**UNIVERSITY OF EDUCATION, WINNEBA**

# EFFECT OF CONCEPT MAPPING ON THE PERFORMANCE OF APAM SENIOR HIGH SCHOOL STUDENTS ON PHOTOSYNTHESIS

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# EFFECT OF CONCEPT MAPPING ON THE PERFORMANCE OF APAM SENIOR HIGH SCHOOL STUDENTS ON PHOTOSYNTHESIS

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**A dissertation in the Department of Science Education,**
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# DECLARATION

**Candidate's Declaration**

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

**Signature: …….**

**Date: …….**

**Supervisor's Declaration**

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

**Supervisor's Name: PROF. JOHN K. EMINAH**

**Signature:…….**

**Date:…….**

# DEDICATION

This work is dedicated to my parents, my Husband Mr. Amoako. I also dedicate this work to all who believe in my ability to succeed.

# ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to all whom in diverse ways contributed towards the writing of this thesis.

First, my special thanks go to **PROF. JOHN K. EMINAH**, my supervisor for his constructive comments and his useful suggestions and comments.

I also thank Mr. Amoako, my dearest husband, for all his prayers and financial supports.

Finally, I am also thanking my colleagues and friends for their prayers too.

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# ABSTRACT

The main purpose of the study was to investigate the the effect of concept maps or mappings on the performance of Apam Senior High School Students on photosynthesis. A convenience sampling was used to select 55 Home Economic students of Apam Senior High School. Biology Achievement Test on photosynthesis was used to assess the students‟ performance. Interviews and a five points Likert scale questionnaire was also designed to determine the students' response to the use of concept maps. A Cronbach alpha coefficient of 0.86 was obtained which indicated that the instruments used were reliable. To ensure that the instruments were valid, both tests were developed from the SHS biology textbooks and the syllabus. Their responses from the questionnaires were also used to design observation schedule to confirm the students‟ responses and opinions in the questionnaire. The major findings that came out of the study were that; there was a significant difference between the pretest and posttest means scores of the students and that they performed better when concept maps were used to teach them. There was also a significant difference between the performance of males to females and that the males outperformed their female counterparts in the study. Also, after the used of the intervention, the students were enthused with the use of concept mapping strategy and that the intervention helped them to perform better. The students also felt that concept mapping helped them to keep ideas longer in their memories and reduced rote memorization of facts.

# CHAPTER ONE

# INTRODUCTION

## 1.0 Overview

This chapter deals with the background of the study, statement of the problem and the purpose of the study. It would also look at the objectives of the study, significance of the study, research questions, significance, limitations and delimitations of the study.

## 1.1 Background to the Study

In all the history of education, the study of science and mathematics has held its leading position among all school subjects because it is considered an indispensable tool in the development of the educated person. Undoubtedly, the study of science and technology in today"s world development cannot be overemphasized. The works of Anamuah - Mensah (1998) even posited that Africa had experienced an immeasurable level of development in this era of globalization and neo-liberalisation for which the study of science and technology is the bedrock. Such development is the advancement in proper healthcare delivery, research into infectious disease and control as well as food production and security.

For these and many other reasons, science educators give special recognition to the study of biology among the sciences because of its educational values, its close relation to man as a living organism, its peculiar field of medicine, and the interrelationship nature of the subject with the other sciences. It is based on these important roles of biology that the Ministry of Education (MOE) through the Ghana Education Service (GES) included biology in the science curriculum.

The main importance of biology education in Ghana is to make the student a critical thinker (CRDD, 2010). However, many variables are known to be contributing factors

to making the students critical thinkers, successful students worldwide and to maintain the development of our era in globalisation and neo-liberalisation. The teachers‟ contributing factor has then been found to stands tall in this regard (Hynie, 2006). This is because the teacher in an attempt to make teaching and learning more effective would have to select the appropriate teaching method and the teaching and learning materials to promote effective teaching and learning. This suggests that the role of the teacher therefore is to facilitate the learning process by making concepts clear and concise to the learner. In teaching concepts like; respiration, digestion, genetics and photosynthesis perceived to be difficult and challenging to students due to their abstract nature (Pop – Pacurar; Doina, 2009), the teacher ought to choose the best of methodology that could make students understand the concepts better for easy learning. It is therefore the need of the biology teacher to help achieve this aim of the biology curriculum. The teacher then performs this role by facilitating the learners‟ acquisition of knowledge and skills by using appropriate teaching methodologies or interventions to help them understand and achieve success. It is therefore imperative for curriculum planners and teachers to fashion out effective ways that could motivate the student to learn effectively.

Effective instruction is often designed based on the learning theories. Many researchers have voiced their concerns about the pedagogical effectiveness of educational software‟s which are available and their importance of integrating learning theories into instructions. Ausbel's learning theory is one of the important cognitive theory that emphasises meaningful learning. For meaningful learning to occur Ausubel advocated for the use of advance organisers which is base on the idea that the teacher is given a short description of the new material before the lesson

begins to prepare the students mind to accept the new material to be taught (Reece & Walker, 2003).

Effective teaching also demands both intellectual skills and interpersonal rapport. Skills used in creating intellectual excitements comprise the clarity of instructional communication and positive emotional impact on learners. Clarity in this case relates to what one presents whiles emotional impact relates to the way the material is presented. However, knowing the content is quite different form how it is presented. The teacher must be able to present the content well so that the student would be able to analyse, integrate, and apply it well in order for effective teaching to occur.

It is out of this that concept map has been suggested to be of a good choice to help the teacher. Concept mapping is an instructional tool that is currently gaining popularity in the field of science education. It is a product of recent advances in cognitive science and a new philosophy of science innovation that helps individual student to remember learned material for long and to be able to use them effectively (Gillmor, Poggio, & Embretson, 2015). These cognitive psychologist views learning as an active process of constructing meaning from learner‟s prior knowledge. In this way they consider learners as the architects of their own knowledge as they construct their own meanings from phenomena.

In this study the researcher adopted the use of concept mapping as a teaching strategy or intervention to help improve upon the interest of home economic students‟ of Apam Senior High School whom despite this all important role of the study of biology still do not pass well in biology due to the lack of the interest in the studying of the subject. However, in solving issues like this, many researchers believe concept

mapping strategy has the tendency to help solve and improve on the student‟s interest and their like for the subject.

### 1.2 Statement of the Problem

For quite some time now, Home Economic students of Apam senior high school have not been performing well in biology. For the past years, students‟ performance in biology at Apam Senior High School has not been encouraging, with the proportion that passed obtaining grade A-D at the final examination, ranging from 39 to 47.9% (WAEC 2006-2014). This WAEC Chief examiner‟s report shows a decline in the performance of biology students in WASCCE.

The researcher‟s investigations on the students revealed that the students do not perform well in biology. They felt that the teaching and learning of biology was boring and full of big words and terminologies that confused, frustrated them and as such discourages them from even reading biology texts. Photosynthesis is also a topic full of big terminologies, abstract and confusing ideas that demand serious analysis and interpretations in order to comprehend. According to Hrefna and Halldóra (2006), Photosynthesis is considered one of the complicated phenomenon to comprehend because, knowledge in chemistry and physics are essential to acquire. These ideas could also be acquired if there is clarity of facts within the concepts.

The work of Gillmor et al. (2015) have shown that when students get confused about a lesson, it could hinder their performance as a result of cognitive overload. Men-lei and Ming-Hsiung (2012) also supported this claim by explaining how confusion about a concept could cause students in Taiwan to perform poorly. In Ghana, a research on basic and senior high schools (Ntim, 2015) has shown that students‟ performance is related to the teaching approaches used by their teachers. To the knowledge of the

researcher, no studies have been done at Apam Senior High using concept mapping to improve the performance of the students in photosynthesis.

### 1.3 Purpose of the Study

The purpose of the study is to investigate the effects of concept maps on the performance of Apam Senior High School students on Photosynthesis. It is in this regard that the researcher sought to employ the use of concept mapping teaching strategy which has been widely recommended by many to help improve and arouse students‟ interest in learning (Adeneye & Adeley, 2011; Candan, 2006; Esiobu & Soyibo, 2006; Meng-Lei & Ming-Hsiung, 2012).

### 1.4 Objectives of the Study

The following are the objectives that guided the study.

1. To determine the difficulties the selected students of Apam Senior High School Students face during lessons on photosynthesis.
2. To determine the effect of concept mapping on the selected students' performance in photosynthesis.
3. To determine the differential effects of concept mapping on the cognitive achievements of the male and female students in photosynthesis.
4. To determine the views of the students on the use of concept mapping during biology lessons.

### 1.5 Research Questions

The following research questions were addressed in the study:

1. What difficulties do the selected students encounter during lessons on photosynthesis?
2. What are the effects of concept mapping on the selected students' performance in photosynthesis?
3. What are the differential effects of concept mapping on the cognitive achievements of the male and females‟ students in photosynthesis?
4. What are the views of the students on the use of concept mapping during biology lessons?

### 1.6 Delimitations of the Study

In order to implement the research tools effectively, this research work involved only form two (2) Home economic students of Apam Senior High School since the researcher observed their peculiar challenge of poor performance in biology examinations in them. The study also focused only on the effect of concept mapping on the performance of Apam senior high school students on photosynthesis.

### 1.7 Limitation of the Study

Students absentee occasionally limited the scope of the study which potentially might have affected the results of the study.

### 1.8 Significance of the Study

The study could be used to help both the teacher and the student to teach and learn biology better for achieving success. This study would provide another alternate way of using concept mapping strategy to teach biology and also help improve upon student"s performance in biology studies.

### 1.9 Definition of Terms

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

**Concept maps:** They are the tools for organising and representing knowledge and are concepts enclosed in circles of boxes of some type and relationship between concepts or propositions indicated by connecting lines between the two concepts.

**Assessment:** An exercise, such as the activity, written exam that seek to measure a students" skills or knowledge in a subject area.

**Cognitive knowledge:** The level of understanding just beyond which may include the application of rules, methods, concepts, principles, laws, and theories. It involves also the knowledge that is concerned with the relationships and identification of the links amongst the item of knowledge.

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

**SHS:** Senior High School.

### 1.10 Organisation of the Study Report

This thesis write-up is segmented under five chapter headings, namely introduction, review of related literature, research methodology, data analysis and discussion of results, and conclusion and recommendations. The introductory chapter, captioned chapter one provides detailed information on the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, limitations and delimitations of the study. Chapter Two of this thesis deals with the review of related and relevant literature from sources like books, journals, abstracts and online resources on the performance of a student in a particular activity involving the use of the concept mapping teaching methodology.

Chapter Three provides detailed information on the conduct of the study, under the following headings; research design, population, sample and sampling technique, research instruments, reliability of the instrument, validation of the instrument, data collection procedure and data analysis procedure. The fourth chapter presents the data collected, their appropriate analysis and discussion of results by research questions whiles the fifth and final chapter presents the summary of the results of the study, conclusions arrived at, recommendations and suggestions for further study made by the researcher.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.0 Overview

This chapter would review existing literature on concept maps. The review would look at the definition and history of concept maps, the importance of concept maps, designing and construction of concept maps. Additionally, a short review of photosynthesis, the methods of scoring concept maps, and the uses of concept maps are described in this chapter.

## 2.1 The Conceptual Framework of the Study

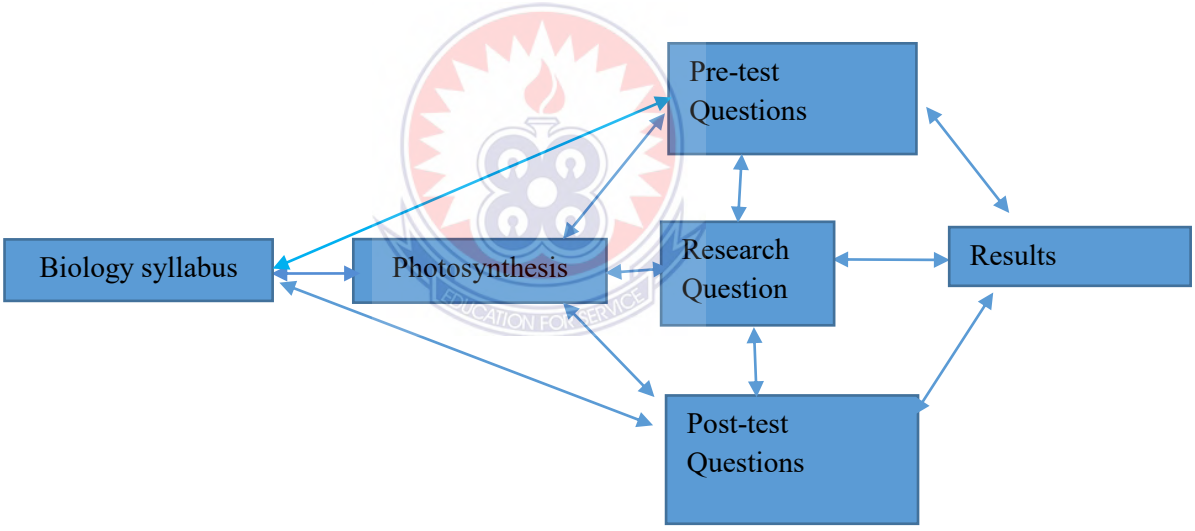


**Figure 1: Conceptual Framework of the Study**

In order to achieve the objectives of the study, the selected biology topic Photosynthesis was selected from the approved GES syllabus. Two types of questions being the pre-test and post-test were set from the selected topic Photosynthesis. The results obtained from each of the groups served as the results of the study which was used to answer the research questions. The research questions therefore conform to the contents of the biology syllabus. After the results have been obtained, an

observation checklist and an interview was conducted to confirm the responses the students gave to support the results obtained.

## 2.2 Concept of Photosynthesis

Photosynthesis is the biological process aided by enzymes in which green plants manufacture their own food with the aid of components such as chlorophyll, sunlight, carbon dioxide to release oxygen (Johnson, 2016).

It is the ultimate source of all of humankind‟s food and oxygen, whereas fossilized photosynthetic fuels provide over 87% of the world‟s energy. It is the biochemical process that sustains the biosphere as the basis for the food chain. The oxygen produced as a by-product of photosynthesis allowed the formation of the ozone layer, the evolution of aerobic respiration and thus complex multicellular life. Oxygenic photosynthesis involves the conversion of water and CO2 into complex organic molecules such as carbohydrates and oxygen (Johnson, 2016).

Photosynthesis may be split into the „light‟ and „dark‟ reactions. In the light reactions, water is split using light into oxygen, protons and electrons, and in the dark reactions, the protons and electrons are used to reduce $CO_2$ to carbohydrate (given here by the general formula $CH_2O$) (Johnson, 2016).The two processes can be summarized thus:

Light reactions: $2H_2O + \text{light} \rightarrow O_2 + 4H^+ + 4e^-$ $\quad G^\circ = +317\ kJ \cdot mol^{-1}$

`Dark reactions: $CO_2 + 4H^+ + 4e^- \rightarrow CH_2O + H_2O$ $\quad G^\circ = +162\ kJ \cdot mol^{-1}$

Overall: $H_2O + \text{light} + CO_2 \rightarrow CH_2O + O_2$ $\quad G^\circ = +479\ kJ \cdot mol^{-1}$

Photosynthesis is a highly regulated, multistep process. It encompasses the harvest of solar energy, transfer of excitation energy, energy conversion, electron transfer from water to $NADP^+$, ATP generation and a series of enzymatic reactions that assimilate carbon dioxide and synthesize carbohydrate.

Chloroplast is an organelle in plants and algae. It contains chlorophyll for trapping sunlight to excite electrons as they move through the electron transport chain. Photosynthesis takes place in chloroplast. There are two stages of photosynthesis, the light and dark stages. The light stage occurs in the thylakoid membranes of the Granum for the production of oxygen, hydrogen and ATP. The dark stage is the stroma leads to the production of starch.

Chloroplast is a double membranous organelle found in plant cells. It is spherical in shape. The inner membrane is fluid filled with many thylakoid membranes. These thylakoid membranes form a stuck of interconnected membranes (pilled coins) called granum. The outer layer is made of the stroma.

**2.3 History of Concept Maps**

Concept maps were developed in 1972 in the course of Novak‟s research programme at Cornell where he sought to follow and understand changes in children‟s knowledge of science. During the course of their study the researchers interviewed many children, and sought to find how they learned. He found it difficult to identify specific changes in the children‟s understanding of science concepts after examining them and the interview of their transcripts. The programme was based on the learning psychology of Ausubel (1978). The fundamental idea in Ausubel's cognitive psychology is that learning takes place by the assimilation of new concepts and propositions into existing concept propositional frameworks held by the learner.

Ausubel was the researcher, who developed comprehensive studies about the cognitive psychology of learning especially in children and believed that learning was given through the assimilation of new concepts and the propositions into an already existing concept and proportional systems already present in the student mind or memory.

This knowledge structure he called the cognitive structure of the individual. In the quest to finding a better way to represent conceptual understanding of children, Novak came up with the idea that children‟s knowledge could be represented by a sort of concept maps basing this assertion on the Ausubel's cognitive structure. Based on this, Novak designed and presented a new tool and a new opportunity that might be used to understand and know the various ways individuals organise the concepts cognitively for the understanding of some subject. Novak developed the concept maps from diagrams indicating relationship between concepts or between words that are used to represent other concepts (Coutinho, 2014).

**2.4 Concept Map and Concept Mapping**

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 (Edmondson, 2005), thus helping students to learn. Concept mapping or map is an instructional tool that is currently gaining popularity in the field of science education (Abimbola, 2007). The concept and theory of Concept Map had its roots in education and learning (Cañas, Valerio, Lalinde-Pulido, Carvalho, & Arguedas, 2003). 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 (Gillmor et al., 2015).

According to Buzzetto-More (2007) Concept map is a graphical representation of concepts and are usually shown by circles of bones, forming the nods of the new work, labelled by links and arranged in a hierarchical manner. The term concept map and concept mapping have been used interchangeably to mean a technique for picturing the relationships among different concepts (Ajaja, 2009). Hence concept mapping and concept maps are synonymous. At first glance, one would observe a concept map to look like a flow chart in which the key terms are placed in boxes connected by directional arrows. The nodes are linked together by propositions and this show how students connect or link concepts. Concept maps are based on the idea that concepts do not exist in isolation but depend upon others for its meaning.

Therefore, concept mapping or map is a technique used to represent the relationships among concept and serves as a strategy to help learners arrange their cognitive frameworks into more powerful integrated patterns (Kinchin, 2005). Most of the definitions of concept mapping describe the techniques as a knowledge representation tool (Huai & Kommers 2004). As a knowledge representation tool, concept mapping has some characteristics that could make it a powerful problem-solving tool as well (Stoyanov, 2001). They believed that the technique is an adequate, flexible and an intuitive way to express the mental model of the problem solver. To Stoyanov (2001) what make concept mapping a powerful problem-solving technique is its knowledge representation, knowledge elicitation, knowledge reflection and a knowledge changing tool.

## 2.5 Types of Concept Mapping Strategies

The three different concept mapping approaches are the paper-and-pencil approach (PAP), the computer-assisted construct-by-self approach (CACBS), and the computer-assisted construct-on-scaffold approach (CACOS).

### *2.5.1 The paper-and-pencil approach (PAP)*

This where the students use pencil or pen to make or construct or draw maps from a given concept showing prepositions and linking phrases or verbs. Although many studies have shown that concept mapping can improve learning, most of these studies are based on the paper-and-pencil approach. However, some studies (Chang, Sung, & Lee, 2003; Liu et al., 2010) have argued that paper-and-pencil concept mapping have many disadvantages such as instant feedback from teachers, and the difficulty to construction of a concept maps by the novices.

