UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF CONCEPT MAPPING ON STUDENTS' UNDERSTANDING OF PHOTOSYNTHESIS AND CELLULAR RESPIRATION AT AKIM SWEDRU SENIOR HIGH SCHOOL

FLORENCE HARVEY

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A THESIS IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE EDUCATION, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF THE UNIVERSITY OF EDUCATION, WINNEBA, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF PHILOSOPHY IN SCIENCE EDUCATION

2015

DECLARATION

STUDENT'S DECLARATION

I declare that this thesis, with the exception of quotations and references contained in published works which have 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.

Student's Name: Florence Harvey

Signature: …………………………

Date:………………………………

SUPERVISOR'S CERTIFICATION

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

Principal Supervisor's Name: Professor John K. Eminah

Signature:………………………

Date: …………………………..

Supervisor's Name: Dr. Joseph Nana Annan

Signature……………………………

Date…………………………………

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DEDICATION

This thesis is dedicated to my two children; Mawuena Tsegah and Mawuenyegah Tsegah.

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ABSTRACT

The aim of this study was to investigate the effect of concept mapping strategy on students' understanding of photosynthesis and cellular respiration at Akim Swedru Senior High School. The study was done with a sample of one hundred and five (105) second year students studying elective biology. The study was conducted over a six-week period. The students were pre- and post-tested using a teacher-constructed biology test. Results showed that there were significant differences between the experimental group taught with concept maps and the control group that learnt with the traditional method. Moreover, there were significant differences in the performance of females taught with concept maps and males taught with concept maps. These indicate that concept maps help students understand, identify the key concepts, and connect the various concepts. It was therefore recommended that concept mapping should be adopted by ags a teaching method by biology teachers in other Senior High Schools. It was also suggested that that the study be replicated across different regions.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter includes the background to the study and the statement of the problem. The purpose and objectives of the study, research questions, hypotheses, significance of the study, delimitations (scope) and limitations of the study are also provided sequentially.

1.1 Background to the study

Indubitably, the essence of Science and technology in today's development cannot be overemphasized. According to Anamuah-Mensah (1998), Africa has experienced immeasurable levels of development particularly in this era of globalization and neoliberalization and science and technology is the crux of this development.

The quest of perking up science and technology in Africa and the world at large has invigorated strategies to sustain the progress of Science and Mathematics. However, the methods of teaching science and mathematics have made the subjects unattractive to students and discourage them from pursuing these “cardinal subjects”. It is therefore important for both curriculum planners and teachers in the country to fashion education in a way that it could motivate and excite the curiosity of students in an informed and measured manner.

Effective instruction is often designed based on learning theories. Many researchers have voiced their concern about the pedagogical effectiveness of education software which are available and the importance of integrating learning theories in instruction. Ausubel’s learning theory is one important cognitive theory which emphasizes meaningful learning. Concept maps were first suggested by Joseph Novak, who had studied the educational field as an aid for learners to increase understanding (Richardson, 2005). The strategy was born out of the constructivist theory of learning which holds that the learner constructs or builds his own knowledge as opposed to the previous one (Basso & Margarita, 2004). Ausubel advocates the use of the advanced organizer which is based on the idea that the teacher is given a short description to the new material before the lesson to prepare the student to accept the new material (Reece & Walker, 2003).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 educational quality, a knowledge base that has not been tapped sufficiently.

Effective teaching also demands both intellectual skills and interpersonal rapport. Skills used in creating an intellectual excitement comprise the clarity of an instructional communication and positive emotional impact on the learners. Clarity is related to what one presents while emotional impact results from the way in which the material is presented. The accuracy of the content is quite important. However, knowing the content is quite different from being able to present it. The teacher must be able to present the material so as to develop the ability to analyze, integrate and apply facts in learners. These underscore the application of concept mapping in teaching.

Concept mapping is an instructional tool that is currently gaining popularity in the of science education (Abimbola, 1997a). It is a product of recent advances in cognitive science and the new philosophy of science innovations that helps individuals to remember learned concepts longer and to be able to use more effectively (Johnson & Raven, 1998).Cognitive psychologists and new philosophers of science, view learning as an active internal process, of construction of meanings where learners' prior knowledge plays a significant role for further conceptual understanding (Ausubel, 1968; Ausubel, Novak & Hanesian, 1978; Novak, 1991).

These educators consider learners to be the architects of their own knowledge for they construct their own idiosyncratic meanings of concepts and natural phenomena. They also consider learning, to be verbatim repetition of what has been presented to the learner or as a change in behaviour (Ausubel, Novak & Hanesian, 1978).

The new philosophers of science reject the traditional cumulative view of scientific knowledge, and replace it with a conceptual-change as reflected in the works of Kuhn (1970), among others. In general, it is these current ideas of cognitive psychologists with constructivist epistemological views, and the new philosophers of science that formed the cornerstone of concept mapping. However, it is the work of Ausubel (1963, 1968) and cognitive assimilation of Ausubel, Novak and Hanesian (1978) theory that formed the theoretical foundation of concept mapping. Novak and Gowin (1984) are the proponents of concept mapping.

Concept map is visualized through a graphical representation. Juall and Moyet (2005) maintained that concept maps are educational techniques that use diagrams to demonstrate the relation of one concept or situation to another by linking a central concept to another one, to help the learners understand the central concept better. So concept maps are presented as pyramids seen from above and they are arranged hierarchically with the super ordinate concept at the top of the map and subordinate at the bottom which are less inclusive than higher ones (Ahlberg & Vukko, 2004). Novak and Canas (2006) stated that concept maps are graphical tools for organizing and representing knowledge. The understanding of the learner and the interest which this understanding builds provide a structure into which the new concept to be learnt can be integrated into the learned concepts that the learner already possesses. That was why Novak (1990) stated that "concept mapping has become an important tool to help students learn meaningfully and to help teachers become more effective teachers". Concept mapping as stated by Novak has various uses. According to him, it is used as an advance organizer and it can be used as a powerful evaluation tool.

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

The study seeks to find out which of the methods will give greater understanding to students in biology and also find out if gender will affect students' understanding after being taught with concept mapping approaches.

1.2 Statement of the problem

For the past decade and over, Students' performance in biology at the SHS has not been good, with the proportion that passed obtaining (grade A-D) at the final examination, ranging from 39 to 47.9% (WAEC 2006-2014).

Many reasons could be cited for this poor performance among which were the prevailing instructional practices that did not actively involve students in the learning process and seemed to prevent them from taking charge of their learning (Francisco, Nicoll & Trautmann, 1998). Other students also perceived biology to involve a lot of reading, making it difficult for them to learn (Mucherah, 2008). Additionally, according to Anthony-Krueger (2007) inadequate and poor practical sessions in the laboratory may be contributing factors to students' poor performance in biology. This has necessitated the need to investigate the effect of using concept maps as an instructional tool in assessing students' understanding of photosynthesis and cellular respiration.

1.3 Purpose of the study

The purpose of the study was to investigate the effect of concept maps on students' understanding of photosynthesis and cellular respiration.

1.4 Objectives of the study

The objectives of this study were:

i. To determine the difficulties students encounter during lessons on photosynthesis and cellular respiration.

ii. To develop and implement concept mapping as a teaching strategy in biology for science students and study its effect on the understanding of photosynthesis and cellular respiration.

iii. To study the gender differences in science achievement in the use of concept maps.

iv. To study the perception of students towards concept mapping in science.

1.5 Research questions

To guide this study, the following research questions were addressed

1. What conceptions do the students hold of photosynthesis and cellular respiration?
2. What would be the effect of concept mapping on the students' understanding of photosynthesis and cellular respiration?
3. Are there differences in the cognitive achievement of the male and female senior high school students after being taught photosynthesis and cellular respiration using concepts maps?
4. What are students' perceptions of concept mapping approach for biology lessons?

1.6 Null hypotheses

The following null hypotheses were also formulated for the study.

1. There is no statistical significant difference between the conceptions held by students of both control and experimental groups on photosynthesis and cellular respiration.
2. There is no statistical significant difference between achievements of students taught photosynthesis and cellular respiration with concept mapping and those taught with traditional method.
3. There is no statistical significant difference in the achievements of male and female students when they are taught photosynthesis and cellular respiration using concept mapping.

1.7 Significance of the study

The findings and recommendations of this study would enable science teachers to use concept mapping strategy in their teaching and learning process. The study is likely to help teachers assist students who have difficulties in biology appreciate, understand and answer questions on photosynthesis and cellular respiration with precision. The study may also serve as reference for educational researchers who wish to study in similar areas. Again, it may help educational curriculum designers to place more emphasis on concept mapping learning strategy in the designing of the curriculum.

1.8 Delimitation

This study focused on the use of concept mapping on selected SHS students' understanding of photosynthesis and cellular respiration only. Other biology topics in the SHS syllabus were excluded. The study involved only SHS two biology students while those in SHS one and SHS three were excluded.

1.9 Limitation

This study was limited to an urban school in the Eastern Region of Ghana. Hence, findings would not be applicable to rural schools in the country. The limited time utilized to collect data may result in findings that may not reflect the true state of affairs. This apart, the use of intact classes may affect the data collected.

1.10 Definition of terms

For this study, the following terms were operationally defined as follows;

Subject matter: It is the topic for discussion or the topic being discussed.

Concept: A perceived regularity in events or objects, or records of events or objects designated by a label.

Concept maps: They are tools for organizing and representing knowledge. They include concept, usually enclosed in circles or boxes of some type, and relationships between concepts or propositions, indicated by a connecting line between two concepts.

Assessment - An exercise, such as an activity, portfolio, written exam, or experiment that seeks to measure a student's skills or knowledge in a subject area. Information may be collected regarding the teacher's or student's performance, student's behavior, and classroom atmosphere.

Cognitive knowledge - The level of understanding just beyond comprehension (basic understanding of meaning), which may include the application of rules, methods, concepts, principles, laws, and theories. It is knowledge that is concerned with the relationships and identification of the links among the 'item' of knowledge.

Conceptual knowledge - It is knowledge rich in relationships and understanding. Conceptual knowledge cannot be learned by rote; it must be learned by thoughtful, reflective learning.

Constructivism - The belief that the mind is active in the construction of knowledge. A constructivist perspective believes that learning is a social and cultural activity, that knowledge is somewhat personal, and that the learners construct meaning through experience and interaction with others.

Evaluation - A process used to analyze, evaluate, and appraise students' achievement, growth, and performance through the use of formal and informal tests and techniques.

Knowledge - A human creation where new ideas are constructed by creative people on the basis of their existing concepts and theories and of a search for new patterns or regularities in events or objects they observe.

Misconceptions - They are previously learned, but incorrect information.

Meaningful Learning - It is the process where the learner chooses conscientiously to integrate new knowledge to prior knowledge already processed by that learner and occurs when students build the knowledge and cognitive processes needed for successful problem solving.

Propositions - They are statements about some object or event in the universe, either naturally occurring or constructed. They may contain two or more concepts connected with other words to form a meaningful statement.

Achlevel 1 and achlevel 2 –Achievement level 1 and Achievement Level 2

SHS – Senior High School.

1.11 Organization of the study report

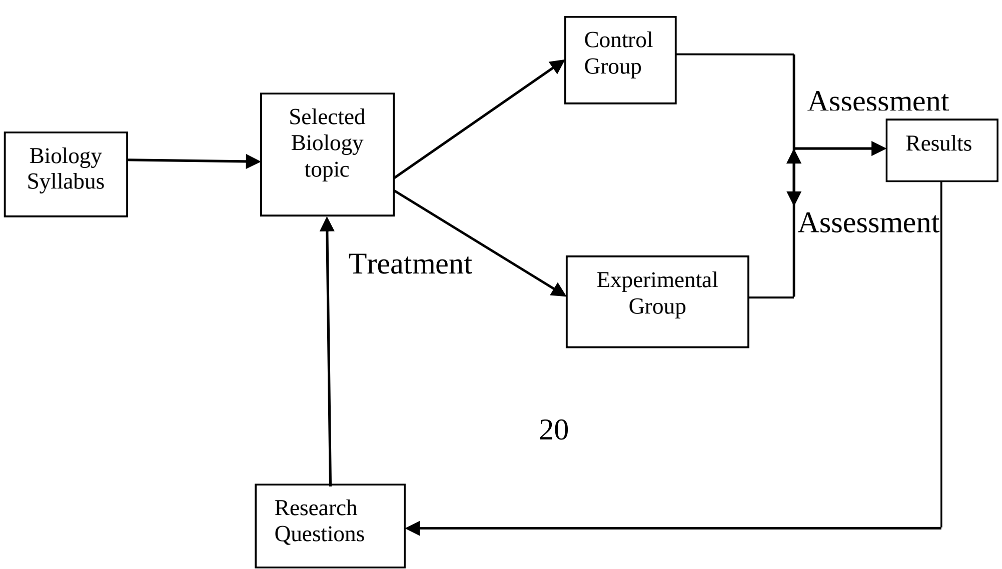
Chapter one is devoted to the introductory information relevant to the study. The literature related to various aspects of the study was reviewed in Chapter two. The procedures followed to carry out the study are described in Chapter three while the results of the study are presented and discussed in chapter four. Chapter five, deals with the summary, conclusions and recommendation of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter is devoted to the review of the literature related to various aspects of the study. It covers the concep tual



framework of the study, meaning and history of concept maps, types of concept maps, constructions of concept maps, attitudes of students on concept maps, effects of concept maps on students' achievements in biology, concept mapping and gender, concept mapping in the classroom and advantages of using concept mapping over traditional method of teaching.

Figure 1: Conceptual framework of the study

2.1 The meaning and history of concept maps

2.1.1 Concept maps

The concept map is a metacognitive tool that is applicable to any discipline at any level and can be used by both students and teachers to better comprehend the content and process of meaningful knowledge (Edmonson, 2000), thus, helping students learn. Concept maps have been popular throughout classrooms to help learners comprehend concepts and principles in their development and understanding of concepts, particularly in science education where they serve as useful and invaluable tools for both the teachers and students.

