UNIVERSITY OF CAPE COAST

COMPARING CONCEPT MAPPING AND TRADITIONAL METHODS IN TEACHING SOME SELECTED TOPICS IN BIOLOGY AT THE SENIOR HIGH SCHOOL LEVEL IN GHANA

EMMANUEL LARBI APPAW

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BY

EMMANUEL LARBI APPAW

Thesis submitted to the Department of Science and Mathematics Education of the Faculty of Education, University of Cape Coast, in partial fulfilment of the requirements for award of Master of Philosophy Degree in Science Education

JUNE 2011

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature…………………………………Date…………………..

Name: Emmanuel Larbi Appaw

Supervisors' declaration

We hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature…………………………..Date………………….

Name: Mr. J. Y. Appiah

Co-supervisor's Signature…………………………………..Date…………………

Name: Mr. R. Quarcoo-Nelson

ABSTRACT

The purpose of this study was to compare the concept mapping approach which is based on constructivist theory to the traditional method of teaching biology in senior high schools. Two intact classes were randomly selected from five co-educational senior high schools offering elective biology in the New Juaben Municipality. The design used was the pretest post nonequivalent quasi design. The sample size was 105 students. The experimental group consisted of 51 students while the control group consisted of 54 students.

The students in the experimental group were instructed with concept mapping while the control group were instructed with the traditional method. Both groups were taught the same content which was on photosynthesis and internal respiration. Means, standard deviations, frequencies, Mann Whitney U, independent sample t-test, paired sample t-test, one way MANOVA, two – way ANOVA, and Pearson's Product Moment Coefficient correlation and thematic content analysis were used to analyse the data. The results indicated that those instructed with concept mapping did better than those instructed with traditional method. The result also revealed that both males and females constructed concept maps alike. Also those exposed to concept mapping showed positive perception towards concept mapping.

It has been recommended that concept mapping method should be encouraged in many biology classes at the SHS. Much attention should be given to students concerning analysis and other high order cognitive level questions.

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DEDICATION

To my dear wife Mrs. Martha Larbi Appaw.

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CHAPTER ONE

INTRODUCTION

Background to the Study

Science and technology are very necessary tools much to be desired in every society for development in this 21st century. The importance of science and technology for the development of Africa in this age of globalization is not debatable (Anamuah-Mensah, 1998). Science and technology are highly promoted through science and technology education. With the increasing technological development in the past two decades, there have been basic changes in educational systems with respect to factors such as teachers, students, and learning environment (Yilmaz & Cavas, 2006). Whitney (as cited in Aboagye, 2009) noted that every country often changes and redesigns her curriculum to include new teaching methods and techniques in order to help students develop scientific concepts better.

It is interesting to note that policy makers and the executive arm of government have from time to time commented on the need for innovative teaching strategies in science and mathematics. For instance, Dapatan (as cited in Wood, 2007) reported that at a conference in Accra in June 2003 on the theme "Strengthening Mathematics and Science in Secondary Education in Western Eastern, Central and Southern Africa" the minister of state in charge of Tertiary

Education (Ghana) called on teachers to evolve innovative knowledge and skills to promote effective teaching of science and mathematics. The minister said the method of teaching those subjects have made the subject unattractive to students and discourage them from pursuing what the minister referred to as 'cardinal subjects'. It is therefore important for both curriculum planners and teachers in the country to fashion education in a way that it could motivate and excite the curiosity of students in an informed and measured manner. This implies there is more that curriculum developers and teachers could do jointly to raise the standard of education in the country.

For Biology teachers in the country who use a fixed curriculum, Wood (2007) suggested they must be informed that the instructional method is one of the options the teacher could modify to enhance students' achievement. Biology teachers need to exploit a host of teaching and learning methods and move away from the traditional method of teaching which is teacher-centred. Teacher-centred instructional techniques perhaps bring about a relatively low achievement in students' performance. The traditional approach seems to encourage students to memorise concepts even in the area of problem-solving, explanation of observed phenomena and comprehension. Capper (1996) asserted that much of the learning in the classroom is superficial; in that facts, rules, laws and formulae are memorised, and these information are not connected to a coherent frame work that would allow students to make sense of it and to apply in other new situations. It is suggested that teachers adopt constructivists approach to learning of which the learner is an active participant in the learning process, and also construct his own knowledge. Many researchers in science education, addressing effective concept development base their studies on the constructive perspective of learning.

According to Capper (1996), one powerful way of organizing knowledge is through the use of concepts. She defined a concept as "a collection of facts principles and ideas that are related to one another in specific ways and have more explanatory power than do isolated facts" (p. 17). To Crowl, Kamisky & Podell, (1997), "concepts are classifications of a set of related ideas or events" (p.142). Klausmeier (1990) gives information about how teachers are to teach concepts. To him, concepts are developed or formed hierarchically; hence, when teaching, the most easily learned concepts are to be selected first, then the most frequently used and most precisely defined followed by the most inclusive. This means that teachers need to always teach easy concepts to be understood by students before complex and most difficult ones.

Cognitive theorists focus on the changes that occur in how people think as they progress from childhood to adulthood and how information is processed in the brain. According to Piaget (as cited in Crowl et al, 1997), concepts are learnt through schemata, assimilation, accommodation and equilibration. He noted that maturation plays an important role in concept acquisition. Brunner (as cited in Woolfolk, 2007) indicated that concepts can be learnt in stages depending on its concrete or abstraction. To him concepts are learnt at the Iconic, Enactive, and the Symbolic phases. Behaviourists also believe that the environment has effect on the learner in concept acquisition. There should be a stimulus to which the learner must respond to. This is referred to as conditioning. The conditioning can be classical or operant. The behaviourists noted that motivation, and reinforcement affects learning (Woolfolk, 2007).

Over the years the instructional approaches that have been used to teach and learn concepts include lecture method, discussion, demonstration, discovery learning, activity method, group work, and project work. (Tamakloe, Amedahe, & Atta, 2005). Other approaches to teaching science concepts include using the Indigenous Science approach (Larbi, 2005; Ogawa, 2001), Computer Assisted Instruction (CAI) (Ryan, 1991; Kausar, Choudry & Gujjar, 2008; Owusu, Monney, Appiah, & Wilmot, 2010), sand Concept Maps (Jonassen 2000; Novak, 1990; Wallace and Mintzes, 1990). Concept mapping is one of the constructivists methods used in teaching science in most Western countries and it has been proved to be robust and versatile (Novak & Canas, 2008). Concept maps have been identified to promote understanding of science concepts hence many studies have been and are being conducted in that area. The extent to which concept mapping could influence students' achievement in Biology is consequently worth exploring.

Concept map according to Novak and Gowin (1984) is a schematic device for representing a set of concept meanings embedded in a framework of propositions. It is a two-dimensional hierarchical diagram that illustrates the interconnection between and among individual concepts. To Jonassen (2000), a concept map is a visual representation of concepts and their interrelationship. Concept maps also known as cognitive maps or organizers, semantic networks, visual or graphic organisers make use of figures, lines, arrows, and spatial configurations to show how content ideas and concepts are organised and related (Anderson & Huang, 1989). The process of concept mapping involves mapping out logical relationships among concepts in an orderly, sequential or hierarchical manner such that the most broad or general concepts are at the top and the most specific ones are at the bottom of the map.

A key feature of concept maps is that, they are constructed to represent text structure patterns which serve to help students' mental constructs or schemata of how texts are organized. By mapping ideas into maps designed to model text structure patterns, teachers help students to visualize relationships and learn patterns (Bos and Anderson as cited in Guastello, Beasely, & Sinatra, 2000).

Concept maps were developed to enhance meaningful learning in the sciences; this is because it promotes meaningful learning rather than rote learning and makes information to be retained longer (Rafferty & Fleschner, 1993). There is research evidence that knowledge is stored in the brain in the form of productions that act on declarative memory content which is also referred to as chunks or propositions. Because concept maps are constructed to reflect organization of the declarative memory system, they facilitate sense-making and meaningful learning on the part of individuals who make concept maps and those who use them. Mapping puts concepts into perspective, analyzes relationships, and prioritizes information (Landsberger, as cited in Scagnelli, 2010).

The technique of concept mapping was developed by Novak in 1972 while undertaking his research programme at Cornwall University where he sought to follow and understand children's knowledge in science (Novak & Canas, 2008). It has subsequently been used as a tool to increase meaningful learning in the sciences and other subjects as well as to represent the expert knowledge of individuals and teams in education, government and business. Concept maps have their origin in the learning movement called constructivism. Novak's work is based on the cognitive theories of Ausubel, who suggested that individuals learn meaningfully by building knowledge on the bases of their prior knowledge. Ausubel (as cited in Novak and Cana, 2008) stated that "the most important single factor influencing learning is what the learner already knows, ascertain this and teach accordingly" (p.3). The fundamental idea in Ausubel's cognitive psychology is that, learning takes place by the assimilation of new concepts and propositions into existing concept and prepositional framework by the learner. This knowledge structure as held by the learner is also referred to as the individual's cognitive structure (Ausubel, Novak, & Hanesian, 1978).

Concept maps have been used successfully for a range of ages and levels of education from inexperienced kindergarten children (Novak, 1980; Stice & Alvarez, 1987) to sophisticated adult graduate students (Buntting, Coll, & Campbell, 2006; Wilkes, Cooper, Lewin, & Batts, 1999). Novak (1980) taught students as young as six years old to make concept maps to represent their response to focus questions such as 'What is water?' 'What causes the seasons?' Novak stated that "meaningful learning involves the assimilation of new concepts and propositions into existing cognitive structures." (p.945). Stice and Alvarez (1987) proposed that if students begin using concept maps at a younger age before their learning patterns are firmly established; mapping will be easier and more influential in their achievements and attitudes. In New Zealand, Bunting, et al (2006) noted that tertiary students in first year introductory Biology class had positive views about concept maps because it promoted their understanding but did not promote rote learning. This is because questions which required recall were poorly answered by students.

Willerman and Harg (1991) realized that concept maps can be use as good advance organizers by teachers to ensure meaningful learning in their students. This in turn reduces the tendency of students engaging in rote learning. With rote learning students just memorize the final form of the information giving to them; hence there is the tendency of forgetting.

Seaman (1990) identified a relationship between concept maps and cooperative learning. To him students will perform well if the strategy of concept maps will be integrated with cooperative learning. This can be very true only if the students are put in very small groups (that is, between three to five students per group). However, Ampiah (2007) noticed that some students in large group may idle about without participating.

Wilkes et al, (1999), indicated that graduates pursuing Bachelor Degree in Nursing in Australia had better knowledge and understanding of content taught after incorporating concept mapping into the curriculum to enable them link concepts in science with Nursing.

In Sub–Saharan Africa study of concept maps begun in the late 1980s into the 1990s. Bello and Abimbola (1997) noted that, the ability to construct good concept maps is not limited to any students' gender. This indicates that concept maps have no influence on gender. Jegede, Alaiyemola and Okebukola (1990) noticed that concept maps used as a teaching and learning technique turns to reduce students' anxiety, and improves students' achievement.

In Ghana, concerns were also raised in the 1990s on the low standards of students' achievements in science in the secondary schools, and the need to improve upon the teaching and learning techniques. Anamuah–Mensah, Otuka, and Ngaman-Wara (1995) and Anamuah–Mensah, Otuka, and Ngaman-Wara (1996) recommended the use of concept maps in the Junior Secondary Schools (JSS) and the Senior Secondary Schools (SSS) to improve upon the teaching and learning of science. On ability to answer question, Ampiah and Quartey (2003), noted that concept maps enable Senior Secondary School (SSS) students to answer questions on comprehension and application well, this is because concept maps boosted their understanding. Irrespective of the research conducted on concept maps in Ghana it is not a popular instructional technique in Ghanaian classrooms. It is worth noting that even though concept map is not a panacea to teaching and learning, its impact in the classroom cannot be ignored.

Statement of the Problem

For the past decade candidates have not been performing well in Biology. For instance, in 2002 out of 8922 candidates who sat for the West African Examination Council (WAEC) examination in Biology, only 3476 (39%) passed with grades A-D. In 2003, 3772 (39.4%) out of 9581 candidates passed with grades A-D. In 2004 out of 10546 candidates, 5051(47.9%) passed with grades A-

D. In 2005, 5803(40.7%) passed with grades A-D out of 14176 candidates (Anamuah–Mensah, 2007; Anthony–Krueger, 2007). The Chief Examiner's Report released by the West African Examination Council (WAEC) in 2000, 2001, 2002, 2003, 2005, 2006 and 2007 indicated that students' general performance was not good. Students showed poor performance in genetics and evolution, internal respiration, co-ordination in mammals, protein synthesis, secondary growth, and auxins (WAEC, 2000, 2001, 2002, 2003, 2004, 2005, 2006 and 2007).

Numerous reasons have been identified to be the underlying factors in the underachievement of SHS elective Biology students. Some students see the subject to be difficult which, according to Abdul-Mumuni (1995), is influenced by their religious and cultural backgrounds. Some students also have the notion that Biology involves a lot of reading, making it difficult for them (Mucherah, 2008). Also Soyinbo, Eke, and Ato (as cited in Shaibu and Olarewaju (2007) attributed students' underachievement in Biology to factors such as teachers' qualification, experience, interest and resourcefulness. Also inadequate and poor practical sessions in the laboratory may be contributing factors to students' poor performance in Biology (Anthony–Krueger, 2007). Fisher and Fraser (1981), Mynt and Goh (2001) noticed that class size in the Biology classroom environment has influence on the achievement of students in Biology.

Aside the above reasons for students' underachievement, the approach to teaching and learning of Biology may also be a contributing factor. Most teachers in the senior high schools are still using the traditional techniques of teaching.

Also some of the methods of teaching do not align themselves to the teaching of some topics hence are seldom used by teachers (Tamakloe, et al, 2005). This seems to cause students to inadequately understand the lessons they are taught hence, might cause them to memorize facts only for examinations and thereafter promptly forgetting what they have learnt. This may be due to the fact that, knowledge does not become internalized and is not transferred between topics and across subjects. Meaningful learning may not be taking place as expected. Anamuah–Mensah, et al (1995) emphasised that, "the present state of science instruction in Ghanaian schools...calls for an introduction of more innovative and effective teaching and learning techniques" (p. 67). One teaching approach that is widely used in the Western countries is concept mapping. Some research studies have revealed that concept maps have been effective for retention and comprehension of concepts, and that there have been significant differences between concept map groups and non-concept map groups (Bunting, et al, 2006; Novak & Canas, 2008; Novak & Gowin, 1984; Scagnelli, 2010; Seaman, 1990).

It appears however, that concept mapping as a method of instruction is not widely used in senior high schools in Ghana. Hence our senior high school students may not be benefiting from the advantages of concept mapping. This study therefore, was designed to explore the comparative advantage of concept mapping over that of the traditional approach to teaching some Biology topics.

Purpose of the Study

The aim of the study was to compare the effectiveness of the concept mapping method as opposed to the traditional method for teaching and learning some selected topics in Biology at the senior high school level. The study focused on whether the concept mapping technique could positively affect students' achievement in Biology and also cause them to learn meaningfully. The study also aimed at comparing how males and females in the experimental group constructed concept maps and also compared their academic outputs. Finally, it was aimed at finding the perception of students towards concept mapping.