To solve these problems, researchers have developed the use of various computer-assisted concept mapping systems, such as the computer-assisted construct-by-self approach (CACBS), and the computer-assisted construct-on-scaffold approach (CACOS) that could help students efficiently construct and revise concept maps, improve the interaction between teacher and student, and enhance student learning achievement (Liu et al., 2010; Royer & Royer, 2004).

### *2.5.2 The computer-assisted construct-by-self approach (CACBS)*

CACBS is the type of concept mapping approach that requires students to use computer software for constructing a correct and appropriate concept map on any concept. This approach is also recognised as a Computer-assisted concept mapping in which concept map construction

Would be aided by a computer. By incorporating computer-assisted learning and concept mapping as a learning strategy, learners can create concept maps and achieve learning effectiveness (Liu et al., 2010).

### *2.5.3 The advantages of the computer-assisted construct-by-self approach (CACBS)*

Advantages of computer-assisted concept mapping include the ease and fast with which concept maps are constructed. This is because construction of concept maps could sometimes be challenging to do and the use of a software tend to simplify the construction. Also the possibility of instant feedback from an instructor, is one of the numerous advantages of computer assisted concept maps. This approach also provides a good interaction between the teachers and learners or students (Kwon & Cifuentes, 2009; Liu, 2011; Liu et al., 2010; Royer & Royer, 2004).

Despite the advantages of the computer-assisted concept mapping, there exist some drawbacks. For instance, novices may get frustrated easily, feedback from experts is difficult, students‟ learning motivation can be decreased and not easily focus on the subject of the mapping process (Chang et al., 2003).

### *2.5.4 The computer-assisted construct-on-scaffold approach (CACOS)*

CACOS requires students to complete unfinished parts of an expert-generated concept maps. This approach gives incomplete expert-generated concept maps as a scaffold in which nodes and links are blank. Students then fill in these concept maps. This technique has been proven to be effective for assessing knowledge structures (Chang et al., 2001). Additionally, the approach provides an expert knowledge structure that reduces the mental load for novice students (Chang et al., 2003).

## 2.6 Construction of Concept Map

As suggested by Akeju, Rotimi, and Kenni (2011) constructing concept maps involves following systematically steps below:

- Identifying the major components of the concept ( topic)
- Arranging the concept‟s components in hierarchical order
- Linking the components with linking phrases
- Making cross links with directed lines

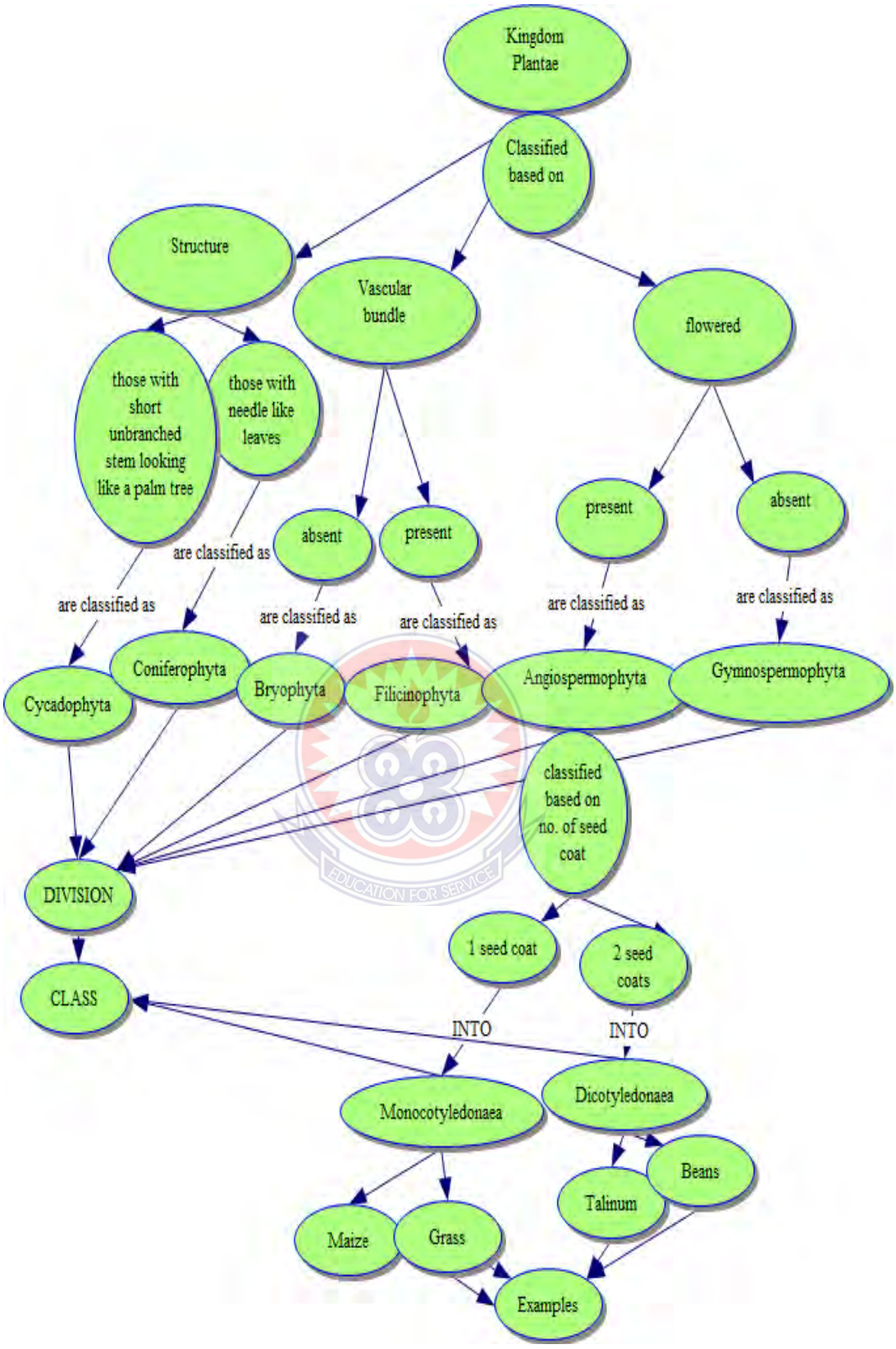


**Figure 2: An example of a Concept Map on Classification of Plants (Amoako, 2016)**

According to Navak and Cañas, (2008), in constructing a concept map, it is important to begin with a domain of knowledge that is very familiar to the person constructing the map. Since concept map structures are dependent on the context in which they will be used, it is best to identify a segment of a text, a laboratory or field activity, or a particular problem or question that one is trying to understand. This creates a context that will help to determine the hierarchical structure of the concept map. It is also helpful to select a limited domain of knowledge for the first concept maps.

A good way to define the context for a concept map according to the two researchers is to construct a „Focus Question" that is, a question that clearly specifies the problem or issue the concept map should help to resolve. Every concept map responds to a focus question, and a good focus question can lead to a much richer concept map.

Given a selected domain and a defined question or problem in this domain, the next step is to identify the key concepts that apply to this domain. Usually 15 to 25 concepts will suffice. These concepts could be listed, and then from this list a rank ordered list should be established from the most general, most inclusive concept, for this particular problem or situation at the top of the list, to the most specific, least general concept at the bottom of the list. Although this rank order may be only approximate, which would help to begin the process of map construction. They referred to the list of concepts as a parking lot, since we will move these concepts into the concept map as we determine where they fit in. Some concepts may remain in the parking lot as the map is completed if the mapmaker sees no good connection for these with other concepts in the map. The next step is to construct a preliminary concept map. This can be done by writing all of the concepts linking them to arrows which extend downwards. This is necessary as one begins to struggle with the process

of building a good hierarchical organisation. After a preliminary map is constructed, it is always necessary to revise this map. Other concepts can be added. Good maps usually result from three to many revisions.

Once the preliminary map is built, cross-links should be sought. These are links between concepts in different segments or domains of knowledge on the map that help to illustrate how these domains are related to one another. Cross-links are important in order to show that the learner understands the relationships between the sub-domains in the map. It is important to help students recognize that all concepts are in some way related to one another. Therefore, it is necessary to be selective in identifying cross-links, and to be as precise as possible in identifying linking words that connect concepts. In addition, one should avoid "sentences in the boxes", that is, full sentences used as concepts, since this usually indicate that a whole subsection of the map could be constructed from the statement in the box.

Once students begin to focus-in on good linking words, and on the identification of good cross-links, they can see that every concept could be related to every other concept. This also produces high levels of cognitive performance. Concept mapping is an easy way to encourage very high levels of cognitive performance, when the process is done well. This is one reason concept mapping can also be a very powerful evaluation tool (Ajaja, 2009).

Finally, the map should be revised, concepts re-positioned in ways that lead to clarity and better over-all structure, and a "final" map prepared. When computer software is used, one can go back, change the size and font style, and add colours to "dress up" the concept map. Thus, we see that concept maps are not only a powerful tool for

capturing, representing, and archiving knowledge of individuals, but also a powerful tool to create new knowledge.

### 2.7 Scoring of Concept Maps

There are numerous methods of scoring concept maps according to Keppens and Hay (2008). They include such methods like; Holistic scoring method, weighted component scoring methods, the closeness index (Quantitative assessment methods) and Linkage analysis (Qualitative assessment method).

#### 2.7.1 Holistic scoring method

In the holistic scoring method, experts score concept maps of students on a scale, say 0 to10, indicating the student‟s overall understanding of the concept. It does not give any algorithm, or guidelines to calculate the scores. (Keppens & Hay, 2008).

#### 2.7.2 Weighted component scoring method

According to Keppens and Hay (2008) the weighted component scoring method gives point scores to certain concepts or links between concepts. The method proposes a relatively small score for each valid link and each valid example of a concept. It also gives a substantially higher score to links that express a hierarchical relation, such as “is a kind of” or “contains” relationships. Thus the highest scores are reserved for links between concepts that are located on different branches of hierarchical structures. In this case, the score associated with a concept map equals the sum of the partial point scores awarded to each component of that concept map.

### *2.7.3 The closeness index*

The closeness index according to Keppens and Hay (2008), is a heuristic approach that aims to calculate the similarity between a student‟s and a teacher‟s concept maps. The approach focuses on the concepts and links between concepts that the two maps have in common, ignoring the labels of the links.

### 2.7.4 Linkage analysis

Linkage analysis, devised by Liu, Don and Tsai (2005), aims to identify potential misconceptions of students by comparing the concepts each individual concept is directly linked to in a student‟s and the teacher‟s concept map of a particular domain. In this way, linkage analysis identifies certain symptoms that indicate potential misconceptions and may be able to suggest improvements to the concept maps.

For example, linkage analysis can identify potentially confused concepts. If a concept **A** in the student‟s map is linked to a set of concepts **C,** whiles the teacher‟s map contains a concept **B** that is mostly connected to most of the concepts in **C**, then the student may be confusing **B** with **A**. In this case, **A** is said to be a confused concept. If a student incorrectly links a concept **A** to a set of concepts **C**, while in the teacher‟s map, a concept **B** is connected to the concepts in **C**, then it can be suggested to the student that **A** may have to be substituted to **B**. Linkage analysis can also identify less obvious misconceptions. For example when a concept **E** is correctly linked to other concepts in a set **D**, but the concepts in **D,** are incorrectly linked, then the student may have misunderstood **E** in the first place. The simplistic nature and the ease at which misconceptions could be detected by students themselves make this a preferred

method in this study. Also this qualitative assessment method is preferred due to its ability to identify and corrects student‟s confusion of concepts.

## 2.8 The Importance of Concept Mapping

### *2.8.1 Concept mapping as an instructional strategy*

Literature on concept mapping indicates that concept mapping has long been used as instructional, assessment and learning strategies (Liu, et al. 2005).

Some studies on the effects of concept mapping when used as an instructional strategy for teaching and learning, indicated its importance in improving the cognitive and affective aspects of learning. Concept mapping is used as an instructional or teaching strategy because, it presents information or knowledge to students in a step-by-step manner where the information is organised in a hierarchical order making the teachers teach from the known to the unknown. This strategy of teaching from known to unknown has always been the basis for all teaching methodologies. This enables students to also learn from the unknown to the known as proposed by Jean Piaget. It is also a good teaching strategy because it offers a great opportunity for students to identify the relationship between concepts or ideas for clarity so as for easy understanding. In teaching, one of the teachers‟ duties is to facilitate learning by making concept clearly understood by the students. Therefore any strategy that offers opportunity for clarity of information becomes a good teaching strategy to be used by teachers. Concept maps with concepts linked with their linking words, or phrase makes concept clearer and as such a good teaching methodology or strategy. Concept mapping is also an example of a teaching strategy in the sense that when teachers use it, it enables the teacher to summarise bulky informations into simpler forms for the students to study with ease.

As a teaching tool, Kabaca (2002) and Mclay and Brown (2003) compared concept mapping to the traditional method of teaching. They concluded that concept mapping was more successful as a teaching and learning tool because students who used it gain higher marks an indication that they understood the concept taught with ease. The reason could be that concept mapping organised and visualised the relationships between the key concepts in a semantic way as was proposed by Pill (2005).

According to Ahmed (2010) and Kommers (2004), concept maps can be used as advanced organiser to improve learner"s achievement. As an advanced organiser, concept mapping can elicit the learner"s previous knowledge about a concept, making the learner learn from known to unknown to promote meaningful learning. This equips teachers with a new approach to make them teach well.

Ajaja (2009), noted that concept maps help in understanding of ideas by showing the connections with other ideas. The process of simplifying concepts and arranging them on a page forces the learner to think about what is most important.

According to the constructivist view, a good instructional strategy is one that make the students to construct their own knowledge and understanding based on prior knowledge that the students already have. In the course of the knowledge construction, the students may obtain some knowledge that are inconsistent of the actual facts especially if the prerequisite knowledge needed by the student is absent. Concept mapping strategy has been recommended to be the best strategy to use to fill this gab in learning that makes learning problematic for students. This is because the concept mapping strategy could make concept stick for long, gives clues in the form of linking phrases that makes students remember concepts faster.

### 2.8.2 Importance of concept mapping as a learning tool

Ajaja (2009) determined the effects of concept mapping as a study tool for student‟s achievement in Biology. The major findings of that study indicated a significant and consistent improvement in Biology achievement as the period of experience with the use of the method increased. The students who learned with concept mapping as a study tool retained biological knowledge longer than those who used other methods. This is because concept map were used to summarise information at the end of teaching for easy revisions and learning afterwards. It was also able to reduce and even remove irrelevant concepts, ideas or informations that were likely to hinder the performance and learning of the students due to the cognitive overloads they may present. All the students interviewed in the concept mapping classroom agreed that concept maps helped them not only in the determination of the relationships among the concepts but also shaped their understanding of the concepts and increased their critical thinking.

The findings of Kinchin (2000) were similar to those of Ajaja, where there was a significant impact of concept mapping on the achievement of biology students. In that study, Kinchin compared the effect of the use of concept mapping as a study skill on student‟s achievement. He found a positive effect on students who used concept maps to revise and summarise the materials they have been given.

### 2.8.3 Concept mapping helps to clear student's misconceptions

The hierarchical arrangement of concepts showing links and interrelationship among other concepts, clarifies learners‟ misconceptions as suggested by Liu, et al. (2005). They are of the view that if students compare their concept maps with their teachers‟,

their misconceptions would be rectified. Concept mapping also allow students to reflect on their own misunderstanding as well as their confused concepts and then take ownership of their learning (Esiobu & Soyibo, 2006). This clarifies the learner‟s thought and understanding making learning more meaningful. It therefore helps in the development of critical thinking skills. Perhaps this is the reason why Johnstone and Otis (2006) suggested concept mapping to be used as a personal learning tool.

### 2.8.3 Concept Mapping as a Pedagogical Tool

A variety of pedagogical tools are open to secondary school teachers to enhance student understanding of scientific concepts. However, concept mapping has been reported to provide a very effective strategy to help students learn meaningfully by making explicit the links between scientific concepts (Fisher, Wandersee & Moody, 2000). Concept mapping also has been reported to aid collaborative learning and to improve students‟ problem-solving ability.

Concept maps are constructed by writing concepts in boxes and linking them by labeled lines. The labels are important because they require whoever is constructing the map to actively select appropriate linking words. The links need to be valid, in that they need to make sense, and to be genuine links between the two concepts. In other words, they need to relate the two concepts in some meaningful way that is in agreement with consensual scientific views. The links then help a reader (for example, the teacher) to make sense of the students‟ concept maps. Concept mapping also is a tool that enables gaps in knowledge and misunderstandings, that later might lead to alternative conceptions, to be identified and addressed. In this way, concept maps can act not only as a pedagogical tool but as a means of formative assessment. These assertions make concept mapping a good pedagogical tool. From the works of

Coutihno, (2014) and other cognitive psychologist concept maps could be used to teach or deliver instructions or topics successfully. It could also be used as an advance organiser to preset an instruction or teaching. It could also be used to assess students understanding of concepts or performance as well as being used as an evaluation tool during and after a lesson has been taught. From all these usages of the concept mapping strategy it could be considered as a good pedagogical tool that could be used to teach or deliver instructions to students understanding and performance.

### 2.8.4 Concept mapping has the ability to helps in recalling information that has been learned promptly

Akeju et al., (2011) in a study discovered a significant effect of concept mapping as an instructional strategy on students‟ learning achievements. The strategy helped in prompt recall of informations or ideas they have learned. Candan (2006) investigated the effect of concept mapping on primary school students understanding of the concepts of force and motion. The result revealed a significant difference between the mean scores of the experimental and control groups and posited that the strategy helped them to remember facts and informations easy, faster and promptly.

Esiobu and Soyibo (2006) investigated the effects of concept mapping and vee mappings on student‟s cognitive achievement in ecology and genetics. They discovered that the experimental groups outperformed the control group. Adeneye and Adeleye (2011) in a similar study also discovered that concept mapping strategy enhanced student‟s achievement in mathematics because the method offered the student‟s another means to create the environment that differentiated mathematics instruction from the series of isolated activities. This is because when students read, see, watch or observe and practice by doing, they do not forget but remember easily

due to the indelible prints it leaves in their minds. However, they tend to forget when they only read. This concept mapping is endowed with because, when students read, they draw their own concepts maps a a way of practicing what they have heard and read.

### 2.8.5 Concept mapping as a strategy to reduce cognitive load

Men-lei and Ming-Hsiung (2012) conducted a study to determine the effect of concept mapping on students‟ cognitive load and discovered that students in the concept mapping class reduced their cognitive load more than students in the traditional teaching class. According to Ajaja (2009) and Bennett (2003) concept mapping is one method that could reduce cognitive load of students especially in biology. The researchers concluded that concept mapping reduced word counts and simplified terminologies; provided visual means of showing connections and relationships between ideas being taught. A reason why the student‟s learning loads were reduced.

On the effect of concept mapping for attitudinal change, the study by Eravwoke (2011) found a significant and positive effect on students‟ attitude when used for chemistry concepts. The students were motivated intrinsically to attend and learn chemistry on their own with the use of concept mapping.

### 2.8.6 Concept map as an evaluative tool

One of the powerful uses of concept maps is not only as a learning tool but also as an evaluation tool, thus encouraging students to use it meaningfully to learning (Mintzes, Wandersee & Novak, 2000). Concept maps are also evaluative tools because they are effective in identifying both valid and invalid ideas held by students after the instructions. During the evaluation stage of the teaching process, concept maps could be used so as to evaluate the valid or invalid informations the students have acquired for judgement on it to be made.