A tool for organizing and representing knowledge, concept maps are described as a two-dimensional node-link representation, which illustrates the most important concepts and relationships in a knowledge domain (Novak, 2001). It is a diagram that includes concepts and represents the connection between concepts, thus intending to “represent meaningful learning between the concepts in the form of propositions”. The concepts are written in enclosed circles or boxes of some type, and linked to each other by lines or labeled arrows (words on lines that connect the concept boxes). The labels or words specify the relationships between the two concepts connected. The concepts on a concept map help illustrate the interrelationship between the concepts and are represented in a hierarchical manner. Concept mapping serves as a strategy to help learners organize their cognitive frameworks into more powerful integrated patterns (Kinchin, 2005). In this regard, it serves as a meta-knowledge and a meta-learning strategy. Indeed, many researches on concept mapping have proved that it can improve meaningful learning and help learners learn independently (Kinchin, 2003; Mintzes, Wandersee& Novak, 2001). A concept is seen as a fundamental building block of knowledge. Novak (1995) defines concepts as a perceived regularity in events or objects, or records of events or objects, designated by a label. Propositions are statements about some object or event in the universe, either naturally occurring or constructed. Propositions contain two or more concepts connected with other words to form a meaningful statement. Sometimes they are called semantic units (p. 229).

2.1.2 Characteristics of concept maps

A major characteristic of concept maps includes the ability to represent knowledge in a hierarchical form. On some maps, the most inclusive and general concepts are located on the top of the map, followed by more specific and detailed concepts below (Novak, 1995). Some concept maps may be arranged in a different format where the most inclusive and general concepts are placed in the centre of the map and the more subordinate concepts are sprawled out in a spider web format, again represented in a hierarchical fashion. This hierarchical structure for the particular domain of knowledge is dependent on the context in which the knowledge is being applied (Novak & Canas, 2006). Concepts may only appear on the maps once, however, may be linked to a number of other concepts; hence functioning as a thinking tool, allowing the learners to draw connections between meanings and relationships between the concepts (van Dried & van Boxtel, 2003).

Concept maps also obtain the essential characteristic of including cross-links. Cross-links are the relationships "between the concepts in the different domains of the concept maps" (Novak, 1995, p. 229) and help to demonstrate how the concepts relate to one another in the concept maps. Cross-links help the learners visually see how some of the domains of knowledge represented on the map relate to each other. "In the creation of new knowledge, cross-links often represent creative leaps on the part of the knowledge producer" (Novak, 1995, p. 230).

Concept maps also have a feature that allows the inclusion of specific examples of events or objects that aid in clarifying the meaning of the concepts (Novak, 1995). Where it is possible, specific examples may be anchored from the concepts. The implementation of the specific examples of events or objects is another advantageous characteristic of concept maps.

The purpose of concept mapping is not the production of a map which represents in absolute terms the relationship between concepts, but the production of a visual layout which can make that specific issue clearer and certainly more understandable to the learner who produces the map (Cicognani, 2000, p. 154).

Concept maps have been utilized in a variety of applications, including as a research tool to help represent knowledge structures. The other applications in which concept maps can be found include:

i. facilitation of meaningful learning,
ii. design of instructional materials,
iii. identification of misconceptions or alternatives conceptions,
iv. evaluation of learning,
v. facilitation of cooperative learning,
vi. And encouragement of teachers and students to understand the constructed nature of knowledge.

Within the aforementioned applications, concept maps serve as a tool to help empower teachers and the learners, thus helping individuals make sense of their own experiences and constructing their own meaning for experience.

2.1.3 Advantages of concept maps

The advantages of the concept maps are:

1. Concept maps can be used as advanced organizer to improve learner's achievement.
2. Provide teachers with a meaningful and practical structured approach
3. Aid the development of deep meaningful teaching moving towards critical thinking rather than surface approaches

4. Concept maps also allow students to reflect their own misunderstanding and take ownership of their learning.
5. Organize their thoughts and visualize the relationships between the key concepts in a semantic way.

Concept maps are not the panacea for teaching and learning and do have some circumstances where the maps would not be advantageous. Some disadvantages of using concept maps encompass the inability of students to develop concept maps effectively, especially students who may lack the skills necessary to synthesize the knowledge. Not all learners benefit from visual aids and learn in a visual fashion; thus requiring a lot of tutorial support to understand the idea of concept mapping and its role in addressing knowledge. An alternative method of assessment may be required for learners who are unable to construct and comprehend concept mapping effectively (Williams, 2005). The construction of a concept map may become more complicated when assessing higher academic levels or multifaceted materials. It is impossible to include all the information into the concept maps.

2.1.4 Types of concept maps

There are four major types of concept maps: spider concept maps, hierarchy concept maps, flowchart concept maps, and system concept maps ("Kinds of Concept Maps", http://classes.aces.uiuc.edu/ACES100/Mind/c-m2.html). The spider concept map is organized with the domain of knowledge in the centre of the map. The sub-ordinate concepts surround the centre of the map. See Figure 2 for an example of a spider concept map.

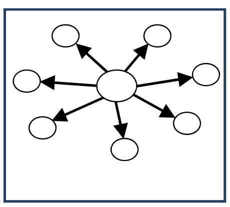


Figure 2: An example of a spider map

The hierarchy concept maps contain the domain of knowledge on the top of the map. The information is presented in a hierarchical structure where the information is in descending order of importance locating the essential information at the top. The less general and examples trickle down from the top of the map. See Figure 3 for an example of a hierarchy concept map.

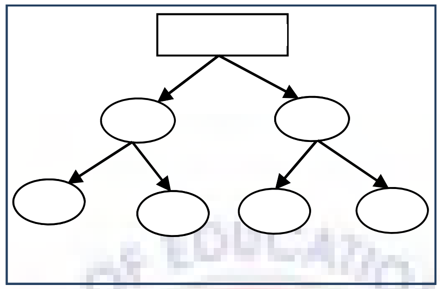


Figure 3: An example of a hierarchy concept map

The flowchart concept map contains information that is presented and organized in a linear format. See Figure 4 for an example of a flowchart concept map.

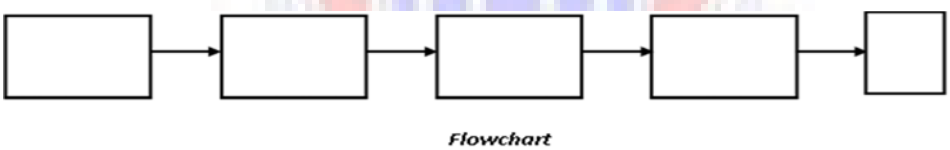


Figure 4: an example of a flowchart concept map.

The systems concept map is similar to the format of a flowchart, but includes inputs and outputs. See Figure 5 for an example of a systems concept map.

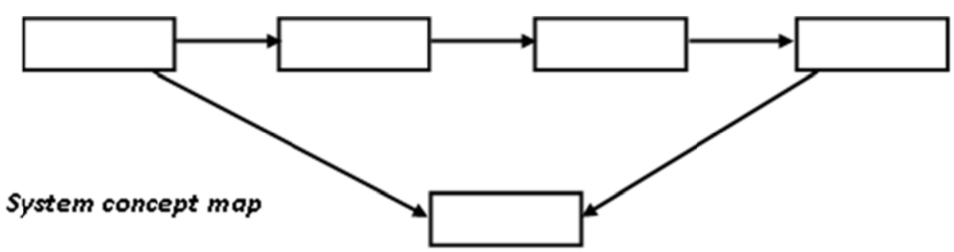


Figure 5: An example of a systems concept map

The standard presentation of concept maps according to Kinchin (2000) can be modified to include color-coding of different types of concepts, grouping of concepts types or usage of various shaped boxes to guide students with special needs. Concept maps with three-dimensional map structures can also be utilized in collaborative settings to facilitate discussions (van Drie and van Boxtel, 2003) or to create concept mapping games.

2.1.5 Construction of concept maps

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

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

1. Begin with the domain of knowledge that is familiar
2. Identify the context of the text, the field of activity or the problem
3. Construct focus questions. These are questions that clearly specify the problem or issue the concept map helps to resolve. Every concept map responds to a focus question. A good focus question can lead to a richer concept.

4. Identify the key concepts that apply to this domain. These key concepts could be listed at first, and then ranked from most general and most inclusive at the top to the most specific and least general at the bottom of the list. This list of concepts is called parking lots.
5. Construct preliminary concept map
6. Make crosslinks. These are links between concepts in different segment or domain of knowledge on the map to illustrate how these domains are related to one another. Cross links are important to show the learner that he understands the relationship between the sub-domains in the map.
7. Revise the map by repositioning the concepts
8. Construct the final map.

Novak and Canas (2008) hinted that, students should be selective in identifying crosslinks. They should also be as precise as possible in identifying linking words. Finally students are to avoid sentences in boxes. In constructing the concept maps, students can work individually in group or whole class with the teacher leading the discussion.

Novak and Canas (2008) think that students who find it difficult to add linking words in the "lines" of their concept maps, may be having poor understanding between the concepts or the meaning of concept and linking words that specify the relationship. They assert that, students‟ ability to identify the prominent and useful cross links is paramount. Bloom (as cited in Novak and Canas, 2008) emphasized that this process of crosslinks involves high level of cognitive performance such as synthesis and evaluation of knowledge. Edmondson (2000) therefore accepted that, this is one reason which makes concept mapping a very powerful evaluating tool.

2.2 Perceptions of students of concept mapping

Anamuah-Mensah et al. (1996) in their study in a secondary school in Ghana using concept map indicated that, students preferred concept mapping as a teaching approach to the traditional method of teaching. Also the students emphasized that concept maps are precise and comprehensive, making it a good technique for learning. The students made an insightful observation that, apart from the method being precise and comprehensive, concept maps present at a glance, the major concepts in a topic and how they relate; making the topic whole rather than a set of disintegrated concepts. The students commented that the discussions between teacher and students and among students themselves during concept mapping class promoted friendliness and cooperation among them and above all understanding of the concept.

Anamuah-Mensah et al. (1996) reported that the discussion among the students “led to personal knowledge of the individual becoming public knowledge” (p. 15). The students accepted the fact that, concept mapping was good for revision before examination. Bunting et al. (2006) studied first year tertiary biology student in New Zealand using concept map approach. Three groups were used, the experimental group were exposed to concept mapping in their tutorial class; the second group did not use concept mapping for the tutorials; the third group had no tutorials. After the intervention, students in the experimental group were asked to give their views on the concept map approach.

The students considered concept mapping to be a helpful strategy to determine the relationships between concepts and between conceptual themes. They reported that concept mapping tutorials helped them to understand lecture content more clearly because they explicitly identified and understood which concepts were related. Many of the students also appreciated the opportunity to work on constructing their own concept maps individually or in small groups. The students accepted the fact that concept mapping helped them to determine areas where they had weaker understanding. Scagneli (2010) in his study on third grade science students also reported that some of the students indicated they had fun and enjoyed constructing the concept maps.

However, some of the students found problem with the concept mapping strategy. Bunting et al. (2006) reported some of the students perceived that constructing concept maps can be time-consuming. Furthermore, some of the students indicated that, concept mapping does not suit every aspect of a topic, since some areas require charts, diagrams and tables. Students found concept mapping different to normal teaching approach and this made them uncomfortable with this approach to teaching and learning biology. Concept mapping does not favour assessments which require rote learning, hence those students glued to rote learning found concept mapping unfriendly.

The above perceptions of students in the various researches conducted, explicitly indicate that, even though concept mapping is innovative and effective compared with the traditional method, it is not a panacea for teaching and learning. As Shulman (1997) categorically pointed out, any educational inquiry possesses some limitations.

2.3 Effect of concept mapping on students' achievement in biology

Bunting et al. (2006) observed that students who studied biology using concept mapping achieved significantly higher marks than those who studied in the traditional way. However, for test items that did not require sophisticated level of conceptual organization, there was no significant difference between concept mapping group and non-concept mapping group.

Seaman (1990), in his study formed three groups: a concept mapping cooperative learning group consisting three small groups with three students each; a standard concept mapping group of 11 students; and a control group of 20 students. All the groups were exposed to the same science unit. Seaman found out that both students in the cooperative and standard mapping groups achieved higher than the control group when they were tested on vocabulary. Seaman noted that the high achievers in the concept mapping cooperative learning group were able to use their text books to gain information to place them in their concept maps, however, the low achievers did not use their text books well and performed very low.

Concept maps were used in a reading clinic to improve the achievements of students classified as learning disabled and students experiencing reading and writing difficulties. In these projects, teachers were given training to use cognitive mapping plans representing the six text structure patterns to help students organize and connect ideas in social studies, science and mathematics. The reading comprehensions and writing proficiency of low achieving 11th graders improved dramatically as did the reading and writing skills of 8th graders (Cronin, Meadow & Sinatra, 1990; Cronin, Sinatra & Barkley 1992; Sinatra et al. 1984).

Bos and Anders (1990) also found out that, junior high students with learning disabilities who used semantic mapping and semantic feature analysis demonstrated greater comprehension and vocabulary learning than those who received treatment with traditional approach Furthermore, Akpinar and Ergin (2008) taught students on animal cell using interactive computer animation instruction accompanied by teacher and student concept maps, and traditional method. They indicated that there was statistically significant difference between the concept map group and the traditional method group in favour of the concept map group. Asan (2007) in his studies, among fifth grade science students in Turkey, used inspiration which is a computer-base concept map to teach the experimental group and traditional method for the control group. It was found out that the experimental group achieved significantly higher than the control group.

A study conducted by Heinze-Fry and Novak (1990) indicated that there was no statistical difference in understanding between the concept mapping and non-concept mapping groups. However, they argued that, it might be due to the limited time for exposing the students to concept mapping as a learning tool. In the same way, Smith and Dwyer (1998) noticed that students in a concept mapping group were given short training session in the use of concept mapping in human circulatory system.When their understanding of the text was evaluated, there existed no significant difference between the concept mapping groups and non-concept mapping group.

Also, Boujaoude and Attieh (2008) indicated that there was no significant difference found between the experimental and the control groups who were taught chemistry using concept map and traditional methods.