Research Hypotheses/ Questions

The study was guided by the following null hypotheses and research questions

Null Hypotheses

1. There is no significant difference in achievement between students taught with concept map technique and those taught with the traditional method.
2. There is no significant difference in achievement in the cognitive levels between students taught with concept mapping and those taught with traditional method.
3. There is no significant difference in achievement between males and females taught with the concept mapping and those taught with traditional method.
4. There is no significant difference in achievement at the comprehension level between males and females taught with concept mapping and those taught with the traditional method.
5. There is no significant difference in achievement at the application level between males and females taught with concept mapping and those taught with the traditional method.

6. There is no significant difference in achievement at the analysis level between males and females taught with concept mapping and those taught with the traditional method.
7. There is no significant difference in achievement between males and females taught with concept mapping.
8. There is no significant difference in male and female concept map construction.
9. There is no significant relationship between students' concept map scores in Biology and their achievement in Biology.

Research Question

1. What are the perceptions of students towards concept mapping?

Significance of the Study

The outcome of this study could inform Biology teachers in the SHS about the effectiveness of the concept mapping technique, to help them improve upon their teaching skills in delivery of Biology lessons.

The results of the study indicate that concept mapping helps students to summarise, organise and logically present their work. This could help students learn how to learn meaningfully thereby improving their academic performance, not only in Biology but in other subjects as well.

Furthermore, the findings of this study could served as a basis for the organization of workshops, seminars and in-service training for Biology teachers to be trained on how to use concept mapping to supplement strategies they have been using in the classroom to bring about improvement in students achievement.

Delimitation

The study delimited itself only to elective Biology students in the New Juaben Municipality in the Eastern Region of Ghana. Since an intact class was used, Quasi-Experimental design was used for the study. Only 105 students were used for the study. The study also delimited itself to only three of the Blooms Taxonomy of Cognitive domains which are comprehension, application and analysis.

Limitations

Since the subjects of the groups, that is, the experimental and control groups were not assigned randomly, generalisation of the outcome of this study should be done with circumspection. Also since only two schools were selected out of six schools in the New Juaben Municipality for the study, there is a constraint on the scope to which the findings can be generalized to other schools outside New Juaben Municipality.

Definition of Terms

Traditional method or conventional method: In this study, this is referred to a teacher centred method of teaching. The teacher explains concepts, demonstrates, occasionally asks questions and answers students' questions.

Entry behavior**:** In this presentation entry behaviour is used to connote the perceived students' content knowledge in photosynthesis and internal respiration before the treatment. The basis used for determining this entry behavior in this study was the pretest means scores for both experimental group and control group. The mean of the pretest scores for each group was used as the index for determining the entry behaviour of the group.

Organisation of the rest of the study

Chapter one dealt with the introduction of the study. It highlighted on the background of the study, statement of the problem, purpose of the study, null hypotheses, research question, significance of the study, delimitation, limitation, definition of terms and organisation of the rest of the study.

Chapter two reviews literature relevant to the study. The literature is focused on concept maps and their uses, theoretical framework, philosophical foundation of concept mapping, epistemological foundations of concept maps, concept mapping and gender, construction of concept map, perceptions of student towards concept mapping, effect of concept mapping on students' achievement in Biology, correlation between achievement test score and concept map scores, traditional method of teaching, and summary of review of related literature.

Chapter three describes the methodology used in the study. This chapter highlighted on the research design, population, sample and sampling techniques, instruments, data collection procedures and data analysis.

Chapter four presents and describes the results in reference to the purpose of the study and previous findings as reviewed in chapter two. The discussion is presented by hypotheses and research question.

Chapter five presents the overview of the research problem and methodology, summarises the key findings, draws conclusions and offers recommendations as well as suggestions.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter deals with the review of related literature relevant to the study. It covers concept maps and their uses, theoretical framework of concept maps, philosophical foundation of concept maps, epistemological foundation of concept mapping, concept mapping and gender, construction of concept maps, perception of students towards concept mapping, effects of concept mapping on students' achievement in Biology, correlation between achievement test score and concept map scores, traditional method of teaching, and summary of review of related literature.

Concept Maps

Pedagogical tools are very important in the teaching and learning of science. They serve as paths leading to the understanding of concepts taught to students. Hence the effectiveness of that pedagogical tool used in teaching is very important. Pedagogy has become an integral part of the classroom experience. A variety of pedagogical tools are open to teachers, right from kindergarten to tertiary levels to enhance students' understanding of scientific concepts. Coll, France and Taylor (2005) pointed out that the use of analogies and mental models can enhance student understanding of complex and abstract scientific conceptions.

Concept mapping is one pedagogical tool which has gained grounds in the teaching and learning of Biology and other related science subjects in the western countries. Concept mapping has been reported to provide a very effective strategy to help students learn meaningfully by making explicit the links between scientific concepts (Adamczyk, Wilson & Williams, 1994; Fisher, Wandersee, & Moody, 2000; Novak & Gowin, 1984). It has also been reported that concept maps improves students' problem solving capabilities and aids collaborative learning (Okebukola, 1992; Sizmur & Osbourne, 1997). A concept map is a tool for showing the conceptual structure of a course discipline in a two dimensional form which is analogous to a road map. Novak and Canas (2008) explained that

> Concept maps are graphical tools used for organizing and representing knowledge. This includes concepts, usually enclosed in circles or boxes of some type, and the relationship between concepts indicated by a connecting line linking to concepts. Words on the line referred to as linking words or linking phrases specify the relationship between the two concepts (p.1).

A concept map is a way of representing relations between ideas or words, in the same way that a sentence diagram represents the grammar of a sentence, a roadmap represents the locations of highways and towns, and a circuit diagram represents the workings of an electrical appliance. In other words, it provides a visual roadmap showing the pathways that we may take to construct meanings of concepts and proposition. It is both meta–learning and meta–knowledge tool (Novak & Gowin, 1984). Concept maps are a way to develop logical thinking and study skills, by revealing connections and helping students see how individual ideas form a larger whole. A key feature of concept maps is that they are constructed to represent text structure patterns which serve to help students' mental constructs or schemata of how texts are organized. By mapping ideas into maps designed to model text structure patterns, teachers help students to visualize relationships and learn patterns (Bos & Anderson as cited in Guastello, Beasely, and Sinatra, 2000).

Features of Concept Maps

Novak and Canas (2008) identified three characteristic features of concept maps. These include:

1. Concept Maps are represented in a hierarchical fashion with the most inclusive, most general at the top of the map, and the more specific, less general concepts arranged hierarchically below. The hierarchical structure for a particular domain of knowledge also depends on the context in which that knowledge is being applied or considered.
2. There is the inclusion of crosslinks. These are relationships of links between concepts in different segments or domains of the concept maps. Cross links help us to see how a concept in one domain of knowledge represented on the map relate to a concept in another domain shown on the map. In the creation of new knowledge cross links are important in the facilitation of creative thinking: the hierarchical structure that is represented in a good map and the ability to search for and characterise new cross links.

3. The final feature is specific examples of events or objects that help clarify the meaning of a given concept. Normally these are not included in the ovals or boxes, since they are specific events or objects and do not represent concepts.

Concept maps show meaningful relationships in the form of propositions existing between concepts. Propositions are two or more concept labels linked by words which provide information on relationships or describing connections between concepts.

Uses of Concept Maps

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

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

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

Concept maps use by students. Using concept maps reinforces students understanding and learning. This enables visualization of the concepts and summarizes their relationship. Many students have difficulty identifying the important concepts in a text, lecture or other form of presentation. Part of the problem stems from a pattern of learning, that simply requires memorization of information, and no evaluation of the information is required. Such students fail to construct powerful concept and propositional frameworks, leading them to see learning as a blur of myriad facts, dates, names, equations, or procedural rules to be memorized. For these students, the subject matter of most disciplines, and especially science, mathematics, and history, is a cacophony of information to memorize, and they usually find this boring. Many feel they cannot master knowledge in the field. If concept maps are used in planning instruction and students are required to construct concept maps as they are learning, previously unsuccessful students can become successful in making sense out of science and any other discipline, acquiring a feeling of control over the subject matter (Bascones & Novak, 1985; Novak, 1991, 1998 cited in Novak & Canas, 2008). Concept map is a strong tool for organization and consolidation of students' knowledge base; and also for promotion of cooperative learning among students (Anamuah-Mensah et *al,* 1996)

Concept maps used as evaluation tool. One of the powerful uses of concept maps is not only as a learning tool but also as an evaluation tool, thus encouraging students to use meaningful-mode learning patterns (Anamuah-Mensah et al, 1996; Mintzes, Wandersee, & Novak., 2000; Novak, 1990a; Novak & Gowin, 1984). Use of concept maps can also assist teachers in evaluating the process of teaching. They can assess the students' achievement by identifying misconceptions and missing concepts. Novak and Canas (2008) view concept mapping as an effective tool for evaluating students' understanding and argue that text books could include the use of concept maps to summarise students' understanding at the end units or chapters. They emphasised that "there is nothing written on stone that says that multiple choice test must be used from grade schools to the university" (p.18). In other words, there is no hard and fact rule for the educational institutions to use only multiple choice or essay tests for evaluation. National achievement examination bodies like the West African Examination Council (WAEC) could utilize concept mapping as a powerful evaluating tool for assessing students performance; but this can be when there are great incentives for teachers to teach students how to use concept maps and if most students have been given the opportunities to use the tool.

Concept maps used for curriculum planning. Novak and Canas (2008) have suggested the enormous use of concept maps in curriculum planning. Concept maps present in a high concise manner the key concepts and principle to be taught. As a characteristic feature of concept mapping, knowledge or ideas are presented beginning from more general and more inclusive to the more specific, hence in using concept map to plan a curriculum, curriculum developers should construct 'macro maps' showing the major ideas that are planned to be presented in a whole course or in a whole curriculum, and specific 'micro maps' to indicate the knowledge for every specific parts or segments of the instructional programme. Novak (1990b) indicated that, in the early 1960s, the National Science Teachers Association (NSTA) in America funded the activities of curriculum committee to help plan science programmes for grades K-12. Even though, it received burst of interest in the proposal put forward, there had not been any significant results from NSTA's work. This Novak said has made American science lagging behind most technological advanced nations. But Novak echoed that the NSTA curriculum effort had less impact because, participants of the seminar found it difficult to describe how curriculum built around the 'major conceptual scheme' of science would differ from what was already in existence. Novak emphasised that concept mapping provides the solution to the problem as it shows how concepts are linked.

Starr and Krajcik (1990) developed the use of concept maps as a heuristic in the process of science curriculum and found out that the use of concept maps changed the view of teachers on curriculum. They emphasised that, the use of concept maps can assist both science teachers and curriculum specialist in developing a curriculum which meets the needs of both the teacher and the learner. Starr and Krajcik reiterated that developing science curriculum with concept maps makes science 'conceptually transparent to both the teacher and the student and this in the long run concurrently improve curriculum development in both process and product.

In another development Lloyd (1990) in using concept maps to plan curriculum observed that, proper elaboration of concepts are essential. She echoed that, little elaborations in text books are not likely to help students to understand concepts. Lloyd asserted that, one important psychological process that affects reading comprehension is the process of elaboration, which she says is the embellishment of ideas either by the learner or reader or by the text. The potential impact of elaboration is to first of all affect one's memory of information of readers at either encoding or retrieval stage (Anderson, 1980; Reder, 1980) and secondly to add meaningfulness of an idea by making concepts relevant or nonarbitrary (Bransford, 1979). To Anderson (1980), "elaborations reduce redundancy with which information is encoded in memory" (p. 194). To help teachers and students in this nation to have a good understanding of our science curriculum it is imperative for The Curriculum Research and Development

Division (CRDD) of the Ministry of Education (MOE) to also try the technique of concept mapping in the planning of the nations' educational curriculum.

Concept mapping for capturing and archiving expert knowledge. According to Novak and Canas (2008), one of the uses of concept maps that is growing at a fast rate is the use of concept maps to capture the 'tacit' knowledge of experts. Experts know many things that they cannot articulate well to others. Often, experts speak of a need to 'get a feeling for what you are working on'. To Novak and Canas (2008), tacit knowledge is acquired over the years of experience and derives in part from activities that involve thinking feeling and acting. Tacit knowledge from groups or individuals is captured through three major approaches which are: interviewing experts, learning by being told and learning by observation (Collins, 2001; Hoffman, Shadbolt, Buton & Klein, 1995; Klein & Hoffman, 1992; Nonaka & Krogh, 2009). In fact, these methods continue to be highly popular with many cognitive scientists, most of whom are unfamiliar with Ausubel's work and the kind of epistemological ideas on which concept mapping is based (Novak & Canas, 2008). Even though Novak and Canas found the above methods useful, it was necessary to invent a better way to represent what learners knew and how knowledge was changing over time. Novak and Canas (2008) used 'clinical interviews' to draw knowledge from a medical expert and from a book he had written on cardiology on how to interpret computer readings from computer outputs of a machine designed to assess problems with heart functions, following injection of a bolus of radioactive solution and diagnose coronary dysfunction (Ford, Coffey, Canas, Andrews, & Turner, 1996). When the expert knowledge from this cardiologist who wrote the book on this technology was concept mapped, it was evident that there were missing concepts in the map, and that tacit knowledge of the expert was not fully expressed in the books and the interviews. While it is expected that interviews, case study analyses, ‘critical incident’ analyses and similar techniques will have value in extracting and representing expert knowledge, it is likely that the end product of these studies might still be best represented in the form of concept maps. This procedure of capturing tacit knowledge could be also used to trace students’ knowledge they possess about a concept of which they could not express well by using concept mapping.

Learning and Learning Theories

Learning according to Bigge and Shermis (2004), is an enduring change in a person that is not heralded by genetic inheritance. To Mazur (1990), learning refers to changes in an individual due to experience. The enduring change or change in a learner occurs within the process of maturation, learning or both. Maturation accounts for some changes in humans but other changes are attributed to learning. Those aspects of learning which stem from maturation, little can teachers do about them.

A lot of theories are used to explain the complex phenomenon of learning. Different educational psychologists have proposed different theories based on the perspective they view learning. Out of these learning theories, instructional strategies are developed to facilitate learning. Hence these learning theories serve as a guide to design such instructional strategies. Some of the influencing learning theories include behaviourist and cognitive theories.

Behaviourists attempt to explain learning in terms of how events in the environment affect behaviour. Children are viewed by the behaviourist as passive learners, having a blank mind, that is, ‘tabula rasa’ to be filled by the teacher. The cognitivists also try to explain learning in terms of how people think. Concept mapping as an instructional strategy was developed on the basis of cognitive theory of learning.

In cognitive theory, thinking plays the central role. Cognition is a term used to describe all of the mental processes such as perception, memory, and judgement (Crowl et al, 1997). The most important mental process is thinking; and cognitvists focus most of their attention on studying how people think. There are two major approaches to the study of thinking. These are cognitive–developmental model and information processing model.

Cognitive–model development according to Crowl et al (1997) focuses on the changes that occur in how people think as they progress from infancy to adulthood. The best known cognitive developmental psychologist is Jean Piaget, who revolutionized our understanding of how children think and construct knowledge. Others include Brunner, Vygotsky, and Ausubel.