Although originally developed as an evaluation tool, concept map is now widely used in many other aspects as an instructional strategy in education. For instance, it has been used as a tool for curriculum development by Edmondson (2005) that helps to move meaningful information into long-term memory. Concept Maps have gained increasing support for use in distance learning courses because of their effectiveness in visually depicting the relationship between complex concepts (Cardellini, 2004). They have numerous educational applications, and are particularly useful for facilitating critical thinking and problem solving among students in asynchronous learning environments (Freeman & Jessup 2004; Chang, Sung, Y. T., & Lee, 2003).

In science education, Concept Map have been widely recommended and used in a variety of ways. It has been used to help teachers and students build an organized knowledge based on a given discipline or on a given topic (Blackwell & Pepper, 2008). It has also been used to facilitate middle level students‟ learning of science content (Adlaon, 2002; Dhaaka, 2012).

According to Coutinho, (2014) there exist seven models for assessing concept maps. These forms of assessment models could also be used to assess the performance of the students in a particular topic when concept maps are drawn.

The first model was prepared by Bartels who established three assessment parameters for assessment namely the concepts and it terminologies; knowledge of the relationships between concepts; and the ability to communicate through concepts maps. In assessing a concept map based on the Concept and Terminology parameter, the criteria is that, some marks would be awarded if the students map show an understanding of the topic"s, concepts, or principles and should also be able to use an appropriate terminology which (the right notations). However, if there exist some mistakes in the terminologies or shows a few misunderstandings of concepts, or makes many mistakes in terminology and shows a lack of understanding of many concepts as well as show no understanding of the topic"s concepts and principles, half the marks or no marks are awarded.

It therefore suggested that the map should be able to identify all the important concepts and shows an understanding of the relationships among them.

The map should be able to also communicate to learners or users with the Concept Maps by constructing an appropriate and complete concept map which places concepts in an appropriate hierarchy and places linking words on all connections. However a lesser mark would be awarded for concepts that places only a few concepts in an appropriate hierarchy or uses a few linking words to produces and no marks awarded for concept map that is difficult to interpret and this would mean a lack of understanding of the information or concept.

The second model was also prepared by Cronin, Dekker and Dunn (1982), This model has a structure very similar to Novak and Gowin scoring method which consist of parameters like identifying concepts; grouping concepts; hierarchy arrangement of concepts, branching and proposition linking concepts are scored individually accordingly. In using this strategy as an assessment scheme, the parameters are clearly defined explained and marks awarded accordingly.

The term grouping shows the ways concepts can be linked or joined together. There are three types of this grouping. This included amongst others as a number of single concepts emanating from one concept. There could be more concepts that are linked to a single chain. A score would be given to any concept map that obeys this parameter. Concepts on a map can also be represented as a hierarchical structure in which the more general, more inclusive concepts are at the top of the map; the specific and exclusive concepts are at the lower end of the map. Concept hierarchy is based upon the extent that concepts are present in an assigned level (as designated by the instructor) and score points are given to each concept correctly assigned to a level. Branching in this case of concept mapping also refers to the level of differentiation among concepts, that is, the extent the more specific concepts are connected to more general concepts.

Proposition are the Relationships between concepts are represented by connecting word(s) and phrases written on the line joining any two concepts. A simple Proposition is a simple English word or phrase in this case they propose that a score of one (1) point be given for each word or phrase and a half point for repeated use of Simple Propositions and a scientific Proposition as well. The third model was prepared by the National Computation Science Education Consortium from

Louisiana, United States (Cronin, et al. 1982). This model evaluates the concept maps based on three components namely structure of concepts, content and cooperation of the concepts with linking words or phrases.

The fourth model was prepared by University of Minnesota where the assessment considers five scales parameters such as structure of concept map, relationship between concepts, exploratory and communication of the concepts (Cronin, et al. 1982). The fifth model was designed by Novak and Canas (2008) and refers to as scoring criteria for concept maps. Nevertheless, this model is structured in four levels: propositions that joins or link concepts; hierarchical arrangement of concepts; cross links of linking words or phrases; and examples of concepts. The sixth model, built by McMurray, is based on Novak and Canas model too (Cronin, et al. 1982). The assessment model has six parameters: these are breadth of the concept, interconnectivity of concepts, use of descriptive links, efficiency of links, layout, and development over time.

Finally, Mueller, who developed the seventh assessment model concept map. The author has established four assessment parameters including the legibility, accuracy, completeness, and sophistication of concept maps (Cronin, et al. 1982).

If a student‟s constructed maps for instance obeys all these parameters, then it could be argued that the student had understood to some extent the concept being taught. The marks obtained also could be used to assess the performance of the students to the understanding of the topic being treated. This then suggest a new way for assessing students conceptual understanding of a topic taught. It could also be a new evaluation tool for the teacher since the students‟ concept could give clues to the teacher as to the students‟ level of understanding and performance for which special

attention could be given. Findings from these studies indicate that Concept Map is an effective tool for aiding students‟ comprehension of science materials.

### 2.8.7 Concept mapping aid students' Prior Knowledge in Introductory Science at the Tertiary Level

Constructivist-based views of learning argue that learners construct knowledge by relating new knowledge to relevant concepts that they already possess. During the learning process students may form understandings that are inconsistent with consensual scientific views or teaching models and concepts (Coll, France & Taylor, 2005), particularly if the prerequisite knowledge necessary for the construction of a new concept is absent from their cognitive structure. Prior knowledge is thus considered to be important because it interacts with knowledge presented during formal instruction, sometimes resulting in undesirable outcomes such as alter-native conceptions for important scientific concepts. Such alternative conceptions frequently make subsequent learning problematic as science understanding, and as a consequence teaching, builds on certain fundamental concepts in meaning-making and learning.

Recent research suggests that there are commonly differences between students‟ actual prior knowledge and the prior knowledge that faculty assume students possess for introductory science studies. Lack of ability to make appropriate connections between related scientific concepts may point to lack of coherence in students‟ cognitive structures and the organization of concepts in students‟ minds, with students considering separate concepts to be isolated and unrelated. In order to understand science in the way desired by teachers and the scientific community, students therefore need particular content knowledge, and the ability to form links between

related scientific concepts. They also need to be able to reorganize their prior knowledge in the light of new knowledge for which the use of concept mapping strategy is the best alternative for the student and the teacher.

### 2.9 The Importance of Concept Mapping to Students' Performance

Concept mapping could also be used by students as a learning tool. By so doing, Ajaja (2009) determined the effects of concept mapping as a study tool for student‟s achievement in Biology. The major findings of that study indicated a significant and consistent improvement in Biology achievement as the period of experience with the use of the method increased. The students who also used concept mapping as a study tool retained biological knowledge longer than those who used other methods. All the students interviewed in the concept mapping classroom agreed that concept maps helped them not only in the determination of the relationships among the concepts but also shaped their understanding of the concepts and increased their critical thinking.

The findings of Kinchin (2000) were similar to those of Ajaja, where there was a significant impact of concept mapping on the achievement of biology students. In that study, Kinchin compared the effect of the use of concept mapping as a study skill on student‟s achievement. He found a positive effect on students who used concept maps to revise and summarise the materials they have been given.

Concept mapping helps to clear student‟s misconceptions that they came with into the classroom. This is because the hierarchical arrangement of concepts showing links and interrelationship among other concepts, clarifies learners‟ misconceptions as suggested by Liu, et al. (2005). They are of the view that if students compare their concept maps with their teachers‟, their misconceptions would be rectified. Concept mapping also allow students to reflect on their own misunderstanding as well as their

confused concepts and then take ownership of their learning. The use of physical models to teach as opined by Gobert and Buckley (2000) also has this advantage of student corrections to their already constructed models so as to correct their misconceptions.

In the works of Clement and Maria (2003), when students were asked to describe the throat in respect to respiration and digestion, it was clear that most student had a wrong impression of the throat. Two kinds of students‟ preconceptions about the throat were detected throughout the research. In the first kind, the students believed that there was only one tube where food and air go together. In the second kind, students believed that there was one tube for the air and another completely independent tube for the food. A few students also believed that a tube connected lungs and stomach. In that lesson, students were asked to draw individually their ideas about the throat. In this lesson, the teacher detected the students‟ conception by asking them to create a model on a small whiteboard to illustrate the structure of the throat. The students‟ misconception was cleared and corrected after the students compared their models to that of their teacher indicating that when images like models and concept mapping as well as mind mapping are used, misconceptions of students could be corrected.

Pankratius (1990), in his study found concept mapping a key to organize an effective knowledge base. The study revealed that those students who used concept mapping prior to, during and subsequent to instruction led to greater achievement than groups that received standard instruction. Thus the acquisition of powerful super ordinate concepts should be a primary goal of effective science teaching.

## 2.10 Effect of Concept Mappings or Maps on the Gender of the Students

Significant researches have indicated that gender plays a role in students‟ academic achievement particularly in Biology and Science in general. Okeke (2007) observed that the consequences of gender disparity cut across social, economic, political and educational development, especially in the areas of science and technology. Offor (2007) identified some reasons for gender disparity in science education to include; opportunity cost of education, early marriage among girls, lack of female role models, poor self-concept, inherent sex differences, teaching methods and gender stereotyping among students and teachers.

In a study conducted by Ogonnaya, Okafor, Abonyi, and Ugama, (2016) despite the gender disparity espoused by Offor (2007), both male and female students performed equally in basic science when concept mapping strategy was used to teach them in class. In that study, the researchers investigated the effect of concept mapping on students' achievement in basic science in Ebonyi state in Nigeria. The study employed the quasi-experimental design with 122 secondary school students. Two schools were used for which one served as the experimental and the other the control. The treatment group was taught with concept mapping whiles the other was taught with the conventional method. Means standard deviations and co - variance were used to analysed the results findings. The results showed that, concept mapping foster student‟s achievements and that there is no gender disparities in the use of concept mapping. Both males and females interacted equally with the use of concept mapping and as such benefited equally from the use of concept mapping. They believed that concept mapping takes care of the student‟s individual needs because it present concepts bit by bit, from known to unknown and also aid to promote critical thinking in both males and females.

From the results obtained and tests based on research questions and the hypothesis, it was evident that the mean achievement of male and female students in basic science was not significant. This meant that the difference between the achievement of male and females in basic science was not significant. This further showed that concept mapping produced the same effect on the mean achievement of the male and female students. The result of this study was contrary to the work of Olatoye and Afuwaye (2004), which revealed that there was gender difference in the achievement of students in science subjects.

Other studies supported the claim that, Concept mapping method favored boys over girls (Karakuyu, 2010). This was because the significant interactions between concept mapping and sex can be interpreted in light of the cognitive style theory that categorises males and females into different learning styles. According to Wapner (1986), males are field-independent learners while females are field-dependent learners. Field independent individuals, such as males, use active reasoning patterns that include cognitive structuring skills, while field dependent individuals, such as females, accept reality and may become passive learners.

Generally, boys outperform girls in mathematics, particularly among children, but in the reading domain, girls outperform boys. The reason the researchers gave was due to the high level of testosterone found in only men. Evidence from laboratory and other experiments indicated that women display less aggressive behaviour and engage less in competitive activities. The experimental results also indicated that women are less likely to take risks all due to the absence of testosterone and therefore more likely not to benefic from learning strategies involving competitions (Zwiers & Gielen,

2018). This cold be the reason why certain vocations and professions such as medicine, engineering, and architecture have traditionally been regarded as men‟s career and others sch as nursing, catering, typing, and arts are women‟s career (Sukola, Abdulmalik & Yunusa, 2016). Occupations sch as medicine, engineering, and architecture are all risk taking jobs where one has to think critically to make the best choice of decision to save either lives or properties. These risk taking hinders most females to make a choice in reading such courses.

Pandian (2004) investigated the effects of cooperative computer-assisted learning method on male and female students‟ achievement in biology. The students were randomly grouped into cooperative computer-assisted learning and traditional method groups. The analysis of results indicated that gender did not express any significant influence on biology achievement.

However, male and female students in the cooperative computer-assisted instruction group showed remarkable post-test mean differences over their respective counterparts who learned the same biology concepts through traditional method. A number of studies concluded that girls‟ outperformance and boys‟ underperformance in education appears to be a global trend (Raza & Hazir, 2019).

Wachanga and Mwangi, (2004) examined how the cooperative class experiment (CCE) teaching methods affect students‟ achievement in Chemistry. They found that there was no significant difference in gender achievement between the experimental and control groups, but girls had a slightly higher mean score than boys did.

### 2.11 Some Reasons why Students do not perform well in Biology

Available research indicates that biology, though important, continuous to be challenging to most students. The difficulty is attributed to many factors either from the students or the teachers. Some also believe that the students challenge to performing well in biology comes from the school environment. Pop – Pacurar and Doina, (2009) believe that the problem of student‟s difficulty in understanding and performance in biology is the teachers‟ fault. Ntim (2015) also blame the poor performance of students on the teachers' choice of teaching strategy. They all argue that the teachers ought to choose the best of methodology that could make students understand the concepts better for easy learning and that the failure of any teacher to provide a method that does not favour the students understanding would cause students to perform poorly in that subject. This claim was also supported by Gillmor et al. (2015) who posited that when a topic is too difficult and confusing to students (like Photosynthesis) the teacher ought to choose the best method for instructions so as to cause cognitive overload on the students. This is because the cognitive overload has the tendency to hinder students understanding and performance.

Other studies have also shown that the schools or classroom environment can hinder students‟ performance. For instance, Ndayambaje, Bikorimana, and Nsanganwimana, (2021) discovered that a crowded class hinders students‟ performance because it can‟t allow teacher to facilitate every individual based on his/her needs and it cannot also allow even cooperative learning. In addition, they believed that shortage in teaching and learning resources in the overcrowded classes can lead to poor learning achievement because the learners are not all taken care for their learning interest and personal problem solving.

However, the above causes cannot be the only causes of students‟ performance in biology. Ndayambaje et al., (2021) again suggested that, English and foreign languages like Latin mostly used as medium of instruction in biology, the insufficient laboratory equipment, insufficient teaching and learning materials, amount of content and time allocated, inadequate involvement of parents in learners‟ education, poverty, and students‟ absenteeism in addition to the school's environment all could corroborate to student‟s underperformance in biology. The use of English and Latin languages that has big terminologies and words tend to confuse students and as such cause cognitive overload that could fail students.

In a similar study conducted by Çimer (2012), to determine the biological topics that students find difficult learning, and the reasons why the students have those difficulties in learning biology, as well as the ways to improve the effectiveness of students‟ biology learning. For these purposes, a self-administered questionnaire including three open-ended questions were employed to collect the data which was administered to 207 11$^{th}$ grade students in the district of Rize, Turkey. The results showed that the students perceived topics like Matter cycles, endocrine system and hormones, aerobic respiration, cell division, and genes and chromosomes as the most difficult to learn. The main reasons they gave for their difficulties were, the nature of the topic, teachers‟ style of teaching, students‟ learning and studying habits, students‟ negative feelings and attitudes towards the topic and a lack of resources.

In that study, the students sampled complaints that there were a lot of concepts, and various biological events that could not be seen by the naked eyes. Some of the concepts were too abstract. Moreover, biology as a discipline encompasses a great deal of topics, concepts and issues that students have to learn which had very detailed

knowledge and covered topics or concepts that were difficult to learn and use in their daily lives. This forces them to memorize biological facts in order to learn them. Thus, memorization as a learning strategy was common among the participants. With the amount of words, informations, ideas and the volume of notes to learn, if one was to even resort to memorisations as a means of learning, the learning would become difficult and challenging. Ndayambaje et al., (2021) also suggested that students find learning of biology difficult because, considering the volume of information and ideas in the biology curriculum needed to be learned and the time allocation for teaching and learning in schools was not proportionate. This does not help teachers to complete the course outlines before examinations. Those who even complete the course outline have to rash over topics that hinders proper understanding.

In other to overcome those difficulties and make their biology learning more effective, the participants, or students sampled suggested that, teaching biology through the use of visual materials, teaching through practical work, reducing the content of the biology curriculum or biology topic, using various study techniques, teaching biology through connecting the topics with daily life, solving more exam questions and making biology learning interesting could be the best strategy to help them perform better. This therefore suggest that when a class is faced with these challenges the enumerated suggestions could be opted to improve on the students' performance.

### 2.12 The Empirical Review

A careful review of empirical studies on concept mapping has unearthed a lot of information on this important teaching strategy. Adlaon (2002) conducted a study on the alternate instructional tools called concept mapping. The goal was to determine

the effectiveness of using concept mapping to improve science achievements of 10th grade students compared to the traditional method. Both control and experimental group was asked to take a pre-test and post-test. The test consisted of 31 questions and was used to assess the students gains in biology. Student constructed maps were scored using the Novak scoring scheme. The findings of the study was that concept mapping exposed students did not perform much better than the students that were exposed to the traditional method. The difference in the learning gains between the experimental and control groups in their test was not solely attributed to the concept mapping. However the study suggested that the careful introduction of concept mapping into the classroom when other contributing factors such as the students preparedness, and motivation, reading abilities levels, time and classroom environment were considered, concept mapping would be beneficial and could have the potential of being an effective instructional or teaching 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 students. 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 the respectively taught the concept of photosynthesis. The groups were post tested for any significant differences in their biology achievements. Analysis of the scores indicated that the group that were taught either the concept mapping strategy performed significantly better than their expository group. Specifically their female slow learners, performed significantly better than their male counterparts taught with the same method. The results had implications for the biology teacher especially in areas of teaching females and identifying slow learners and adopting effective method for tackling their problems. However, teachers must

not forget the individualistic nature of the student hence the need to vary teaching methods to suit the need for every student.

Furthermore, Ajaja (2009) conducted an experiment to know that if concept map is used as a study skill would influence students‟ achievement in biology. The design was a quasi-experimental design where 280 students from shs2 from which 120 were selected. 100 students were used for the study and 20 students dropped out. To guide the study, five research questions were formulated from the objectives which were tested at 0.05 significance level. The major instrument was a biology achievement test. Another instrument which was interview schedule to determine the students‟ perception on the use of concept mapping was also used to collect data. The major findings were that there was no significant difference between the immediate post test scores of the students who used concept mapping as a study skill and those who were not taught with concept maps. However, there was a steady significance increase in the test scores of the students who used concept maps as a study skill across achievement across some achievement tests. There was also a significant increase in the retention rate in those that used concept maps as a study skill and all the student interviewed agreed that concept maps helped them to determine the relationship between concepts, sharpened their understanding and increased their critical thinking skills. It was concluded that the concept mapping strategy could serve as an appropriate alternative to teaching biology since what is learned through it could be retained for long.

Another important work as far as the use of concept mapping as an instructional tool is concern was a study of Morse and Jutras (2008), this research was an experiment explicitly introducing a new learning strategy to a large first year undergraduate cell

biology course to see whether the awareness and use of a particular strategy had any impact on student performances. The construction of concept mapping was selected as the strategy to be introduced due to its inherent and coherence to the course structure. Data was collected over three different semester of an introduction to cell biology course. The first group taught was considered the control group and did not construct concept maps. The second group constructed individual concept maps and the third group first constructed individual maps and they validated their maps in a small group to provide peer feedbacks about their individual maps. Assessment of the students‟ performance involved the students‟ performance in the final exam, anonymous poll of students‟ perceptions, failure rate and retention rate of the information after the start of a new semester the following year. The main conclusion was that concept maps without feedback had no significant effect on the students‟ performance whiles the concept map with feedback produced an increased in the students‟ problem-solving performance and increase retention rates and decrease rate of failure.