However, Bunting et al. (2006) think that the reason many studies report no significance in understanding between concept map and non-concept map groups may be due to the focus of rote learning questions rather than tasks that require more sophisticated understanding of concepts. To Bunting et al., current findings also contribute to the broader concept mapping literature by distinguishing between the cognitive effects of concept mapping for different types of tasks, that is, those that require rote memorisation and those that entail deeper learning and the linking of several different concepts.

Ampiah and Quartey (2003) in their study using SSS 2 elective chemistry students in a girls' school in Ghana noticed that the experimental group achieved far better than the control group in acids bases and salts after the treatments. However, there was little difference between the non-concept mapping group (control group) and the concept mapping group (experimental group) in questions that demanded recall of facts. However they observed that students in the experimental group performed better than students in the control group in all questions involving understanding, explanation and application. Ampiah and Quartey indicated that "students in the non-concept mapping group provided answers that were mere statements of facts and lacked the systematic explanation to arrive at correct answers in some questions that require reflective thinking" (p.41). Nonetheless, they identified that both groups performed abysmally in test items that required problem solving. Boujaoude and Attieh (2008) also found out that there was significant difference at the knowledge level of which the experimental group scored higher than the control group. However, they found no significant difference at the comprehension and application-and-above level. Achlevel I (below average students) and Achlevel II (above average students) of the experimental group gained more than their counterparts in the control group at the post test in comprehension and application-and- above levels. They posited that concept mapping helped students who scored below the average mark achieve better on high cognitive level questions.

From the above, it is important that students engaged in concept mapping are exposed for longer periods for them to be conversant with its use and construction; since the duration of exposure has effect on students' performance. Also it is clear that, the type of questions or test items students are given is important. Students engaged in concept mapping tend to achieve significantly the same and sometimes below their non-concept mapping counterparts in questions demanding recall. Since concept mapping does not favour rote learning, students may perform significantly low if most of the test items measure knowledge.

Bunting et al (2006) added that concept mapping is useful for tasks that require understanding of links between concepts. Novak (1990a) further argues that concept map is no “magic bullets” or “quick fix” for classrooms where rote learning predominates. In other words concept mapping is not a solid ground for rote learning From the above, it is important that students engaged in concept mapping are exposed to longer periods for them to be conversant with its use and construction; since the duration of exposure has effect on students’ performance.

Bos and Anders (1990) as cited by Guastello et al., 2000) indicated that graphic plans or presentations serve to help students make mental constructs or schemata on how texts are organized. By mapping ideas into maps designed to model text structure patterns, teachers help students to visualize relationships and learn structures.

Jegede et al. (1990) conducted a case study in Ahmadu Bello University Demonstration Secondary School in Zariah Nigeria to find out the effect of concept mapping and students’ anxiety and achievement in biology. In all, 51 students comprising 30 males and 21 females were used for the studies. Both the control group and experimental group were exposed to same periods of instruction in cell respiration and nutrition in green plants. They found out that concept mapping group achieved significantly higher than their counterparts in the traditional method group. Also, they indicated that concept mapping reduced the anxiety of biology students.

Concept mapping can reduce anxiety of students, especially female students if they find it interesting and enjoyable. Hence the way concept mapping is introduced to students may motivate or demotivate them. Teachers therefore ought to be cautious about how concept maps are presented to students.

2.4 Concept mapping and gender

Novak and Musonda (1991) indicated that female students tend to construct less integrated and less complex or poor concept map than their male counterparts. However, Bello and Abimbola (1997) conducted a study on gender influence on biology students' concept mapping ability and achievement in evolution and found out that the ability to construct good concept maps is not limited to any student gender. They indicated that ability to construct properly integrated and complex concept maps was observed among both male and female students. However, the percentage of male students who constructed good concept maps was slightly higher than their female counterparts. It is important to explicitly indicate that concept map construction processes are free from sex related skills hence no particular gender has an advantage over the other. To Bello and Abimbola (1997), concept mapping requires logical and analytical thinking skills to construct a logical relationship among concepts in a hierarchical order. They further accepted the fact that their results could be facilitated by the student-teacher-centered concept mapping instructional strategy which enhanced students' ability to construct appropriate conceptions of evolution than the teacher-centered concept mapping instructional approach.

The finding of Bello and Abimbola (1997) is in agreement with findings of studies conducted by Abayomi (1988) and Bello (1997). Bello and Abimbola (1997) argued that this finding was so because the items in the achievement test were free from sex related issues and that the concept mapping technique used was a novel experience to all the students who took part in the study. They therefore concluded that concept mapping as an instructional strategy could be used in mixed gender classroom situation.

Boujaoude and Attieh (2008), in their study used a two-way ANOVA to find out whether or not there was group-sex interaction. They found out that there was significant interaction between group and sex. To find out the sources of the interaction, the means of the males and females were calculated. They indicated that females in the control group had mean scores lower than their male counterparts. However, the females in the experimental group had higher mean scores than their male counterparts. Also, they found out that there was no significant difference between the males in both groups.

In the same study, Boujaoude and Attieh (2008) found out that there was significant interaction between group and sex at the knowledge level. To find the sources of interaction, the means of males and females on the knowledge level was computed for both experimental and control groups. Females in the control group gained lower than their male counterparts. However, the females in the experimental group gained more than their male counterparts. Also there was significant interaction between group and sex at the comprehension level. The sources of interaction indicated that the scores of the females in the control group were lower than their male counterparts. However, the mean of the females in the experimental group was higher than that of the females in the control group. They however, did not find any significant interaction between group and sex at the application level. Boujaoude and Attieh explained that the cognitive learning styles of male and females should have favored the males to perform better than the females. However; he explained that the females who are field-dependent learners might have paid attention and followed instructions from teacher which made them perform better than the males who are field-independent learners.

Hall (2000) indicated that field independent learners have been referred to as " analytical, competitive, individualistic, task oriented, internally referent, intrinsically motivated, hypothesis testing, self-structuring, linear, detail oriented and visually perceptive" (p.5). Hall further described field dependent learners as "group oriented, global sensitive to social interaction and criticism, extrinsically motivated, externally referential, not visually perceptive, non-verbal and passive learners who prefer external information structures" (p.6). Governor (1998) added that field dependent learners are in more need of social input and external help in interpreting clues embedded in a particular learning task. Hu (1998) observed that field independent learners are more analytical and rely on less external clues than their field dependent counterparts. Field independent learners appear to have the ability to generate and structure their own knowledge rather than accepting knowledge reprocessed by others. The description of the two learning styles indicates that concept mapping may be an antidote to the individual differences that exist between these two categories of learners. However, the readiness of these learners to adopt the method easily is a way forward in improving on their learning and achievement in biology.

Dwyer (1998) also recommended removing hierarchical barriers in terms of classroom organization or forms of threat that have the potential of invalidating females learning efficacy, independent of course content. Mann (1994) reported that females faced with several challenging learning conditions such as instructor bias and passivity, and institutions that destroy friendship networks, were less likely to exemplify their learning styles in subject areas such as mathematics and sciences. It is therefore important to encourage teaching techniques that place more emphasis on collaboration and hands-on learning as well as recommend textbooks that depict females as authors of science books and originators of novel scientific discoveries.

Jegede, Alaiyemola and Okebukola (1990) in their study to find out the effect of concept mapping on students anxiety and achievement in biology indicated that female students had anxiety in the use of concept mapping; however there was a statistical reduction in anxiety of the part of the male counterparts. They explained that the statistical difference in anxiety against the females should be seen within the context of the pressures this society exerts on females who opt to study science in "male dominated" society in which science is seen as "masculine" (Jegede & Okebukola, 1988). They also found out there was no statistical difference in performance between male and female with the use of concept mapping. However, the conventional method of teaching seemed particularly unsuitable for girls as already indicated by Lynch and Peterson (1980) and Ruman, (1997). Jegede et al (1990) gave a reason that, "the metacognitive strategy of concept mapping can be used to overcome differential gender-related performance with respect to learning and achievement in science and technology" (p.957). This means that concept mapping and other metacognitive techniques of teaching and learning biology should be encouraged in biology and other science lessons.

Even though anxiety has been seen as a negative effect against females in science, one is of the view that in this present era, the anxiety in females towards biology and science in general should reduce drastically. However, biases and discriminating against females continues to pose a threat to promoting women into science. Erinosho (2005) asserted that, these biases and misconception about women and science are great challenges in the field of science education as people continue to describe science as a male enterprise. In Nigeria and Africa in general, gender biasness is still prevalent (Arigbabu & Mji, 2004). This according to Onyeizugbo (2003) is due to the sex roles which are rigid in Africa and Nigeria in particular, where gender differences are emphasized. It is suggested that, gender equitable instructional strategies in science, such as concept mapping should be used extensively by teachers as these could minimize the negative trend of gender on science achievement.

2.5 Concept maps as a form of evaluation

Concept maps can be used as a powerful evaluation tool because of the ability to evaluate the students' ability to map out concepts. Knowledge in the form of propositional statements can help teachers evaluate the learners' understanding of the concepts as opposed to looking at the learners' collection of discrete facts. Concept maps can help document changes in the students' learning and understanding of the material over time and can be utilized as tools to see the comparison between the students' generate maps and the expert's concept maps. According to Edmondson (2000, p. 20): Depicting student understanding in graphic or pictorial terms makes it accessible; when the structure of knowledge is made explicit, teachers (and students) can more easily correct common errors or misconceptions. They can focus explicitly on interrelationships, promoting integration, and tie examples or particulars to important key ideas, facilitating assimilation of the concrete with the abstract. Traditional paper and pencil tests are often inadequate for assessing these properties of the developing structure of students' knowledge.

Concept maps also provide students with immediate feedback regarding the depth of understanding that may not otherwise be reflected on paper and pencil exams (Edmondson, 2000). Concept maps also allow teachers to identify any misconceptions that are held. According to Novak (1996), Concept maps, on the other hand, can be utilized as powerful evaluation tools requiring high levels of synthesis and evaluation by simply asking students to map out a set of related concepts for any topic of instruction. If students are provided with 10 to 20 concepts to map for a given topic of study, they must evaluate which concepts are the most significant super ordinate concepts and also determine the subordinate concepts and appropriate linking words to describe the concept relationships. This requires successive efforts at synthesis and evaluation, as well as knowledge of the specific concepts and their definitions. If students also are asked to add to their maps several more concepts that are related to the concepts given, the challenge of recall, synthesis, and evaluation is strengthened further. This form of evaluation serves also as a powerful teaching vehicle. It is relatively easy for a teacher to identify the 10-30 concepts that are relevant to any given topic (pp. 39-40).Concept maps may also reveal specific information to teachers in identifying specific sections especially where the instruction was unsuccessful in teaching the important concepts or propositions (Novak, 1996).

Research in cognitive science has demonstrated that learning is meaningful when students are active and when they relate new knowledge to relevant concepts they already know (Canas, Hoffman, Coffey and Novak, 2003). In parallel with the recent advancements in computer-based visualisation, there has been growing interest in the application of concept map to enhance the quality of teaching and learning in higher education (Hay, Kinchin and Lygo-Baker, 2008) concept maps can also be developed using computer software that simplifies the inclusion and conversion of various colours, shapes, figures, hyperlinks, and audio. Such computer programs support easy manipulation, dynamic linking, publishing, and storage advantages (Canas et al., 2003). Prior research demonstrated that constructing a map with a coNovak, J. D. (1990a). Concept maps and vee diagrams: Two metacognitive tools for science and mathematics education. *Instructional Science, 19*, 29-52. Computer was perceived to be interesting and easier than doing with a paper and pencil (Chang, Sung and Chen, 2001). In addition to their application for representing knowledge, concept maps have been used in various ways including to evaluate learners' performance and diagnose misunderstandings (Ruiz-Primo, Schultz and Shavelson, 1997), design and develop a project, learning materials, and decision making (Coffey, 2007; Hughes and Hay, 2001), visualize information to foster cognitive processing of retrieving knowledge (Tergan, Keller & Burkhard, 2006), support problem solving performance (Kinchin, 2000), and assist navigation, search, and knowledge management in web-based learning environments (Canas et al., 2003). Higher-order mental functions can be developed by engaging in concept map. Jonassen (1996) states that concept map is a constructivist-based mind tool, "a way of using a computer application program to engage learners in constructive, higher-order, critical thinking about the subjects they are studying" (p.IV). Mackinnon (2006) showed positive impact of concept map on students' abilities to formulate arguments, lead effective discussions, and substantiate their conceptual frameworks. Contemporary research indicated that concept map had a positive effect on student achievement (Asan, 2007; Chiou, 2008; and Erdogan, 2009). Researchers employed concept map as a measurement or data analysis tool especially in qualitative studies of teacher education. For example, Lim (2011) utilized concept map as a heuristic approach to investigate the underlying structure of Korean student teachers' autobiographical reflections on their professional identity formation. Wilson, Nash and Earl (2010) explored the impact of collaboration between teachers and students with language learning difficulties on teachers' thinking about vocabulary teaching through the use of concept map as measurement of teacher knowledge and understanding. Similarly, Miller et al. (2009) employed concept map as a pre-test and a post-test to empirically measure teachers' conceptual growth after participation in a multimedia case-based instruction and recommended concept map as a credible and effective research tool. Cabellero, Moreira and Rodriguez (2008) found that concept map had great pedagogical potential for mental modeling to explore teachers' internal representations and their possible evolutions.

Assessment was another area in which the potential of concept map in teacher education has been investigated. Oliver and Raubenheimer (2006) incorporated online concept as an alternative assessment tool for distance education courses. The researchers observed student teachers' great interest in CM assignments and recommended using pre-selected term maps for assessments with reduced level of subjectivity, and open-ended maps for higher-order learning purposes. Buldu and Buldu (2010) investigated the potential contributions of concept map as a formative assessment in teacher education. The results of participant observations, questionnaires and focus group interviews showed that student teachers found concept map satisfactory and useful in reducing learning barriers, stimulating reflective thinking, and increasing student involvement and dialogue. The researchers affirmed that concept map could inform both instructors and students about the possible adjustments in their teaching and learning when implemented as formative assessment in the instructional process. Although these studies revealed promoting results, little is known about what pre-service teachers think about concept map tasks.

