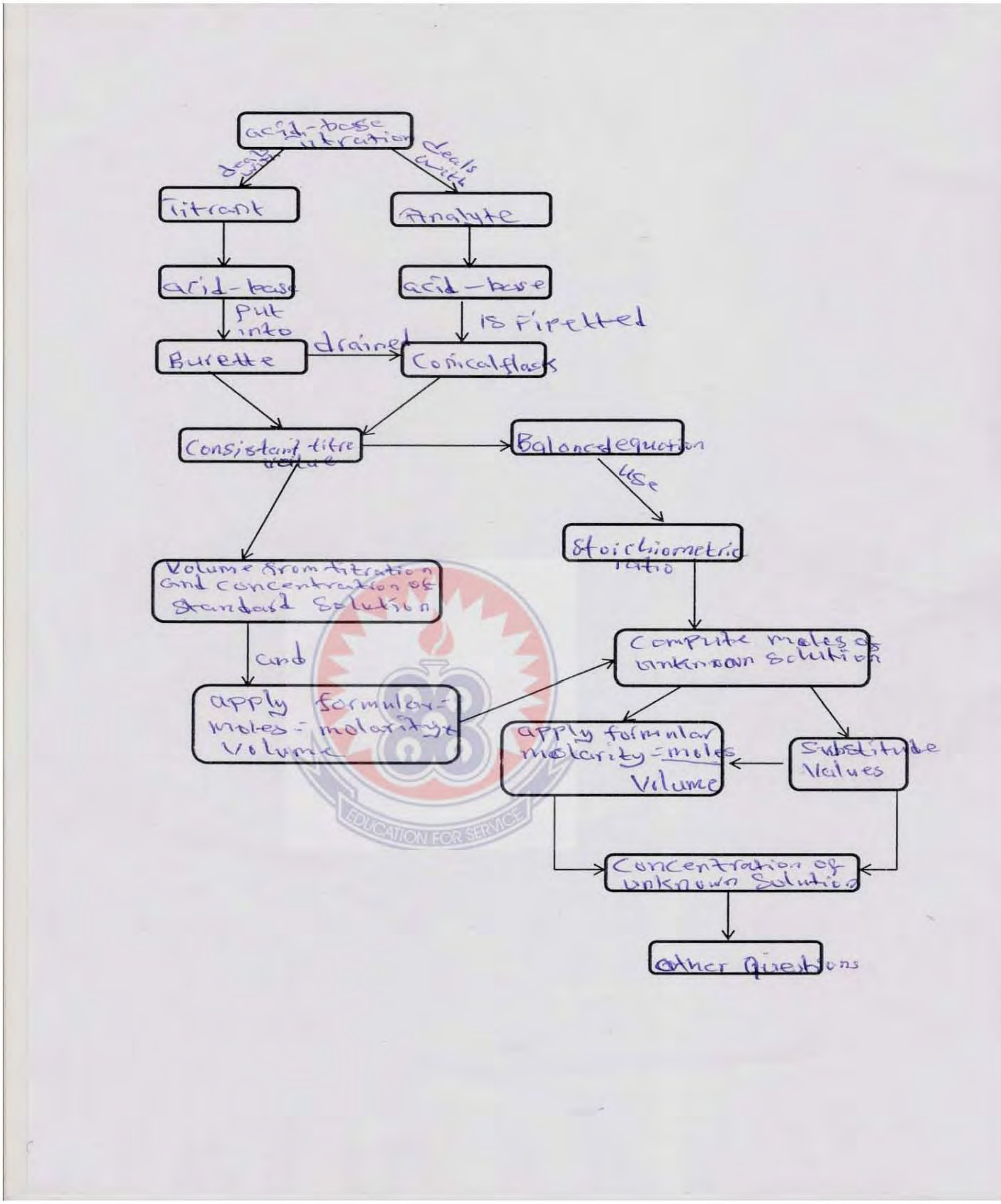


Fig. 18: A student concept map on acid base titration.

APPENDIX E

Wenchi Senior School SSCE results analysis

Table 5: Wenchi Senior School SSCE results analysis.

Year	**Total Entry**	**% that sat for the Examination**	**% Credit & above Grade**	**% Pass Grade (D7 & D8)**	**% Fail Grade (F9)**	**% Pass & Fail Grade (D7, D8 & F9)**
2002	840	96.85	34.42	29.47	36.09	65.56
2003	848	97.84	50.98	24.26	21.84	46.10
2004	930	98.07	38.97	26.38	34.19	60.57
2005	856	97.84	50.94	18.71	27.28	45.99
2006	980	97.59	44.90	22.73	30.11	52.84
2007	860	97.79	45.96	24.76	26.33	51.09
2008	890	97.65	44.44	27.41	26.39	53.80
Average %			42.87%	23.90%	28.81%	52.71%