In addition, a study was conducted by Amoako (2016) to show the impact concept mapping has as a teaching strategy in an attempt to reduce cognitive load of first year biology students of St. Dominic‟s Senior High School. In that study, the students were taught how to construct concept maps on classification of plants. The used the convenience sampling technique to select a sample of sixty (60) in-tact class of form one biology students in the school. An observation schedule was used by the Researcher in this case the teacher, to collect data and analysed them. The students sampled for the research were taught how to construct concept maps for the first period of the five intended period for the study. In the course of the study each period lasted 30 minutes. After the first period, the sampled students were then taken through lessons in classification of organisms for the remaining four periods. All lessons were

guided by a teacher-made concept map. In all, the lessons were undertaken in five days in order to minimise pressure on the students. During the study, the Teacher provided the class with a chart showing different kinds of plant species. The Teacher again asked students to list some characteristics or features of the plants they observed. The students were made to construct detailed concept maps on classification of plants individually from their own observations which were marked using the linkage analysis. The results of the students were analysed to enable the Researcher know how well each student constructed his or her map.

To determine whether the method used in teaching, had any impact on the students‟ cognitive loads, the Researcher in the course of the lessons, observed the concept maps drawn by the students. Additionally the behaviours of the students in class were also observed and recorded. These observations that were done by the Researcher were discussed.

The results from the study showed that the students were able to construct concept maps correctly and were able to use them to study effectively. Again the students constructed concept maps were able to help reduce cognitive loads of the students, because the concept maps drawn by the students help summarised the information the students needed to learned , identify and correct misconceptions, presented concepts in a manner that promoted easy recall of information.

In another study conducted by Ofosu (2016) which was to investigate the use of concept map to enhance the teaching and learning of Cell Biology in Senior High Schools form one students. The research focused on two groups from senior high schools namely Nifa senior high school and H‟Mount Sinai senior high school of the Akuapem-North District in the Eastern Region of Ghana. The study used a pre-test-

post-test-2-group comparison study. Both the control and experimental groups were required to take a pre-test before instruction and a post-test at the end of three weeks. The text consisting of 20 questions was used to assess students‟ performance. Student‟s constructed concept maps were scored using Novak‟s scoring scheme. Participants included 64 students.

An objective test consisting of twenty questions on Cell Biology was administered to all the 64 Form One „B‟ Science students from Nifa Senior High School and H‟Mount Sinai Senior High School as a pre-intervention test with the assistance of four science teachers (two from Nifa Senior High School and two from H‟Mount Sinai Senior High School) all in the Akuapem- North District.

In that study, the control group on the first day was given an introductory lesson on Cell Biology that included the unit objectives and some interesting questions designed to instil motivation. The subsequent days consisted of regular traditional lecture by the teacher, writing down of notes and followed by textbook exercises.

With regard to the use of Concept Map as the strategy, the researcher first introduced the lesson and held discussions with the students on Cell Biology. She followed the discussions on the Cell Biology with the meaning of „concepts‟. Concept Map was used to begin the unit on the first day. On the same day, the experimental group received blank Concept Map with spaces assigned for the concepts in hierarchical fashion. The students complemented their concept maps by copying the teachers‟ example, which was on the board.

The experimental group of students was given tuition on how to construct concept maps based on the following general procedure for constructing Concept Maps.

The first finding of the study was that, students when exposed to concept maps performed better than when taught with the traditional method. The difference in the learning gains between the experimental and the control group was statistically significant and this was solely due to the use of concept maps in the learning of Cell Biology. The second finding also indicated that, there was no gender disparity among students with the introduction of concept maps, although there were some increases in the mean scores among the females. Nevertheless, the study also suggested that, there was the need for future research to improve and strengthen the relationship between Concept Mapping and academic learning, specifically in science.

# CHAPTER THREE

# METHODOLOGY

## 3.0 Overview

This chapter would focus on the research methodology used. It would also look at the research design, population and sampling procedure, instrumentation, reliability and validity, data collection and data analysis.

## 3.1 Research Design

This study was an action research which aimed at using concept mapping to improve the students‟ conceptual understanding and performance in Photosynthesis, an important topic in Biology. This involves identifying a problem in a school and using appropriate interventions to rectify it. Again an action research fosters an informed decision - making and systematic problem solving among practitioners. Action research has thus been found useful for this study due to these reasons.

This study was inclined to the use of quantitative and qualitative methods of data collection and analysis. This utilised a pre-intervention test and post-intervention test called the Biology Assessment Test on Photosynthesis (BATP). The pre-intervention test and post-intervention test were essay type questions which looked similar. In this study the researcher had taught the class a lesson on Photosynthesis using the traditional method. After the teaching with the traditional method, the essay type question or test was administered to the class. The answers and responses from the students revealed some of their challenges and misconceptions on the topic, which in turn affected their conceptual understanding and performance.

The revelations from the results served as the bases for the introduction of the concept mapping approach in order to help address the students' challenges and for better conceptual understandings of the topic. This was done for every period for the study. After the intervention, a similar test was given to the students to assess any improvement in their performance after the introduction of the intervention.

This pre- intervention test consisted of fifteen questions made up of five essay questions and ten multiple choice questions which were similar to the post-intervention test. The pre-intervention test was administered to all the 55 Home Economics students offering Biology at Apam Senior High School, in the Central Region of Ghana. The post-intervention test was used to determine students‟ understanding and achievement in the lesson after the use of the intervention.

### 3.2 Population

The target population is the group of individuals to whom the researcher is interested in generalising his research findings to, whiles the accessible population is the group the researcher selected the sample to which the intervention would be administered to in this study.

The target population for this study was all the 220 biology students in Apam senior high school. However, the data assembled in this study came from all the form two biology students totaling 90 students. This study was carried out in Apam senior high school in the Central Region of Ghana.

### 3.3 Sample and Sampling Technique

In this study, the Researcher used convenience sampling to select intact class of 55 students of the form 2 Home Economic class for the study out of the entire 90 form two biology students because the Researcher teaches that class and has found this

peculiar problem of lack of interest and poor performance among the students in learning biology.

### 3.4 Research Instruments

The instrument used were the pre-test post-test on Biology Achievement Test on photosynthesis (BATP), Observation, interview and questionnaires.

#### *3.4.1 Biology achievement test on photosynthesis (BATP)*

A pre-test on photosynthesis was given to the students. The results obtained by the students gave the researcher a fair knowledge on the students' performance and understanding of the concept base on their marks. The Researcher in this case spent some time with the students in their class and taught them how to construct concept maps correctly. The teacher also taught the students how to use concept mapping as a strategy to study. After numerous use of concept maps by the students to learn concepts in photosynthesis, a post test on photosynthesis was given to the students. The results from the post-test and the pre-test was compared and analysed using excel and spss to assess the effect of the intervention on the students' performance.

The BATP consisted of fifteen multiple choice questions and five subjective questions where students were to provide correct answers to the pre-test. The post test questions also consisted of two parts the part A which consisted of multiple choice questions similar to the pre-test. Part B also consisted of five subjective questions where students are required to provide answers to.

### *3.4.2 Questionnaire*

The questionnaires were divided into two sections. Each section had a different theme with its explanation which reflected the main ideas in the theme. The questions were made to conform to the research questions raised in Chapter 1.

Section A had five questions which were asked to gather information on the bio-data of respondents. These questions requested the respondents to indicate their school, their age and class.

Section B consisted of a 25 close-ended questionnaire items. These questions were to assess the students‟ knowledge, perceptions on the effectiveness of concept mapping as a teaching strategy and their attitude towards the use of the intervention.

Each questionnaire item consisted of a statement followed by a five-point likert scale with five weighted options, namely strongly agree (SA), agree (A), neutral (N), disagree (D) and strongly disagree (SD). A mean above 3.0 for each item or statement in the questionnaire was considered as an agreement to the statement whiles a mean lesser than or equal to 3.0 was considered a disagreement to the statement. In determining the attitude of the respondents, a mean lesser than 3.0 indicated a negative attitude whiles a mean above 3.0 indicated a positive attitude as used by Yunus and Ali (2012) in a similar study.

The likert scale was used because Robson (2002) reiterated that Likert-scaled items look interesting to respondents and they enjoy completing them.

### *3.4.3 Observation*

An observation schedule was design to view the behaviour of the students in the classroom as they attempted to construct concepts maps and learned using the maps. Also the concepts maps drawn by the individual groups of students were observed and compared to that of the teacher to ascertain how well they were able to draw correct maps for assessments.

### *3.4.4 Interview questions*

An interview question was also designed to ascertain the root causes of the students' performance in the pretest. The interview questions were open ended where the students were at liberty to and freedom to express their feelings without any limits. The questions consisted of five questions about the students perception and about the topic or concept taught. The interview questions were administered to the students after their pre test scores were given to the students.

### *3.4.5 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 were determined by subjecting them to experts judgement. To ensure that the instruments measures what they profess to measure, and can be consistent at producing similar results at different times, both pre and post-test were developed based on the SHS sylabus and textbooks as well as the use of modified questions from the west African Examination Council. The test were also given to three teachers who have had five years of teaching experience in the field of biology. The teachers evaluated the test to ensure that the reliability. The

observation schedule and the interview questions were also validated by the supervisor and the experienced teachers in the science department of the school.

### *3.4.6 Reliability of the main instrument*

To ensure consistency of the results, a pilot test was done at Winneba senior high school to check the reliability of the instruments. In doing so the pre-test was given to the students to answer after which they were taken through the use of concept mapping to learn. A post-test was then given after a week followed by the questionnaire about the concept mapping intervention. A cronbach alpha coefficient formular was used to calculate the reliability of the study to check for the appropriateness of the data collection instruments. The Alpha value was obtained to be 0.86.

## 3.5 Scoring of the Concept Map

Linkage analysis as used by Liu et al., (2005) was used to assess the concept maps drawn by the students in the classroom. Here the Researcher (teacher) constructed his own concept map on photosynthesis. The Researcher then compared his to that of the students to check for misconceptions, wrong links and confused concepts. For instance, if a concept A in the student‟s map is linked to concepts C while the Researcher‟s own is linked to concept B, then the student may be confusing B with A. In this case, A is said to be a confused concept. The lesser the misconceptions and confused statements, the better the concept map constructed.

### 3.6 Data Collection

The study took place in Apam Senior High School of the Central Region of Ghana. The Home Economics class used for the study had four periods per week and each period lasted for forty - five minutes. An intact class of all the form two Home economics class (2H) were used.

This Home Economics Class had already done some aspects of the topic; Introduction to Photosynthesis, which dealt with the Description of the term Photosynthesis and the various test to determine the conditions necessary for photosynthesis to occur. The structure of the leaf and how it is adapted for photosynthesis.

During those instructional processes in each of the topics, the teacher used the lecture method, where the teacher did most of the talking and explanations while the students listened quietly and jotted down points. The teacher occasionally engaged the students by asking questions and by having brief discussions with them.

The response from the students gave a clue to the students performance with the topic. Base on the feedback from the response, an interview question was designed to assess the reasons for their performance. Afterwards the intervention with the use of concept map was used to teach and post-test was given to the students.

The observation checklist was designed to find out the behaviour and attitude of students during the use of the intervention as well as to confirm some of the response the student gave in the interview. The results analysed after which a questionnaires were designed to identify the students perception or opinion towards the use of the intervention in their learning and performance.

### 3.7 Data Collection Procedure

The data collection began with the pre intervention activities. The whole intervention process lasted for five weeks.

#### *3.7.1 Week one*

In the subsequent periods of the class before the first week of the study, the Home Economics class was supposed to continue with the topics Photosynthesis which dealt with the biochemistry of Photosynthesis as in the syllabus which appears to be a more challenging to most biology students due to their big terminologies and abstractness.

In order that the lesson begun, the teacher, used an advance organisers as a way of revising the topic with the students. The advance organiser was also used to test the students‟ conceptual understanding and performance on the topic which they had already been taught. This advance organiser was in a form of a text that served as the pre-intervention test.

#### *3.7.2 Pre - intervention process*

Prior to the use of the intervention, a BATP was administered to the class during their first lesson for the study in the first week as described in the lesson plan for the study in Appendix B. The pre- intervention test (advance organiser) was given to the Home Economics class for them to answer within forty minutes for the first lesson for the week. The teacher marked the test and recorded the results. The teacher showed to the students their performance and scores in the pre-intervention test in their next meeting (second meeting or lesson) within the first week.

The test consisted of fifteen questions on Introduction to Photosynthesis as in Appendix A.

The answers the students provided in the pre intervention test, indicated that they had soon forgotten about some of the concepts and ideas of the previous lessons on the topic. They were not able to recall basic facts and were also unable to explain basic facts too. For instance when the students were asked to describe the term Photosynthesis, most of the students (Home Economic class) answered the question correctly. A few of them too were unable to distinguish between the stroma and the Granum which form the chloroplast as shown in appendix D.

Majority of the students were also able to state all the conditions necessary for photosynthesis to occur, but they were not able to demonstrate that these conditions were necessary for Photosynthesis to occur. This made the teacher believed that the students were confused with the detailed description for the test for the presence of these conditions for Photosynthesis to occur and as such they were unable to retain these facts for long a reason why they performed poorly in the pre intervention test. These also showed that the students did not understand the concepts very well because they were not able to summarise the concept to the essential facts and as such their inability to keep the concepts and information in their memories. This abysmal performance of the student was attributed to the utilisation of the teachers' strategy of teaching. There was the need for a new strategy for teaching the topic. This was because the introductory part of the topic was perceived to be less challenging and if the students could perform that way, meant that there was the need for a new approach that could help them in the subsequent lessons that might look more challenging.

There was therefore the need to use strategies to aid students to understand, to comprehend and to recall facts ideas and concept easier. These characteristics would be necessary for the next subtopic which is perceived by students to have more complex concepts and ideas. This would therefore make the learning of the next topic easier.

### *3.7.3 Week two*

Following the feedbacks on the students‟ performance, the researcher discussed with the students the new approach of using concept mapping in teaching that could aid easy comprehension and retention of learned concepts.

### *3.7.4 Intervention process*

During the second week, the Teacher taught the class the topic Photosynthesis, which dealt with the structure of the organelle needed for photosynthesis and the processes involved in the biochemistry of the process with the use of concept mapping for four periods which also lasted for forty five minute for the two different days in the week (week two). The teacher taught the structure of the Chloroplast, the organelle needed for photosynthesis to occur within a week.

In this case the teacher presented to the students a picture of the chloroplast and her/his constructed concept map on the structure of the chloroplast. The teacher engaged the students in a discussion of the structure of the chloroplast with the class by using the picture and following the concept map where the teacher occasionally asked questions to get the students involved and focused as stated in the lesson plan designed by the teacher in Appendix B.

On the third meeting, in the second week, the teacher introduced the students to concept mapping and how to construct good concept maps after the teacher had shown a sample of concept map on the topic to them in the second meeting. He spent time educating the students on how to construct correct concept maps. The class was taught how to construct concept maps in two lessons in a topic on photosynthesis which they had already learned and this lasted for thirty minutes also.

To do so, the teacher inquired ideas, knowledge and inputs from the students about the structure of the chloroplast a concept they had learnt in the previous semester. These ideas were the concepts needed to be linked meaningfully together. These ideas (concepts) presented by students were further put into categories by the help of the teacher. After the ideas were arranged in categories, they were then put into a hierarchical order. The teacher then guided the students to correctly link one concept to the order. By so doing, they linked various linking verbs and phrases to concepts to make them meaningful expressions.

Students were then asked to practice the construction of concept maps by constructing concept maps on already learned topic in Photosynthesis for which the teacher supervised as a way of revision. This was done in the classroom. During this process, the researcher went round checking student‟s progress and gave advices where necessary.

### *3.7.5 How the concept maps (Intervention) were constructed and used to teach each lesson*

In this study, the students individually constructed their own maps with the guidance of the teacher which were compared with that of the teachers own as explained below.

***Week Two***

**Topic:** Photosynthesis

**Subtopic:** Structure of Chloroplast

**Objectives**

The objective of the study was to:

1. Identify the structure of the chloroplast
2. Distinguish between the Stroma and Granna
3. Identify the function of the thylakoids.

In teaching the topic, the teacher guided the students to brainstorm on the components of the structure of the Chloroplast using their knowledge on the study of Organelles.

The teacher in this study presented a picture of the chloroplast to the class and requested from the students some concepts and ideas of how the chloroplast is upon observing the picture. The students presented the ideas and concepts like "*chloroplast, oval"* and "*double stranded" "stroma,* and *granum" thylakoids and* "*chlorophyll".*

The teacher wrote those key words on the board and guided students to link them together from the hierarchical order. The concept, *chloroplast* was the broad concept for which the concept *oval* and D*ouble stranded* which where the specific concepts were linked to. The concepts *Outer layer* and *Inner layers* which are intermediate concepts were also linked to the concept *Double stranded.* Under the intermediate concept, *Inner layer*, *Stroma* and *Grannum* were connected individually to by two downward arrows. Under the concept *Grannum*, another concept *Thylakoid* was liked

and "*Photosysterms I,* and *II"* also linked to *Thylakoid*. In all these instance, the phrase "*which contains*" was linked to each as shown n the concept map below.

The teacher intermittently gave some explanations to some concepts for clarity. The students also asked questions when confused with some of the explanations to the concepts for which the teacher gave.

On the second day of the lesson, which was the end of the period for the week, a short drill exercise was conducted to assess the level of the students" understanding of the topic for the week.

***Week Three***

**Topic: Photosynthesis**

**Subtopic: Biochemical process of Photosynthesis**

**Objectives of the Lesson**

By the end of the lesson the students should be able to

1. Explain the stages of photosynthesis.
2. Distinguish between the stages of photosynthesis

On the first day of the third week, in teaching the topic, the teacher discussed and explained the process of photosynthesis with the students. After the teacher's explanation of the stages of photosynthesis, the teacher asked the class to list any ideas or concepts or words or information they remembered or heard form the delivery. Concepts such as; "*Light stage"*, *Dark stage"*, *Calvin Burnson cycle","*

*photolysis of water"*, *"phosphorylation of ATP"* and *"Energy"* where jotted down together by the students and teacher.

The teacher asked the students to link these concepts together to form a concept map for which the teacher supervised and aided the students base on the explanation and discussions the teacher gave on the topic.

The students choose the broader concept "*Photosynthesis"*. The two concepts *Light stage*, and *Dark stage* which were considered the specific concepts were linked to the broader concept *Photosynthesis* by the phrase *"the two stages"* by two downward arrows. The concept *Dark stage* was linked to the concept *Calvin Burnson cycle* on the other hand. On the other hand, the concept, *Light stage* was also linked with the concepts *photolysis of water*, and *phosphorylation of ATP* with the linking phrase *"the two processes"*. The concepts *photolysis of water*, and *phosphorylation of ATP* were therefore considered as the intermediate concepts. These two concepts were also linked with a downward arrow to concept *energy*. This concept was again linked to the concept *Calvin Burnson cycle* with the linking verb *'for'* with an upward arrow to show a direct link with the concepts as shown below. In all these cases the teacher engaged the students asked questions and answered students questions too.

The students were given time to discuss their concept maps amongst themselves for better understanding and clarity. At the end of the days lesson, the teacher drilled the students on the topics as a way of summarising the lesson for the day.

On the second day, the last period for the week, the next topic was treated with the objectives below.

**Topic:** Photosynthesis

**Subtopic:** Photolysis of water

**Objectives**

By the end of the lesson the students should be able to

1. Describe the process involve in the Photolysis of water for photosynthesis to occur.
2. Indicate where the oxygen from plants comes from.

The teacher led the students to brainstorm on the process of photolysis of water in photosynthesis. The teacher then described the whole process vividly to the class after which the teacher guided the students to list key concepts about the topic that they heard.

Below are some of the key terms or concepts that were listed by the students from the teacher‟s descriptions. "*stomata", adenosine triophosphate", electron aceeptor"*, *electron transport chain"*, etc.

The teacher led the students to construct a concept map on the process the teacher described.

In this instance, the students used the broader concept, "*Water"* as the highest hierarchy for the map. An arrow leading to the phrase "*split into"* was used to linked the concept *water* to "*Oxygen "* and "*Hydrogen ions" w*hich were the next specific broader concepts.