2.6 Concept maps in the classroom

Concept mapping is not a new commodity to education. They have been used in various classrooms, particularly in science education (Kinchin, 2000, 2001; Liu, 2004). Research studies reported in this literature review have indicated that concept maps have been useful as a powerful pedagogical tool to help students generate meaningful learning and to help teachers evaluate the students' understanding of conceptual knowledge.

In education, the concept mapping tool has been used for research, served as a communication tool, and as an efficient means of teaching and learning, specifically to help stimulate prior knowledge and to establish the relationships between concepts. Concept maps allow previous information and knowledge to be taken into consideration when implementing new ideas into a perceptual framework; thus following a constructivist epistemology.

A study by Turns, Atman and Adams (2000), focused on the usage of concept maps for both course-level and program-level assessment in engineering education. Turns et al. (2000) used intrinsic examples of concept maps to demonstrate how concept maps can serve as an assessment on a variety of functions ranging from everyday grading to the exploration of the conceptual structures of the high-level students. According to Turns et al., concept maps are "not a perfect assessment solution" and may "require extensive time to interpret and can still remain ambiguous" (2000, p. 172). Therefore, demonstrating the conceptual knowledge and the relationships between the concepts through the students' concept maps does not "guarantee that the students will be able to use the concepts to support design or other authentic engineering activities" (p. 172).

Although popular in secondary science education classrooms, concept maps have also been used in social study classrooms (van Drie and van Boxtel, 2003) to help students develop conceptual understanding of history. van Drie and van Boxtel believe that "concept mapping is a powerful strategy which enables pupils to construct a deep understanding of crucial substantive historical concepts" and also recommend using concept maps in history lessons as an introductory task, concluding task, and as an inquiry (2003, p. 40).

Students have the potential to move from patterns of rote learning to patterns of meaningful learning when asked to generate a concept map. According to Novak (1996), there has not been a single case in which a student who attempts to produce a hierarchical structured concept map failed to achieve patterns of meaningful learning.

2.7 Advantages of using concept mapping strategy over the traditional method of teaching

Concept mapping as a teaching method has numerous advantages over the traditional methods of teaching. These include concept mapping as a metacognitive tool. Concept maps have been described as "metacognitive tools" that encourage students to think reflectively about what they know through the visual representation of concept meanings and relationships. Harpaz, et al. (2004) stressed that the mapping technique enables the learner to understand the main concepts of the area of knowledge and the connections between them, and to represent the concepts in a way that shows his or her way of understanding. Concept maps are metacognitive tools that assist learners to "see" their own thinking and reasoning about a topic as they depict relationships among factors, note causes and effects, identify predisposing factors, formulate expected outcomes, and so on. The process of creating and modifying a concept map involves making decisions about the different ways concepts are related to one another, leading the individual to reflect on prior knowledge as it relates to new material (McAleese, 1998).

The author Chabel (2010) believes that concept-mapping is an integral teaching method to facilitate metacognitive thinking. Concept-mapping encourages meaningful understanding by helping students to organize and connect the information they already know about a subject with the new knowledge. The student's conceptual knowledge is illustrated well through concept-mapping. It is recommended by Chabeli (2010) that educators can use concept-mapping to facilitate critical thinking and encourage a deep approach to learning. Based on observations and interviews with students engaged in academic reading, Marton and Saljo (1976) have been credited with identifying two fundamental approaches to learning: deep and surface. The deep approach to learning is directed at understanding meaning that resulted in greater retention of learned material over time. The surface approach to learning is directed toward learning the text itself, with less attention on understanding the meaning of the text. Metacognitive processes, enable the learner to flexibly and selectively coordinate knowledge, lead to a deeper level of understanding by making students responsible for their own learning (Georghiades, 2000). The goal of this method is to achieve a method of meaningful learning that occurs when the learner actively connects new concepts to existing concepts from former formation of knowledge. Accordingly, this helps complete the missing knowledge and clarify existing knowledge (Harpaz et al., 2004).

The studies of Chabeli, (2010), Taylor, and Wros (2007) and August-Brady (2005), manifest that concept mapping is an effective metacognitive tool and an effective teaching strategy in science to evaluate both content knowledge and student thinking patterns.

However, the traditional teaching method lacks student focused learning that is, it inherently places the most value on standards, curriculum and passing tests as opposed to student-focused learning. Student-focused learning places value on the student and builds the curriculum around the questions young people need answered in order to understand the material. Constructivist learning builds on the knowledge students already have allowing them to form concrete associations to new information, which improves retention. Traditional learning is based on repetition and memorization of facts that students care less about and retain at lower rates after testing.

Concept mapping has also been found as a tool for improving critical thinking. A number of articles in the nursing literature support the use of concept mapping to promote critical thinking in nursing education. Abel and Freeze (2006) noted that concept mapping diagrams the critical thinking strategy involved in using the nursing process. The ability to think critically and solve problems in different clinical practice settings is required for all nurses, including those who are newly registered and nursing students. Toofany (2008) stated that the selection and implementation of learning activities that promote critical thinking and the use of the nursing process are essential elements of nursing education. As for Chabeli (2010) concept maps are valuable tools with which to harness the power of the learners' vision to understand complex information at a glance. Concept-mapping is a teaching method to facilitate critical thinking. The concept map is recognized as a teaching strategy that promotes critical thinking because it stimulates deep understanding. Students work through the process of organizing, analyzing, and communicating interrelationships among concepts through a visual representation of components (Hsu, 2004).

Meanwhile the traditional teaching methods lack emphasis on critical thinking; it does not encourage critical thinking skills, the ability to actively apply information gained through experience and reasoning. Instead, traditional training emphasizes the role of teachers as knowledge dispensers and students as repositories. This style of learning does not allow students deeper levels of understanding required for complex concepts and lifelong learning (Jaebi, 2013).

Again, concept mapping have been widely accepted as a good teaching and learning method. Harpaz, et al. (2004) revealed that one of the goals of nursing educators is to help students develop skills that enable them to continue acquiring knowledge independently, even after their formal education is completed. In this era of abundant information and technology that is characterized by rapidly changing data and knowledge, it is up to the students to learn how to study, and even more, how to organize the knowledge and differentiate between significant and insignificant information. There are several methods of teaching that can help the student in the process of becoming a "smart learner." One of the strategies of teaching - learning that promotes this educational concept is called concept mapping.

Clayton (2006) advocates concept mapping as an active teaching strategy that can help educators prepare students to think critically. Educators are urged to use concept-mapping as a method of individual or group assessment and evaluation to assess the learners' conceptual understanding and handling of complex information (Chabeli, 2010). Concept mapping involves the use of flow charts to organize central concepts and which facilitates understanding of the relationships between them. Research has shown that concept mapping is an advanced method for successful learning (Harpaz, et al., 2004).

The article of Kostovich, et al. (2007) focused on the use of concept mapping as a way to tutor students who were having difficulty in their senior adult health course. The use of concept mapping was then extended and used as a teaching tool for all students in the course and as one way to evaluate students' understanding of key concepts in the course. The literature describes concept mapping as an effective strategy for many kinds of learners, especially for students in health related programs. From the study of MacNeil, (2007), pre-lecture and post-lecture concept maps describing wellness were used to measure teaching effectiveness. The pre lecture concept maps help determine what students know about general concepts prior to instruction, and the post lecture concept maps helps determine the knowledge that has developed. The use of a pre-lecture and post-lecture concept mapping process provided an authentic and innovative evaluative technique to determine understanding of concepts. The post-lecture concept maps showed significantly more detail than did the pre lecture concept maps, and the complexity of the post-lecture maps provided evidence that the students had a clearer understanding of the nursing course, as a result from the studies of Wilgis, and McConnell, (2008), MacNeil, (2007) and Abel, and Freeze, (2006).

Concept mapping has been found to be a useful teaching strategy and an effective method to evaluate students thought processes as depicted from the study of Wilgis, and McConnell, (2008). The improvement in concept mapping scores shows that even a brief experience with using this strategy during a two-day orientation program can be very valuable in accelerating students' ability to synthesize and prioritize information, formulate appropriate care plans, and make judicious decisions about critical situations.

Even though traditional teaching methods are effective tools for helping students learn, they have been criticized for resulting in linear thinking, whereas concept mapping promotes nonlinear thinking. Several authors recommend replacing traditional methods with concept mapping to help students learn how various problems are connected to one another, which also pre supposes that one solution is always a clue for another solution (Chabeli, 2010, Kostovich, et al., 2007 and Abel, and Freeze, 2006). A traditional teaching method also places students in a passive rather than an active role, which hinders learning. It also encourages one-way communication; therefore, the teacher must make a conscious effort to become aware of student problems and student understanding of content without verbal feedback, this particularly has to do with the lecture method of teaching (Centre for the integration of Research, Teaching and learning, 2010).

According to Stoica, Moraru, and Miron (2010), the main advantage of concept mapping method is the fact that it provides a powerful representation tool to show complex interrelations, respectively establishing a transparent link, between different concepts. They however, came out with three other advantages which are:

1. Teaching and revision topic: Difficult concepts can be clarified and can be arranged in a systematic order. Using this concept map in teaching enables teachers to be more conscious of the key concepts and relationship among them. This helps teachers to convey a clear general picture of the topics and their relationships to their students. In this way, it is less likely to miss and misinterpret any important concepts. However, tradition teaching methods do not possess this characteristic.
2. Reinforce understanding. Using concept maps can reinforce students' understanding and learning more easily. This enables visualization of key concepts and summarizes their relationship.

3. Check learning and identify misconceptions. The use of concept maps can also assist teachers in evaluating the process of teaching. They can assess the students' achievement by identifying misconceptions and missing concepts. Concept mapping is also gaining inroads as a tool for problem-solving in education. Concept mapping may be used to enhance the problem-solving phases of generating alternative solutions and options. Since problem-solving in education is usually done in small groups, learning should also benefit from the communication enhancing properties of concept mapping.

2.8 Correlation between achievement test score and concept map scores

In a recent study conducted by Asan (2007) on 5th grade science students in Turkey, students concept map scores were correlated with the achievement of students in a multiple choice test. He reported that the correlation was high hence this provided evidence for the content validity of the concept maps scores. To him these results indicated that students were performing quite similar on concept map items and multiple choice items designed to measure similar content. Asan therefore concluded that concept map scores were indicators of students" knowledge of content which had been emphasized during instruction.

2.9 Traditional method of teaching

This is also referred to as conventional method or expository method of teaching. It is also referred to as the lecture method of teaching, and is the oldest method of teaching. It is mostly described as teacher-centered, teacher dominated, teacher activity method, or top-down transmission teaching. The role of the student is less active and more passive in the teaching and learning interaction.

In Ghanaian secondary schools, traditional method is most often used by biology teacher for instruction. Teachers occasionally may demonstrate a process for students to observe, engage students in brief discussion and questioning, and often use illustration from diagrams, charts and relia. Discourse between teacher and student is minimal, teacher mostly does the talking. Wood (2007) observed that biology teachers in the secondary schools introduce lesson followed by explanation and demonstration. Wood (2000) noticed that most schools had inadequate relia, charts and diagrams hence sometimes illustrations are missing from teaching and also few questions were asked by students for teachers to answer. After each explanation, teacher dictates copious notes for students to write. Wood (2000) reported that during his research, he inspected the notebooks of the students and found out that all of them had the same notes, indicating that they had their notes solely from their biology teachers. He reported that teaching was direct from teacher to learner.

According to Tamakloe et al (2005), for students to benefit fully from such a method which is teacher centered, teacher must prepare adequately, reading from many sources to get quality information. This will help him get mastery over the subject matter leading to good delivery. The teacher should be able to get the attention of the students from the beginning of the lesson and sustain it to the end. Teacher stimulates and excites students to arouse their curiosity. This will make them pay rapt attention to the teacher. The teacher should also be audible enough and make frugal use of illustrations, right gestures and deliver coherently and sequentially. They agreed that the variation of the voice of the teacher prevents monotone and this may give clues to students on important.

The teacher should get a reasonable speed by which all students can cope with. He should not be too slow or too fast. If the he is too slow, students may feel lazy or even sleep; and if he is too fast students may not be able to write and comprehend at the same time. This may lead to a lot of ‘pot holes’ to fill which may frustrate students. The teacher must therefore judge the amount of information which he can effectively deal with within the specified period allotted (Tamakloe et al, 2005). Also, the language used by the teacher should be at the level and comprehension of students. The language or expression should be familiar and simple. The teacher should judiciously plan repetition to iterate major issues raise in the lesson. Dictation of notes is often frowned upon by some educationists since they believe it will make students think what the teacher gives to them in the notes is the ultimate or all there is about the topic. Tamakloe et al (2005) posited that, in the secondary schools if the teacher resorts to giving students notes he must be convince whatever he decides to dictate to his students are of great importance and they must have it verbatim. Normally students are expected to make their own notes. To help students get an overview of the lesson, the main points, issues raised in the lesson must be summarized.

2.10 Merits of traditional method

Tamakloe et al (2005) enumerated the following merit of the traditional method.

1. It provides great opportunity for students to learn to take down notes.
2. It helps provides information on topics which are not available or easily accessible to students.
3. The teachers have greater control over what is being taught in class.
4. Logistically traditional method is often easier to create than other methods of instruction.
5. The traditional method enables a great amount of course content to be covered in the face of a heavy loaded syllabus or programme of instruction.
6. The traditional method makes for economy since a large number of students can be taught at a time in one classroom. It is a straight forward way to impart knowledge into students.
7. It is more helpful for teaching specific facts, concept or laws.

2.11 Demerits of traditional method of teaching

As Shulman (1997) categorically pointed out, any educational inquiry possesses some limitations. Tamakloe et al (2005) pointed out the following disadvantages of the traditional method.

1. Generally, traditional method is not suitable for students who are low on the academic ladder. They find it difficult to listen and take notes at the same time.
2. It does not take into consideration individual differences.
3. The traditional method in most cases encourages rote learning.
4. It does not give the students enough chance to develop their oral skills.
5. Teacher activity overshadows that of students making them play comparatively passive role in the teaching and learning process.
6. On the spot feedback is usually very scanty and unreliable.
7. There is little scope for student activity; hence traditional method goes against the principle of learning by doing.
8. In the traditional method, the teacher to a large extent spoon feeds the students and does not allow them to develop their powers of reasoning.