Theoretical Framework of Learning with Concept Maps

Concept mapping is based on the learning psychology of Ausubel’s Assimilation Theory of Meaningful Verbal Learning (Ausubel, Novak & Hanesian, 1978; Ausubel as cited in Novak & Canas, 2008). The underlying basis of Ausubel's theory is that meaningful learning occurs when new knowledge is consciously and purposively linked to an existing framework of prior knowledge in a non-arbitrary, substantive fashion. In other words, the basic idea in Ausubel's cognitive theory is that meaningful learning takes place by the assimilation of new concepts and propositions into existing concept and propositional frameworks held by the learner. To him, this knowledge structure as held by the learner is also referred to as the individual's cognitive structure. Ausubel (as cited in Novak & Canas, 2008) asserted that, for meaningful learning to occur the new ideas must have potential meaning and the learner must possess relevant concepts that can anchor new ideas. The learner must also consciously relate the new ideas or verbal propositions to relevant aspects of their current knowledge structure in a conscious manner. According to Ausubel (as cited in Novak & Canas, 2008), meaningful learning occurs by the process of subsumption when potentially meaningful propositions are subsumed under more inclusive ideas in existing cognitive structure. The new propositional meanings are hierarchically organized with respect to the level of abstraction, generality and inclusiveness.

Novak (1977), out of the necessity to find a better way to represent children's conceptual understanding, utilised Ausubel's cognitive theory to craft the idea of concept mapping. Novak observed that the process of meaningful learning could be improved by concept mapping. Concept maps show the interconnectedness between and among individual concepts. Novak and Gowin (1984) pointed out that concept maps rely on three fundamental qualities: hierarchical structure, progressive differentiation and integrative reconciliation.

Novak (1990a) emphasized that, during concept mapping, the learner graphically represents concepts in hierarchical arranged structure and begin to progressively differentiate among concepts. With progressive differentiation, Novak meant the learning process in which learners differentiate between concepts as they learn more about them. During integrative reconciliation, the learner views relationships between concepts and does not compartmentalize them. Illustrating integrative reconciliation requires connection among concepts, both super ordinate and subsumed, as well as between concepts which may be on different branches, yet the same level. Starr and Krajcik (1990) noted that, integrative reconciliation can be assessed by considering the quality of verbal links between concept maps.

One of the strong foundations of concept mapping is constructivism. In particular, constructivists hold the view that construction of knowledge is a personal activity in which the selection and reorganization of sensory data varies depending on the individual's prior knowledge. In other words, constructivists posit that, learners are not passive receivers of knowledge, but they actively construct their own knowledge. Constructivists also believe that, social interactions are important to knowledge construction (Buntting et al, 2006; Crowl et al, 1997; Vygotsky, 1978; Woolfolk, 2007). In the use of concept mapping, learning occurs under social setting as teacher interacts with student and the students interacting among themselves as well. The construction of knowledge during instruction is viewed basically as being driven by social interaction which ideally involves "negotiating understanding through dialogue or discourse shared by two or more members of a community of people who are pursuing shared goals" (Brophy, 2002, p. ix). In this context, Good and Brophy (2000) noted that the teacher's role is to act as a discussion leader, posing questions, seeking clarifications promoting dialogue and helping groups of students to recognize areas of consensus and continuing disagreement. Here it is viewed that the interaction helps the learners to make sense of new input by relating it to their prior experiences and by collaborating in dialogue with others to co-construct shared understanding. Vygotsky (as cited in Crowl et al, 1997) indicated that teachers, parents, siblings and peers provide the social context in which a child's higher mental functions develop. According to Vygotsky, as the teacher asks students questions, gives suggestions and hints, it helps students to reach their zones of proximal development. Also as the student engages in collaborative learning with capable peers he is able to get to his zone of proximal development. Vygotsky (as cited in Crowl et al, 1997) defined the zone of proximal development as "the distance between the actual development level as determined by independently problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with capable peers" (p. 71). The support which the teacher or capable peers give to the student through questions, suggestions and hint in order to accomplish a task, according to Vygotsky is called scaffolding. The student, who uses concept mapping as a learning technique on his own, uses it in constructing his own knowledge as he learns. In this way, the use of concept mapping employs both cognitive (individual) and social constructivists' approaches.

Various researches as already indicated reveal that concept mapping promotes meaningful learning. In order to ensure meaningful learning, one area to consider is the complex set of interrelated memory systems. The memory system comprises the short term memory, the working memory and the long term memory. These memory systems show interdependency. The most critical memory systems for incorporating knowledge into long-term memory are the short-term and working memory. Incoming information is organized and processed in the working memory by interaction with knowledge in the long term memory (Crowl et al 1997). The only limiting factor here is that working memory can process only a relatively small number of psychological units at any one moment (Miller as cited in Novak & Canas, 2008). To Novak and Canas (2008), this means that the relationship among two or three concepts are about the limit of working memory's processing capacity.

It is noted that retention of information learned by rote still takes place in the long term memory as does information learned meaningfully, the difference is that in rote learning there is no little or no integration of new knowledge with existing knowledge resulting in two negative responses. Firstly, knowledge learned by rote tends to be quickly forgotten, unless rehearsed for a longer period. Secondly, the knowledge structure or cognitive structure of the learner is not enhanced or modified to clear up faulty ideas. Thus misconceptions will persist, and knowledge learned has little or no potential for use in further learning and/or problem solving (Novak, 2002). Therefore, to structure large bodies of knowledge requires an orderly sequence of iterations between working memory and long-term memory as new knowledge is being received and processed (Anderson, 1992). Novak, (1990b), Novak and Wandersee, (1991) and Novak and Canas, (2008) believe that one of the reasons concept mapping is so powerful for the facilitation of meaningful learning is that it serves as a kind of template or scaffold to help to organize knowledge and to structure it, even though the structure must be built up piece by piece with small units of interacting concept and propositional frameworks. To Bransford, Brown and Cocking (1999) and Tsien (2007), there is still relatively little known about memory processes and how knowledge finally gets incorporated into our brain, but it seems evident from diverse sources of research that our brain works to organize knowledge in hierarchical frameworks and that learning approaches that facilitate this process significantly enhance the learning capability of all learners. Obviously, our brains store more than concepts and propositions.

Iconic learning involves the storage of images of scenes we encounter, people we meet, photos, and a host of other images. These are also referred to as iconic memories (Sperling, 1960; 1963). While the alphanumeric images Sperling used in his studies were quickly forgotten, other kinds of images are retained much longer. Our brains have a remarkable capacity for acquiring and retaining visual images of people or photos. For example, in one study Shepard (1967) presented 612 pictures of common scenes to subjects, and later asked “which of two similar pictures shown was one of the 612 seen earlier?” After the presentation the subjects were 97% correct in identifying picture they had seen. Three days later, they were still 92% correct, and three months later they were correct 58% of the time. This and many other studies have shown that humans have a remarkable ability to recall images. This buttresses the fact that since concept mapping gives a pictorial representation of ideas, students can easily capture ideas in a concept than those counterparts who may not employ concept mapping. It will therefore be prudent that various images within a conceptual framework being taught are integrated into concept maps to enhance iconic memory. This integration according to Novak and Canas (2008) would be possible in the use of concept mapping software like CmapTools.

Philosophical foundation of concept mapping

Concept mapping has its philosophical basis in rationalism. Rationalists believe that human beings are born with innate need to find meaning in the world and that what we perceive is determined as much as much by how our minds interpret the stimuli we encounter (Crowl, et al 1997). To Crowl et al, cognitive theories of learning have their bases in the philosophy of rationalism and attempt to explain how learning occurs by describing and explaining the nature of our internal mental ability. Since the technique of concept mapping has its root in cognitive theory, it is then clear that concept mapping has its philosophical foundation in rationalism.

Epistemological Foundation of Concept Mapping

Epistemology is the branch of philosophy which is concerned with the nature and scope of knowledge. It addresses the questions:

1. What is knowledge?
2. How is knowledge constructed?

3. What do people know?
4. How do we know we know?

However, Novak and Canas (2008) opined that epistemology also includes creation of new knowledge. To them, there is an important relationship between the psychologies of learning, as we understand it today, and the growing consensus among philosophers and epistemologists that new knowledge creation is a constructive process involving both our knowledge and our emotions or the drive to create new meanings and new ways to represent these meanings. Novak (as cited in Novak & Canas, 2008) argued that new knowledge creation is nothing more than a relatively high level of meaningful learning accomplished by individuals who have a well organized knowledge structure in the particular area of knowledge, and also a strong emotional commitment to persist in finding new meanings. It is intriguing to find out that meaningful learning processes have been recognized as being the same processes used by scientists, mathematicians and other expects to create new knowledge.

It has been recognized that learning with concept maps ensures meaningful learning, and as a matter of fact creating knowledge. Learners struggling to create or construct good concept maps by themselves are a way of engaging in creative process. On the contrast, engaging in creative process may be challenging or a herculean task to learners who have spent most of their lives learning by rote. This is because rote learning according to Novak and Canas (2008) contribute very little at best to our knowledge structures and therefore cannot underlie creative thinking or novel problem solving.

It is widely accepted that concepts and propositions are the building blocks of knowledge in any domain. With concept mapping, as one links concepts by means of proposition meaning and knowledge are created. There are only 26 English alphabets, but combinations of these alphabets in a variety of ways give us thousands of words with valid meanings. These words can also be put into different expressions to give various meanings. Hence poets, novelists, scientists and other experts will never run short of ideas as these words are combined to form expressions or ideas for meaning. So is concept mapping, as learners combine concepts and propositions they shall never run out of opportunity for new knowledge.

To Novak and Canas (2008), as people create and observe new or existing objects, these creative people will continue to create new consents and new knowledge. Creating new methods of observing and recording events usually open up new opportunities for new knowledge creation. In essence, continuous use of concept mapping for learning will give learners the ability and the opportunity to understand the learning process and new knowledge creation.

Concept Mapping and Gender

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

Bello and Abimbola (1997) found no significant difference in achievement in evolution between male and female students who were taught using the concept mapping method. This finding is in agreement with findings of studies conducted by Abayomi (1988) and Bello (1997). Bello and Abimbola (1997) argued that this finding was so because the items in the achievement test were free from sex related issues and that the concept mapping technique used was a novel experience to all the students who took part in the study. They therefore concluded that concept mapping as an instructional strategy could be used in mixed gender classroom situation.

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

In the same study, Boujaoude and Attieh (2008) found out that there was significant interaction between group and sex at the knowledge level. To find the sources of interaction, the means of males and females on the knowledge level was computed for both experimental and control groups. Females in the control group gained lower than their male counterparts. However, the females in the experimental group gained more than their male counterparts. Also there was significant interaction between group and sex at the comprehension level. The sources of interaction indicated that the scores of the females in the control group were lower than their male counterparts. However, the mean of the females in the experimental group was higher than that of the females in the control group. They however, did not find any significant interaction between group and sex at the application level. Boujaoude and Attieh explained that the cognitive learning styles of male and females should have favoured the males to perform better than the males. However, he explained that the females who are field-dependent learners might have paid attention and followed instructions from teacher which made them perform better than the males who are field-independent learners. Hall (2000) indicated that field independent learners have been referred to as " analytical, competitive, individualistic, task oriented, internally referent, intrinsically motivated, hypothesis testing, self structuring, linear, detail oriented and visually perceptive" (p.5). Hall further described field dependent learners as "group oriented, global sensitive to social interaction and criticism, extrinsically motivated, externally referential, not visually perceptive, non-verbal and passive learners who prefer external information structures" (p.6). Governor (1998) added that field dependent learners are in more need of social input and external help in interpreting clues embedded in a particular learning task. Hu (1998) observed that field independent learners are more analytical and rely on less external clues than their field dependent counterparts. Field independent learners appear to have the ability to generate and structure their own knowledge rather than accepting knowledge reprocessed by others. The description of the two learning styles indicates that concept mapping may be an antidote to the individual differences that exist between these two categories of learners. However, the readiness of theses learners to adopt the method easily is a way forward in improving on their learning and achievement in Biology.

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

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

Even though anxiety has been seen as a negative effect against females in science, one is of the view that in this present era, the anxiety in females towards Biology and science in general should reduce drastically. However, biases and discriminating against females continues to pose a threat to promoting women into science. Erinosho (2005) asserted that, these biases and misconception about women and science are great challenges in the field of science education as people continue to describe science as a male enterprise. In Nigeria and Africa in general, gender biasness is still prevalent (Arigbabu & Mji, 2004). This according to Onyeizugbo (2003) is due to the sex roles which are rigid in Africa and Nigeria in particular, where gender differences are emphasised. No wonder that the school which is seen as a microcosm of society consciously or unconsciously perpetuates stereotyping behaviour, with teachers exhibiting gender biasness in the classroom (Arigbabu & Mji, 2004). In Ghana, the big gap between male and female enrollment has been reduced in the basic schools through the introduction of the Free Compulsory Universal Basic Education (FCUBE) by the Ministry of Education (GES). Furthermore, in an attempt to avert the negative trend of gender biasness in science, the GES introduced the annual Science Technology and Mathematics Education (STME) Clinic programme in the JHS and SHS as an intervention to arouse the interest of girls in science, mathematics and technology (Awortwi, 1999). According to Awortwi, this intervention has increased the population of girls in science programmes in the SHS, Polytechnics and Universities.

Since most females now do science and rub shoulders with their male counterparts, it is likely that their anxiety level will reduce. But how much this anxiety has reduced to is a question to answer. It is suggested that, gender equitable instructional strategies in science, such as concept mapping should be used extensively by teachers as these could minimize the negative trend of gender on science achievement.

Construction of Concept Maps

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

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

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

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

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

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

Edmondson (2000) therefore accepted that, this is one reason which makes concept mapping a very powerful evaluating tool.

Perception of Students towards Concept Mapping

Anamuah-Mensah et al (1996) in their study in a secondary school in Ghana using concept map indicated that, students preferred concept mapping as a teaching approach to the traditional method of teaching. Also the students emphasised that concept maps are precise and comprehensive making it a good technique for learning. The students made an insightful observation that, apart from the method being precise and comprehensive, concept maps presents at a glance, the major concepts in a topic and how they relate; making the topic whole rather than a set of disintegrated concepts. The students commented that the discussions between teacher and students and among students themselves during concept mapping class promoted friendliness and cooperation among them and above all understanding of the concept. Anamual-Mensah et al (1996) reported that the discussion among the students "led to personal knowledge of the individual becoming public knowledge" (p. 15). The students accepted the fact that, concept mapping was good for revision before examination.

Bunting et al (2006) researched on first year tertiary Biology student in New Zealand using concept map approach. Three groups were used, the experimental group were exposed to concept mapping in their tutorial class; the second group did not use concept mapping for the tutorials; the third group had no tutorials. After the intervention students in the experimental group were ask to give their views on the concept map approach. The students considered concept mapping to be a helpful strategy to determine the relationships between concepts and between conceptual themes. They reported that concept mapping tutorials helped them to understand lecture content more clearly because they explicitly identified and understood which concepts were related. Many of the students also appreciated the opportunity to work on constructing their own concept maps or in small groups. The students accepted the fact that concept mapping helped them to determine areas where they had weaker understanding. Scagneli (2010) in his study on third grade science students also reported that some of the students indicated they had fun and enjoyed constructing the concept maps.

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

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

Effect of Concept Mapping On Students' Achievement in Biology

Bunting et al (2006) observed that students who attended tutorial using concept mapping achieved significantly higher marks than those who attended a convectional tutorial or no tutorial. However, test items that did not require sophisticated level of conceptual organisation, there was no significant difference between concept mapping group and non-concept mapping group.

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

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

Bos and Anders (1990) also found out that, junior high students with learning disabilities who used semantic mapping and semantic feature analysis demonstrated greater comprehension and vocabulary learning than those who received treatment with traditional approach.