Under the concept *Oxygen*, the linking phrase, *"leaves out from"*, was linked to the concept "*Stomata"*. The concept *stomata* was also linked to "*Atmosphere"* by the linking verb *to"* as shown in the concept map below with downward pointing arrows.

On the other hand, the concept "*Hydrogen ion"* was linked with the phrase "*release energy to"* to two concepts, "*electron transport systems* and *enzymes"* also with downward pointing arrows. Under the concept *electron transport chain*, concepts like, energy, *Adenosine diphosphate (ADP) and Adenosinetriophosphate (ATP)* were linked with the linking phrase, "*release to"*.

Under the concept "*Enzyme",* a branch under the specific concept H*ydrogen ion*, the concept E*nergy* again was linked to the concept *Enzyme* directly with an arrow. *Energy* was also linked to *Photosysterm* I by the phrase, *to replace* as shown below.

In each link or branch in the map, the teacher provided additional information and explanations to clarify the ideas better. The students too asked questions and the discussed amongst themselves their maps. After the days lesson, a short quiz was organised by the teacher to summarise the lesson.

***Week Four***

During the fourth week of the study, the teacher again taught the next lesson with the objectives below.

**Topic:** Photosynthesis

**Subtopic:** Photophosphorylation of ATP for photosynthesis

**Objectives**

By the end of the lesson the students should be able to

1. Describe the two stages of the photophosphorylation of ATP.
2. Name at least two electron transport molecules in photosynthesis and their roles.

On the first lesson for the week, the teacher guided the students to brainstorm on the processes of Photophosphorylation of ATP. The teacher described the process by making references to the previous lessons. In the teacher‟s description of the process, concepts such as *adenosine triophosphate, electron aceeptor*, *electron transport chain, ferrodoxin, cytochrome B6 Complex,* and *Nicotinamide adenine dinucleotide* phosphate (NADP) were listed as key concepts by the students.

The students from the teachers‟ description made the concept "*Photophosphorylation of ATP"* the broader concept that was divided into two by two branching downward pointed arrows to the concepts "*cyclic* and *non cyclic photophosphorylation"* by a linking phrase *divided into"* as shown in the concept map below.

Both specific concepts "C*yclic* and N*on Cyclic photophosphorylation"* which are after the broader concepts were linked to the concept *Sun"*, which was also linked with a linking downward arrow to the concept "C*hloroplast"*. The linking word, "*released"* was connected to the concepts "C*hloroplast"* and "E*xcited electrons"* with an arrow. Under the concept *Excited electron*, the phrase "*Release energised electron to"*, was also linked with two arrows to the concepts *Electron acceptors*. The concept E*lectron acceptor* was also linked to two words "*Ferrodoxin* and *Cytochrome B6 complex"* by the linking word *Examples*. For the concept *Ferrodoxine* was linked to "*NADP"* by the Phrase *sent to"*. Also for the *Cytochrome B6 complex,* the phrase *Release to*,

linked the concept *ATP* to the *Cytchrome B6 complex* as shown in the concept map below.

After the days lessons, the teacher conducted a short drill test to summarise the whole lesson on the topic of Photosynthesis. In this test some of the concepts of photosynthesis were placed in a bowl for each of the students to pick and answer the corresponding questions it may come with. This was done to summarise the whole topic of photosynthesis.

In all the lessons, the teacher observed the students" behaviour during the teaching of the lesson using the intervention. The observation checklist was used to select and identify the attitude and behaviour of the students in class and towards the utilisation of the intervention.

The student questionnaire items were then administered to the class after the lessons to find from them their perception and attitude to the intervention. The responds the student gave was used to design the observation schedule for the students to confirm the responds they gave during the intervention class.

### *3.7.6 Post intervention activities*

***Week Five***

At the end of the intervention, the class took the post-test examinations. This test lasted for thirty minutes on the last day of the study. The teacher marked the test and showed the results to the students. The post intervention questions were similar in strength to the pre intervention questions used before the intervention but not the

same. The teacher marked the test and gave prompt feedback for the students. The marks were then recorded and used subsequently for the analysis.

The student questionnaire items were then administered to the class after the post intervention test to find from them their perception about and attitude to the intervention. The responds the student gave were analysed and used to answer the research questions posed in chapter one.

### 3.8 Data Analysis

The statistical program SPSS was used for the analysis. The results from the two tests were subjected to inferential and descriptive statistics. The descriptive statistics produced the means, frequency counts and percentages of the responses and test. The inferential statistics used was the t test at a statistical significance of 0-5 alpha level. When the p value was below 0.5, there was a significance difference whiles there was no statistically significance when the value was above 0.5.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.0 Overview

This chapter presents the results of the study. The results of the data analysis are used to answer the research questions posed in chapter one. It also discussed the research findings in relation to literature reviewed. The results were divided into two sections. The first section described the background data on the students based on the responses of the interview questions and the biodata of the respondents. The second section described the findings from the investigation into the influence of concept mapping on students‟ performance in photosynthesis. The research questions were presented and discussed sequentially and methodically in the order in which they were posed in chapter one of this thesis report.

## 4.1 Biodata of Respondents

This study involved 55 Home Economic students of Apam Senior High School, Apam who were taught photosynthesis using the concept mapping strategy. The demographic characteristics such as sex and age distribution of all respondents and their percentages are represented below.

Below is a Table 1 showing the gender distribution of the students or respondents for the study.

**Table 1: The Sex Distribution of Students in the Home Economic Class**

| Sex | N | % |
|---|---|---|
| Male | 12 | 21.82 |
| Female | 43 | 78.18 |

From the Table 1, there are more female than there are males in the class. The males were 12 out of the total of 55 representing 21.82% while the rest (43) comprised female representing 78.18%. This was because the Home Economic course is a female dominated programme in most Senior High Schools in Ghana. This is because the vocational courses run are perceived more in Ghana as feminine and loved mostly by females. Also the job opportunities for these programmes favour the females more as compared to the males as suggested by Sukola et al., 2016).

Figure 4 is a chart showing the age distribution of the respondents for the study.

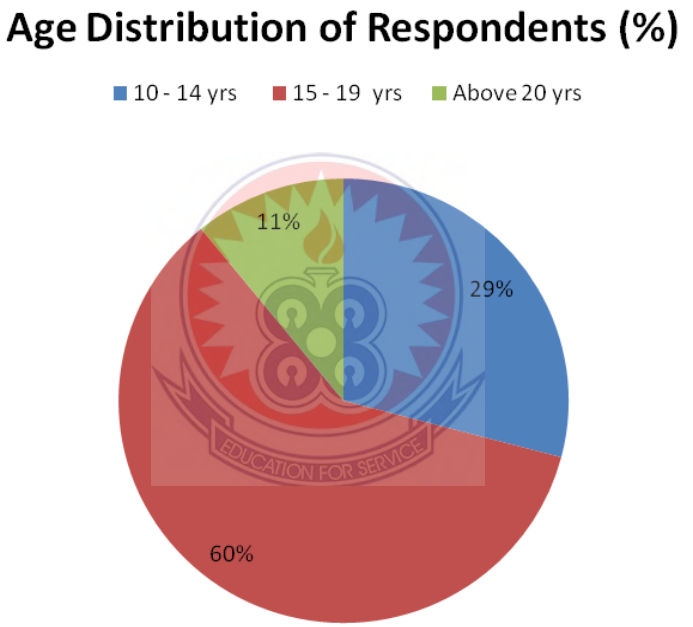


**Figure 3: Show a piechart showing the range of age distribution of the respondents**

From the Table 2.0 and the pie chart above, the ages of the students ranges from 10 yrs to 20 yrs and above. Few of the students were above 20 yrs. For the ages between 10 to 14 yrs, 18 out of the 55 students which is 30% of the total students sampled were within that age range. The largest age groups in the class was the ages between 15 to 19 yrs. This is because, most students in Ghana start schooling at early ages and by age six they are almost in class 1 or BS 1. Therefore by age 14, 15 and 16 they may

probably be in SHS one already. According to Piaget again, children within the ages 12 to 19 years look a little matured and can synthesis and analysed concepts correctly and effectively for easy comprehension. To Piaget (1970), these ranges of age are also good for learners to think hypothetically about the world around them, and develop scientific reasoning. Hence, the participants in this study could be described as cognitively ready, and could perform well in Biology subjects such as Photosynthesis perceived to be difficult since is has more concepts to cognitively comprehend. This conforms to the claims of the ministry of education, the GES and the entire nation whose vision is to see all students within this age category to be able to think critically, by being able to synthesis and analyse issues better.

Presentation of the results by research questions and the analysed study are now presented as follows.

### 4.2 Research Question One

- **What difficulties do the selected students' encounter during lessons on photosynthesis?**

This question was asked to find from the students their peculiar challenges and the difficulties they face in learning the topic Photosynthesis when teachers teach it in the old traditional ways. It was also to find out from the students the bases or the origin of their difficulties and to attempt to address them. In trying to achieve this, an interview question was designed and administered to the students after the pretest results have been given to the students. The responses to the interview items were later grouped and analysed using descriptive statistics to find frequencies and percentages.

Below are some of the responses the students gave to the interview items.

**For the interview Item 1.**

- ***What marks did you obtain in the test?***

This question was asked to find out how well the students performed in the pre intervention test. Table 2 shows the range of marks obtained and the associated frequencies.

**Table 2: The Range of Marks and their Frequencies from the Students' Pre - Intervention Test**

| Marks | Freq(%) |
|---|---|
| 0 – 5 | 31(56.36%) |
| 6 – 10 | 11(20.0%) |
| 11 – 15 | 7(12.72%) |
| 16 – 20 | 3(5.45%) |
| 21 – 25 | 3(5.45%) |
| 26 – 30 | 0(0.0%) |

From the Table 2, the majority of the students who took part in the pretest did not perform well. A total of 31 out of the 55 students scored between 0 - 5 marks which amounted to 56.36% of the students. A very few of the students who took part in the test scored above 16 marks out of a possible 30 marks. More worrying was the fact that a total of 42 (89.08%) of the total students who took part in the test did not score more than half of the marks. This therefore meant that the students generally did not perform better in the pretest after they were taught with the old traditional methods of teaching. The researcher attributed to the teachers method of teaching and the students own efforts and attitude to learning the subject.

From the second question, that sought to find from the students‟ opinions if they really feel they did well in the pretest that was given. Below are the summary of the responds the students gave to the interview item 2.

**Interview Item 2:**

- ***From your own opinion, did you do well in the test that was given to you?***

Table 3 shows the frequencies of the students‟ response to the interview question two.

**Table 3: Students' Responses on Whether or not They Felt They did Well in the Pre Intervention Test**

| Responses | Freq(%) |
|---|---|
| Yes | 19(34.54%) |
| No | 30(54.54%) |
| Could do better | 6(16.36%) |

From Table 3, many of the students themselves felt that they did not perform well in the test base on the feedback they got as was seen in the range of marks they obtained from the pretest questions in table 3.0 above. However, 19 of the students constituting 34.54% believed that they did well base on the fact that to them the questions were very difficult and that the topic "Photosynthesis" was naturally confusion with big terminologies as explained by Hrefna and Halldóra (2006) and that if they could obtain this score, then they had done well to the best of their opinion.

**Interview Item 3**

- **Give reasons for your performance**

From this next question, the interviewer requested for reasons from the students why they think they performed the way they did. Below is a summary of some of their reasons.

**Table 4: Shows the Reasons Students Gave to Why They Performed the Way They did in the Test**

| Suggested Reasons | Freq(%) |
|---|---|
| The questions were too difficult | 31(56.36%) |
| When I learn the topic I soon forget | 30(54.54%) |
| The topic is difficult to learn and understand | 36(65.45%) |
| The topic has big terminologies | 38(69.09%) |
| The notes were plenty and was difficult to read over before the test | 40(72.72%) |
| The notes on the topic are too boring to read and learn. | 28(50.90%) |
| When the teacher teaches I do not understand. | 30(54.54%) |

From the results of Table 4 above most of the students 56.36% believed they did not perform well in the test because of various reasons such as, t*he questions were too difficult f*or them. Also 72.72% of the students believed that t*he notes given to them were plenty and was difficult to read over before the test.*

The results meant that the students were unable to revise for the test due to the voluminous information they needed to read before the test. The students who even managed to read the notes before the test got confused after several attempts to revise the notes. This explains why 38 out of 55 of the selected students making 69.09% of them believed that *the topic has big terminologies.* These results suggests that the teachers methodology did not facilitate the students to gain knowledge for themselves and also was not able to simplify big terminologies or words for the students but only read out informations for them to copy with little or no discussions, demonstration and group works with explanations that have been taunted as best methods of teaching effectively. This is why 30 out of 55 of the students which is 54.54% believe that *When the teacher teaches we do not understand.*

These deductions were supported by the works of Çimer, (2012) and Ndayambaje, (2021) who all believed that biology students do not perform well in biology because, the subject has many confused statements students do not understand because of the big english words and gargons as well as the unfamiliar latin language used to express most phenomena in science especially in biology. From the findings above, it is clear that the teachers teaching methodology did not help the students to perform in the test.

**Interview Item 4**

- ***In your own words suggest any means to improve on your performance in subsequent tests***

From that interview item the teacher wanted to find out from the students how best the lesson could be taught for them to understand, learn effectively and perform better in subsequent tests.

From Table 5, the students opted for a lot of suggestions to help them learn and better their performance in the subject. Notable amongst them are listed in Table 5.

**Table 5: The Summary of the Students' Suggestions for Easy Learning and Understanding**

| S/N | Suggestions |
|---|---|
| 1 | The teachers should reduce the volume of notes for students (summarise lessons) |
| 2 | The teachers must involve the students most often when describing concepts in the topic. |
| 3 | The teachers must reduce or simplify the big terminologies or jargons for easy learning and understanding. |
| 4 | The teachers must ask students more questions to help students revise the topic often. |
| 5 | The teachers must incorporate the use of pictures or audio visuals to teach the topic better for students understanding. |

From the table 5 above the students sampled for the study suggested that for their teachers to aid them learn, understand and perform better in Photosynthesis and for that matter biology, they should, *"incorporate the use of pictures or audio visuals to teach the topic better for students understanding". The teachers must ask students more questions to help students revise the topic often". The teachers must reduce or simplify the big terminologies or jargons for easy learning and understanding". The teachers must involve the students most often when describing concepts in the topic. "The teachers should reduce the volume of notes for students (summary of lessons)"*

These suggestions and recommendations from the students were seen as valid and as such had been supported greatly by Ajaja (2009); Çimer, (2012); Hrefna and Halldóra (2006); Pop – Pacurar; and Doina,(2009) who agreed that Photosynthesis like all other biology topics is difficult for students to learn, understand and pass because of the big terminologies and jargons it possess due to the unfamiliar Latinised terms and big English words used to explain phenomena or concepts in the topic photosynthesis or biology in general. In fact Çimer (2012) emphatically explained that if the content of the biology curriculum needed to be learnt are not reduced drastically by an appropriate teaching style or methodology and that if the methodology does not show connection between concepts and real life situations, students would continue to underperform in most biology topics.

### 4.3 Research Question Two

**What are the effects of concept mapping on the selected students' performance in photosynthesis?**

This question was asked to identify the impact concept map play on students achievement. In doing so an independent sample t test was conducted to see the effect of the intervention on the students achievement as shown in the table 6.

**Table 6: Showing the Mean and SD of Both Pretest and Posttest Scores of the Respondents**

| Test | N | Mean | SD | df | p |
|---|---|---|---|---|---|
| Pre-test | 45 | 12.4222 | 1.6440 | 54 | 0.001 |
| Post-test | 45 | 28.8444 | 134.760 | | |

**Significance at p<0.05**

The mean score of students on the post-test (28.844) was greater than their score on the pre-test (12.422). Since the p value of 0.001 is less than 0.05($p < 0.05$), it implies that there is a statistically significant difference between the score obtained by students on the pre intervention test, and that obtained on the post intervention test and that the students performed better in the posttest than in the pretest before the intervention was introduced.

The results from the study show a significant difference in the achievement between the students‟ performance in the post- test after they were exposed to the use of concept mapping to teach. The results showed that in using concept mapping strategy to teach, the students performed very well compared to the older teaching methodologies in the classroom process. The results also indicated that the concept mapping teaching approach was used in teaching photosynthesis, the students actively participated in the teaching and learning process and the thinking abilities of the student increased. More so, the students performed better in the post-test than the pre-test because the concept mapping strategy aided the students to revise previously taught lessons before the next one on the students‟ personal time for better comprehension.

Again, during the use of concept mapping, the teacher had a brief discussion with the students about the topic before making their maps. This serves as a means of

repeating and rehearsing what has been taught which help students to keep the information taught in their memory for long. Bigger terminologies were simplified and the number of words too reduced for easy learning. All these aided the students to understand the concept taught and as such performed well as shown in the results above. This teaching approach therefore allow the students to understand and focus on the content they have been exposed to. These findings are agreed to by Ajaja, (2009); Amoako, (2016); Kinchin, (2000); Lui et al., (2005) and Ofosu, (2016) who posited that the use of concept mapping strategy helped to improve the performance of students whenever it was adopted to teach any topic. They all cited that concept mapping helped in recalling informations promptly, because concept maps organised concept hierarchically to help fix ideas in to already existing knowledge of the students for better comprehension, reducing the volume of load needed to be learnt into simple mental pictures and simplifying foreign words and big terminologies for essay comprehension and storage just as it was espoused in this study too.

### 4.4 Research Question Three

- **What are the differential effect of concept mapping on the cognitive achievements of the male and females students in photosynthesis?**

This question was asked to identify the effect of concept mapping on the females or male students in the class who took part in the tests. In doing so an independent sample t test was conducted to see the effect of the intervention on the performance of the students based on their gender as shown in the Table 7.

**Table 7: The Mean and SD of Both Male and Females Scores of the Posttest**

| Variables | N | Mean | SD | T | p |
|---|---|---|---|---|---|
| Male | 10 | 7.600 | 1.505 | 32.99 | 0.00 |
| Female | 35 | 5.4286 | 1.289 | | |

**Significance at p<0.05**

Table 7 shows that the males had a mean (7.6000) which was higher than that of the females (5.4286) with a mean difference of 2.172. This meant that the males performed better than the females when the intervention was introduced.

In other to find out if the difference in achievement was statistically significant, a t-test was conducted. From the results in table 8, there was a significant difference in achievement between the males and the female students taught with concept mapping (p=0.00). This finding indicated that males in this study out - performed their female counterparts when concept map was used to teach photosynthesis.

The results above disagree with Ogonnaya et al., (2016) who posited that when concept mapping strategy is used to teach biology there would not be any gender disparity and that all the students would perform equally. For Raza and Hazir (2019) also, girls always outperform boys when concept mapping is used because boys do not pay much attention and always absent themselves from school when concept maps were used to teach.

However, this result is in agreement with (Karakuyu, 2010) and Wapner (1986) who found that, when concept mapping method when used to teach, favored boys over girls due to the different learning styles of both males and females. From Wapner (1986) perspective, males are field-independent learners who frequently depended on active reasoning patterns to analyse and solve problems. He again believed that

females were field-dependent learners who easily accepted realities and as such became passive in an actively engaging classroom atmosphere. They also believed that girls loved to read and listen whiles boys prefer calculations and critical thinking activities.

In this study, the teacher guided students in their various groups to discuss and brainstorm on a particular concept and deduced a meaningful concept map from it. This activity packed lesson motivated the males or boys to participate fully, joyfully and always participated in class activities than the girls. This ended up making the boys take control over the discussions more due to their hyperactiveness leaving most of the females‟ passive and disadvantaged. According to Zwiers and Gielen (2018), when girls or females in nature are engaged in competitive learning with peers also, they tend to be disadvantaged and do not perform well in those subjects. This could be the possible reason why the boys dominated the group discussions, the drawing of the maps, and the asking of questions in the class more than the girls and as such they performing lesser.