Since science mainly involves activity to help students explore, the traditional method is therefore not the best for solely teaching science. As already stated, the traditional method rather promotes rote learning. Wood (2007) indicated that biology teachers resort to the traditional method because of the work load. He reported that the enrolment in most science classes is about 50 to 70 students, making it difficult for teachers to resort to the use of more competitive methods. Biology teachers can enrich traditional method of teaching by using more realia, slides and overhead projectors. But the question is how many of our schools are resourced with these technologies.

2.12 Review of related literature

A careful review of empirical studies on concept maps has unearthed a significant amount of information on this rather all important instructional pedagogy. Adlaon, (2002) conducted a study on an alternate instructional tool called "Concept Map". The goal of this study was to determine the effectiveness of using concept maps in improving the science achievement of 10th -grade students and compare it with a traditional approach for a Biology unit. Furthermore, the interaction of the student's concept mapping ability and their learning gains was investigated. Both the control and the experimental groups were required to take a pre-test before instruction and a posttest at the end of three weeks. The test consisting of 31 questions was used to assess learning gains on a Biology Unit about Balance in Nature. Student-constructed maps were scored using Novak's scoring scheme. The first finding of the study was that concept map-exposed students did not perform much better than the same level students in the traditional group. The difference in the learning gains between the experimental and the control group in their unit test, though statistically significant, did not seem to be solely due to concept mapping. The second finding indicated that total scores in concept maps did not strongly predict student achievement in Science. Moreover, results showed that the levels of concept mapping ability were not associated with the concept-mapping students' learning gains. Nevertheless, the study suggests that, when carefully integrated into the normal classroom procedure and when other contributing factors such as student motivation and preparedness, reading ability levels, time and classroom environment are considered, concept mapping has a potential to be an effective instructional strategy.

Udeani and Okafor (2012) also investigated the comparative effectiveness of the expository and concept mapping instructional strategy of presenting secondary school biology concepts to slow learners. One hundred and twenty four biology slow learners were identified and randomly assigned to the expository group (n=62) and concept mapping group (n=62) and respectively taught the concept of photosynthesis. The groups were post-tested after two weeks of teaching for any significant differences in their biology achievement. Analysis of post-test scores indicated that the group taught by the concept mapping instructional strategy performed significantly ($p<0.05$) better than their expository group counterparts. Specifically, female slow learners taught with the concept mapping instructional strategy performed significantly ($p<0.05$) better than their male counterparts taught by the same method. These results have implications for biology teacher preparation, especially in the areas of teaching females and identifying slow learners and adopting effective methods of tackling their problems. However teachers must not forget the individualistic nature of the students, hence the need to vary teaching methods to suit the need of every student.

Furthermore, Ajaja (2011) also conducted a study to determine if the use of concept mapping as study skill can influence students' achievement in biology. The design of the study was quasi experimental Pretest Posttest control group design. The population consisted of 280 SS 2 students from where 120 students were selected. 100 students were used for analysis while 20 students dropped out of the study. To guide this study five research questions were raised and three hypotheses stated and tested at 0.05 level of significance. The major instrument used for data collection was biology achievement test. Another instrument used for data collection was an interview schedule to determine the students' perception of the usefulness of concept mapping in their studies. The major findings of this study include: a non-significant difference in immediate post achievement test scores between students who used concept mapping as a study skill and those who reviewed and summarized in their studies; a steady, consistent and significant increase in test scores of students who used concept mapping as study skill across achievement tests 1-6; a significant difference in estimated retention between students who used concept mapping as study skill and those who summarized after review, and all the students interviewed agreed that concept maps helped them to determine relationships among concepts, sharpened their understandings and increased their critical thinking. It was concluded that concept mapping could serve as an appropriate alternative for studying biology since what is learned through it can be retained for a long time. Of course this study did not operationally defined what it meant by retaining what is learnt for a long time, teachers should not assume therefore that using concept maps is the best as far as retaining what is learnt for a long time is concern.

Another important work as far as the use concept maps as an instructional tool is concern was a study conducted by Morse and Jutras, (2008), this research was an experiment explicitly introducing learning strategies to a large, first-year undergraduate cell biology course was undertaken to see whether awareness and use of strategies had a measurable impact on student performance. The construction of concept maps was selected as the strategy to be introduced because of an inherent coherence with a course structured by concepts. Data were collected over three different semesters of an introductory cell biology course, all teaching similar course material with the same professor and all evaluated using similar examinations. The first group, used as a control, did not construct concept maps, the second group constructed individual concept maps, and the third group first constructed individual maps then validated their maps in small teams to provide peer feedback about the individual maps. Assessment of the experiment involved student performance on the final exam, anonymous polls of student perceptions, failure rate, and retention of information at the start of the following year. The main conclusion drawn is that concept maps without feedback have no significant effect on student performance, whereas concept maps with feedback produced a measurable increase in student problem-solving performance and a decrease in failure rates. Wang (2003), also explored the instructional effects of prior knowledge and three concept mapping strategies in facilitating achievement of different educational objectives. The three concept mapping strategies were concept matching, proposition identifying, and student-generated concept mapping. The instructional material used for the study was a 2,000-word expository text about the physiology and functioning of the human heart. The prior knowledge levels of the subjects were identified through a general physiology test. Achievement was measured by the identification, terminology, and comprehension tests and the total test. The criterion tests were designed to measure achievement of different educational objectives at factual, conceptual, and rules and principles levels and general academic performance of university undergraduate students. The experimental population included 290 undergraduate students from a large comprehensive state university. The subjects completed the prior knowledge test, and participated in a 50-minute workshop on concept mapping one week prior to the experimental treatment. The experiment was conducted in a web-enhanced learning environment. The subjects browsed the given study website, interacted with the online learning material, and then, took the three criterion tests online and submitted the test results. The concept mapping activities were completed on paper. From four experimental treatments (T1: control, n = 42; T2: concept matching mapping, n = 50; T3: proposition identifying mapping, n = 44; and T4: student-generated concept mapping, n = 46), 182 sets of data were used for hypothesis testing by using MANOVA with the alpha level set at .05. The findings included the following:

- In examining the main effects of concept mapping, the three concept mapping strategies were found to be not equally effective in facilitating achievement of different educational objectives. Significant differences were found between concept matching mapping (T2) and the control group (T1) on all of the criterion tests. Significant differences were also found between student-generated concept mapping (T4) and the control group (T1) on the terminology and the total criterion tests. When comparing achievement of students receiving concept mapping strategies (T2, T3, and T4), insignificant differences were found to exist on all criterion measures. Among the subjects identified as possessing low prior knowledge, concept matching mapping (T2) achieved significantly higher scores than the control on all of the criterion tests. Student receiving proposition identifying mapping strategy (T3) achieved significantly higher scores than the control group (T1) on the criterion test of terminology and on the total test. The student-generated concept mapping treatment (T4) achieved significantly higher score than the control (T1) on the terminology criterion test. Regarding there was no significant interaction between levels of prior knowledge and concept mapping treatment types on any of the criterion tests in this study. The significant differences found on the terminology criterion test, concept matching mapping (T2) was the most effective and student-generated concept mapping (T4) was the least effective. Among the subjects identified as possessing high prior knowledge, significant differences were found in achievement only between concept matching mapping (2) and the control group (T1) on all of the criterion tests.

- Being knowledgeable means not only knowing the concepts, ideas, terms, and rules that make up the knowledge domain, but also entails a correct understanding of their interrelationships. Concept maps have been found effective in representing those meaningful relationships and enhancing students' learning activities. In this research, we examine whether concept mapping can be further improved by incorporating self-explanation activities. Specifically, while controlling for total training time, Cho, Yi and Jackson (2010) compared three alternative learning conditions: a control group (no concept mapping), a regular concept mapping group (provided with an expert skeleton diagram), and a concept mapping reinforced with self-explanation group (started with an expert skeleton and finished with self-explanation activities), in the experimental setting of learning a new programming language, Ruby. Sixty undergraduate and graduate students at KAIST (Korea Advanced Institute of Science & Technology) participated in the experiment. The results overall indicate that the proposed method of concept mapping reinforced with self-explanation is the most effective among the three experimental conditions and can further enhance the training efficacy of the concept mapping methodology.

To know learners' achievement, and their attitudes towards concept mapping. In short, this study sought to:

(1) find out whether concept mapping improved students' learning achievement in an advanced accounting course within the School of Management; and

(2) identify students' attitudes towards using concept mapping as a learning tool.

The participants in this study were 124 students from two classes in advanced accounting courses at the School of Management of a university in Taiwan enrolled in the first semester of 2002. One class of 62 students was randomly assigned as the experimental group; the other class of 62 students was used as the control group. The experimental class utilized concept maps in teaching and learning, while the control class maintained normal traditional curriculum activities. The teacher and the textbooks for both classes were the same to avoid confounding effects on the experiment. None of the students reported previous experience in concept mapping.

An intermediate accounting score and an intermediate accounting achievement test were used in the pre-tests and an advanced accounting achievement test was administered as a post-test. A questionnaire was used to investigate the students' attitude towards their learning experiences. Each is briefly explained below.

In this study, an intermediate accounting score was the average score of the participants in intermediate accounting courses in the first and second semesters of 2001. With the same teacher and textbooks in both classes, the intermediate accounting score can be utilized to determine the homogeneity of the participants. An intermediate accounting achievement pre-test, developed from the National CPA TEST sponsored by the Ministry of Examination of the Examination Yuan of ROC, was another way to determine the homogeneity of the participants. An advanced accounting achievement post-test, also developed from the National CPA TEST, was administered to measure the experimental effect on achievement. Both instruments consisted of 10 multiple choice questions, four journal entries and accounting reports. The K-R 20 reliability coefficients of the two instruments were 0.92 and 0.89 for the sample used in this study. The students were asked to complete these tests in three hours, under test conditions.

A satisfaction questionnaire was designed to investigate the attitude of participants towards adopting concept mapping to learn advanced accounting. The questionnaire comprised 10 items, and was rated on a four-point Likert scale from ‘strongly disagree’ to ‘strongly agree’. The Cronbach Alpha coefficient of the instrument was 0.85 for the study sample. The instrument had high construct validity (with a part–whole correlation of 0.91) (Kerlinger, 1986). The main objective of this study was to investigate whether the meta-learning strategy of concept mapping could be used to help students in the School of Management improve their learning achievement in an advanced accounting course. Two classes at the School of Management of a university in Taiwan were chosen to participate in the experiment. The results showed that students in the concept mapping class improved in their learning achievement more than did students in the traditional expository teaching class. This finding is in agreement with earlier findings in other disciplines such as Ahlberg, Aanismaa, & Dillon (2005), Arnaudin, Mintzes, Dunn, & Schafter (1984), Bernard & Naidu

(1992), Chang, Sung, &Chiou (2002), Chularut & DeBacker (2004), Cliburn (1990), McCagg & Dansereau (1991), Novak et al. (1983), Pankratius (1990), Ritchie & Volkl (2000), and Schmid & Telaro (1990).

The second research question focused on the perceptions of students regarding adopting concept mapping to learn. The whole experimental group was more positive about the usefulness of concept mapping in enhancing learning effectiveness after they took the concept mapping course. Almost all students expressed the view that the concept mapping strategy was really helpful for learning accounting and understanding the structure and inter-relations of the curriculum content. The opinions of students support the merit of concept mapping in the integration of knowledge (Ahlberg et al., 2005; Harpaz, Balik, and Ehrenfeld, 2004; Kinchin, De-Leij, and Hay, 2005; Novak and Gowin, 1984; Shavelson, Ruiz-Primo, and Wiley, 2005). The original intent of the concept mapping strategy (Ahlberg et al., 2005; Harpaz et al., 2004; Novak et al., 1983; Novak and Gowin, 1984) was to facilitate students' independent learning and thinking. The views of students in this study are in agreement with this idea. Furthermore, most students pointed out that adopting the concept mapping strategy helped them reduce the barriers and promote their interests in learning accounting. In terms of affective acceptance, the experimental group had a more affirmative attitude for using the concept mapping strategy. The overwhelming majority of the students were of the opinion that concept mapping can be a feasible accounting instructional strategy. Most of the students liked, and felt satisfied with, adopting concept mapping as an assistive learning strategy. The students in the concept mapping group also believed that concept mapping could be easily applied to other subjects. These opinions are consistent with the successful examples of using concept mapping in other disciplines (Ahlberg et al., 2005; Chang et al., 2002; Harpaz et al., 2004; Ritchie and Volkl, 2000). However, nearly half the students indicated that they could not quickly adapt to the approach of concept mapping. The result points out the importance and difficulty of preparing and training students for concept mapping tasks.

As McCagg and Dansereau (1991, p. 320), said, 'studies of student mapping have indicated that a lack of familiarity with the technique can be frustrating for novice map makers … training students to use the concept mapping technique can be tedious and time-consuming' This is also a common problem in other successful examples (Jegede et al., 1990; McCagg and Dansereau, 1991; Ruiz-Primo and Shavelson, 1996). This affective response by students, therefore, perhaps implicated the importance of having an efficient map-training procedure for accounting (or business) instructors interested in using the concept mapping strategy to support teaching and learning activities.

2.13 The effects of concept mapping on students understanding of photosynthesis and respiration

The main purpose of our education system is to master skills that could help students to reach to the information themselves, rather than transmitting existing information to them. Furthermore, apart from memorizing, the system should improve students' problem solving skills that they can use in a new scenario of the situation. Parallel to transmitting information to the students, the aim is to teach students about producing information and reaching the information that they will need. The expectation from current science education is a student-centered learning process with the guidance of a teacher. The teacher should be a guide that tries to understand the student's construction of knowledge, and in some cases facilitating learning process by asking some effective questions and additionally support them by guiding students to the right resources (Gedik et al., 2002). In this learning process, information that will be learnt should be arranged one by one to create a group of interrelated information. However, students will have some previous knowledge before coming into the education environment. This previous knowledge prevents the students from reaching scientifically proved information (realities), and as a result of this, it becomes hard or even impossible for the students to gain new information. In some research, researchers consider this situation and try to find ways to reach to the desired information in the teaching and learning process by using student's previous knowledge (Novak, 1984). New learning methods should be prepared and designed to integrate new information with his/her previous experiences based on discovery.