Furthermore, Akpinar and Ergin (2008) taught students on animal cell using interactive computer animation instruction accompanied by teacher and student concept maps, and traditional method. They indicated that there was statistically significant difference between the concept map group and the traditional method group in favour of the concept map group. Asan (2007), in his studies among fifth grade science students in Turkey, used inspiration which is a computer base concept map to teach the experimental group and traditional method for the control group. It was found out that the experimental group achieved significantly higher than the control group.

A study conducted by Heinze-Fry and Novak (1990) indicated that there was no statistical difference in understanding between the concept mapping and non-concept mapping groups. However, they argued that, it might be due to the limited time for exposing the students to concept mapping as a learning tool. In the same way, Smith and Dwyer (1995) noticed that students in a concept mapping group were given short training session in the use of concept mapping in human circulatory system, when their understanding of the text was evaluated, there existed no significant difference between the concept mapping groups and non-concept mapping group. Also Boujaoude and Attieh (2008) indicated that there was no significant difference found between the experimental and the control groups who were taught chemistry using concept map and traditional methods.

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

Ampiah and Quartey (2003) in their study using SSS 2 elective chemistry students in a girls' school in Ghana noticed that the experimental group achieved far better than the control group in acids bases and salts after the treatments. However, there was little difference between the non-concept mapping group (control group) and the concept mapping group (experimental group) in questions that demanded recall of facts. However they observed that students in the experimental group performed better than students in the experimental group in all questions involving understanding, explanation and application. Ampiah and Quartey indicated that "students in the non-concept mapping group provided answers that were mere statements of facts and lacked the systematic explanation to arrive at correct answers in some questions that requires reflective thinking" (p.

41). Nonetheless, they identified that both groups performed abysmally in test items that required problem solving. Boujaoude and Attieh (2008) also found out that there was significant difference at the knowledge level of which the experimental group scored higher than the control group. However, they found no significant difference at the comprehension and application-and-above level. Achlevel I (below average students) and Achlevel II (above average students) of the experimental group gained more than their counterparts in the control group at the posttest in comprehension and application-and- above levels. They posited that concept mapping helped students who score below the average mark to achieve better on high cognitive level questions.

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

Bunting et al (2006) added that concept mapping is useful for tasks that require understanding of links between concepts. Novak (1990a) further argues that concept map is no 'magic bullets' or 'quick fix' for classrooms where rote learning predominates. In other words concept mapping is not a solid ground for rote learning but a sure anchor for meaningful learning. Butting *et al* indicated again that “students are likely to value strategies that encourage deep learning only if this kind of learning is rewarding” (p. 662). This, they said means that, teachers and educational authorities who wish to consider the introduction and use of concept mapping as a teaching and learning tool need to also consider the overall objectives of the course and the type of learning that students are required to do. Guastello et al (2000), working on concept mapping effect of science comprehension of low achieving inner city seventh graders in New York found out that concept mapping method improved the comprehension scores of students exposed to the concept mapping treatment. To them, concept mapping usage may assist students to build schemata for understanding a lesson’s concept. Guastello et al (2000) further asserted that students who use concept map are able to learn to translate ideas from text to visual graphic arrays that display whole relationship of content ideas (p. 357). Similarly, Bos and Anders (as cited by Guastello et al, 2000) indicated that such graphic plans or presentations serve to help students make mental constructs or schemata on how texts are organized. By mapping ideas into maps designed to model text structure patterns, teachers help students to visualize relationships and learn structures

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

Concept mapping can reduce anxiety of students, especially female students if they find it interesting and enjoyable. Hence the way concept mapping is introduced to students may motivate or not motivate them. Teachers therefore ought to be cautious about how concept maps are presented to students.

Correlation between Achievement Test Score and Concept Map Scores

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

Even though Asan (2007) recorded a high correlation between concept map scores and achievement in Biology, I am of the view that, that comparison would have been perfect if the achievement test was essay instead of multiple choice items. This is because there is the tendency of guessing with the use of multiple choice items. Also the impact of concept mapping is evident when it is used for meaningful learning where students express ideas through writing.

Traditional Method of Teaching

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

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

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

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

Merits of Traditional Method

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

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

Demerits of Traditional Method of Teaching

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

1. Generally, traditional method is not suitable for students who are low on the academic ladder. They find it difficult to listen and take notes at the same time.

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

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

Effects of Traditional Method on Achievement

Many researchers have compared the traditional method to other methods of teaching in students' achievement. They found out that students normally taught with other methods do perform better than those taught with the traditional method. For instance, Apafo (as cited by Wood, 2007) conducted a study in Cape Coast using 45 males in Senior Secondary School on the topic balancing of chemical equation. The experimental group were exposed to games' simulation approach and the control group exposed to traditional method. He reported that the experimental group achieved significantly higher than the control group. Larbi (2005) also conducted a study in the eastern region of Ghana comparing the indigenous method approach to the traditional method of teaching. He found out that students taught with indigenous method of teaching science achieved significantly higher than those taught with the traditional method. Likewise, Wood (2007) reported that students who were exposed to the constructivists approach achieved significantly higher than their counterparts exposed to traditional method. Research shows that those exposed to concept mapping achieved significantly than those exposed to traditional method (Akpinar & Ergin, 2008; Asan , 2007; Bos & Anders, 1990; Buntting et al 2005; Jegede et al 1990 and Seaman,1990).

However, a study conducted by Heinze-Fry and Novak (1990) indicated that there was no statistical difference in understanding between the concept mapping and non-concept mapping groups. Also Boujaoude and Attieh (2007) indicated that there was no significant difference found between the experimental and the control groups who were taught chemistry using concept map and traditional methods. Owusu et al (2010) in their study used 65 students to find the effect of computer assisted instruction (CAI) on students' achievement in Biology. The experimental group were exposed CAIs and control group exposed to traditional method. Cell cycle was the content which both groups were taught. They reported that, students instructed with the traditional method achieved significantly higher than those instructed with computer assisted instruction (CAI).

Summary of Review of Related Literature

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

The literature also revealed that concept maps can be used for teaching and learning in the classroom, evaluation, curriculum design and for capturing and archiving expert knowledge. There is an indication that concept mapping is used extensively in educational setting as a teaching and learning technique.

It was also noted that concept mapping was developed by Novak in Cornwall University in the 1970s and has its theoretical foundation in the cognitive theory of learning, but specifically in Ausubel's cognitive theory of meaningful verbal learning and constuctivism.

Looking at the effectiveness of concept mapping, the literature provided empirical evidence for differences in achievements in Biology favouring the concept mapping groups in most cases. Also there were no statistical differences between the achievement of males and females in Biology, indicating that it is a good technique for teaching both sexes in the classroom. Most students had positive perception towards concept mapping while accepting the fact that it boosted the organisation of their knowledge. However it was seen that concept mapping could not reduce the anxiety females have towards science (Jegede et al, 1990). Also it was indicated by students that concept map construction is time consuming.

It was confirmed that concept mapping promoted meaningful learning (as against rote learning) as those in the concept mapping group achieved higher in areas of comprehension and application than their convention teaching method counterparts (Ampiah & Quartey, 2003). This study used the concept mapping alone because is quite effective and innovative but less used in our Ghanaian schools as used extensively in the western countries.

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

CHAPTER THREE

METHODOLOGY

This chapter covers the research design, population, sample and sampling procedure, instrument, data collection procedure, description of treatment/ interventions and data analysis.

Research Design

A pretest-posttest nonequivalent quasi-experimental design was used for the study since the subjects were not to be assigned randomly to the experimental and control groups (Cohen, Manion, & Morrison, 2000; Creswell, 1994). In a typical school situation, classes cannot be disrupted or reorganised for the Researcher to conduct his study, therefore in such a case, it is better to use groups that are already organized or intact (Ary, Jacobs, & Razavieh, 2002). Even though this design suits this study, it has some weaknesses. The major weakness lies in its inferiority to randomized experiments in terms of internal validity (Trochim, 2000). Hence some extraneous factors such as age, ability, maturation and previous learning experiences were not controlled in this study. Another weakness of this design which is a threat to internal validity is the interaction between the control and the experimental groups notably when both groups are on same school premises. However, this weakness was reduced in this study since both groups were about 20km apart.

Both qualitative and quantitative data were used for the study. Scores of students' achievement test for pretest and posttest constituted the quantitative data while the interview and questionnaire on students' perception towards concept mapping constituted the qualitative data. The achievement tests which were Pretest- Posttest were administered to both the control and experimental groups. The experimental group received treatment using the concept mapping method while the control group received treatment using the traditional method. Both groups however covered the same content in photosynthesis and respiration.

In this study, the achievement of the students was the dependent variable while the teaching approaches (concept mapping and the traditional method) were the independent variables.

Population

The target population for the study was all SHS students offering elective Biology in the New Juaben Municipality. There are six public SHSs in the New Juaben Municipality. Five schools are co-educational and one is a single sex school. It was estimated that about 2000 students offer elective Biology in the New Juaben Municipality. However the accessible population was SHS 3 elective Biology students in the New Juaben Municipality whose population was about 500. The students admitted into the schools in the New Juaben Municipality are from various parts of the country, with different socio-economic backgrounds; hence the population for the study would have characteristic features of SHS students in all parts of the country.

Sample and Sampling Procedure

The sample comprised of two Senior High Schools (SHSs) in the New Juaben Metropolis. Out of the six SHSs, five are co-educational. Two schools were randomly sampled from the five co-educational schools using computer generated numbers from Microsoft excel programme. This ensured that each of the members of the population had equal and independent chance of being selected (Sarantakos, 2005). The school selected first was assigned as the experimental group (named school A for anonymity) and the school selected second was assigned the control group (named school B for anonymity). SHS 3 students were also selected purposively for the study, because the concept of respiration and photosynthesis which are some of the difficult concepts for students, comprehension are treated in SHS 3 as the elective Biology syllabus demands. In the case where the sampled schools had more than one science class offering elective Biology, one was selected by simple random sampling. Convenience sampling was used in selecting the students in the control and experimental groups, since all the students in each class were used for the study (Creswell, 1994). The experimental group was made of 51 students while the students in the control group were 54 in number. Therefore, the sample size for the study was 105 SHS 3 elective Biology students. The two schools selected were about 20km apart and almost all the students were boarders; this reduced the interaction between the control and experimental groups.

Instruments

Three instruments were used for the data collection in this study. A Biology achievement test (BAT), questionnaire on students' perception towards concept mapping (QSPTCM) and a semi-structured interview.

Biology Achievement Tests (BAT)

The Biology achievement test was categorized into BAT1 and BAT2 (APPENDIX A). BAT1 which comprised four essay test items was used as the pretest and posttest for both the control and experimental groups. Each question had three sub-questions. Sub-question 'a' consists of comprehension questions, sub-question 'b' consist of application questions while sub-question 'c' consist of analysis questions. BAT1 has total score of 80. However, all the comprehension question items had total score of 27, application has total score of 27 and analysis 26. The pretest was used to ascertain the amount of knowledge the students have on photosynthesis and respiration and to determine the homogeneity or the heterogeneity of the control and experimental groups. Students have had lessons on photosynthesis and respiration in their second year in integrated science. The posttest was administered after the treatment has been given. The achievement of the posttest was compared between the experimental and the control groups. The BAT2 was administered to only the experimental group to ascertain from the students how they answered essay questions and how they constructed concept map. BAT2A comprised an essay question; and with BAT2B, students were to construct a concept map on that same question. The total score of BAT2A was 25 while the total score for BAT2B was 78. The scores of the concept map and the essay were correlated.

The test items were developed based on the SHS Biology syllabus and textbooks, and some modified past questions of the West African Examinations Council (WAEC). To ensure content and face validity of the instrument, the test items were subjected to expert judgment by renowned science education lecturers in the Department of Science and Mathematics Education, and their corrections and suggestions were used to improve upon the instruments.

Scoring rubrics (see APPENDIX E) were developed for both BAT1 and BAT2 to facilitate in the scoring. For BAT1 each correct answer or response was assigned 1 mark and a wrong response was assigned zero mark. The total mark for the BAT1 was 80. BAT2A had a maximum score of 25 marks and BAT2B had a maximum sore of 78. For BAT2B, four areas were looked at; the hierarchies, the concepts, the propositions and crosslinks.

To ensure internal consistencies of the achievement tests, the assistance of three raters were sought, one for BAT1 pretest, one for BAT1 posttest and another for BAT2. The raters for BAT1 have about 6- 8 years of teaching experience as Biology tutors and are also assistant examiners of the West African Examination Council. The raters for BAT1 and I discussed the scheme and agreed on the marks awarded. Eight Photocopies of the students' script were marked and the scores compared and the differences analysed before the live scripts were given out. Eight days were spent in marking the scripts.

The second rater was recruited specifically for scoring the students constructed concept maps. The second rater being a graduate student of the University of Cape Coast at the Department of Science and Mathematics Education had taken a semester course on concept mapping, hence was given a limited training in scoring concept maps. The scoring rubric was adapted from Novak & Gowin (1984) and Cronin, Dekker & Dunn (1982). Five marks was allocated for each correct hierarchy and zero for an incorrect hierarchy, one mark was allocated for each correct concept and zero for an incorrect concept; one mark was also allocated for each correct proposition and zero mark for an incorrect proposition.

Questionnaire on Perception of Students towards Concept Mapping (QSPTCM)

The questionnaire (see APPENDIX B) was developed to find out the perceptions of students in the experimental group towards concept mapping. Since concept mapping was a novel method introduced to the students, it was important to find out from students who were exposed to this treatment their perceptions towards this new method.

The QSPTCM consisted of two sections; the first was to get background information about the students while a second section consisted of 24 items bases on the Likert scale with ‘strongly agree’, ‘agree’, ‘undecided’, ‘disagree’ and ‘strongly disagree’. Scores of 1,2,3,4, and 5 were assigned, respectively. For each item, students were requested to indicate their responses by ticking the appropriate column. Likert-type scale appears easy to construct, produces more homogeneous scales, permits spread of variance and allows subjects to indicate their degree of feeling or opinion; this makes it one of the most popular method of perception and attitudinal scales construction (Lehmann & Mehrens, 1991). Cronbach Coefficient Alpha was deemed suitable for measuring the reliability of QSPTCM because it is used when measures have multiple-scored items such as perception and attitudinal scales (Payne & Payne, 2005).

Structured Interview

A structured interview (see APPENDIX C) was further used to find out students opinions on the concept mapping approach. Four areas were covered, interest in concept mapping, performance in class, class participation and construction of concept maps. Only ten students were randomly selected for the interview.

Validity and Reliability

The content validity of the instruments was determined by subjecting them to expert judgment (Lomask, Jacobson & Hafner, 1995). By this, the instruments (BAT, QSPTCM and semi-structured interview outline) were subjected to inspection by experts including two supervisors, some science education lecturers, Master of philosophy and Doctor of philosophy (science education) students, two SHS Biology teachers who have had 5-8 years of teaching experience for their judgments on the content and the level of language. To ensure validity of the interview, the transcribed responses were read back to the students interviewed to ascertain from them whether the responses were exactly what they said. The reliability of the QSPTCM was 0.90, while the interrater reliability of BAT1 pretest was 0.99 and posttest was 0.99. interrater reliability for BAT2A and BAT2B were 0.99 and 0.99 respectively.

Pilot Testing

A pilot test was conducted in two schools in the Central Region in order to check for the appropriateness of the data collection instrument. Each of the schools took a pretest and also a posttest after two weeks of treatment. The students which received instruction through concept mapping approach were given questionnaire to respond on their perceptions towards concept mapping after they have taken the posttest. The interrater reliability of the BAT1 pretest was 0.98 and 0.99 for the posttest. BAT2A and BAT2B had interrater reliabilities 0.98 and 0.99 respectively. Cronbach Alpha coefficient of reliability for QSPTCM was 0.90.