### 4.5 Research Question Four

- **What are the views of the students on the use of concept mapping for biology lessons?**

This question was asked to solicit the views and opinions of the students on the concept mapping when it was used to teach the topic Photosynthesis.

In order to ascertain the impact of learning through the use of the concept mapping Instructional Method the researcher not only taught the 55 participants using primarily the concept mapping strategy but also, solicited information from students about their

perceptions of the effectiveness of the multimedia approach on their learning through a Likert-scale questionnaire.

The post-intervention questionnaire consisted of a bio-data section and 20 items on a five-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). It was designed by the researcher to elicit how Concept mapping instructional approach might have helped the participants or students in a variety of ways and to measure the perceived impact of the strategy on their learning of the topic Photosynthesis. Qualitative descriptive analysis was performed for the Likert scale statements. The Table 8 below shows the reports of the questions and a summary of the responses provided by all 55 participants.

**Table 8: Results of Students' Responses to Likert Scale Statements**

| No. | Statements | Strongly Agree N (%) | Agree N (%) | Neutral N (%) | Disagree N (%) | Strongly Disagree N (%) |
|---|---|---|---|---|---|---|
| 1 | I was more enthusiastic and motivated during the use of Concept Mapping in the teaching and learning of Photosynthesis. | 28 (50.9) | 26 (47.3) | 1 (1.8) | 0 (0.0) | 0 (0.0) |
| 2 | The use of Concept Mapping as instructional techniques is an effective strategy for students of all abilities. | 32 (58.2) | 23(41.8) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| 3 | The use of concept mapping to teach did not help me to perform well in test | 0.(0.0) | 0.(0.0) | 0.(0.0) | 20(45.5) | 30 (54.5) |
| 4 | The use of Concept Maps strategy in instruction reduces my personal interaction with my colleagues. | 28 (50.9) | 24 (43.6) | 3 (5.5) | 0 (0.0) | 0 (0.0) |
| 5 | The use of Concept Mapping did not provide any means of expanding and applying what has been taught in class. | 0.(0.0) | 0 (0.0) | 1 (1.8) | 28(50.9) | 26 (47.3) |
| 8 | The use of Concept Maps instruction would promote the student understanding of concepts and remove rote memorization of facts. | 20 (36.4) | 18(32.7) | 10 (18.2) | 5 (9.09) | 2 (3.6) |

| No. | Statements | Strongly Agree SA(%) | Agree A (%) | Neutral N (%) | Disagree D (%) | Strongly Disagree S (%) |
|---|---|---|---|---|---|---|
| 10 | The use of Concept Mapping instruction did not help me to understand the relationships between concepts. | 1 (1.8) | 0 (0.0) | 2 (3.6) | 17 (30.9) | 30 (54.5) |
| 11 | The use of Concept Maps instruction made the students feel more involved and to cooperate more on projects in class. | 41 (74.5) | 14 (25.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| 12 | The use of Concept Maps for learning almost and always reduces forgetfulness during examinations. | 20 (36.4) | 20(36.4) | 2 (3.6) | 3 (5.5) | 10 (18.2) |
| 14 | Concept Maps for instruction would enable me to interact more with other students to promote group discussions. | 40 (72.7) | 15 (27.3) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| 15 | I feel the use of concept maps for instruction would help my learning during my private time in a positive way. | 30 (54.5) | 25 (45.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| 16 | The use of concept mapping has helped me to show interest in the learning and reading of biology. | 41 (74.5) | 14 (25.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) |

From the Table 8, the students generally disagreed to the opinion that, *the use of concept mapping to teach did not help me to perform well in the test. The use of Concept Mapping did not provide any means of expanding and applying what has been taught in class. The use of Concept Mapping instruction did not help me to understand the relationships between concepts.* This because from the table 6.0, all those statements had 100% (45.5% D; 54.5% SD),8.2% (50.9% D; 47.3% SD) and 85.4% (30.9 D; 54.5% SD) respectively. In all, two (2) students representing 3.6% of the students who answered the questionnaire were not sure of their stand to the statement that *The use of Concept Mapping instruction did not help me to understand the relationships between concepts.* Also, only a single student out of the 55 students sampled and answered the questionnaire, was also confused of the position to take with respect to the statement that, *The use of Concept Mapping did not provide any means of expanding and applying what has been taught in class.*

However, the majority of the students agreed and strongly agreed to the opinion that, *The use of Concept Mapping as instructional techniques is an effective strategy for students of all abilities.* This is why 32(58.2%) out of the 55 students strongly agreed to the statement and 23 (41.8%) also simply agreed to it. On the statement that, *The use of Concept Maps strategy in instruction reduces my personal interaction with my colleagues,* 28 out of 55 representing 50.9% of the total Home Economic students sampled strongly agreed to the statement and 45.6% simply agreed. This meant that 96.5% of the students agreed to the statement. More so, the majority of the students were in agreement to the opinion that, *The use of Concept Maps instruction would promote the student understanding of concepts and remove rote memorization of facts* and that *The use of Concept Maps for learning almost and always reduces forgetfulness during examinations.* That is why 38% of the students constituting,

36.4% strongly agreeing to it and 32% simply agreeing to it also. Most of the students again believed also that, *Concept Maps for instruction would enable them to interact more with other students to promote group discussions.*

In other to confirm the students‟ response to the students‟ questionnaires, an observation schedule was designed. Table 9 shows the students' observation in class when concept map was used to teach them.

***Table 9: Showing the Students Observation When They were being Taught with Concept Mapping***

| SN | Observed Behaviour | Yes (%) | No vhbn vb(%) |
|---|---|---|---|
| 1 | Students were seen discussing the topic amongst themselves in the class | 48(87%) | 7(13%) |
| 2 | Students were seen revising from their constructed maps after the lesson | 43(78%) | 12(22%) |
| 3 | Students were punctual in class | 47(85%) | 8 (15%) |
| 4 | Students were seen practising the construction of concept maps on other topics in the absent of the teacher | 48(87%) | 7(13%) |
| 5 | The teacher always completed lesson within the allocated time periods. | 55(100%) | 0(0.0%) |
| 6 | Most of the students were seen participating in group discussions and cooperate learning in class | 44(80%) | 11(17%) |

From the table 9 the, majority of the s*tudents were seen discussing the topic amongst themselves in the class, participating in group discussions and cooperate learning in class and practicing the construction of concept maps on other topics in the absent of the teacher.* Only *78%* indicating 43 out of 55 of the total students were seen *revising from their constructed maps after each lesson.* In addition, whenever the teacher

taught with concept mapping strategy, *The teacher always completed and concluded his or her lesson within the allocated time periods.*

In all these instance none of the observation was below 80%. This meant that the intervention (concept maps) had a positive impact on the students and the reason they performed creditably well after the introduction of the intervention. These observations conforms to the students responses to the questionnaire item that were given to the students.

During the study, the teacher sometimes grouped the students to construct concept maps on topics they discuss in class. The groupings offered the students the opportunity to learn from each other, and correct their mistakes because of the collaboration that would exist between them. The individual students also got the chance to participate and make contributions to the ideas for the maps. The students in these ways gain the knowledge and understanding for themselves and this made them own the knowledge or ideas themselves. This is why the students agreed and believed from the students‟ questionnaire that the use of concept Maps for instruction would enable them to interact more with other students to promote group discussions as well as believing that the use of concept Maps instruction would make the students feel more involved and to cooperate more on projects in classroom.

These opinions suggest that frequent interactions with colleagues in class, and regular participating in class activities impact learning and understanding of concepts better because they are able to identify their wrong perceptions, or mistakes and correct them. This claim is in tandem with the opinion of Clement and Maria (2003), where students were able to understand and describe the throat well and performed better after their views or ideas were compared to that of their colleagues and teacher's. This

perhaps corroborated to the reason why Johnstone and Otis (2006) suggested concept mapping to be used as a personal learning tool.

Again in this same study, the students constructed their concept maps after a brief discussion or brainstorming on the topic to be treated by the students and the teacher. This meant that the construction of the concept maps was a means of repeating what has been discussed in the class. It also meant that the construction of the maps summaries the whole idea or information on a topic by focusing on important ideas or concepts for easy understanding. This helps to reduce irrelevant concepts or ideas that could impede understanding as opined and supported by Ajaja (2009); Amoako (2016); Men-lei and Ming-Hsiung (2012) who all believed that concept mapping reduce word counts or curriculum on information needed to be processed, summarises concepts for better understanding and as such increased students‟ performance.

The reduction of the entire lesson into a meaningful map serves as a means of revising daily lessons easily. This is because the concepts with their hierarchies linked with their linking words or phrases left indelible marks in the minds of students and hence gave clues to the meaning of the concept for faster recall. This believe was supported by Ajaja (2009) where he claimed that the use of concept mapping helped students to retain what they have learned for long and aided them to recall them easier during examinations. Also the reduction of the whole lesson into meaningful and easy to learn maps, helped the teacher to complete course outline within time. These offered the students more time to revise, understand and try hands on some questions as a way of revision before taking the test. There was therefore no haste or rash in teaching, but effective and efficient teaching taking into consideration every detail, a reason the researcher believed strongly catapulted students understanding and performance.

All these discussions corroborated to the reason why majority of the students questioned about the effect of concept mapping did not agree to the opinion that the use of concept mapping to teach did not help them to perform well in test but rather helped them to perform better.

# CHAPTER FIVE

# SUMMARY, CONCLUSIONS AND RECOMMENDATONS

## 5.0 Overview

This chapter presents the summary of the findings from the study and conclusions made by the Researcher. The chapter also looked at the recommendations made by the Researcher to biology teachers in particular about their curriculum materials as well as suggestions for further research on the topic.

## 5.1 Summary of the Major Findings

The main purpose of the study was to investigate the the effect of concept maps or mappings on the performance of Apam Senior High School Students on Photosynthesis. The researcher used an action research with a convenience sampling to select 55 Home Economic students of Apam Senior High School. The researcher employed the use of concept mapping or maps as the intervention. Biology Achievement Test on Photosynthesis was used to design a pre and post-tests to assess the students performance. The results from the pre and post test showed a significant difference in the performance of the students indicating an improvement in the students performance after the use of the intervention.

Interviews and a five point Likert scale questionnaire was also designed to determine the students' response to the use of concept maps. Their responses from the questionnaires were also used to design observation schedule to confirm the students‟ responses and opinions in the questionnaire. The findings suggested that concept maps aided the students to revise their lesson on their own with ease. The concept

map also summarises concept and made concept clearly for easy comprehension and retention.

## 5.2 Key Findings

The major findings that came out of the study were as follows;

1. There was a significant difference between the pretest and posttest means scores of the students and that the students performed better when concept maps were used to teach them.
2. There was also a significant difference between the performance of males to females and that the males outperformed their female counterparts in the study.
3. In addition, after the used of the intervention, the students were enthused with the use of concept mapping strategy and that the intervention helped them to perform better.
4. The students also agreed that concept mapping help them to keep ideas longer in their memories and reduced rote memorization of facts.

## 5.3 Conclusion

The study concluded that whenever concept mapping strategy was used to teach biology, the students tend to enjoy it and as such they perform better as compared to the other traditional methods of teaching. The study also concluded that even though all students in this study had improvement in their posttest performance, the males were those who benefited more. More so, it was concluded that for the students to benefit greatly from the use of concept mapping strategy, the teacher should employ it as an advance organiser before the lesson, to summaries the lesson, and as an evaluative tool after the lesson. One could also conclude that due to the nature of

concept mapping strategy, the teacher who intend to use this approach must revise the topic very well so as to be more knowledgeable on the topic to help address the students misconceptions and help them to learn well. The males outperformed the females. In addition one could conclude also that, when concept map is used in a step by step manner, involving group discussions, the students enjoy the lesson more and participate fully in the lessons. And that if teachers want to make students always punctual in class and love the learning of photosynthesis, the use of concept mapping is the ideal.

### 5.4 Recommendations

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

1. Biology teachers in Apam senior high school must try and use concept mapping strategy to teach abstract concepts such as photosynthesis for students" conceptual understanding.
2. To make use of concept mapping as an effective strategy to teach, biology teachers in Apam senior high school must use the intervention in a step by step manner and in tandem with discussions.
3. Simple and small maps must also be constructed for easy comprehension.
4. Biology teachers in Apam senior high school should use concept mapping techniques to unearth their students' misconceptions on photosynthesis and concepts such as respiration and excretion.
5. Biology Heads of Department should organise in - service training courses for their teachers on the use of concept mapping for biology lessons.

## 5.5 Suggestions for Further Studies

1. It is recommended that further studies should be conducted to establish the impact of concept maps on the students' performance in other topics to confirm its authenticity. The study should be replicated in other schools in other district too.
2. It was found from the study that the males outperformed the females when concept mapping strategy was used to teach photosynthesis. Further studies should be conducted on other topics to check whether males would still benefit more than females.
3. A survey of the interventions biology teachers design for their students learning difficulties should be conducted to provide insight into the workability of each of the intervention strategies.
4. A study should be conducted to determine the preferred learning style of biology students to enable biology teachers organise credible interventions for their students.

# REFERENCES


Abimbola. I. O. (2007). *Teachers' perceptions of important and difficult biology concepts*. Lagos: Kutin Publishers.

Adlaon, R. B. (2002). *Assessing effectiveness of concept map as instructional tool in high school biology*. Unpublished Master"s Thesis: Louisiana State University.

Adeneye, O., & Adeleye, A. (2011). Effect of concept mapping strategy on students achievement in junior secondary school mathematics. *International Journal of Mathematics Trends and Technology, 2*(3), 11-15.

Ahmad B. C., Mirza, M. S. (2013). Effect of concept mapping on students" academic achievement. *Journal of Research and Reflections in Education*, *7*(2), 125 - 132

Ahmed, O. Q. (2010). The effect of using concept mapping in teaching on the achievement of fifth graders in Science. *Studies on Home and Community Science, 4*(3).155-160.

Ajaja, O. P. (2009). *Teaching method across disciplines*. Ibadan: Bomn Prints.

Akeju, O. O., Rotimi, C. O., & Kenni, A. M. (2011). *Teaching with concept mapping Instructional strategy in Nigeria. Proceedings of the 2011. International Conference on Teaching, Learning and Change*. International Association for Teaching and Learning (IATEL).

Alhassan, S. (2009). *Modern approaches to research in educational administration.* Kumasi. Payless Publication Ltd.

Amoako, P. A. (2016). *Impact of concept mapping in reducing cognitive load of biology students*. Unpublished M. Ed Thesis. Faculty of science education, Winneba: University of Education, Winneba.

Anamuah-Mensah, J. (1998). Native science beliefs among some Ghanaian students. *International journal of science Education*, *20*(1), 115 – 124.

Ausbel, D. (1978). In defense of advance organizer: A reply to critics. Review of *Educational Research,48*, 251-257.

Blaxter, L., Hughes, C., & Tight, M. (2001). *How to research, (*3rd ed.) Maidenhead: Open University Press.

Bell, J. (2008). *Doing your research project: A guide for first - time researchers in education and social science, (*4th ed.) Maidenhead: Open University Press.

Blackwell, S., & Pepper, K. (2008). The effect of concept maps on preservice teachers' reflective practices when making pedagogical decisions. *Journal of Effective Teaching, 8*(2), 77-93.

Buzzetto-More, N. A. (2007). *Advanced principles of effective e-Learning*. California: Information Science Press.

Candan, A. Y. (2006). The effect of concept mapping on Primary School Students understanding of the concepts of the force and motion. *Journal of Turkish Science Education, 3*(1) 66-75.

Cañas, A. J., Valerio, A., Lalinde-Pulido, J., Carvalho, M., &Arguedas, M. (2003). Using word net for word sense disambiguation to support concept map construction. *In String Processing and Information Retrieval*, 350-359.

Cardellini, L. (2004). Conceiving of concept maps to foster meaningful learning: An interview with Joseph D. Novak. *Journal. of Chemistry Education, 81*(9), 13-23.

Chang, K. E., Sung, Y.-T., & Lee, C.-L. (2003). Web-based collaborative inquiry learning. *Journal of Computer Assisted Learning*, *19*, 56-59.

Çimer, A. (2012). What makes biology learning difficult and effective: Students‟ views. *Educational Research and Reviews, 7*(3), 61-71.

Clement, J. J., & Maria, N. O., (2003). *Abduction and Analogy in Scientific Model Construction.* Paper presented at the annual meeting of the national association of researchers in science teaching. Philadelphia. USA.

Coll, R. K., France & Taylor (2005). The role of models and analogies in science education: Implications from research. *International Journal of Science Education,27*(2), 183 - 198.

Coutinho, E. (2014). Concept maps: Evaluation models for educators. *Journal of Business and Management Sciences, 2*(5), 111-117.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative and mixed method approaches (2nd ed.).* London: SAGE Publication. Ltd.

Creswell, J.W. (2008). *Educational research: Planning, conducting and evaluating qualitative, quantitative research* (3rd ed.). New Jersey: Pearson Education.

Cronin, P. J., Dekker, J. & Dunn, J.G.1982. A procedure for using and evaluating concepts maps. *Research in Science Education,12*(1), 17-24.

Curriculum Research and Development Division (CRDD). (2010). *The ministry of education: Teaching syllabus for biology.* Accra: MoE, Ghana.

Dhaaka, A. (2012). Concept maps: Effective tool in biology teaching. *VSRD-TNTJ*, *3*(6), 225-230

Edmondson, K. M. (2005). Concept maps for the development of medical curricula. *Journal of Research in Science Teaching, 32*(7), 777-793.

Eravwoke, O. U. (2011). *The effect of concept mapping teaching-learning technique on teachers' attitude and students' achievement in chemistry*. Unpublished M. Ed Thesis. Benin-City: University of Benin.

Esiobu, O. G., & Soyibo, K. (2006). Effects of concept and vee mapping under three learning modes on students' cognitive achievement in ecology and genetics. *Journal of Research Science Teaching, 32*(9), 101-121.

Fisher, K.M., Wandersee, J.H. & Moody, D.E. (2000). *Mapping biology knowledge.* Dordrecht, Netherlands: Kluwer.

Freeman, L. A., & Jessup, L. M. (2004). The power and benefits on concept mapping: Measuring use, usefulness, ease of use, and satisfaction. *International Journal of Science Education, 26*, 151–169.

Gillmor, S. C., Poggio, J., & Embretson, S. (2015). Effects of reducing the cognitive load of mathematics test items on student performance. *Numeracy*, *8*(1), 1-18.

Hrefna, S., & Halldóra, L. T. (2006). *How well do pupils understand photosynthesis? A study in three small rural schools in Iceland*. Unpublished B.ED thesis University of Iceland, Stakkahlíd, Iceland. 105.

Huai, H. , & Kommers, P. (2004). *Cognitive styles and concept mapping*. In P. Kommers, Cognitive support for learning. Amsterdam: IOS Press.

Hynie, M. (2006). Parent-child value transmission among chinese imigrants in north america: The case of traditional mate preference. *Cultural Diversity and Ethnic Minority Psychology, 12*(2), 230 – 244.

Johnson, M. P. (2016). Photosynthesis. *Essays in Biochemistry,60*. 255–273

Johnstone, A., & Otis, K. (2006). Concept mapping in problem based learning: A cautionary tale. *Chemistry Education Research and Practice, (7),* 84-95.

Kabaca, T. (2002). *Using Concept mapping technique on algebra in high school mathematics teaching*. Master"s thesis. Istanbul: Marmara University Graduate School of Technology Science.