2.14 Summary

This review has shown that concept maps are graphical tools for organising and representing knowledge. Using concept maps make the individual present concepts hierarchically from the most inclusive, most general at the top, to the more specific and less inclusive (Novak & Canas 2008)

The literature also revealed that concept maps can be used for teaching and learning in the classroom. Concept mapping was developed by Novak in Cornwall University in the 1970s and has its theoretical foundation in the cognitive theory of learning, specifically in Ausubel's cognitive theory of meaningful verbal learning and constuctivism.

Looking at the effectiveness of concept mapping, the literature provided empirical evidence for differences in achievements in biology favouring the concept mapping groups in most cases. Also there were statistical differences between the achievement of males and females in biology, indicating that it is a good technique for teaching girls in the classroom. Therefore, it was seen that concept mapping could reduce the anxiety females have towards science (Jegede et al, 1990). Most students had positive perception towards concept mapping while accepting the fact that it boosted the organisation of their knowledge. However, students perceive concept map construction as time consuming.

Students indicated that concept mapping promoted meaningful learning (as against rote learning) as those in the concept mapping group achieved higher in the posttest. This study used the concept mapping alone because is quite effective and innovative but less used in our Ghanaian schools as used extensively in the western countries.

Finally, the literature revealed that the traditional method is teacher centered and it encourages rote learning. However in the SHS, it is the method frequently used by most biology teachers (Wood, 2007). Other studies indicated that students exposed to the traditional method normally perform lower than their counterpart exposed to other teaching methods. However, there were some cases that there were no significant difference between the traditional method and the methods compared with.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter explains the research method used in the study. These were captured under such headings as: research design, the population, sample and sampling technique, research instrument, data collection procedures, and method of data analysis.

3.1 Research design

The study adopted aquasi-experimental research design with mixed quantitative and qualitative data. This research design made use of concept mapping as an intervention, and the use of pre and post test as well as students' questionnaire items. The design helped the researcher to use questionnaire to objectively measure the effectiveness of concept mapping integration in instructional process of biology. The groups chosen were assigned out of convenience rather than through randomization into control and experimental groups. The control and experimental groups consisted of two separate form 2 biology classes which were present in the same school. Intact classes were used.

3.2 Population

The target population for this research was all students studying science in Akim Swedru Senior High School in the Eastern Region of Ghana. The accessible population was all second year students studying elective biology whose population was 105. These students were selected for the research because it was expected that they have been exposed to at least one year of science teaching and learning at the senior high school.

3.3 Sampling procedure

The students were selected using the purposive sampling technique. The sample was students of Science and Home Economics classes. These classes were selected purposively because they are the only classes that are studying elective biology. The purposive sampling technique is deemed appropriate as it is the method that allows manipulation of the sample to meet the needs of the research (Cohen and Manion, 2004).

3.4 Instrumentation

- **Questionnaire**

A set of questionnaire was used for data collection for this study. This was administered to students to assess their perceptions towards biology and their attitude towards the concept mapping. The rational for the use of a questionnaire stemmed from what Tuckman (1992) said about the benefits of questionnaire to the researcher. A questionnaire is easy to enter, analyze and tabulation can be easily done with many computer software packages, especially the statistical package for the social sciences (SPSS). Again, Fraenkel & Wallen (2000) and Muijs (2004) asset that there are other benefits of questionnaire which include consistency of presentation of questions to the respondents, the assurance of anonymity for the respondents and the less time it takes to administer. Questionnaire was also found to be appropriate for the study because the study employed a discussion of experimental students' perception on the effectiveness of concept mapping integration in biology instruction. Questionnaire was probably the most common data collection instrument used in educational research which is more familiar to respondents (Muijs, 2004). However, the disadvantages are that they often have low response rates and cannot probe deeply into respondents' opinions and feelings (Fraenkel & Wallen, 2000; Muijs, 2004; Alhassan, 2006), but this was not the case with this study because the sample size was well manageable. Closed-ended items made respondents to choose between answers of the researcher while an open-ended item allow respondents to formulate their own answer. The researcher used both open and closed ended items in questionnaire because respondents are more inclined to answer closed-ended items and open-ended item provided a greater depth of response since there was no standardized answer across responses (Oppenheim, 1992).

- **Description of the questionnaire items**

The items consists of two (2) main parts (A–B) contains four (4) items that elicit information on the demographic or background of the participants. The variables in part (A) covered respondents' gender, age and hometown. These data are in tune with the purpose of this research since the respondents' gender, age might have sufficient influence on their perceptions about concept mapping integration.

The second part (B) consists of sixteen (16) items (i.e. items 5–20 that elicited information on respondents' perception of the effectiveness of concept mapping in teaching and learning of biology. 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 biology instruction.

- **Scoring the questionnaire items**

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. The items on the questionnaire were positively and negatively worded in order to minimize participant satisfying responses. Positively worded items (i. e "Students are more enthusiastic about the subject for whom they use concept mapping") were scored as follows:

Response Intensity	**Symbol**	**Score**
Strongly Agree	SA	5
Agree	A	4
Neutral	N	3
Disagree	D	2
Strongly Disagree	SD	1

Negatively worded items (e.g "Concept mapping hinder students' ability with learning tasks") were scored as follows:

Response Intensity	**Symbol**	**Score**
Strongly Agree	SA	1
Agree	A	2
Neutral	N	3
Disagree	D	4
Strongly Disagree	SD	5

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 Analysis of Variance (ANOVA), T-test and regression analysis (Fraenkel & Wallen, 2000; Muijs, 2004). Additionally, Likert scales are often found to provide data with relatively high reliability (Oppenheim, 1992; Fraenkel & Wallen, 2000).

3.5 Biology achievement tests

The dependent variable in this study is the students' biology achievement. Two tests were used to measure achievement. One of the tests (pre-test) measured students' prior-knowledge in topics related to the ones covered during the study. The second test measured students' achievement at the conclusion of the study. The achievement test was developed from the topic in the science syllabus for SHS. Some the items were also selected from past WASSCE questions to determine the effect of using the concept mapping. The instrument consisted of 5 essay type questions: 2 knowledge questions, 2 comprehension questions and

1 application question. The questions were worth four points each and the tests were rated on a 20 point scale.

According to Lehman, Carter, and Kahle (1985) and Willerman and MacHarg (1991), a test must be at the comprehension level and above in order to measure meaningful learning. Consequently, the items on the achievement tests were at the comprehension level or above. Moreover, a detailed description of the three levels of Blooms' taxonomy (Bloom, 1969) was used to make sure that the items were at the different levels of Blooms taxonomy.

3.6 Validity of the main instrument

Content validity was established prior to the start of the study by the following procedures. The content validity of the instruments was determined by subjecting them to expert judgment. To ensure that the instruments measure what they profess to measure and can be consistent at producing similar results at different times, both pre and post tests were developed based on the SHS biology syllabus, text books, and modified questions of the West African Examination Council. The test items were provided to five teachers who have at least five years of teaching experience in Biology. These teachers evaluated the tests to make sure that the questions were aligned with the course content and level. The biology teachers also evaluated the instrument project for readability. Only when the tests were returned with the approval of all five biology teachers were they used for this research.

3.7 Reliability of the main instrument

Reliability of a research instrument is the consistency of the instrument producing similar results given the same condition on different occasions.(Gravette & Forzano, 2006).It measures the dependability of the items used in collecting data (Cohen et al, 2007).To ensure the consistency of the results, pilot testing was done at Achiase Senior High to check the reliability of the study. Cronbach Alpha coefficient formula was used to find the reliability of the study in order to check for the appropriateness of the data collection instrument. The school took a pretest and also a posttest after a week of treatment. The students that received instruction through concept mapping approach were given questionnaire to respond on their perceptions towards concept mapping after they have taken the posttest. The inter-rater reliability of the biology achievement pretest- posttest was 0.78 and 0.79 for the posttest. Cronbach Alpha coefficient of reliability was 0.90.

3.8 Pilot testing

Pilot testing was done at Achiase Senior High School in the Birim South District of the Eastern Region of Ghana. The school was selected because it has similar characteristics with the other school understudy. The pilot test enables the researcher to restructure the questionnaire to help elicit the right responses.

3.9 Data collection procedures

This research was carried out at Akim Swedru Senior High in the Birim South District of the Eastern region over a period of six weeks with the Science and Home Economics classes which met three times per week for ninety minutes. Intact classes were used and the materials that were covered were outlined in the biology syllabus.

The study pre-intervention test was administered to all one hundred and five second year biology students. The results of the pre-intervention test was used to classify the Home Economics class as the experimental group since they scored below fifty percent while the science class was used as the control group because they scored above sixty percent. Both classes were taught photosynthesis and cellular respiration as outlined in the biology syllabus. In the control class, the students were taught four lessons on photosynthesis using the traditional method lasting ninety minutes each. Subsequently, four lessons on cellular respiration were taught which also lasted ninety minutes per lesson. Here the researcher did most of the talking while the students did the listening. Researcher occasionally demonstrates a process for students observe, engage students in brief discussion and questioning and often use illustration from diagrams, charts and relia.

In the experimental class, the students were given tuition on how to create concept maps in five lessons on photosynthesis which lasted for ninety minutes each. This was also followed by another four lessons on cellular respiration using concept mapping as a mode of instructions. Shortly thereafter, the students were placed into groups of five and given a short activity to construct micro-concept maps on the content of each lesson. These concept maps were scored using the researcher's scoring rubric and returned the next day to the students (Appendix C). The experimental students were asked to construct detailed samples of concept maps on both photosynthesis and cellular respiration. At the end of the treatment period, both the experimental and control groups took the post-test at the same time. The student's questionnaire items were administered to the experimental students after the post-treatment test for analysis.

3.10 Data analysis

The statistical program SPSS 16.0 was used for analysis of data. The scores from pretest and posttest in the achievement tests were subjected to descriptive and inferential statistics. Descriptive statistics included mean, standard deviation and percentages etc. Inferential statistics used was t-test at testing of the statistical significance at 0.5 alpha levels were employed for the analysis of data. When the P values from the results of these statistical tools are above 0.5, then there is no significant difference, but if the P values are less than 0.5, then there is significant difference. Thematic content analysis was used to analyze student responses to the questionnaire.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter presents the results from the questionnaire and test data. The results were analyzed and discussed.

4.1 Descriptive statistics of sampled population

There were fifty-one (51) students in the Science class and fifty-four students in the Home Economics class. In the control group, twenty students (39%) were females and thirty one (61%) were males while in the experimental group, thirty-four students (63%) were females an twenty(37%) were males (see figures 6-8).

Figure 6: Sex Distribution of control group

Figure 7: Sex Distribution of experimental group

Figure 8: Sex distribution of sampled population

4.2 Data presentation by research questions

The data collected and test results were presented based on the research questions formulated for the study.

4.2.1 Research question 1: *What conceptions do the students hold of photosynthesis and cellular respiration?*

Null Hypothesis 1: There is no statistical significant difference between the performance of students in the control and experimental groups before the instructions. Initial analysis was done by comparing group mean scores from the pretest (see APPENDIX E). Comparison of pretest scores between the experimental and control group is presented in Table 1.

Table 1: **The pretest means scores of students in the experimental and control groups on photosynthesis and cellular respiration.**

Group	**N**	**Mean**	**SD**	**df**	***P***
Control	51	6.47	1.554	103	0.417
Experimental	54	6.24	1.577	-	-

* Not significant at P > .05 Total score =20

When the P value is less than 0.05 it means the test is significant, but when the P value is greater than 0.05 then the test is not significant. This indicates that there was no statistical significant difference between the performance of students in the control and the experimental groups. Therefore the null hypothesis is upheld.

They both performed almost at the same level. This indicates that students in both groups had similar knowledge about photosynthesis and cellular respiration which were the biology content examined in this study before the interventions were given. Some of the conceptions were wrong ideas. The common misconceptions held by students of both groups were related to definitions of Photosynthesis and Respiration, energy sources for photosynthesis, chemical reactions of photosynthesis, concepts of plant nutrition, the role of water and leaves in plants, gas exchange, the role of light and chlorophyll in photosynthesis, the relationships between food and energy, and the nature of respiration and energy transformation.

4.2.2 Research question 2 and null hypothesis 2

Research question 2:

What would be the effect of concept mapping on the students' understanding of photosynthesis and cellular respiration?

Null hypothesis 2

There is no significance difference between achievements of students taught biology lessons on photosynthesis and cellular respiration with concept mapping and those taught with the traditional method.

Research question 2 and Null hypothesis 2 were presented in tables 2 and 3. Paired sample t-test was conducted to see the effect of the intervention on the experimental group and this has been presented in Table 2 below.

Table 2: Means and standard deviations for both control and experiment groups before and after the treatment

Group	**Variable**	**N**	**Mean**	**Sd**	***P***
Experimental	Pre-test	54	6.24	1.577	0.000
	Post-test	54	15.16	1.953	
Control	Pre-test	51	6.47	1.554	0.000
	Post-test	51	14.22	1.265	

Significant $P<0.05$

Table 2 shows a statistical significant difference between the two groups' pre-test and post-test scores. The experimental group's mean for post-test was significantly higher than its mean scores for pre-test. The magnitude of the difference in mean was very large with a standard effect size index of 7.41. According to Green, Salkind and Akey (1997), and Cohen (1988) an effect size of 0.20 is small, 0.50 is moderate and 0.80 is large. Also the control group's mean from post-test was significantly higher than the pre-test. The effect size of 3.97 was also very moderate. Results in Table 2 clearly show that both the concept mapping and traditional approaches to teaching had significant effect on students' achievement in photosynthesis and cellular respiration. The difference in the mean scores for the pre-test and post-test of the experimental group is 9.370, and that for the control group is 7.745. The difference in mean scores for the experimental group indicates that when concept mapping is used as an instructional strategy in teaching photosynthesis and cellular respiration students easily grasp the concepts. The corresponding increase in the mean score of the control group also showed that they also understood the concept of photosynthesis and cellular respiration.