Data Collection Procedure

Letters of introduction from the Department of Science and Mathematics Education (DSME) of the Faculty of Education were sent to the headmasters of schools where the research took place. I met the headmasters of the respective schools who after explaining the rationale of the study to them introduced me to the respective heads of science departments. I was then introduced to the teachers handling SHS 3 Biology by the heads of the science departments. This was followed by interactions with the SHS 3 Biology teachers to know from them the methods they most often used for teaching the students in their respective classes. It was revealed that the method mostly adopted by these teachers for teaching was the traditional method of teaching where the lesson is introduced followed by expository explanation. Students also had to write copious notes given by the teacher. After going through the note books of the students it was realized that they all had the same notes indicating they had their notes from their teachers. I took time to observe the teachers teach, but this was done with their consent; this helped to know how to exactly teach the control group. I also took time to familiarize with the students as well. The rapport which was created between the teachers and the students created a congenial atmosphere throughout the period of data collection. During the familiarization, the experimental group was introduced to concept mapping. The topic on cell was used to teach student the stages of concept mapping. Cell was not part of the topics to be treated in the main study. This topic was chosen because it was treated in the first year of SHS 1 and this served as revision for them. Students were given photocopy of a Researcher - made concept map of the cell (Appendix F). The explanation was mainly centred on linkages between concepts (propositions) and the hierarchical arrangement of concepts on the concept map. The Researcher gave students various exercises to make them conversant with concept mapping.

The control group were also were taught the same topic. Students were briefed on how they could receive much from lesson taught using the expository method. They were told to pay attention to the voice variation of the teacher and certain phrases like, ‘the most important’ ‘the two main stages are’.

At the end of the five days of familiarization, a pretest on the Biology achievement test (BAT 1) was administered to both the control and experimental groups. The test comprised items on the topics photosynthesis and internal respiration. The pretest was to ascertain the homogeneity of the experimental and control groups, and also to know the level of knowledge each group has on photosynthesis and respiration before the intervention is given. Time allocation for the pretest was two hours. Students were encouraged to do independent work. The class teachers helped in the sitting arrangement and the supervision of students. Another rater who is also a Biology teacher and I marked the pretest.

After the pretest, the treatment followed. Students in both the control and the experimental groups were taught for two weeks. I, being a qualified Biology teacher taught both groups. Researcher bias, which is often associated with this type of design, was thought to be a risk worth taking. The treatment covered four days for each group during which each class met for 80 minutes for each day. The experimental group had Biology on Monday 10:30 – 11:50 and on Wednesday 11:50 – 1:10 while the control group had Biology on Tuesday 7:40 – 9:00 and on Thursday 1:10 – 2:30. The flexibility of the time Table made it possible for commuting between both schools by the researcher easier. I went to the experimental school first followed by the control group the following day. I alternated between both schools based on the time Table. Hence I visited each school two times in a week for four weeks. The first week was for familiarization, the other two weeks was for teaching the topics and the last week was for administration of the achievement posttests, questionnaire and the interview. Both the control and the experimental group were taught the same content, had the same instructional objectives, same lesson duration and class assignment. Both groups were taught on the units of photosynthesis and internal respiration. Topics under photosynthesis treated include factors affecting rate of photosynthesis, leaf adaptations to photosynthesis, light and dark reaction stages of photosynthesis and fate of photosynthesis. Under internal respiration, some of the topics treated were aerobic and anaerobic respiration.

Description of Treatments/Interventions

The treatment started with the experimental group who were taught using the concept map approach. This approach is based on the constructivist view of learning where learners take active role in learning to ensure meaningful learning. Before the start of the lesson, students were put into groups each comprising four members. Each group selected its own leaders comprising the group leader and the secretary. The groups facilitated collaborative learning and allowed students to agree on consensus concerning the tasks assigned. Three stages were involved in the delivery of the lessons using the concept mapping approach:

1. The introductory stage. At this stage students' previous concept maps are reviewed. During the review, the hierarchical arrangement of concepts and propositions are discussed whether they are valid or not
2. The presentation stage. At this stage the major and sub concepts of the topic were written on the board. This was followed by explanation of the concepts and concept map illustrations of the ideas. During this period the students were engaged in a discourse or discussion involving questioning and answering of questions and expression of opinions. This helped student to have pictorial presentation of ideas to boost their understanding of the topics that were taught. Concepts were explained to students using concept maps,

3. The practice/application stage. At this stage students were asked to construct their own concept maps in groups or individually using pencils or pens. The students were provided with sheets of paper to construct the concept map. The secretaries in each group constructed the maps as they were fed with information from peers in the group while the chair moderates the activities in the group. As this went on, I went round to provide help to students or groups who may have some difficulties. Students were also given assignments or homework to do either individually of in groups.

On the first day, the topic treated was photosynthesis. The students’ ideas on concept map were refreshed before the lesson continued. Sub headings considered under this topic were explanation of photosynthesis, adaptations of the leaf to photosynthesis, and factors affecting rate of photosynthesis. The lesson ended with concept mapping exercise. Students were put into their groups and giving a focus question with list of concepts, and sheets of paper to construct concept maps. Groups submitted their maps for scoring after the exercise.

On the second day, the sub heading under photosynthesis considered were the light reaction stage, dark reaction stage and fate of photosynthesis. The students’ previous knowledge was reviewed before treating the topics of the day. Students were made to construct concept maps individually and in groups and submitted at the end of the exercise.

On the third and fourth day the concept of respiration was treated and followed the same pattern as the second day. The sub headings treated on the third day were explanation of respiration and aerobic respiration and for the fourth day were hydrogen carrier system, anaerobic respiration and use of energy from respiration. Students were made to construct concept map individually or in groups on these days.

The control group was taught on Tuesdays and Thursdays. The control group was taught the same content and in the same sequence as the experimental group. However, they were taught using the traditional method. The traditional method involves teaching topics in a regular Biology class where teaching and learning activities are mainly teacher-centred. The researcher prepared his notes and did most of the talking during the teaching process. Students occasionally asked questions and the researcher answered their question. The researcher explained concepts to students followed by writing main ideas on the board for students to copy. Each lesson ended with summary. After each lesson was taught, students were given assignments.

After the interventions to both the experimental and the control groups, they were given the same Biology achievement test administered in the pretest, as the posttest the following week. The experimental group did BAT1 on Monday and BAT2 on Wednesday. The BAT2 was to compare the males and females in their concept map construction and also to correlate the concept map scores to their essay scores. After the BAT2, the experimental group was given the questionnaires to respond to. They were given 30 minutes to answer but most of them finished between 15 to 30 minutes. After the administration of the questionnaire 10 of the students comprising six males and four females in the experimental group were randomly selected for the interview. The questionnaire and the interview were to find out students perception towards concept mapping. The control group did only BAT1 and this was administered to them on Thursday. The Biology teachers in both schools helped in the arrangement and the supervision of the tests. Two hours was required to be used for the BAT1 and on hour for BAT2. After the test, the scripts were collected for scoring. See appendix G for the lesson notes used for instructing both the control and experimental groups.

Data Analysis

The data received were entered separately into SPSS 16.0 for data output. The scores from pretest and posttest in BAT 1 and scores of students in BAT 2 were subjected to descriptive and inferential statistics. Descriptive statistics used include mean and standard deviation frequencies and percentages. Furthermore, histograms and box plots were drawn and normality tested using Kolmogorov-smirnov test statistics. The normality of the pretest of Kolmogorov-Smirnov value of 0.035 at $p = 0.05$ showed that the data were not normally distributed. The normality of Kolmogorov-Smirnov value of 0.200 for posttest (BAT1) and 0.200 for BAT2A at $p=0.05$ showed that the data were normally distributed. Depending on the result of the normality test, the statistical tools, Mann Whitney U, t – test, multivariate analysis of variance (MANOVA), two-way ANOVA which allow for the testing of the statistical significance at 0.5 alpha level were employed for the analysis of data. When the P values from the results of these statistical tools are above 0.5, then there is no significant difference, but if the P values are less than 0.5, then there is significant difference.

Mann Whitney U was used to compare the pretest mean scores in achievement for the experimental and control groups to ascertain the entry behavior of the students. Also independent sample t-test was used to compare the posttest mean scores in BAT1 between the experimental and control groups in order to test hypothesis 1. Hypothesis 2 was tested using (MANOVA) to find out whether significant difference existed between the experimental and control groups at the three cognitive levels (comprehension, application, and analysis). MANOVA was used because three dependent variables (comprehension, application, and analysis) and one independent variable which is group (experimental and control groups) were involved. The group on which the teaching methods were used on is the independent variable because it has effect on the dependent variables. Hypotheses 3, 4, 5, and 6 were tested using two-way analysis of variance. Two independent variables which are gender (male and female) and group (experimental and control groups) against one dependent variable which is achievement. Hypothesis 7 and 8 were also tested using independent sample t-test. Research question 9 was answered using Pearson's Product Moment Correlation to find the relationship which existed between BAT2A and BAT2B at 0.01 alpha level.

Thematic content analysis was used to analyse student responses to the questionnaire and the structured interview to answer research question 8. By this, the major area of the questionnaires and the interview were put into themes to determine the perception of students about the concept map approach to teaching and learning.

CHAPTER FOUR

RESULTS AND DISCUSSION

In this chapter the results from the study is analysed and discussed in relation to nine stated hypotheses and one research question.

Difference in Achievement between Students Taught With Concept Mapping and Those Taught With the Traditional Method

Preliminary analysis was done by comparing groups' scores from the pretest (see APPENDIX H) using Mann Whitney U test. Mann Whitney U test was used because the normality test had a Kolmogorov-Smirnov value of 0.035, which indicates the data, is not normally distributed. Comparison of pretest scores between the experimental and control group is presented in Table 1

Table1: Pretest Results of Experimental and Control Groups in BAT 1

Group	N	Mean Rank	z	P
Experimental	51	53.14	-.045	.964*
Control	54	52.87		

*Not significant at P > .05 maximum score = 80

When the P value is less than 0.05 it means the test is significant, but when the P value is greater than 0.05 then the test is significant. Results from Table 1 shows that there was no statistically significant difference between performance of students in the experimental group and control group (Mann Whitney U z = 0.045, p = 0.964) in the BAT1 before instruction. The mean ranks which are the averages of the ranks of the scores of both groups respectively also showed that both the experimental and the control groups performed almost at the same level. This indicates that students in both groups had similar knowledge about photosynthesis and internal respiration which were the Biology content examined in this study before the interventions were given.

Also paired sample t-test was conducted to see the effect of the intervention on each group and this has been presented in Table 2.

Table 2: Results of Dependent Sample T-Test for Pretest and Posttest Scores

Group	Variable	N	Mean	SD	t	p
Experimental	Pretest	51	12.53	5.697	17.364	.001*
	Posttest	51	35.25	12.959		
Control	Pretest	54	12.57	6.762	17.053	.001*
	Posttest	54	25.80	10.113		

* Not significant at P > .05

When the P value is less than 0.05 it means the test is significant, but when the P value is greater than 0.05 then the test is not significant. Table 2 shows a statistically significant difference between the two groups' pretest and posttest scores. The experimental group's mean for posttest (M= 35.25, SD=

12.959) was significantly higher than its mean scores for pretest (M = 12.53, SD = 5.679; t(50) = -17.364, p = 0.001). The magnitude of the difference in mean was very large with a standard effect size index of 2.43. According to Green, Salkind and Akey (1997), an effect size of 0.20 is small, 0.50 is moderate and 0.80 is large. Also the control group's mean from posttest (M= 25.80, SD= 9.360) was significantly higher than its pretest (M =12.57, SD = 6.762; t(53) = -17.053, p =0.001). The effect size of 2.30 was also very large. Results in Table 2 clearly show that both the concept mapping and traditional approaches to teaching had significant effect on students' achievement in photosynthesis and internal respiration. The difference in the mean scores for the pretest and posttest of the experimental group is 22.72, and that for the control group is 13.57. The large difference in mean scores for the experimental group indicates that when concept mapping is used as an instructional strategy in teaching photosynthesis and internal respiration students easily grasp the concepts. The corresponding increase in the mean score of the control group also showed that they also understood the concept of photosynthesis and internal respiration.

The researcher taught both groups. However the control group received instruction after the experimental group. As expected of every teacher to improve upon subsequent deliveries, the difficulties experienced in the experimental group were corrected before the instructions in the control group. This factor could have accounted for the significant improvement in the mean scores of the control group.

To investigate the difference in posttest BAT 1 scores between the experimental and the control groups, the mean scores were compared using independent sample t-test. Independent sample t-test was deemed appropriate because the data showed normal distribution with Kolmogorov-Smirnov value of 0.200. Results of independent sample t-test for the posttest for both the experimental and the control groups are presented in Table 3.

Table 3: Results of BAT1 Posttest of Experimental in Control Groups

Group	N	Mean	SD	t	P
Experimental	51	35.25	13.05	4.193	.001*
Control	54	25.80			

*Not significant at P > .05 maximum score = 80

As shown in Table 3, there was statistically significant difference between the mean scores of experimental (M = 35.25, SD = 13.053) and control (M =25.80, SD =9.953; t(103) = 4.193, P= 0.001). Therefore the null hypothesis is rejected. Table 3 indicates that students exposed to concept mapping performed better than their counterparts exposed to the normal traditional method of teaching with a difference in mean score of 9.45. The concept mapping group achieved significantly higher than the traditional method group. An effect size of 0.82 is large. According to Green, Salkind and Akey (1997) effect size of .20 is very small, .50 is moderate and .80 is large. Bunting et al (2005) observed that students who attended tutorial using concept mapping as an instructional strategy achieved significantly higher than those who attended a convectional class or no tutorials. In similar works by Asan (2007) and Akpinar & Ergin (2008), students taught with concept map had significantly achieved higher than their counterparts taught with the traditional method.

These works give clear evidence attesting to the ability of concept mapping in promoting students' achievement in Biology. The links and interrelationships among the concepts as depicted in the concept mapping might have made the students in the concept mapping group learn more meaningfully. According to Ausubel (as cited in Novak & Canas, 2008), meaningful learning is promoted by the understanding of the hierarchical relationships and linkages between concepts.

Guastello et al (2000) asserted that students who use concept map are able to learn to translate ideas from text to visual graphic arrays that display whole relationship of content ideas. Similarly, Bos and Anders (as cited in Guastello et al, 2000) indicated that such graphic plans or presentations serve to help students make mental constructs or schemata on how texts are organized. By mapping ideas into maps designed to model text structure patterns, teachers help students to visualize relationships and learn structures.

The significant difference in achievement between the experimental and the control groups shows the capabilities that lie in the concept mapping as a method to improve teaching and learning in Biology classrooms. The students in the experimental group were able to see links among concepts and this boosted their comprehension on topics which they were taught. Also the social constructivist approach used in concept mapping is an added advantage of providing an incentive which influenced students understanding. Students' ideas were fully involved in the construction of concept maps to encourage them and also help them to see links. The lists of concepts were generated by the teacher in conjunction with students input. Students were put into groups of four to construct concept maps. As they constructed, they shared ideas, and the best ones were taken for the construction of their maps; as indicated by Anamuah-Mensah et al (1996) this ideas became a public knowledge. Students were also made to construct concept maps individually. As they make links between one concept and another they created their own knowledge. Also students recording their ideas in a concept map meant they had visual representation of the concept being discussed, and the linking term made the relationship between concepts explicit (Bunting et al, 2005).While students were constructing maps (either individually or in groups) I moved around the class and used the time to discuss and make input to their maps. The concept maps were marked and returned to students on time which gave students constant feedbacks. This attention and formative feedback might have served as a motivation for them and made them focus on relevant portions of content taught.