Karakuyu, Y. (2010). The effect of concept mapping on attitude and achievement in a physics course. *International Journal of the Physical Sciences, 5*(6), 724-737.

Keppens, J., & Hay, D. (2008). Concept map assessment for teaching computer programming. *Computer Science Education, 18*(1). 31-42

Kinchin, I. M. (2005). Writing to be published or writing to be read. *Journal of Natural History*. *39*, 3229-3233.

Kinchin, I. M. (2000). Concept mapping in biology. *Journal of Biological Education*, *34*, 6-68.

Kommers, P.A. (2004). *Cognitive support for learning: imagining the unknown*. London: Los Press.

Kwon, S. Y., & Cifuentes, L. (2009). The comparative effect of individually-constructed vs. collaboratively constructed computer-based concept maps. *Computers & Education, 52,* 365 - 376.

Liu, C., Don, P. Tsai, C. (2005). Assessment based on linkage patterns in concept maps. *Journal of Information Science and Engineering, 21*. 873-890.

Liu, P. L. (2011). A study on the use of computized concept mapping to assist ESL learners‟ writing. *Computers & Education, 57*, 2548-2558.

Liu, P. L., Chen, C. J., & Chang, Y. J. (2010). Effects of a computer-assisted concept mapping learning strategy on EFL college students‟ English reading comprehension. *Computers & Education, 54*, 436 - 445.

Mclay, M., & Brown, M. (2003). Using concept mapping to evaluate the training of primary school leaders. *International Journal of Leadership in Education 6*(10), 73-87.

Meng-Lei, M. H., & Ming-Hsiung, W. (2012). The effect of concept mapping on students‟ cognitive load. *World transactions on engineering and technology education, 10*(2), 134- 137.

Mintzes, J. J., Wandersee, J. H., & Novak, J. D. (2000). *Assessing science understanding: A human constructivist view*. San Diego: Academic Press.

Morse, D., & Jutras, F. (2008). Implementing concept-based learning in a large undergraduate classroom. *Life Sciences Education, 7*, 243– 253.

Ndayambaje, B. J., Bikorimana, E., & Nsanganwimana, F. (2021). Factors contributing to the students‟ poor performance in biology subject: A case study of ordinary level in rural secondary schools of Rwamagana district. *GSC Biological and Pharmaceutical Sciences, 15*(3), 249–261.

Novak, J. D., & A. J. Cañas (2008). *The theory underlying concept maps and how to construct and use them*. Technical Report IHMC CmapTools. Florida: Institute for Human and Machine Cognition.

Ntim, S. (2015). Cognitive demands of processing expository text: Pedagogical implications for enhancing coherent text base among less skilled readers. *International Journal of Research Studies in Psychology, 4*(4), 29- 46.

Offor, E. N. (2007). Refocusing science and technology education toward national development. Knowledge Review. *A Multidisciplinary Journal of NAFAK, 15*(6), 53-55.

Ofosu, C. (2016). *The Effect of Concept Mapping on the Performance of Biology Students of Nifa Senior High School on Cell Division*. Unpublished Master‟s Thesis university of education , Winneba, Ghana.

Ogonnaya, U. P., Okafor, G., Abonyi, O. S., Ugama, J.O. (2016). Effect of concept mapping instruction approach on students‟ achievement in basic science. *Journal of Education and Practice, 7*(8), 7 - 84.

Okeke, E. A. C. (2007). *Making Science Education Accessible to all: 23rd Inaugural Lecture.* Nsukka: University of Nigeria.

Olatoye, R. A. & Afuwape, M. O. (2004). Emergent issues in enhancing the teaching and learning of science in schools. In: O. A. Afemikhe and J. G. Adewale (Eds.). *Issues in educational measurement and evaluation in Nigeria.* Institute of Education, University of Ibadan, Ibadan.

Pandian, S. S. (2004). *Cooperative Learning in Biology: The Effect of Computers*. Department of Education, Arunachi University, India.

Pankratius, J. W. (1990). Building an organized knowledge base: Concept mapping and achievement in secondary school physics. *Journal of Research in Science Teaching, 27*(4). 315-333.

Piaget, J. (1970). *Piaget's Theory*. In P.H. Mussed (ED). Carmichael‟s manual of child psychology, New York: Wiley, 3(1); 7033-32.

Pill, M. (2005). *Enhancing teaching in high education*. NY: Routledge.

Pop-Pacurar, I., & Tirla, F. D. (2009). Within active learning in biology. A case Study. *Acta Didactica Napocensia, 2*(2). 41 – 50.

Raza, U., & Hazir, U. (2019). Boys versus girls‟ educational performance: Empirical evidences from global north and global south. *African Educational Research Journal, 7*(4), 163- 167.

Reece, I., & Walker, S. (2003). *Teaching, training and learning: A practical guide.* 5th edition., business education publishers. Britain.

Royer, J., & Royer, R. (2004). Comparing hand drawn and computer generated concept mapping. *Journal of Computers in Mathematics and Science Teaching, 23*(1), 67–81.

Sidhu, K. S. (2009). *Methodology of research in education.* New Delhi: Sterling Publishers.

Simon, M. K,, & Goes. (2013) *Dissertation and scholarly research: Recipes for success*. Seatle, WA: Dissertation Success LLC.

Stoyanov, S. (2001). *Mapping in the educational and training design*. Doctoral dissertation, University of Twente, Netherlands. Enschede: Print Partners Ipskamp.

Sukola, I. T., Abdulmalik S & Yunusa M. M. (2016) Comparative Analysis of Gender Performances in Biology, Chemistry and Physics among Pre-Degree Students of Federal University, Dutsinma. *International Journal of Education Benchmark (IJEB), 5*(1) 108 - 118.

Udeani, U., & Okafor, P. U. (2012). The effect of concept mapping instructional strategy on the biology achievement of senior secondary school slow learners. *Journal of Emerging Trends in Educational Research and Policy Studies,3(*2), 137-142.

Wachanga, S. W & Mwangi, J. G. (2004). Effects of the cooperative class experiment teaching method on secondary school students‟ chemistry achievement in Kenya‟s nakuru district. *International Education Journal, 5*(1). 26-36.

Wallace, J. D., & Mintzes, J. J. (1990). The concept map as a research tool: Exploring conceptual change in biology. *Journal of Research in Science Teaching, 27*(10), 1033-1052.

Wapner, S. (1986). Introductory *remarks.* In M.Bertini, L. Pizzamiglio, & S. Wapner (Eds). *Field dependence in psychological theory, research, and application*. Hillsale, NJ: Lawrence Erlbaun Associates.

Yunus, F. W., & Ali, Z. M. (2012). Urban students' attitude towards learning chemistry. *ASIA Pacific International Conference on Environment - Behaviour Studies, 68*, 25 - 304.

Zwiers, E. S., & Gielen, A. C.(2018). Biology and the gender gap in educational performance - The role of prenatal testosterone in test scores. *JEL (20)*16, 1 - 37.

# APPENDIX A

## PRE-TEST

**UNIVERSITY OF EDUCATION, WINNEBA**

**DEPARTMENT OF SCIENCE EDUCATION**

**BIOLOGY ACHIEVEMENT TEST ON PHOTOSYNTHESIS (BATP)**

**Time 1hr:30min**

Answer all questions in this section.

Q1.

a. What is photosynthesis?

b. State any three conditions necessary for photosynthesis to occur.

Q2.

a. Describe a test to demonstrate that Chlorophyll and sunlight are necessary for photosynthesis to occur.

b. State three importance of photosynthesis.

Q3.

a. Explain four ways in which the structure of the leaf is adapted to photosynthesis.

b. Explain the role of chloroplast to photosynthesis.

Q4. Describe the structure of the chloroplast.

Q5. Name the types of chloroplast pigments necessary for photosynthesis to occur.

# APPENDIX B

## MARKING SCHEME FOR BATP PRE-TEST

**Time 1hr:30min**

**Objective Questions**

1. Most photosynthesis occurs on the a) upper epidermis b)lower epidermis c) guard cell

2. Oxygen from photosynthesis is released from the light stage when water splits in

a) photosystem I b) Photosystem II c) Calvin cycle

3. Which of the following is not a condition for photosynthesis to occur a)sunlight b) chlorophyll c) presence of a leaf

4. Which of the following is not a product of photosynthesis a) heat b) oxygen

c) starch

5. In testing for the presence of chlorophyll in a green leaf, some of the leaves of a photosynthesising plant is kept in the dark for which of the following reasons

a) to stop the leaf from undergoing photosynthesis b) to remove stored starch from the leaf

c) kill the cell of the leaf

6. A variegated leaf is used for what purpose n the test for photosynthesis

a) the need for chlorophyll in photosynthesis b) need for sunlight for photosynthesis

c) the need for carbon dioxide for photosynthesis

7. Photosynthesis occurs in ? a) Chloroplast b) Nucleus c) Mitochondria

d) Golgi body

8. Where does dark reaction take place? a) Grana b) Stroma lamellae c) Stroma

d) all

9. During photosynthesis oxygen is evolved from a) Water b) Sunlight c) $CO_2$

d) Chlorophyll

10. Which of the following is a reactant of photosynthesis a) water b) carbon dioxide c) sunlight

## Essay Questions

**Question 1. a.What is photosynthesis?**

Is the biological process aided by enzymes in which green plants manufacture their own food with the aid of components such as chlorophyll, sunlight, carbon dioxide to release oxygen.

1. b.State any three conditions necessary for photosynthesis to occur.

1. Chlorophyl
2. Cardon dioxide
3. Sunlight

**Question 2. a. Describe a test to demonstrate that Chlorophyll and sunlight are necessary for photosynthesis to occur.**

Pick a variegated leaf that has been in the sun for more than 24hrs. Draw the patten on a paper and identify the part that has green pigment separately from those with colors other than green. Test for starch . Compare the leave to the drawn patten to compare the parts. It could be observe that the part that had green pigmented color turned blue black indicating that photosynthesis had occurred there. The other coloured parts wold show brown indicating absence of chlorophyll and photosynthesis.

**Question 2.b. State three importance of photosynthesis to living organisms.**

1. Provide food for plant and other organisms
2. Produce oxygen for living organisms like mammals
3. Reduce the carbon dioxide concentration in the atmosphere.

**Question 3. a. Explain four ways in which the structure of the leaf is adapted to photosynthesis.**

1. The leaf has broad has broad leaves given it large surface area for maximum absorption of sunlight.
2. The leaf is thin enabling carbon dioxide to diffuse efficiently.
3. Presence of stomata to enable exchange of gases effectively
4. Presence of large amount of chloroplast, palisade mesophyll cells as the site for photosynthesis.

**Question 3. b.Explain the role of chloroplast to photosynthesis.**

Chloroplast is an organelle in plants and algae. It contains chlorophyll for trapping sunlight to excite electrons as they move through the electron transport chain. Photosynthesis takes place in chloroplast. There are two stages of photosynthesis, the

lght and dark stages.The light stage occurs in the thylakoid membranes of the Granum for the production of oxygen , hydrogen and ATP. The dark stage is the stroma leads to the production of starch.

**Q4. Describe the structure of the chloroplast.**

Chloroplast is a double membranous organelle found in plant cells. It is spherical in shape. The inner membrane is fluid filled with many thylakoid membrane. These thylakoid membranes form a stuck of interconnected membranes (pilled coins) called granum. The outer layer is made of the stroma.

**Q5. Name the types of chloroplast pigments necessary for photosynthesis to occur.**

A. Chlorophyll a

B. Chlorophyll b

C. Carotenoids

# APPENDIX C

## POST-TEST

## BIOLOGY ASSESSMENT TEST 2

**Time 1hr:30min**

**Objective Questions**

Q1. Photosynthesis occurs in : a) Chloroplast b) Nucleus c) Mitochondria d) Golgi body
Ans: a) Chloroplast
Q2. Kranz anatomy is found in the leaves of: a) C3 Plants b) C4 Plants c) both d) none
Ans: b) C4 Plants
Q3. Photosynthetically active radiation (PAR) is represented by the range of wavelength of :
a) 350-450 nm b) 400-700 nm c) 500-600 nm d) 450-950 nm
Ans: b) 400-700 nm
Q4 Where does light reaction take place: a) Grana b) Stroma c) Cytoplasm d) Ribosome
Ans: a) Grana
Q5 Non-cyclic photophosphorylation results in the formation of :
a) ATP b) ATP and NADPH c) NADPH d) None
Ans: b) ATP and NADPH
Q6 Where does dark reaction take place:
a) Grana b) Stroma lamellae c) Stroma d) all
Ans: c) Stroma
Q7 The first acceptor of $CO_2$ in C4 plants is :
a) Malic acid b) Oxaloacetic acid c) Phosphoenol pyruvate (PEP) d) Aspartic acid
Ans: C) Phosphoenol pyruvate (PEP)
Q8 The first stable product of C3 cycle is :
a) PGA b) OAA c) PEP d) RUBP
Ans : a) PGA
Q9 Rubisco enzyme in C4 plant is found in :
a) Mesophyll cell b) Mitochondria c) Peroxisome d) Bundle Sheath cell
Ans: d) Bundle Sheath cell
Q10 In PS II the reaction centre is :
a) P700 b) P 680 c) P 400 d) P 650
Ans: b) P 680
Q11 Which is the primary acceptor of $CO_2$ in C3 plants:
a) RUBP b) PEP c) OAA d)PGA
Ans: a) RUBP
Q12 Photorespiration occurs in :
a) C4 plants b)C3 plants c) Both d) None
Ans : C3 plants
Q13 During photosynthesis oxygen is evolved from :
a) Water b) Sunlight c) $CO_2$ d)Chlorophyll

Ans: a) water
Q14 Which element or enzyme is required for photolysis of water:
a) Mg b) Mn c) Fe d) Zn
Ans: B) Mn
Q15

**Essay Questions**

Q1. Photosynthesis occur in two stages, name these strategies

Q2. Within the thylakoid membranes, chlorophyll pigments are arranged into ..... And there are two of them namely, ..... And .....

Q3. Describe the light stage of photosynthesis

Q4. Describe the role of the electron transport chain molecules ferrodoxin and cytochrome B6 complex to photosynthesis.

Q5. Describe the process of photophosphorylation of ATP in photosynthesis.

## ANSWERS TO THE BIOLOGY ASSESSMENT TEST 2

### POST TEST

**1.**

A. Light stage

B. Dark stage

**2.**

A. Photosytems

B.Photosystem I and photosystem II

**Q3.**

A photon of light excites electrons of photosystem II and the energy release splits water to release oxygen and energised electron. The energised electrons are used to phosphorylate ADP to ATP. The energised electron is also accepted by NADP+ to form reduced NADPH which would be used later in the dark stage of the photosynthesis.

# APPENDIX D

## SCORING RUBRICS FOR CONCEPT MAPPING

1. Concepts : score 1 pont for each concept that is connected to another concept by a preposition

2. Hierarchy: score 1 point for each valid level

3. Preposition: score 1 point for each meaningful preposition.

**Penalty**

Score zero for the following

1. Concept not placed in box

2. Omitted concept

3. Invalid concept

4. Omitted labels

# APPENDIX E

## STUDENTS' QUESTIONNAIRE

## TEACHING WITH CONCEPT MAPS STRATEGY

**INSTRUCTIONS**

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

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

**A. Background information**

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

1. Gender [ ] Female [ ] Male
2. Age ……years
3. At what level were you taught the use of concept maps? Please, tick [ ] only one level.

**B. Perceptions of the effectiveness of Concept maps on teaching and learning.**

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

Rating Scale: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD)

| **Statements** | **SA** | **A** | **N** | **D** | **SD** |
|---|---|---|---|---|---|
| I was more enthusiastic and motivated during the use of Concept Maps in the teaching and learning of Photosynthesis. | | | | | |
| The use of Concept Maps as instructional techniques is an effective strategy for students of all abilities. | | | | | |
| The use of concept mapping to teach has helped me to perform better in biology | | | | | |

| Statements | SA | A | N | D | SD |
|---|---|---|---|---|---|
| The use of Concept Maps strategy in instruction reduces my personal interaction with my colleagues. | | | | | |
| The use of Concept Maps provides a means of expanding and applying what has been taught in class. | | | | | |
| When using Concept Maps to explain un-grasped concept to a colleague, my role will be as a facilitator of theirs learning. | | | | | |
| The use of Concept Maps instruction would promote the student understanding of concepts and do away rote learning memorization of facts. | | | | | |
| The use of Concept Maps instruction is an effective means of helping students to understand relationships among concepts. | | | | | |
| The use of Concept Maps instruction would make the student feel more involved and to cooperate more on projects in class. | | | | | |
| The use of Concept Maps for learning almost and always reduces the personal undue forgetfulness and recitation of mnemonics as well as acronyms during examinations. | | | | | |
| Concept Maps for instruction would enable me to interact more with other students to promote group discussions. | | | | | |
| I feel the use of concept maps for instruction would help my learning during my private time in a positive way. | | | | | |
| The use of concept mapping has helped me to show interest in the learning and reading of biology. | | | | | |
| I feel bored when the teacher uses concept mapping to teach biology. | | | | | |

# APPENDIX F

# OBSERVATION GUIDE

**INSTRUCTIONS**

Thank you for taking time to complete this observation schedule. Please answer each question to the best of your ability. Your responses will be kept completely confidential and will not be disclosed anywhere.

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

| **Observed Action** | **YES** | **NO** |
|---|---|---|
| Most of the students were seen participating in class activities. Ie asking questions, discussions with group members etc. | | |
| Majority of the students were always present in class during biology lessons | | |
| The students were seen drawing their own concept maps and learning with their personal maps in their private studies. | | |
| The students' generally performed better in class contributions, discussions, and drills on any biology topic taught. | | |

# APPENDIX G

# INTERVIEW QUESTIONS

**INSTRUCTIONS**

Thank you for taking time to complete this interview questions. Please answer each question to the best of your ability. Your thoughtful and truthful responses will be greatly appreciated. Your individual name or any identification number is not required and will not at any time be associated with your responses. Your responses will be kept completely confidential and would not be disclosed anywhere.

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

1. What marks did you obtain in the test? .....
2. From your own opinion did you do well in the test that was given? .....
3. Enumerate reasons for your answer in question 2 above

.....

.....

.....

.....

.....

.....

4. In your own words suggest any means to improve on your performance in subsequent tests.

.....

.....

.....

.....

# APPENDIX H

# LESSON PLAN ON PHOTOSYNTHESIS

## LESSON PLAN FOR THE STUDY

**Topic:** Photosynthesis

**Class:** SHS 2 (Home Economics)

**Week:** One

**Subtopic:** Introduction to Photosynthesis

**RPK:** Students already familiar with the introduction to Photosynthesis **from** SHS 1 and previous lessons.

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

1. Guide students to revise concepts on previous lessons on Photosynthesis.
2. Identify students challenges with the concept of Photosynthesis.

**TLM**

1. Textbooks , Biology syllabus

**Teacher and Learner Activities**

1. Teacher guides students to revise concepts on the introduction of Photosynthesis by using an advance organiser.
2. Teacher gives the pre-intervention test (BATP) to the class.
3. Teacher gives feedback of the questions given to the students and identify misconceptions, and abysmal performance of students.

**CLOSURE**

1. The performance of the students served as the basis for the introduction of the use of multimedia as a means of teaching the topic on Photosynthesis.

**REMARKS**

Students were able to answer most of the questions but were unable to recollect some basic concepts and facts on previous lesson taught.