The researcher taught both groups. However, the control group received instruction after the experimental group. As expected of every teacher to improve upon subsequent deliveries, the difficulties experienced in the experimental group were corrected before the instructions in the control group. This factor could have accounted for the significant improvement in the mean scores of the control group. To investigate the difference in post-test scores between the experimental and the control groups, the mean scores were compared using independent sample t-test. Results of independent sample t-test for the post-test for both the experimental and the control groups are presented in Table 3.

Table 3: Means and standard deviations of experimental and control groups after the treatment.

Group	**N**	**Mean**	**SD**	**t**	***P***
Control	54	15.61	1.953	4.370	.000
Experimental	51	14.22	1.265	-	-

Significant at P< 0.05

As shown in Table 3 there was significant difference between the mean scores of experimental and control. Hence, the null hypothesis is rejected. Table 3 indicates that students exposed to concept mapping performed better than their counterparts exposed to the normal traditional method of teaching with a difference in mean score of 1.395. The concept mapping group achieved significantly higher scores than the traditional method group. An effect size of 0.71 is large. According to Green, Salkind and Akey (1997) and Cohen (1988) effect size of 0.20 is very small, 0.50 is moderate and 0.80 is large. Bunting et al (2006) observed that students who attended tutorial using concept mapping as an instructional strategy achieved significantly higher scores than those who attended a convectional class or no tutorials. In similar works by Asan (2007) and Akpinar & Ergin (2008), students taught with concept map had significantly achieved higher than their counterparts taught with the traditional method.

4.2.3 Research questions 3 and null hypothesis 3

Research question 3

Are there differences in the cognitive achievement of the male and female senior high school students after being taught photosynthesis and cellular respiration using concepts maps?

- **Null hypothesis 3**

There is no significant difference in the cognitive achievements of male and female students when they were taught biology lessons on photosynthesis and cellular respiration using concept mapping.

- **Differences in achievement of male and female SHS after being taught biology using concepts maps**

To test the statistical difference in achievement in post-test of male and female students exposed to concept mapping, an independent sample t-test was used. A result of independent sample t-test for males and females in the experimental group is shown in Table 4.

Table 4: Means and standard deviations for males and females in experimental group after being taught biology using concept maps

Variable	N	Mean	SD	t	*p*
Male	20	15.24	1.424	3.393	.001
Female	34	16.35	0.987		

Significant at $P<0.05$

Table 4 shows that there was significant difference in achievement between males and females ($p = 0.001$). Hence the null hypothesis which states that there is no significant difference between the achievement of male and female students taught with concept maps is rejected. The females in the concept mapping group achieved higher scores than their male counterparts with mean difference of 1.115. This is in confirmation to Bello and Abimbola (1997), Abayomi (1988), and Jegede and Okebukola (1998) who found out that there were statistical differences in achievements between male and female students in Biology who were taught using concept mapping.

This is also in line with the findings of Boujaoude and Attieh (2008) that females performed better than males when they were taught with concept mapping method. They gave reasons that the females might have been consistent in conforming to teachers demand in following instruction to master the techniques of building the concept maps. The difference in achievement can be explained by the different learning styles between males and females. According to Wapner (cited in Boujaoude &Attieh, 2008), males are field-independent learners who use reasoning pattern that include cognitive structuring skills, while females are field dependent learners who accept realities and may become passive learners.

4.2.4 Research question 4

What are students' perceptions of concept mapping approach for biology lessons?

Responses from questionnaire on students' perception towards concept mapping were used to see if there was consensus of opinion about the use of concept maps. A Likert scale (strongly agree = 1, agree = 2, undecided = 3, disagree = 4 and strongly disagree = 5) was used to determine the degree of agreement with statement about concept mapping. Strongly agree and agree were considered to be positive perception, undecided was considered neutral while disagree and strongly disagree was considered negative perception. The mean of the responses from the total items were computed for each student. Total mean between 1 and 3 was considered positive perception, total mean between 3 and 4 was considered neutral while total 4 and above was considered negative perception. All the 54 students in the experimental group were given the questionnaire to respond to. Table 5 shows the representation of students' perception towards concept mapping.

Table 5: **Perception of students of concept maps on teaching and learning of biology**

PERCEPTION	SA n /%	A n /%	UN n /%	D n /%	SD n /%
Concept mapping makes biology class interesting.	27(50)	24(44.4)	1(1.9)	2(3.7)	-
Concept maps link the various concepts together.	19(35.2)	21(38.8)	-	14(25.7)	-
Concept maps summarize the topic.	33(61.1)	11(20.4)	3(5.6)	7(13)	-
Students are much involved in concept mapping.	18(33.3)	36(66.7)	-	-	-
Concept maps bring out the meaning of the topic better.	27(50)	19(35.2)	-	5(9.3)	3(5.6)
Concept maps stimulate me to learn biology.	27(50)	24(44.4)	-	3(5.6)	-
Concept maps demand a lot of thinking.	13(24.1)	17(31.5)	3(5.6)	21(38.9)	-
Concept mapping assignments help me prepare for my exams.	12(22.2)	30(55.6)	-	9(16.6)	3(5.6)
Concept map provides me with better understanding of complex issues.	13(24.1)	27(50)	1(1.9)	8(14.8)	(9.2)
Concept maps facilitate making interconnections among (sub) chapters.	7(13)	44(81.5)	-	3(5.6)	-
Concept mapping can be used for other courses.	29(53.7)	22(40.7)	1(1.9)	2(3.7)	-
Sharing mappings with friends helps me address my misunderstandings.	32(59.3)	19(35.2)	-	3(5.6)	-
Sharing maps helps me identify the relations amongst the concepts.	20(37.4)	15(27.8)	2(3.7)	10(18.5)	7(13)
Concept mapping helps me to understand information better.	12(22.2)	20(37.4)	1(1.9)	11(20.4)	10(18.5)
Constructing concept maps is not time-consuming.	10(18.5)	10 (18.5)	4(7.4)	20(37.4)	10(18.5)

Table 5 shows that majority of the students exposed to concept mapping responded to 'strongly agree' and 'agree'. For instance, 27 and 24 respondents responded 'strongly agree' and 'agree' respectively to item 'Preparatory assignments prepare me well for class sessions'. In the same way, 19 and 21 respondents responded to 'strongly agree' and 'agree' respectively to item 'Concept maps links the various concepts in photosynthesis and cellular Respiration', however 14 respondents disagreed.

Thirty three (33) and eleven (11) respondents responded to 'strongly agree' and 'agree' respectively to item 'Concept maps summaries the topic' while 7 disagreed. 18 and 36 respondents responded to 'strongly agree' and 'agree' respectively to item 'Students are much involved in concept maps'. However, there were some items that some students responded 'disagreed', or 'strongly disagreed'. For instance, 5 respondents responded disagree to the item 'Concept maps brings out the meaning of photosynthesis and cellular Respiration', and 9 disagreed to the item 'Concept map assignments help me prepare for my exams'.

Asan, (2007) also indicated that very low percentage of students responded to 'disagree' or 'strongly disagree'. Bunting et al (2006) also indicated that greater percentage of the students responded to 'agree' or 'strongly agree' to concept mapping. These findings are consistent with this study showing that students have positive perception towards concept mapping. This study is consistent with studies conducted by Scagnelli (2010), Bunting et al (2005), and Asan (2007) who also found out that student who showed positive attitudes and perception towards concept mapping achieved higher in their post-test.

The whole experimental group was more positive about the usefulness of concept mapping in enhancing learning effectiveness after they took the concept mapping course. Almost all students expressed the view that the concept mapping strategy was really helpful for learning photosynthesis and cellular respiration. Furthermore, most students pointed out that adopting the concept mapping strategy helped them reduce the barriers and promote their interests in learning biology. In terms of affective acceptance, the experimental group had a more affirmative attitude for using the concept mapping strategy. The overwhelming majority of the students were of the opinion that concept mapping can be a feasible instructional strategy. Most of the students liked, and felt satisfied with adopting concept mapping as an assistive learning strategy. The students in the concept mapping group also believed that concept mapping could be easily applied to other subjects. These opinions are consistent with the successful examples of using concept mapping in other disciplines (Ahlberg et al., 2005; Chang et al., 2002; Freeman and Jessup, 2004; Harpaz et al., 2004; Ritchie and Volkl, 2000). However, nearly half the students indicated that they could not quickly adapt to the approach of concept mapping. The result points out the importance and difficulty of preparing and training students for concept mapping tasks.

As McCagg and Dansereau (1991), said, ‘studies of student mapping have indicated that a lack of familiarity with the technique can be frustrating for novice map makers … training students to use the concept mapping technique can be tedious and time-consuming’ This is also a common problem in other successful examples (Jegede et al., 1990; McCagg and Dansereau, 1991; Ruiz-Primo and Shavelson, 1996).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This is the concluding chapter of the thesis and the key findings of the research are presented. Also recommendations and suggestions for future research are made.

5.1 Summary

The quasi-experimental design involving two intact classes was used for the study. The comparison between the pre-test and post-test of the experimental and control groups showed that each group performed well in the post-test. Analysis of the post-test scores using independent sample t-test indicated there was significant difference between the mean scores of the experimental and the control groups after the treatment. This implies that the use of concept mapping approach was successful and boosted students' understanding in photosynthesis and cellular respiration. There was also a significant effect in gender interaction. The females in the experimental group performed better than the males in the experimental group.

In effect, students had positive perception towards concept mapping. Students indicated that they had interest in concept mapping. They also emphasized that concept mapping helped them to summarized, organize and logically present their work. Moreover, concept mapping helped them to contribute in class, socialize and ask questions in class.

5.2 Conclusion

The results of the study support using concept mapping as a teaching strategy to engage students in constructing and altering their own knowledge structures. However, there is a need to help males to understand and engage in the use of concept mapping because of its possible benefits. In addition, concept maps were successful tools in helping experimental group improve their grades. There is a need for longer training sessions and direct feedback to give learners the opportunity to master concept mapping technique.

5.3 Recommendations

1. Concept mapping is worth adopting as a teaching method by Biology teachers at the SHS level in the Birim South District because of its effectiveness.
2. The concept mapping method should be encouraged in many Biology classes since it gives students opportunity to see links between concepts, summarise and organize their works and thoughts logically and sequentially.
3. Both genders must be encouraged to use concept maps for studying Biology.

5.4 Suggestions for further research

1. The study may be replicated in other districts and regions of Ghana
2. The period for the intervention may be extended to cover a whole term. Hence about four or five topics can be used for future studies.
3. Future research can be carried out with four different groups at the same level. One group may be taught with concept mapping strategy, another group doing collaborative concept mapping, and a third group with interactive computer animation accompanied by concept mapping, and the last group traditional.

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Appendix A

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

BIOLOGY ACHIEVEMENT TEST (BAT)

Answer all questions in this section

Q1.

a) What is respiration?

b) Distinguish between aerobic and anaerobic respiration

Q2.

a) What are the main stages in glycolysis?

b) State three factors that affect the rate of photosynthesis.

Q3.

a) Explain the roles of (i) chlorophyll (ii) ATP (iii) NADP and (iv) CO_2 in photosynthesis.

b) Explain the functions of chloroplast and mitochondrion.

Q4.

a) Explain four ways the structure of the leaf adapts its photosynthetic functions.

b) What is the fate of pyruvate under anaerobic condition and aerobic condition?

Q5.

a) How would you convince a friend that the lives of humans and other living organisms

are ultimately dependent on solar energy?

b) Okoto after running the 500metres race look very exhausted. However, he was given gluconade to regain his energy to run in the 4 x 400metres race in the next 30 minutes. How will this soft drink provide him instant energy?

Appendix B

MARKING SCHEME FOR BAT

Question 1

1. Respiration is the sum total of the chemical processes that releases energy from food substances within cells, with or without the participation of molecular oxygen.

Aerobic respiration	**Anaerobic respiration**
Is the release of energy from food with the use of oxygen	Is the release of energy from food without the use of oxygen
Respiration occurs in most cells	Respiration occurs mostly in prokaryotes
High energy produced (36 – 38 ATP molecules)	Low energy produced (2 ATP molecules)
The process is not toxic to plants	It is toxic to plant
Carbon dioxide, water, ATP	Carbon dioxide, reduced species, ATP
The process takes place partly (glycolysis) in the cytosol and partly (Krebs cycle) inside the mitochondria	The process occurs only in the cytosol
Glucose, oxygen	Glucose, electron acceptor (not oxygen)
It is common to all plants	It is of rare occurrence
The end – products are carbon dioxide and water	The end –products are lactic acid in animals or ethanol in plants

2. (b)

i. Temperature
ii. Light
iii. Chlorophyll

3. (ai). Chlorophyll is a green pigment found in the thylakoids of the chloroplast. It traps

light energy to excite the electrons as they move through the electron transport chain.

ii. ATP produced in the light stage provides energy for the dark stage for the production of triose phosphate.

iii. NADPH produced in the light stage reduces glycerate - 3 - phosphate (1mark) to trios phosphate/Phosphoglyceraldehye used to form glucose (1mark)

iv. CO_2 is from the atmosphere, it diffuses into the stroma to react with Ribulose – 1, 5 – bisphosphate (RUBP), a five- carbon compound in the Calvin cycle in the presence of the enzyme RUBP carboxylase to form an unstable six carbon compound which split into glycerate – 3 – phosphate.

e. Chloroplast is an organelle found in plant cells and in some algae. It contains chlorophyll for trapping light. Photosynthesis takes place in the chloroplast. The light stage which occurs in the thylakoids uses light energy for the production of oxygen, hydrogen and ATP. The dark stage which occurs in the stoma leads to the production of starch.

bi. Mitochondrion is found in all eukaryotic cells. It is the powerhouse of the cell by producing energy in the form of ATP. The energy is produced by Krebs cycle and Hydrogen carrier system occurs in the cristae of the mitochondrion.

Q4.