In contrast, these were lacking in the control group who were taught the normal way of teaching using traditional method. However, the manner in which the traditional method was used for instructions made students to perform well. For instance, voice was audible enough; there was good voice variation to give clues to students. Students were made to take clues from, some phrases such as ‘there are two main types of…’ ‘the following are’ ‘the main stages are’ ‘the differences are’ and ‘in conclusion’. Also language was at the level of students, the pace of the lessons was such that students could cope, and students’ attention was sustained throughout the lessons. Students were also taught how to answer question involving the various cognitive levels. Also because the control group was in most cases instructed after the experimental group, there would be improvement in teaching the same content. These might have helped them to improve in the BAT1.

As concept map give students, visual representation of concepts, they could retain information without easily forgetting. Sperling (1960; 1963) referred to these as iconic memories. Shepard (1967) indicated that higher percentage of students who were instructed using graphical and pictorial presentation were able to remember facts presented to them at a later time than those who were not.

Students in the concept mapping group might have learnt meaningfully because of the hierarchical, logical and sequential presentation of concept. Ausubel (as cited in Novak & Canas, 2008) asserted that, for meaningful learning to occur the new ideas must have potential meaning and the learner must possess relevant concepts that can anchor new ideas. The learner must also consciously relate the new ideas or verbal propositions to relevant aspects of their current knowledge structure in a conscious manner. According to Ausubel, meaningful learning occurs by the process of subsumption when potentially meaningful propositions are subsumed under more inclusive ideas in existing cognitive structure. The new propositional meanings are hierarchically organised with respect to the level of abstraction, generality and inclusiveness.

Novak and Gowin (1984) pointed out that concept maps rely on three fundamental qualities: hierarchical structure, progressive differentiation and integrative reconciliation. Novak (1990a) emphasized that, during concept mapping, the learner graphically represents concepts in hierarchical arranged structure and begin to progressively differentiate among concepts. With progressive differentiation, Novak meant the learning process in which learners differentiate between concepts as they learn more about them. During integrative reconciliation, the learner views relationships between concepts and does not compartmentalize them. Illustrating integrative reconciliation requires connection among concepts, both super ordinate and subsumed, as well as between concepts which may be on different branches, yet the same level. Starr and Krajcik (1990) noted that, integrative reconciliation can be assessed by considering the quality of verbal links between concept maps. Boujaoude and Attieh (2008) asserted that concept mapping presented to students a novel experience making them active in the process of identifying links between concepts. Novak, (1990b), Novak & Wandersee (1991) and Novak & Canas (2008) believe that one of the reasons concept mapping is so powerful for the facilitation of meaningful learning is that it serves as a kind of template or scaffold to help to organise knowledge and to structure it, even though the structure must be built up piece by piece with small units of interacting concept and propositional frameworks. These capabilities in concept mapping could be the reasons behind the higher achievements in the experimental group.

Group Difference in BAT 1 at the Three Cognitive Levels

Each test item had three sub-items, ‘a’ for comprehension test items, ‘b’ for application test items and ‘c’ for analysis test items. These sub-items were also in order of difficulty. Comprehension items had total score of 27, that of application was 27 and that of application was 26. To investigate group difference in the cognitive levels (comprehension, application and analysis) of BAT1, one-way between groups multivariate analysis of variance (MANOVA) was used. The dependent variables are comprehension, application and analysis while the independent variable is group at two levels (experimental and control groups). The experimental group was taught with the concept map method and the control group, the traditional method. Preliminary assumption test was conducted for normality, linearity univariate and multivariate outliers, homogeneity of variance covariate matrices and multicolinearity with no serious violations noted. It was found out that there were no multivariate outliers while there were two univriate outliers for analysis but this did not pose any serious violation. Homogeneity of variance covariate matrices had a value of 0.015 at $p = 0.001$, while for multicolinearity, there was moderate correlation between the dependent variable which are comprehension, application, and analysis. A mahalanobis distance of 12.24 which was less than chi square critical value of 16.27 at $p = 0.001$ shows that there were no multivariate outliers. Table 4 shows the multivariate test result the control and experimental groups.

Table 4: Multivariate Test Results for Group

	Group		
Effect	F	sig.	Partial eta sq.
Wilks' Lambda	6.798	0.001*	0.168

*Not significant at p > .05

Sig. (significant) is the same as P. When the P or sig. value is less than 0.05 it means the test is significant, but when the P or sig. value is greater than 0.05 then the test is significant.Table 4 shows there was significant difference between the experimental and control groups on combined dependent variables [F(3, 103) = 6.798, p = 0.001, Wilks' Lambda = 0.822, partial eta = 0.168]. Hence the null hypothesis is rejected.

Table 5 shows the results of the dependent variables when considered separately for the group.

Table 5: Test of Between Subject Effect

Variable	F	Sig.	Partial eta square
Comprehension	13.330	.001*	.141
Application	9.287	.003*	.132
Analysis	19.843	.001*	.200

*Not significant at p > .017

Table 5 shows that using Bonferroni's adjusted alpha level of 0.017, there was statistically significant difference between the experimental and control groups for comprehension [F(1,103) = 13. 330, p = 0.001, partial eta square = 0.14], application [F(1,105) = 9.287, p = 0.003, partial eta square = 0.132] and analysis [F(1, 103) = 19.843, p = 0.001, partial eta square =0.200.]

Table 6 shows the means and standard deviation of the control groups in each cognitive level.

Table 6: Mean and Standard Deviation Scores of Experimental and Control Groups at the Various Cognitive Levels

Variable	Group	N	Mean	SD
Comprehension	Experimental	51	14.75	5.422
	Control	54	10.98	5.141
Application	Experimental	51	11.14	5.292
	Control	54	8.44	3.658
Analysis	Experimental	51	9.33	4.053
	Control	54	6.33	2.761

Maximum score for Comprehension = 27 maximum score for application = 27 maximum score for analysis = 26

An inspection of the mean scores in Table 6 indicates that experimental group recorded high score in comprehension (M = 14.75, SD = 5.422) than the control group (M = 10.98, SD = 5.141). Also the experimental group recorded higher scores in application (M = 11.14, SD = 5.292) than the control group (M = 8.44, SD = 3.658). The experimental group again recorded high scores in analysis (M =9.33, SD = 4.053) than the control group (M = 6.33, SD = 2.761)

From Table 4, there is a clear statistically significant difference between the experimental and control group on combined dependent variables. A partial eta square of 0.168 shows a very large effect size. According to Cohen (1988) an eta square of 0.01 is small, 0.06 is moderate and 0.14 is very large. Also, when the dependent variables were considered separately, it was found that significant differences existed between the experimental and control groups in comprehension, application and analysis. This indicates that concept mapping assisted students to learn meaningfully and to achieve higher in the experimental group than the control group in the three cognitive domains.

Boujaoude and Attieh (2008) also found out that there was significant difference at the knowledge level of which the experimental group scored higher than the control group. However, they found no significant difference at the comprehension and application-and-above level. Achlevel I (below average students) and Achlevel II (above average students) of the experimental group gained more than their counterparts in the control group at the posttest in comprehension and application-and- above levels. They posited that concept mapping helped students who score below the average mark to achieve better on high cognitive level questions.

Further analysis was done on students' performance at the cognitive levels by examining how each group answered the questions. At the comprehension levels students were expected to explain processes or events base on how they understood the Biology content. Students used facts and supported them with their views showing that they all learnt meaningfully. Both groups performed very well at the comprehension level; however the experimental group attained higher marks than the control group.

At the application level, students were to apply knowledge obtained in the Biology content to real life situation. Most students in the control group wrote answers which were merely statement of facts from their notes which had no bearing on what was required of them. But majority of students in the concept mapping group were able to apply the Biology content learnt to real life situation hence performed better than students in the traditional approach group.

At the analysis level, students were required to break ideas into their component units with the view of making the relationship between the parts clearer. Even though the experimental group achieved significantly higher than control group, it can be said that both groups performed not quite well at the analysis level. It is important to motivate students to learn meaningfully to help them to improve upon their achievements at such higher order levels of the cognitive domain. Students should be guided on how to answer questions on analysis level and other higher cognitive levels. Since concept mapping shows the linkages and hierarchies between concepts, students who use them are likely to see components units between concepts, do proper organisation and systematic arrangements to answer questions relating to analysis well. Ampiah and Quartey (2003) compared the experimental and control groups in knowledge, understanding, explanation, application and problem solving and found out that both groups performed almost the same at the knowledge level. But found out that the concept mapping group performed better at the comprehension level than the expository group which is consistent to this study's finding. The experimental group also performed better than the control group at the application level, which is also consistent to this study. However, they found out that both groups performed poorly on questions which required problem solving. In this current study, the efficacy of concept map over the traditional method was clear. Students who learn meaningfully were able to answer high order cognitive domain questions better.

Gender Difference in Achievement between Experimental and Control Groups

The third hypothesis sought to test whether there was any statistically significance between males and female taught with concept mapping and the traditional method. A two-way analysis of variance was conducted to explore the gender difference in achievement in the experimental and control groups in the posttest of BAT 1. A two–way ANOVA was used because two independent variable that is, sex and group were involved against one dependent variable which is achievement. A test of normality indicated Kolmogorov-Smirnov value of 0.200 at $p = 0.05$ showing normal distribution of the data. Result showing main effect and group interactions is presented in Table 7. Table 7 indicates that there is significant difference in effect in gender and group interaction [F (2,105) =10.034, $p = 0.002$, partial eta square =0.120. Also there is statistically main effect for sex [F (1,105) =5.938, P = 0.017, partial eta square = 0.086.] and group [F (1,105) = 14.713, p = 0.001, partial eta square = 0.147]. Hence the null hypothesis is rejected.

Table 7: Test of Between Subjects Effect

Source	F	Sig.	Partial eta square
Sex	5.938	.017*	.086
Group	14.713	.001*	.147
Sex * Group	10.034	.002*	.120

*Not significant at p> .05

Table 7 shows that the effect size for sex and group interaction was large. There was significant difference for sex, and this means males and females differ significantly in terms of their achievements in the posttest. Also the significant difference in group means that the experimental and control groups differ in term of their achievement in the posttest

To find the source of interaction, the means of the two groups were further calculated and this is indicated in Table 8. Results fromTable 8 shows the mean scores for male experimental (M= 40.03, SD =11.496) and control (M = 24.68, SD = 10.414); and female experimental (M =27.75, SD = 11.693) and control (M =26.29, SD = 9.934).

Table 8: Results of Means and Standard Deviations for Gender in Both Experimental and Control Groups

Gender	Group	N	Mean	SD
Male	Experimental	31	40.03	11.496
	Control	19	24.68	10.414
Female	Experimental	20	27.75	11.693
	Control	35	26.29	9.934

Maximum score = 80

From Table 8, it is observed that males in the experimental group performed better than their counterparts in the control group by mean difference of 15.35. While females in experimental group achieved slightly higher than their counterparts in the control group by mean difference of 1.46. The males in the control group had lower mean scores than their female counterparts in both the control and experimental groups. Table 6 shows significant effect of sex on achievement, and this significant effect could come from males and female in the experimental and control groups. The combined effect of male achievement exceeds that of combined effect of female achievement. This shows that males performed better than the females in BAT1 posttest. I think this is not a good sign in an era where females are being encouraged to pursue science. More has to be done to motivate females to be at par with their male counterparts (Awortwi, 1999; Erinosho, 2005). Dwyer (1998) recommended removal of hierarchical barriers in terms of classroom organization or forms of threat that have the potential of invalidating females learning efficacy, independent of course content.

In a similar study Boujaoude and Attieh (2008), found out that there was significant interaction between group and sex. They indicated that females in the control group had mean scores lower than their male counterpart. However, the females in the experimental group had higher mean scores than their male counterparts. Also, they found out that there was no significant difference between the males in both groups.

Performance of Males and Females at the Comprehension Level in Both Experimental and Control Groups

To test hypothesis four, a two-way analysis of variance was conducted to explore the gender difference at the comprehension level in the experimental and control groups. The dependent variable is achievement at the comprehension level while the independent variables are sex (male and female) and group (experimental and control). The result of test of between groups for comprehension is shown in Table 9.

Table 9 shows that there was significant effect in gender and group interaction [$F(2,105) = 7.181$, $p = 0.009$, partial eta square = 0.106]. There was also statistical main effect for sex [$F(2,105) = 4.625$, $p = 0.034$, partial eta square = 0.084], and group [$F(2, 105) = 10.543$, $p = 0.002$, partial eta square = 0.115]. Hence the null hypothesis was rejected. This means that differences lie in the achievement of males and females combined in the experimental and male and females combined in the control group at comprehension level. The effect size was large.

Table 9: Test of Between Subjects Effect in Comprehension

	Comprehension		
Source	F	Sig.	Partial eta square
Sex	4.625	.034*	.084
Group	10.543	.002 *	.115
Sex * Group	7.181	.009 *	.106

*Not significant at p > .05

There was significant difference for sex and this means differences lie in the achievement of males and females at the comprehension level in both groups. The effect size was large. The results of means and standard deviation for males and females in the control and experimental groups are presented in Table 10. Table 10 shows a further inspection of the mean scores at comprehension level for male experimental (M= 16.68, SD = 4.707) and control (M = 10.63, SD = 5.134) and female experimental (M = 11.75, SD = 5.180) and control (M = 11.17, SD = 5.210).

From Table 9, it is observed that males in the experimental group performed better at the comprehension level than their counterparts in the control group by mean difference of 6.05 while females in experimental group performed almost the same as their counterparts in the control group by mean difference of 0.58. These show that the combined effect of gender on achievement in the experimental group exceeds that of the control group.

Table 10: Results of Means and Standard Deviations of Sex in Both Groups

		Comprehension		
Gender	Group	N	Mean	SD
Male	Experimental	31	16.68	4.707
	Control	19	10.63	5.134
Female	Experimental	20	11.75	5.180
	Control	35	11.17	5.210

Maximum score = 27

Furthermore, the females in the experimental group performed better at the comprehension level than their male counterparts in the control group. Table 8 shows significant effect of sex on achievement at the comprehension level and this means males and females differ significantly in terms of their achievements at the comprehension level. The effect size was large. The combined effect of male achievement exceeds that of combined effect of female achievement. This shows that males performed better than the females at the comprehension level in BAT1 posttest. Also the significant difference in group means that the experimental and control groups differ in term of their achievement at the comprehension level.

Boujaoude and Attieh (2008) found that there was significant interaction between group and sex at the comprehension level of the posttest which is consistent with this study. They found out that female mean score in control group was lower than that of their male counterparts. However, the females in the experimental group had high mean scores than their male counterparts.

Performance of Males and Females at the Application Level in Both Experimental and Control Groups

To test hypothesis five, a two-way analysis of variance was conducted to explore the gender difference at the application level in the experimental and control groups. The dependent variable is achievement at the application level while the independent variables are sex (male and female) and group (experimental and control). The result of test of between subjects effect for application is shown in Table 11.