**Week Two**

**Topic:** **Photosynthesis**

**Subtopic:** **Structure of the Chloroplast**.

**RPK:** **S**tudents already familiar with the organelle Chloroplast from SHS 1**.**

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

1. Identify the structure of the Chloroplast
2. Identify the components of the Chloroplast.

**TLM**

1. Textbooks, and a concept map on Photosynthesis.

**Teacher and Learner Activities**

1. Teacher guides students to identify the structure of the Chloroplast by showing them a picture of the chloroplast. Below is a picture of the chloroplast.

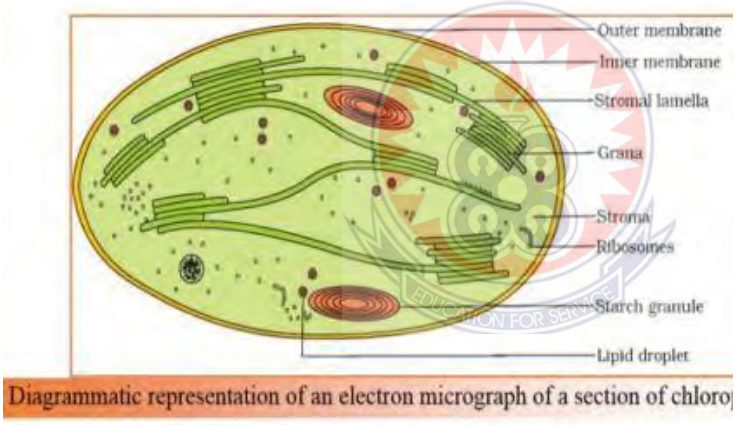


**Fig. 1: Showing a picture of the chloroplast**

2. The teacher also make the students aware of the fact that the chloroplast stores chlorophyll
3. The students also were able to identify that the chloroplast has two layers for which the inner layer has both the stroma and the grana from the concept map.
4. From the same fig. 1.0 above the teacher shows to the students, the chloroplast has, the granna containing the thylakoids which also contains the various photosysterms.
5. The teacher guided the students to describe the roles of all the various components of the chloroplast using the concept map as the learning resource.

6. Teacher summarise the lesson with a short drill test.
7. The teacher shows to the students how to make concept map of the structure of Chloroplast.

Below is a concept map showing the structure of the chloroplast.

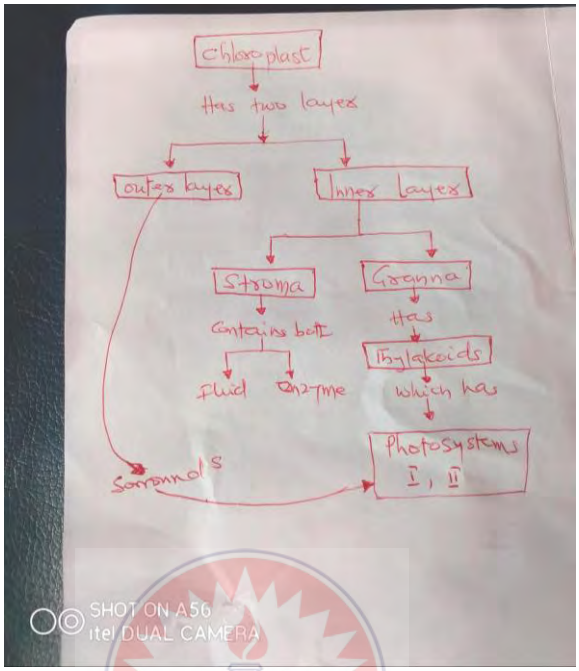


**Fig. 2: A concept map showing the structure of the chloroplast**

**CLOSURE**

The teacher summarises lesson by using a short drill test on the topic. In this case a component of the chloroplast molecules were written on a card and placed into a box for students to pick and identify and explain what it is and its role in photosynthesis.

**REMARKS**

Lesson ended successfully.

**Week Three**

**Topic:** Photosynthesis

**Subtopic:** General overview of the process of photosynthesis.

**RPK:** **S**tudents already familiar with the term Photosynthesis**.**

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

1. Explain the processes involved in Photosynthesis.

**TLM**

1. Textbooks, concept map on the process of Photosynthesis

**Teacher and Learner Activities**

1. Teacher guides students to explain the process of Photosynthesis by using concept mapping.

**Activities**

1. From the concept map below the students were able to identify two stages of the process of photosynthesis; Dark and Light stages. The teacher explains that then explain the process with the concept map as reference material for the first and second stage.

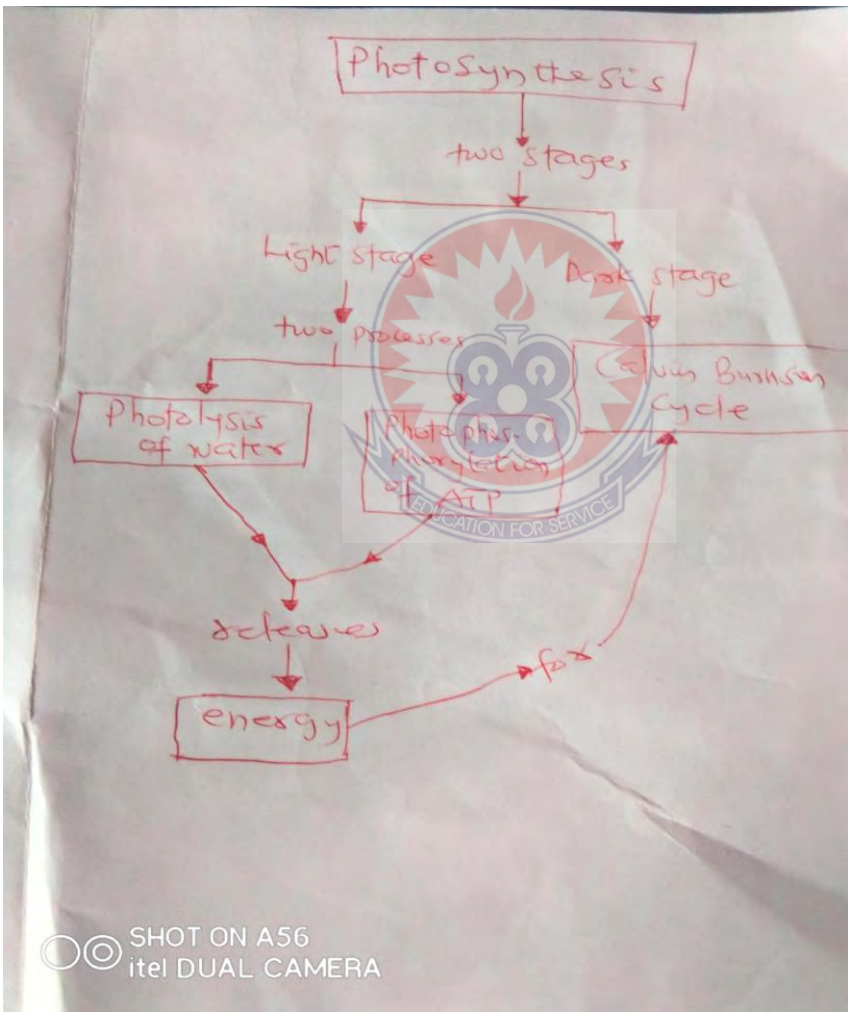


**Fig. 3: A sample of a concept map on the process of photosynthesis by students**

2. Stage 3 of photosynthesis is where the two processes were also described by the teacher using the same concept map. Here the light stage also had two steps; the photolysis of water and the phosphorylation of ATP as seen in the next level under the Light stage.

3. At stage 4, the concept map depicted that both the photolysis and photophosphorylation of ATP leads to the release of Energy.

**CLOSURE**

The teacher summarises lesson by using a short drill test on the topic. In this case a component of the chloroplast molecules were written on a card and placed into a box for students to pick and identify and explain what it is and its role in photosynthesis.

**REMARKS**

Lesson ended successfully.

**Week Four**

**Topic:** Photosynthesis

**Subtopic:** Photophosphorylation of ATP

**RPK:** **S**tudents already familiar with the process of photosynthesis**.**

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

1. Photolysis of water
2. Explain the processes involved in Photophosphorylation of ATP.

**TLM**

1. Textbooks, concept map on the process of Photosynthesis

**Teacher and Learner Activities**

1. Teacher guides students to explain the process of Photolysis of water by using concept mapping.
2. Teacher guides students to explain the process of Photophosphorylation of ATP by using concept mapping.

**Activities**

1. From the concept map below the students were able to identify two stages of the process of photosynthesis; Dark and Light stages. The teacher explains that then explain the process with the concept map as reference material for the first and second stage.
2. Stage 3 of photosynthesis is where the two processes were also described by the teacher using the same concept map. Here the light stage also had two steps ; the photolysis of water and the phosphorylation of ATP as seen in the next level under the Light stage.

3. At stage 4, the concept map depicted that both the photolysis and photophosphorylation of ATP leads to the release of Energy.
4. The teacher then guides to explain the detailed steps and process as shown in the concept maps drawn by the teacher and the students.

Below is the concept map on photolysis of water.

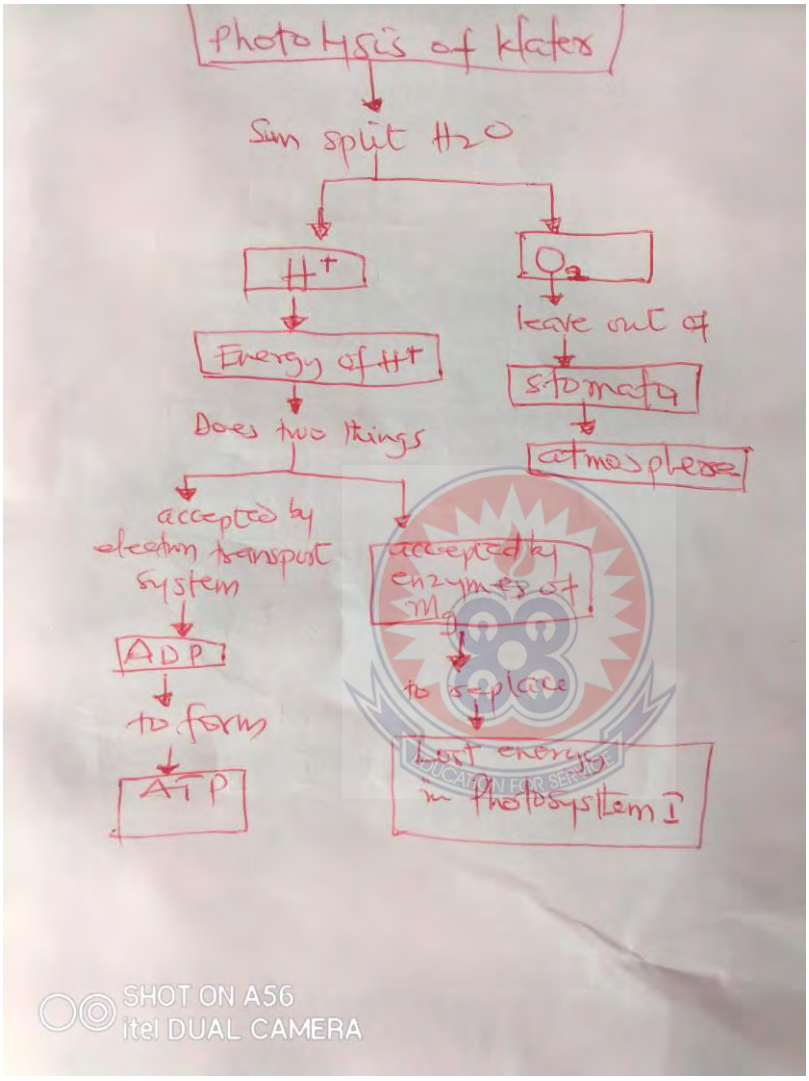


**Fig. 4: A concept map on photolysis of water by students**

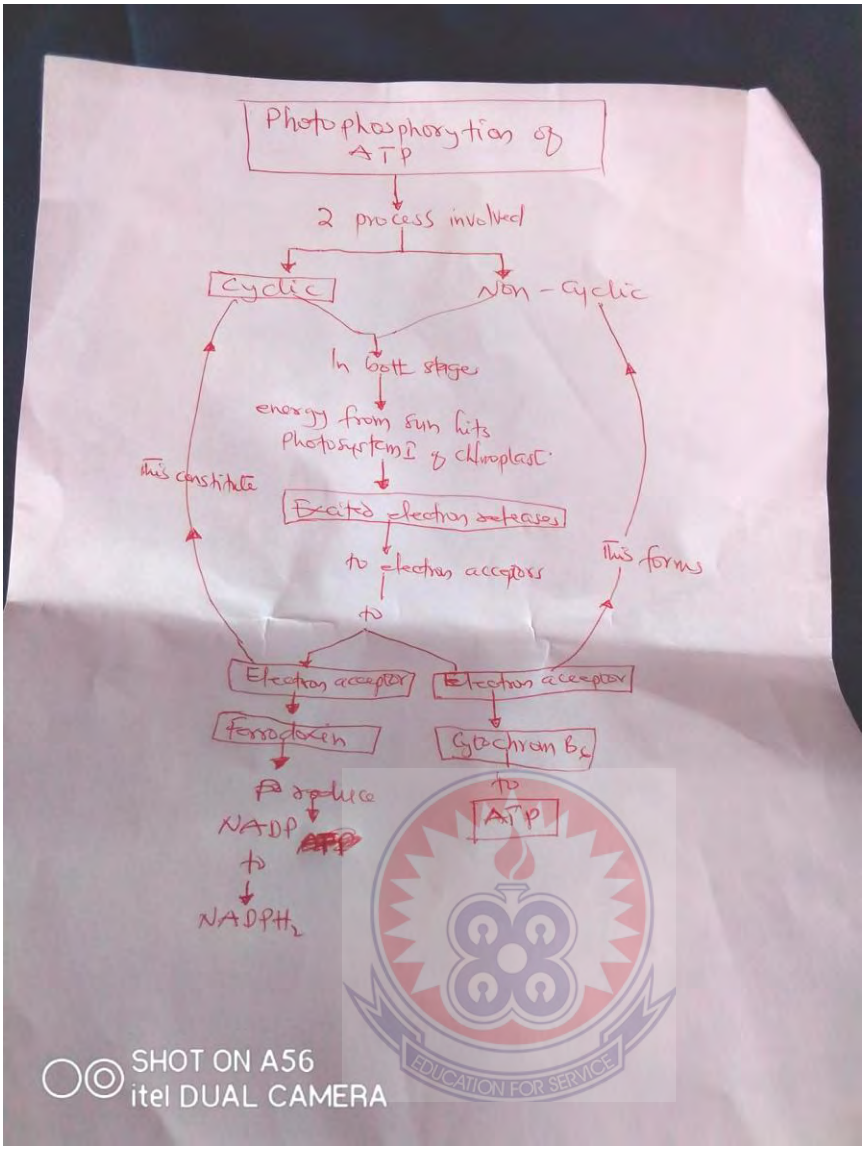


**Fig. 5: A concept map on photophosphorylation of ATP**

**CLOSURE**

The teacher summarises lesson by using a short drill test on the topic. In this case a component of the chloroplast molecules were written on a card and placed into a box for students to pick and identify and explain what it is and its role in photosynthesis.

**REMARKS**

Lesson ended successfully.

**Week Five**

**Topic:** Photosynthesis

**Subtopic:** Photolysis and photophosphorylation of ATP

**RPK:** **S**tudents already familiar with the process of photosynthesis**.**

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

1. To answer the post intervention questions correctly.

**TLM**

1. Concept map
2. Exercise books

**Teacher and Learner Activities**

**Activities**

1. Teacher gives a test (Post intervention test) to the students to answer within thirty minutes.
2. Teacher marks and gives prompt feedback to the students

**CLOSURE**

1. Teacher summarises lesson by discussing their results on Post intervention test with the students.

**REMARKS**

Lesson ended successfully.

# APPENDIX I

## DESCRIPTIVE STATISTICS

| Statement | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Age of student | 41 | 1.00 | 3.00 | 1.8293 | .66717 |
| the sexes of the student | 42 | 1.00 | 2.00 | 1.5238 | .50549 |
| The use of concept mapping instructional technique an effective strategy for students of all abilities | 42 | 2.00 | 2.00 | 2.0000 | .00000 |
| The use of concept mapping to teach did not help me to perform well in biology | 42 | 1.00 | 5.00 | 4.0000 | .85540 |
| I was more enthusiastic and motivated during the use of concept mapping to learn | 42 | 1.00 | 2.00 | 1.4286 | .50087 |
| The use of concept mapping as an instructional technique reduced my personal interaction with my colleagues | 42 | 2.00 | 5.00 | 3.7143 | 1.08843 |
| Concept mapping did not provide any means of expanding and applying what has been taught in class | 41 | 1.00 | 5.00 | 3.6829 | 1.49062 |
| concept mapping helped the to facilitate our teaching and learning | 42 | 1.00 | 4.00 | 1.8571 | .92582 |

| Statement | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Concept mapping made me learn by rote | 42 | 2.00 | 5.00 | 4.4524 | .88902 |
| Concept mapping did not allow me to know the relationship between concepts or ideas in class | 42 | 1.00 | 3.00 | 1.9048 | .61721 |
| I felt more involved in the class when concept mapping strategy is used to teach | 42 | 1.00 | 3.00 | 1.7857 | .75015 |
| The use of concept mapping almost and always reduced the rate at which i forget ideas, during examinations | 42 | 1.00 | 5.00 | 3.4762 | 1.53397 |
| The use of concept mapping promote group discussions and interactions in class | 42 | 1.00 | 5.00 | 3.7619 | 1.14358 |
| I feel the use of concept mapping as an instruction would help my personal learning during my private time in a positive way | 42 | 1.00 | 3.00 | 1.6429 | .69217 |
| Teaching with concept mapping was not interesting to me. | 42 | 1.00 | 5.00 | 2.6429 | 1.20611 |
| I feel bored whenever the teacher uses concept mapping strategy to teach biology | 42 | 1.00 | 3.00 | 1.6190 | .79487 |
| Valid N (listwise) | 41 | | | | |

# APPENDIX J

## INDEPENDENT SAMPLE T TEST

### Paired Samples Correlations

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | pretest os respondents & posttest of respondents | 55 | .071 | .644 |

### Paired Samples Statistics

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest os respondents | 28.8444 | 55 | 134.76022 | 20.08887 |
| | posttest of respondents | 12.4222 | 55 | 1.64440 | .24513 |

### Sex of respondents

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | male | 12.0 | 22.2 | 22.2 | 22.2 |
| | female | 43.0 | 77.8 | 77.8 | 100.0 |
| | Total | 55 | 100.0 | 100.0 | |

**Paired Samples Test**

| | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | Lower | Upper | | | |
| Pair 1 sex of respondents - mean | -1.60222E1 | 3.25778 | .48564 | -17.00097 | -15.04348 | -32.992 | 54 | .000 |

**Group Statistics**

| | sex of responders | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Posttest | male | 12.0 | 14.0000 | 1.63299 | .51640 |
| | female | 43 | 11.2857 | 1.07297 | .18136 |

**Group Statistics**

| | sex of respondents | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pretest | male | 12 | 7.6000 | 1.50555 | .47610 |
| | female | 43 | 5.4286 | 1.28991 | .21803 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Pretest | Equal variances assumed | .160 | .691 | 4.526 | 54 | .000 | 2.17143 | .47974 | 1.20395 | 3.13891 |
| | Equal variances not assumed | | | 4.147 | 13.019 | .001 | 2.17143 | .52365 | 1.04033 | 3.30253 |

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Posttest | Equal variances assumed | 1.152 | .289 | 6.247 | 54 | .000 | 2.71429 | .43451 | 1.83801 | 3.59056 |
| | Equal variances not assumed | | | 4.959 | 11.312 | .000 | 2.71429 | .54732 | 1.51368 | 3.91489 |