(a) The leaf has broad flat surface giving it a large surface area to allow absorption of light and carbon (IV) oxide/CO_2.

ii. The leaf is thin; enabling CO_2 to diffuse easily to the mesophyll cells

iii. The presence of stomata for exchange of gases

iv. Presence of large amount of chloroplast in the palisade mesophyll as site for photosynthesis

v. Presence of xylem to transport water to leaf

vi. Presence of phloem to transport products of photosynthesis

vii. Arrangement of leaves on the stem allows maximum exposure of leaves to sunlight

a. Pyruvate a three carbon compound is produced from glycolysis.

Under anaerobic conditions, pyruvate is converted to alcohol in plants or lactic acid in some bacteria and the skeletal muscle.

Under aerobic condition, pyruvate is decarboxylated to form an acetyl group which is a two carbon compound. This reacts with co – enzyme A to form acetyl-coA. Acetyl-COA enters the Kerbs cycle where a series of reactions occur to release large amount of ATP/energy

Q5. Gluconade contain more glucose which is absorbed into the bloodstream, upon drinking, the glucose undergoes glycolysis to form pyruvate. Pyruvate is also converted to acetyl COA which enters the Kerbs cycle to release more energy. Thirty eight ATP of energy is produced under aerobic condition for every molecule of glucose. Okoto could therefore gain more energy from the gluconade to run again.

Appendix C

SCORING RUBRICS FOR CONCEPT MAPS

1. Concepts: Score 1 point for each concept that is connected to another concept by a preposition
2. Hierarchy: Score 1 points for each valid level
3. Preposition: score 1 for each meaningful valid preposition

Penalty

Score zero (0) for the following:

1. Concepts not placed in a box /circle /oval
2. Omitted concepts
3. Invalid preposition
4. Omitted labels

Appendix D

UNIVERSITY OF EDUCATION, WINNEBA

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Questionnaire on students' perception of the effectiveness of concept mapping in the teaching and learning of biology.

Students' code-------------------

Section A: Respondents Bio-Data

1. Sex--------------------------------

2. Age: --

3. Nationality-- 4. Hometown----------------------------

Section B:

Instruction: Please tick in the appropriate box by indicating your extent of agreement or otherwise to the following on teaching with concept maps.

SA=strongly agree A=agree UN= undecided D=disagree SD=strongly disagree

Questions	**SA**	**A**	**UN**	**D**	**SD**
Concept mapping makes biology class interesting					
Concept mapping links the various concepts together					
concept mapping summarizes the topic					
Students are much involved in concept maps					
Concept maps bring out the meaning of the topic better.					
Concept maps provide aids for expanding what has been learned.					
Concept maps demand a lot of thinking					
Concept mapping assignments help me prepare for my exams					
Concept Map provides me with better understanding of complex issues					
Concept Maps facilitate making interconnections among (sub) chapters					
It is worthwhile developing maps for other courses					
Sharing mappings with friends helps me address my misunderstandings					
Sharing mappings help me identify the relations amongst the concepts					
Concept mapping helps me to understand information better					
Constructing concept maps is not time-consuming					
Concept mapping can be used for other courses					

Please write any other comments you have about concept mapping in the space provided

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THANK YOU

Appendix E

SCORES OBTAINED BY BOTH THE EXPERIMENTAL AND CONTROL GROUPS BEFORE AND AFTER THE TREATMENT

	Control Group		Experimental	
Gender	**Pre – test**	**Post – test**	**Pre – test**	**Post – test**
F	5	13	8	16
F	4	12	9	16
F	5	17	5	14
F	3	15	4	16
F	6	16	4	17
F	8	12	3	17
F	6	18	2	16
F	9	16	5	17
F	7	17	6	15
F	8	12	7	16
F	4	16	7	15
F	7	15	4	16
F	6	14	4	14
F	6	16	3	14
F	8	17	5	14
F	9	14	6	15
F	8	15	5	16
F	8	14	7	15
F	7	12	7	15
F	8	13	6	14
F	5	11	5	14
F	5	14	7	15
F	8	13	8	15
F	8	12	7	16
M	9	14	7	15
M	9	17	8	16
M	8	16	6	16
M	6	12	5	15
M	5	18	5	15
M	4	14	7	16
M	3	13	8	15
M	5	17	6	14
M	1	15	8	15
M	4	14	4	13
M	6	12	7	17
M	5	11	8	16

M	4	12	8	17
M	3	13	7	14
M	7	16	6	18
M	6	12	5	16
M	5	13	4	17
M	5	16	7	15
M	4	14	7	18
M	6	13	8	15
M	8	13	7	15
M	6	12	8	18
M	9	17	8	15
M	7	15	6	16
M	8	16	5	14
M	4	12	8	19
M	7	14	7	18
M			8	16
M			9	17
M			3	16

Appendix F

LESSON PLAN FOR EXPERIMENTAL GROUP USING CONCEPT MAPS

SUBJECT: Elective Biology **Duration:** 80mins

Topic: Photosynthesis **Form:** Two

Place: Classroom **No on Roll:** 54 Students

Previous Knowledge: Students can describe autotrophic and heterotrophic mode of nutrition.

Objective: By the end of the lesson, students should be able to:

i. Explain the term photosynthesis

ii. List at least two adaptations of the leaf to photosynthesis

iii. List at least three factors affecting the rate of photosynthesis

iv. Explain one of the listed factors affecting of photosynthesis

Teacher Activity	Student Activity	Core Point	Evaluation
Introduction-5min Explain concept map and its uses to students **<u>Step 1</u>-30mins** ii) Put students into groups of five. Give each group an example of concept map of the cell. b) Teach students how to draw a concept map by constructing one on the board.	Students listen, write and study the map given them.		

INSTRUCTIONAL ACTIVITIES		
Teacher Activity	**Student Activity**	**Core Point**
<u>Step II</u> Explain photosynthesis to students. i. Lead students to explain the term photosynthesis ii. Guide students to construct concept map to explain photosynthesis iii. Ask students to give an equation to explain the process of photosynthesis **Step III** Adaptation of the leaf for photosynthesis Teacher show a chart of the structure of the leaf (morphology) and anatomy Discuss with students the structural adaptation of the leaf for photosynthesis	Students explain photosynthesis e.g. Photosynthesis is the process whereby plants prepare their food. Students construct concept maps using the concepts and preposition given by the teacher Students write the equation for photosynthesis in their notebook Students observed and contribute to the discussions by answering questions posed by the teacher	Photosynthesis is a process whereby green plants (some bacteria and algae) prepare food (glucose) using carbon dioxide and water in the presence of chlorophyll and energy from sunlight $6CO_2 + H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$ The leaf is the main photosynthesis organ. It is well adapted to photosynthesis as follows: 1. It has a broad, flat shape, giving a large surface area to allow absorption of light and carbon dioxide. 2. It is thin, enabling carbon dioxide to diffuse easily to the mesophyll cells. 3. The palisade mesopyll cells have a large number of chloroplast Factors that affect the rate of photosynthesis are carbon dioxide, concentration, chlorophyll concentration, light temperature, pollution content.

Step IV Factors affecting the rate of photosynthesis Teacher ask students to mention some of the factors affecting the rate of photosynthesis Lead students to discuss the factors that affect the rate of photosynthesis, eg. How does CO_2 affect the rate of photosynthesis Write concepts and the various prepositions of photosynthesis on the board Ask students to construct maps on their own	Students answered question passed by the teacher Expected when the CO_2 concentration in the atmosphere increase, the rate of photosynthesis increase but when the concentration of carbon dioxide in the atmosphere is low, photosynthesis decreases. Students construct their concept maps by arranging concepts hierarchically. Use arrows to link concepts to each other and prepositions (words) on the arrows are use describing connections	Factors that affect the rate of photosynthesis are carbon dioxide concentration, chlorophyll concentration, light intensity etc. an increase in the carbon dioxide concentration, the rate at which carbon is incorporated into carbohydrate in the light – independent reason, so the rate of photosynthesis generally increases. Photosynthesis concept oxygen Glucose Carbon dioxide Chlorophyll Green leaves Chloroplast Stomata Atmosphere Soil Light Mesophyll Thylakoid Stoma Equation Autotrophy

Lesson Plan for experimental group using concept maps

Subject: Elective Biology

Topic: Biochemical nature of photosynthesis

Place: Classroom

Duration: 80mins

Form: Form two Home Economics Class

No on Roll: 54 Students

R. P. K.: Students can explain the photosynthesis

OBJECTIVE: By the end of the lesson, students should be able to;

i. Explain the step – by – step process of the light – dependent phase of photosynthesis

ii. Explain the step – by – step process of the dark – independent phase of photosynthesis

Lesson Plan for Experimental Group Using Concept Maps

Subject: Elective Biology **Class:** S.H. S. TWO

Topic: Respiration **NO OF STUDENTS: 54**

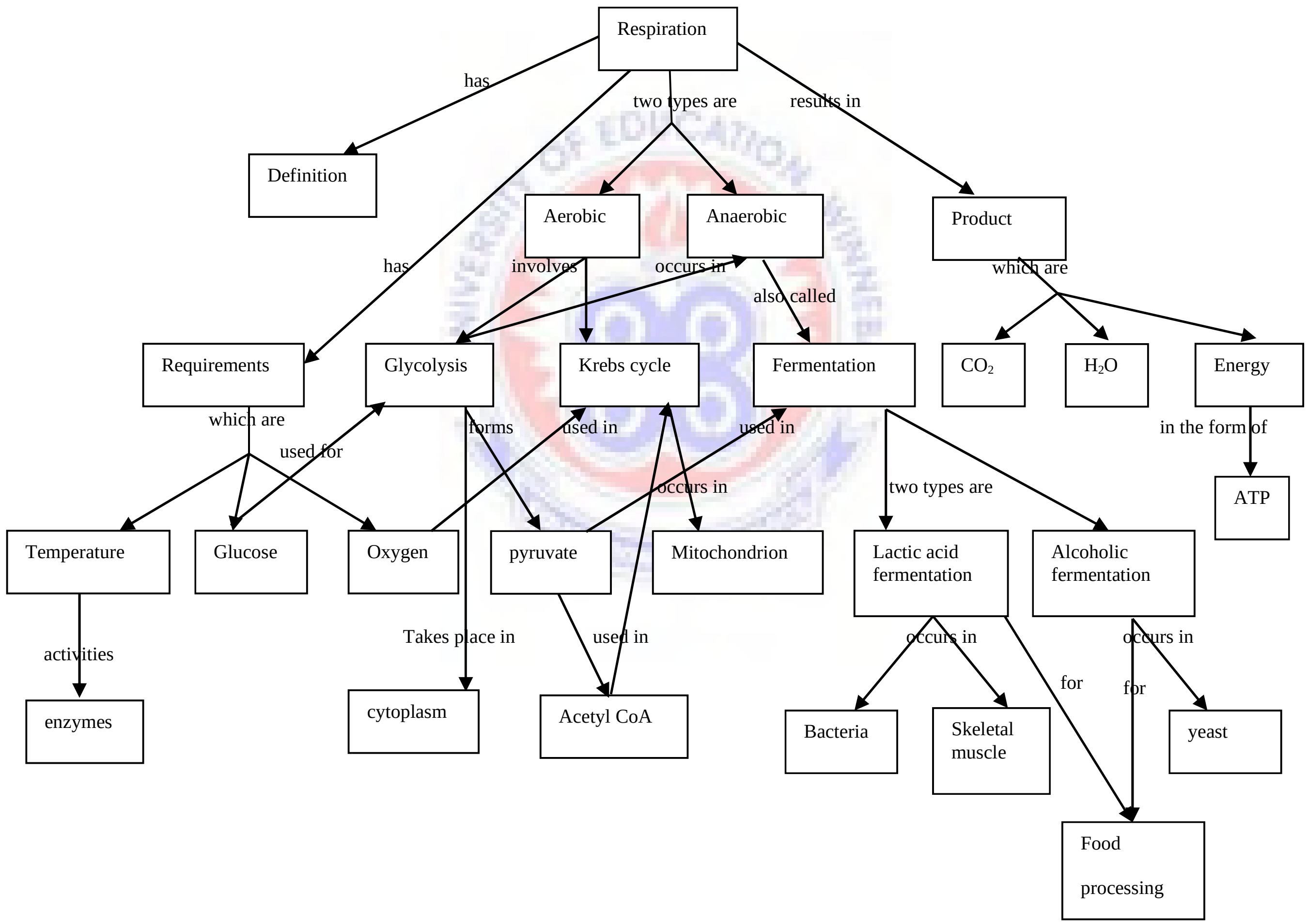
Date:

Date/ Duration	Objective	Teacher Activity	Learner Activity	Core points	Evaluation
Date	**Objective** By the end of the lesson, students should be able to explain respiration ii. describe the process of aerobic respiration	Ask the students to bring out the meaning of gaseous exchange Ask students to explain respiration explain respiration in their own words. Eg. Explain respiration in your own words	Gaseous exchange is also known as breathing in mammals Students try to explain respiration in their own words as the process where glucose is oxidized to produced water, carbon dioxide and energy Students listen and write in their notebooks	Gaseous exchange is the diffusion of the oxygen and carbon dioxide that takes place in the alveoli part of the lungs. When oxygen goes into the capillaries carrying blood, the oxygen is diffused into the blood cells and the carbon dioxide is diffused into the Respiration is the sum total of the chemical processes that release energy from food substance within cells, with or without the participation of molecular oxygen This makes use of oxygen in the breakdown of organic food substance to produce energy carbon dioxide and water. This can be represented by the	

	R. P. K. Students can explain the concept of gaseous exchange	Teacher lead students discuss the aerobic respiration and stages of aerobic respiration		following equation Aerobic respiration consist of stage a. Glycolysis b. Kreb's cycle and c. Hydrogen carrier system	
		Teacher Activity	**Student Activity**	**Major Ideas**	**Evaluation**
Step III Glycolysis		Explain steps in glycolysis using illustrations on the board	Student listen and written steps of glycolysis into their notebooks	It is a series of reaction in which glucose molecules is broken down into two molecules of pyruvic acid. It occurs in the cytoplasm of every cell and oxygen is absent. It involves the following stages; a. Glucose molecule is converted into glucose phosphate. The phosphate group is donated by ATP	

Appendix G

GENERAL CONCEPT MAP OF CELLULAR RESPIRATION



Appendix H

GENERAL CONCEPT MAP OF PHOTOSYNTHESIS