Table 11: Test of Between Subjects Effect in Application

	Application		
Source	F	Sig.	Partial eta square
Sex	3.974	.049*	.088
Group	7.711	.007*	.121
Sex * Group	12.620	.001*	.151

*Not significant at p > .05

Table 11 indicates there was significant effect in sex and group interaction [F (2,105) = 12.620, p = 0.001, partial eta square = 0.151]. The effect size of

0.111 was large. There was statistical main effect for sex [F (1,105) = 3.974, p= 0.049, partial eta square =0.088] and group [F (1,105) = 7.711, p = 0.007, partial eta square =0.121]. Hence the null hypothesis is rejected. There was a large effect size of 0.151 for sex and group interaction at the application level. This indicates that significant difference in effect of gender on achievement at application level in the experimental and control groups was accounted for by 15.1%. There was significant difference for sex; the effect size of 0.088 was large. Effect size of 0.121 was also moderate for group.

Mean and standard deviation scores at application level are presented in Table 12 for both gender in the control and experimental groups.

Table 12: Results of Means and Standard Deviations of Both Genders in Application

		Application		
Gender	Group	N	Mean	SD
Male	Experimental	31	13.00	4.655
	Control	19	7.58	3.133
Female	Experimental	20	8.25	5.004
	Control	35	8.91	3.876

Maximum score = 27

Table 12 shows a further inspection of the mean scores at application level for male experimental (M = 13.00, SD = 4.655) and control (M = 7.58, SD =

3.133) and female experimental (M = 8.25, SD = 5.004) and control (M =8.91, SD = 3.876). From Table 12, it is observed that males in the experimental group performed better at the application level than their counterparts in the control group by mean difference of 5.42. It can also be observed that the males in the experimental group performed better than the females in both the experimental and control groups. Females in the experimental and control groups performed almost the same. The combined effect of gender on achievement at application level in the experimental group did not far exceed that of the control group. Table 11 shows significant effect of sex on achievement, and this significant effect could come from males in the experimental group. The combined effect of male achievement at the application level exceeds that of combined female achievement. Boujaoude and Attieh (2008) found that there was no significant interaction between group and sex at the application level of the posttest which is not consistent with this study.

Performance of Males and Females at the Analysis Level in Both Experimental and Control Groups

A two-way analysis of variance was conducted to explore the gender difference at the analysis level in the experimental and control groups. The dependent variable is achievement at the analysis level while the independent variables are sex (male and female) and group (experimental and control). The result of test of between groups for analysis is shown in Table 13.

Results from Table 13 indicate that there was statistical effect for sex [F (1,105) = 4.306, p = 0.041, partial eta square = 0.041] and group [F (1,105) =

15.622, p =0.001, partial eta square = 0.154]. However sex and group interaction effect [F (2,105) = 3.085, p = 0.082] did not reach statistical significance.

Table 13: Test of Between Subjects Effect in Analysis

	Analysis		
Source	F	Sig.	Partial eta square
Sex	4.306	.041*	.041
Group	15.622	.001*	.154
Sex * Group	3.085	.082*	.030

*Not significant at p > .05

The results in Table 13 show that there was no significant difference for sex and group interaction at analysis level. This means that males and females combined in the experimental and male and females combined in the control group almost achieved the same at analysis level.

Table 14 shows the mean and standard deviation scores at analysis level. Table 14 shows the mean scores at analysis level for male experimental (M= 10.35, SD = 4.208) and control (M = 6.37, SD = 3.204); and female experimental (M = 7.75, SD = 3.307) and control (M = 6.26, SD = 2.536). From Table 14, it is observed that males in the experimental group performed better at the analysis level than their counterparts in the control group by mean difference of 3.98. Females in experimental group achieved slightly higher than their counterparts in the control group by mean difference of 1.49. These show that the combined effect of gender at the analysis level in the experimental group exceeds that of the control group.

Table 14: Results of Means and Standard Deviations for Gender in Both Experimental and Control Groups

		Analysis		
Gender	Group	N	Mean	SD
Male	Experimental	31	10.35	4.208
	Control	19	6.37	3.204
Female	Experimental	20	7.75	3.307
	Control	25	6.26	2.536

Maximum score = 26

Table 13 shows significant effect of sex on achievement at analysis level, and this significant effect means combined male achievement exceeds that of the combined achievement of the females at the analysis level. However, the effect size of 0.041 was small. The low mean scores of males and females in both experimental and control groups indicate that both did not perform remarkably at the analysis level and that answering of high order questions was a problem for both genders.

At all cognitive levels considered in this study, the males in the experimental group performed better than their female counterparts. I think this is not a good sign in an era where females are being encouraged to pursue science.

More has to be done to motivate females to be at par with their male counterparts (Awortwi, 1999; Erinosho, 2005).

Difference in Achievement between Males and Females Taught with Concept Mapping

To test the statistical difference in achievement in posttest of BAT 1 between male and female students exposed to concept mapping, an independent sample t-test was used. The normality test indicated a Kolmogorov-Smirnov value of 0.200 at p = 0.05 showing normal distribution of the data. A result of independent sample t-test for males and females in the experimental group is shown in Table 15.

Table 15: **Result of Independent Sample T-Test for Males and Females in Experimental Group**

Variable	N	Mean	SD	t	P
Male	31	40.03	11.496	3.700	.001*
Female	20	27.75	11.693		

*Not significance at p > .05 maximum score = 80

Table 15 shows that there was significant difference between males (M = 39.97, SD = 11.315) and females (M = 27.21, SD = 11.755, t (103) = 3.838, p = 0.001). Therefore the null hypothesis is rejected. The males in the concept mapping group achieved significantly higher than their female counterparts with mean difference of 12.28. An effect size of 1.06 is very large. According to

Green, Salkind and Akey (1997) an effect size of 0.2 is small, 0.5 is moderate and 0.8 very large. This is in contradiction to Bello and Abimbola (1997), Abayomi (1985), and Jegede and Okebukola (1998) who found out that there were no statistical differences in achievements between male and female students in Biology who were taught using concept mapping. Boujaoude and Attieh (2008) indicated that females performed better than males when they were taught with concept mapping method. They gave reasons that the females might have been consistent in conforming to teachers demand in following instruction to master the techniques of building the concept maps.

How could the difference in achievement be explained by the different learning styles between males and females? According to Wapner (cited in Boujaoude & Attieh, 2008), males are field-independent learners who use reasoning pattern that include cognitive structuring skills, while females are field dependent learners who accept realities and may become passive learners. Hall (2000) indicated that field independent learners have been referred to as " analytical, competitive, individualistic, task oriented, internally referent, intrinsically motivated, hypothesis testing, self structuring, linear, detail oriented and visually perceptive" (p.5). Hall also described field dependent learners as "group oriented, global sensitive to social interaction and criticism, extrinsically motivated, externally referential, not visually perceptive, non-verbal and passive learners who prefer external information structures" (p.6). Governor (1998) added that field dependent learners are in more need of social input and external help in interpreting clues embedded in a particular learning task. Hu (1998) observed that field independent learners are more analytical and rely on less external clues than their field dependent counterparts. Field independent learners appear to have the ability to generate and structure their own knowledge rather than accepting knowledge reprocessed by others. The descriptions of both field dependent and independent learners show that concept mapping caters for the individual differences of both learning styles; in that the constructive approach allows for individual creation of knowledge and social discourse. However, the females might have not been as curious as the males to incorporate concept mapping as a novel method of teaching and learning. Being passive learners they might have needed more time to accept the reality of concept mapping; hence the three weeks for the study might have not been enough. Hence it is imperative for educators to consider all learners' learning-style strength to maximize instructional outcome. However, since the females in the experimental group performed better than their counterparts in the control group, it meant concept mapping improved their learning. The females needed much motivation and encouragement. Dwyer (1998) also recommended removing hierarchical barriers in terms of classroom organization or forms of threat that have the potential of invalidating females learning efficacy, independent of course content. Mann (1994) reported that females faced with several challenging learning conditions such as instructor bias and passivity, and institutions that destroy friendship networks, were less likely to exemplify their learning styles in subject areas such as mathematics and sciences. It is therefore important to encourage teaching techniques that place more emphasis on collaboration and hands-on learning as well as recommended text books that depict females as authors of science books and originators of novel scientific discoveries.

Gender Difference in Concept Map Construction

To find out whether there was significant difference between male and female concept map construction capabilities, their concept map scores were subjected to independent sample t-test. The data showed normal distribution with a Kolmogorov-Smirnov value of 0.200 at p = 0.05. Table 16 shows results of independent sample t-test male and female concept map scores.

Table 16: Results of Independent Sample T-Test of Concept Map Scores of Both Males and Female

Variable	N	Mean	SD	t	P
Male	31	38.94	17.620	.022	.982*
Female	20	38.85	9.681		

*Not significant at p > .05 maximum score = 78

Table 16 shows that there was no significant difference in concept map scores between males (M = 39.72, SD = 17.891) and females (M = 37.53, SD = 7.870, t (51) = 0.602, p = 0.550). Hence the null hypothesis is upheld. This result is consistent with findings of Bello and Abimbola (1997) who also found no difference in male and female concept maps. Whereas in the BAT1 the males achieved higher than their females counterparts, both gender performed almost at the same level in constructing concept maps. This may mean the females might have preferred drawing concept maps to writing to represent their answers.

A further analysis was done to find out whether the maps they constructed was good or bad by comparing their maps to an expert map; in this case the map prepared by the teacher. The expert concept map was scored and the concept map scores of the students were divided by the score of the expert map and expressed in percentages. Maps below 40% were considered bad and those above 40% were considered good. The bad maps were classified as very poor if student had below 15% and poor from 15% -39%. The good maps were classified excellent from 80% and above, very good from 79% -75%, good from 74% -65%, credit from 64%-50%, pass from 49% -40%. In maps which were considered as good, students were able to provide at least 10 sub-concepts, showed at least three hierarchies, 10 propositions and perhaps showed one crosslink. Table 17 shows students' concept map scores

Table 17: Concept Map Scores of Male and Female Biology Students in Experimental Group

Male			Female		
Score	rating/%	remarks	score	rating/%	remarks
52	67	good	42	54	credit
48	62	credit	34	44	pass
60	78	very good	46	59	credit

Table 17 (continued)

Male			Female		
score	rating /%	remarks	score	rating /%	remarks
44	56	credit	43	55	credit
21	27	poor	41	53	credit
42	54	credit	42	54	credit
1	1	very poor	64	82	excellent
46	59	credit	48	62	credit
23	29	poor	35	45	pass
50	64	credit	33	42	pass
1	1	very poor	34	44	pass
65	83	excellent	34	44	pass
58	74	good	43	55	credit
9	12	very poor	48	62	credit
49	63	credit	33	42	pass
16	21	poor	25	32	poor
26	33	poor	26	33	poor
40	51	credit	50	64	credit
60	78	very good	8	6	poor
59	76	very good			

Table 17 (continued)

Male			Female		
score	rating /%	remarks	score	rating /%	remarks
46	59	credit			
46	59	credit			
40	1	credit			
66	85	excellent			
35	45	pass			
31	40	pass			
30	38	poor			
37	47	pass			
26	33	poor			
31	40	pass			

Maximum score = 78

From Table 17, 29% of males and 20% of females constructed poor concept maps while 71% males and 80% of females constructed good concept maps. Figure 1 illustrates the quality of the concept maps constructed by both males and females.

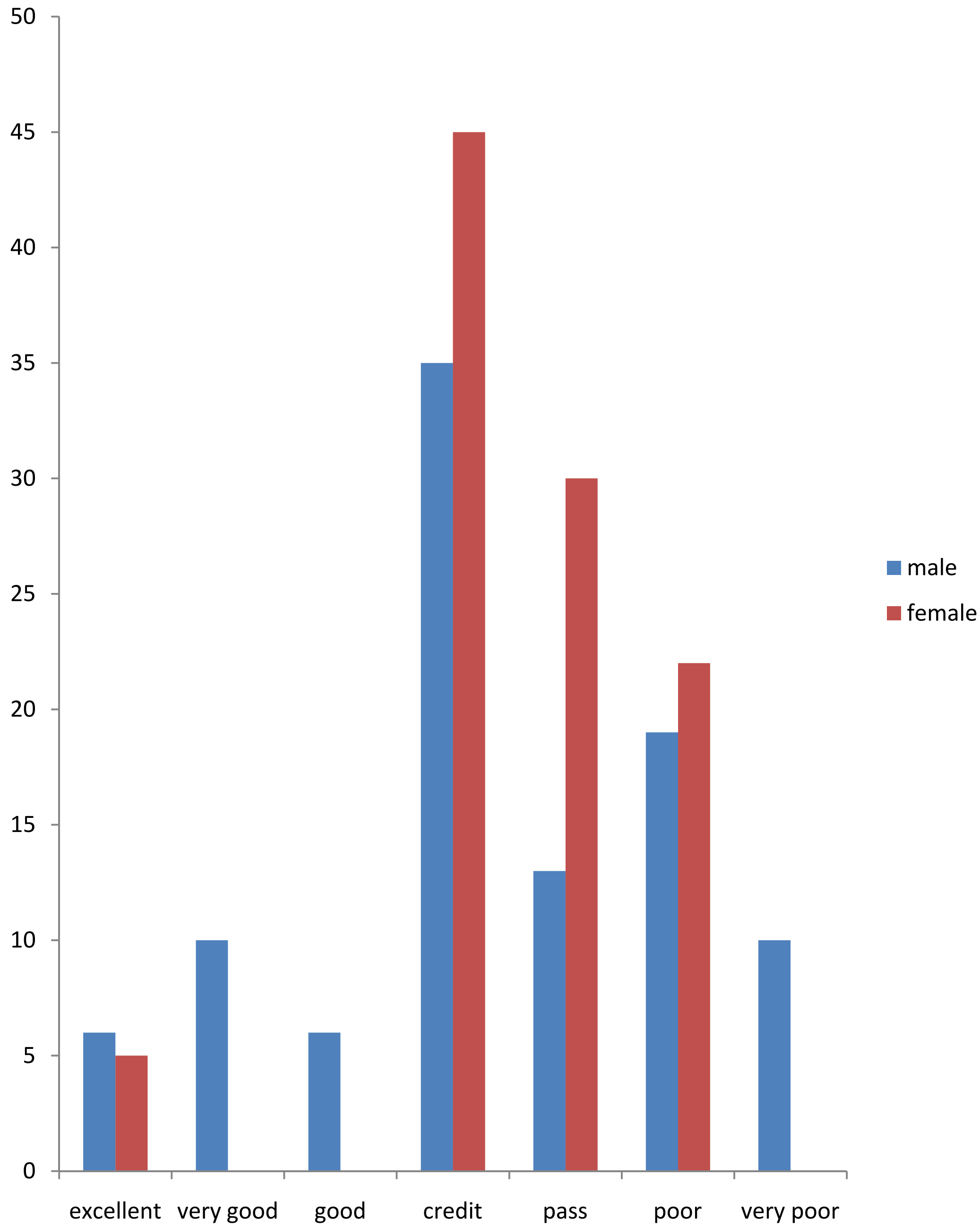

Figure 1: Quality of Male and Female Concept Maps in Percentages

Figure 1 indicates that the females did not construct "very good" and "good" concept maps. On the contrary the males had as much as 10 % constructing very poor concept with the females constructing none. Majority of the males and females constructed "credit" maps. This indicates that both males and female constructed good and poor concept maps. Figure 2 and 3 show examples poor and good concept maps constructed by students.

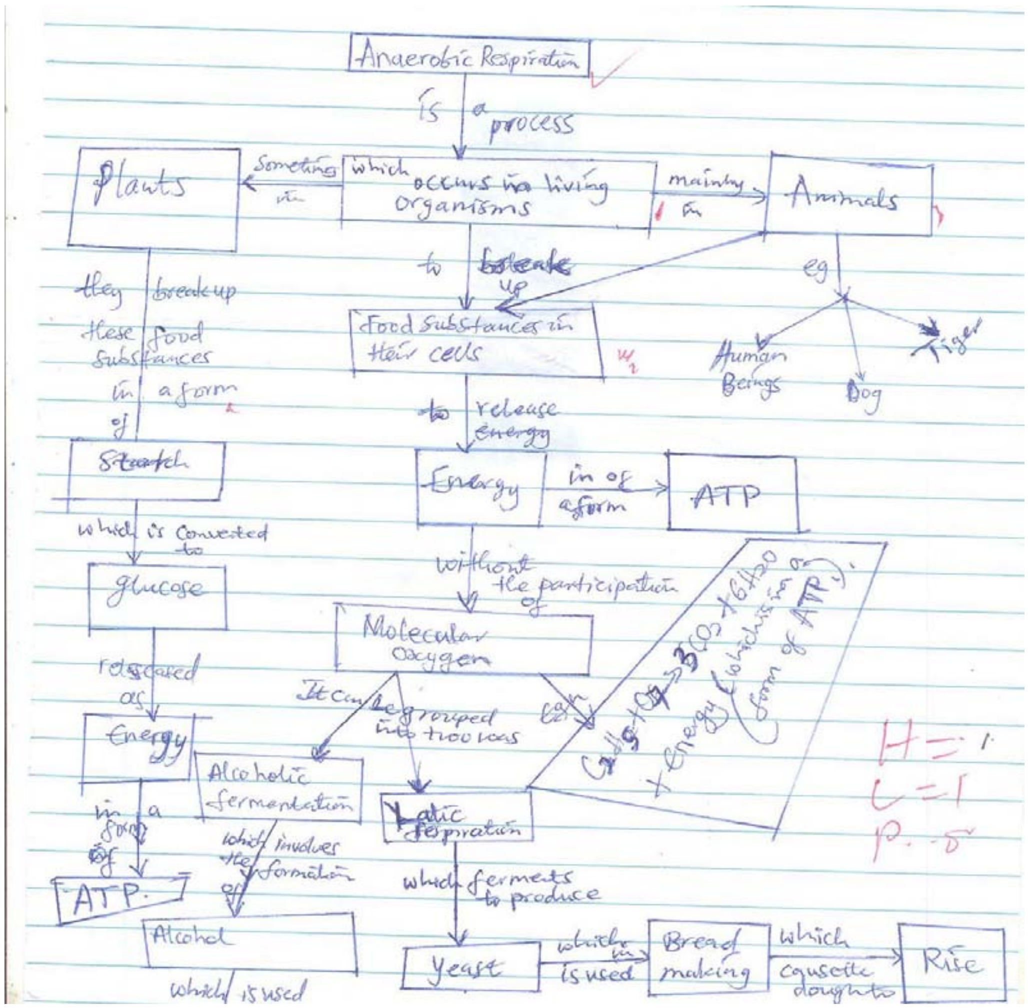

Figure 2: Poor Concept Map on Anaerobic Respiration Constructed by a Student

The concept map in figure 2 is poor because the student could not put concepts in order and in hierarchies to make any meaning. Instead of writing phrases on the arrows, the student was sometimes writing sentences. Also instead of writing key concepts the student was writing sentences in the boxes.

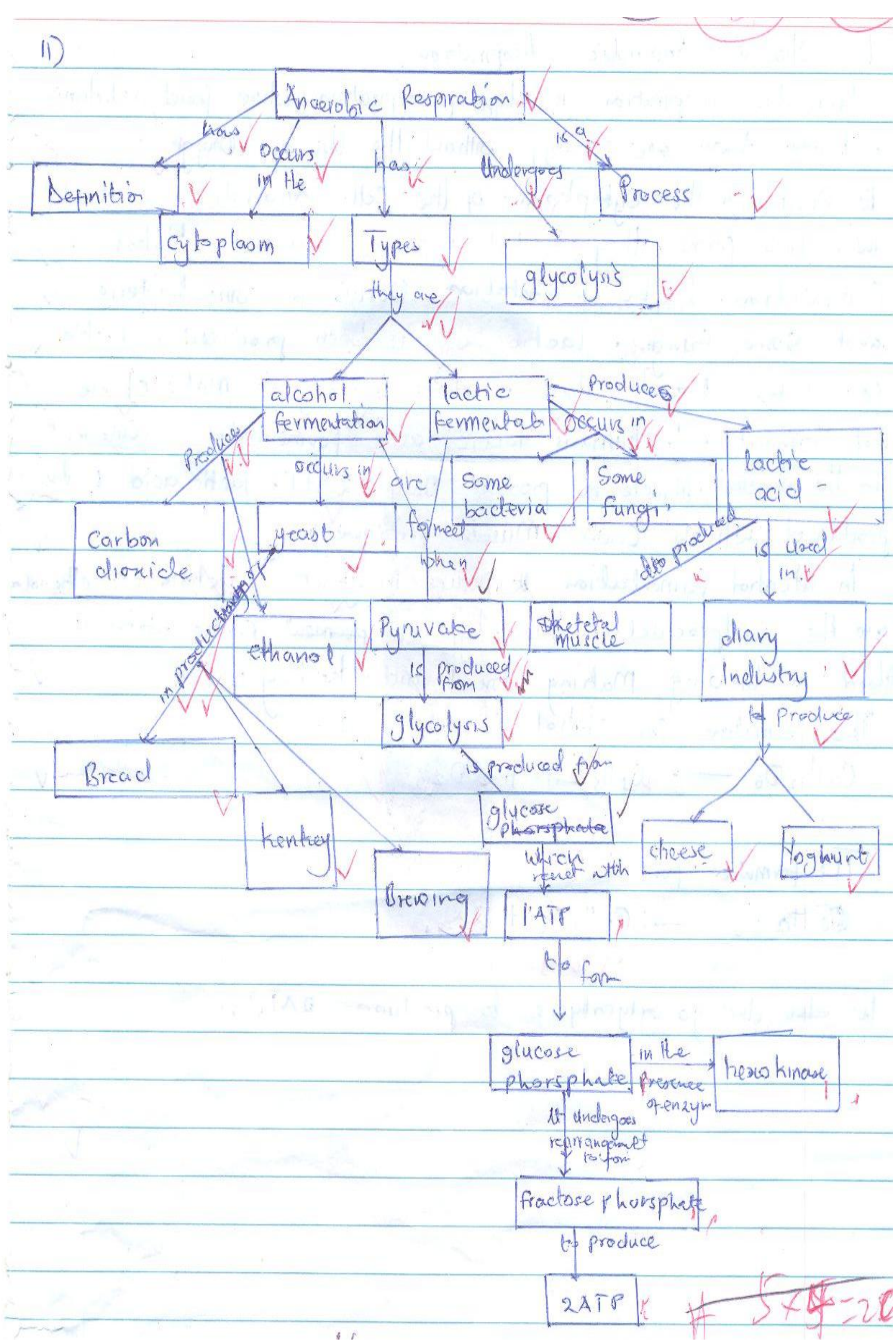

Figure 3. Good Concept Map on Anaerobic Respiration Constructed by a Student

The concept map in figure 3 is good because the student was able to place concepts in order and in hierarchies. Sub concepts followed main concepts. Propositions were correct and there were more than three correct hierarchies. One can easily get the meaning of anaerobic respiration from the concept map in figure 3. Some males construct good concept maps while some constructed bad ones. Also some females constructed good concept maps while some also constructed bad ones.

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

Relationship between Students' BAT2A Scores and Concept Map Scores

To find the relationship between students' BAT2A scores and BAT2B (concept map) scores, Pearson's Product Moment coefficient was used. The BAT2A and BAT2B had Kolmogorov-Smirnov values of 0.200 and 0.200 respectively at $p = 0.05$ (see appendix c for scores). The result of correlation between student BAT2A scores and concept map scores is presented in Table 18.

Table 18 indicates there was strong positive correlation between the two variables ($r = 0.568$, $n = 51$, $p = .001$). According to Cohen (1988) the strength of correlation of $r = 0.10 – 0.29$ is small, $r = 0.30 - 0.49$ is medium and $r = 0.50 – 1.0$

is large. By squaring ‘r’ one will obtain the coefficient of determination. Also multiplying the coefficient of determination by 100% will give the percentage of shared variance. The coefficient of determination of 0.32 indicates 32% shared variance.

Table 18: **Results of Correlation between BAT2A and BAT2B Scores**

		BAT2A	BAT2B
BAT2A	Pearson correlation	1	.568
	Sig (2-tailed)		.001*
	N	51	51
BAT2B	Pearson correlation	.568	1
	Sig. (2-tailed)	.001*	
	N	51	51

*Not significant at p > .01

Table 18 indicates that the students were performing quite similar on the concept map items and essay item designed to measure similar content. Further the strong positive correlation between students’ BAT2A scores and BAT2B scores might be attributed to the power of concept maps to enhance students’ ability to identify clearly interrelationships between concepts and learn meaningfully (Novak & Gowin, 1984). Having to organise their information on the concept maps might have helped the students to organise and provide the right answers for their essay. The high level of correlation between students' concept map scores and BAT2A scores is consistent with the finding of Asan (2007). Asan posited that the strong positive correlation provides evidence for the content validity of the concept map scores. Furthermore, students are able to perform similarly on concept map items and the achievement test meant to measure similar content.

On the contrary, Novak, Gowin and Johansen (1983) showed that concept mapping scores were not significantly related to students' SAT scores. This meant sometimes students concept map scores may not correlate with their achievement test score, indicating that some students who might have scored low in the achievement test might score high in the concept map construction, and vice versa.

Perception of Biology Students towards Concept Mapping

Responses from questionnaire and structured interview on students' perception towards concept mapping were used to see if there was consensus of opinion about the use of concept maps. A Likert scale (strongly agree = 1, agree = 2, undecided = 3, disagree = 4 and strongly disagree = 5) was used on the questionnaire to determine the degree of agreement with statement about concept mapping. Strongly agree and agree were considered to be positive perception, undecided was considered neutral while disagree and strongly disagree was considered negative perception. The mean of the responses from the total items were computed for each student. Total mean between 1 and 3 was considered positive perception, total mean between 3 and 4 was considered neutral while total 4 and above was considered negative perception. All the 51students in the experimental group were given the questionnaire to respond to.

Table 19 shows mean score of males and female perception toward concept mapping and their posttest achievement scores.

Table 19: Mean Scores of Perception and Posttest Scores of Concept Mapping Group in Females

	Male			Female	
Student	perception mean score	posttest	student	perception mean score	posttest
MS1	2.21	58	FS1	2.83	18
MS2	2.79	47	FS2	2.42	23
MS3	3.00	33	FS3	3.75	41
MS4	1.38	54	FS4	2.00	22
MS5	2.83	39	FS5	2.58	16
MS6	2.71	32	FS6	2.55	12
MS7	2.33	23	FS7	1.92	40
MS8	2.50	31	FS8	2.92	38
MS9	2.08	32	FS9	2.50	14
MS10	1.79	36	FS10	2.29	38
MS11	3.04	44	FS11	1.88	33
MS12	1.74	17	FS12	1.62	23

Table 19 (continued)

	Male			Female	
Student	perception mean score	posttest	student	perception mean score	posttest
MS13	1.29	58	FS13	1.96	14
MS14	1.42	55	FS14	2.08	18
MS15	3.62	35	FS15	1.71	41
MS16	1.96	52	FS16	2.75	50
MS17	2.38	27	FS17	2.79	18
MS18	2.42	21	FS18	2.08	26
MS19	3.25	37	FS19	3.0	43
MS20	2.42	46	FS20	2.50	27
MS21	1.42	43			
MS22	1.42	46			
MS23	1.79	38			
MS24	1.62	42			
MS25	1.75	46			
MS26	1.75	65			
MS27	2.0	32			
MS28	2.12	27			

Table 19 (continued)

	Male		Female		
Student	perception Mean score	posttest	student	perception mean score	posttest
MS29	3.58	44			
MS30	2.42	41			
MS31	2.88	39			
Total	2.26			2.56	

MS = male student   FS = female student

Group total mean = 2. 41

A grand total mean value of 2.41 meant the students had positive perception towards concept mapping. Table 19 shows that both males and females had positive perception towards concept mapping. Also some of the students who achieved low as well as majority who achieved high in the posttest had positive perception towards concept mapping. It can be said categorically that, the positive perception towards concept mapping might have caused students to achieve higher in the posttest. This study is consistent studies conducted by Scagnelli (2010), Bunting et al (2005), and Asan (2007) who also found out that student who showed positive attitudes and perception towards concept mapping achieved higher in their posttest. From Table 18, 14% of the students exposed to concept mapping were neutral to perception towards concept mapping. About 86% showing positive perception indicates that most students agreed or strongly agreed to the statements. Table 20 shows the representation of students' perception towards Biology.

Table 20: Students Response to Perception towards Concept Mapping

Perception	SA n /%	A n /%	UN n /%	D n /%	SD n /%
Concept mapping makes Biology class interesting.	17(33.3)	25(49)	3(5.9)	6(11.8)	-
Concept mapping is fascinating.	12(23.5)	28(54.9)	9(19.6)	1(2.0)	1(2.0)
Concept mapping makes me feel comfortable.	8(15.7)	19(37.3)	12(23.5)	10(19.6)	2(3.9)
Concept mapping makes me feel relaxed in classroom environment	7(13.7)	20(39.2)	12(23.5)	7(13.7)	5(9.8)
Concept mapping stimulates me to learn Biology	11(21.6)	21(41.2)	7(13.7)	10(19.6)	2(3.9)
I enjoy making concept maps	14(27.5)	13(25.5)	10(19.6)	14(27.5)	
I would like to use concept maps often	10(19.6)	12(23.5)	14(27.5)	10(19.6)	5(9.8)

Table 20 (continued)

Perception	SA n /%	A n /%	UN n /%	D n /%	SD n /%
Concept map helps me to see links between concepts	29(56.9)	21(41.2)	-	1(2.0)	-
Concept mapping helps me summarise concepts	21(41.2)	23(45.1)	3(5.9)	3(5.9)	1(2.0)
Concept map has improve my learning	6(11)	23(45.1)	12(23.5)	7(13.7)	3(5.9)
Concept mapping helps me to understand information better	11(21.6)	28(54.8)	6(11.8)	4(7.8)	2(3.9)
Concept map makes me organise my thought	16(31.4)	26(51.0)	4(7.8)	4(7.8)	1(2.0)
When teacher uses concept Map to explain thing, it makes more sense	15(29.4)	23(45.1)	6(11.8)	5(9.8)	2(3.9)
Concept mapping shows me what I know and what I need to learn more	19(37.3)	23(45.1)	4(7.8)	4(7.8)	1(2.0)
It is easy to construct concept map	11(21.6)	17(33.0)	7(13.7)	11(21.6)	5(9.8)

Table 20 (continued)

Perception	SA n /%	A n /%	UN n /%	D n /%	SD n/%
Constructing concept map is not time consuming	12(23.5)	14(27.5)	5(9.8)	13(25.5)	7(13.7)
Concept mapping does not scare me	18(35.3)	23(45.1)	7(13.7)	1(2.0)	2(3.9)
I am under terrible strain when concept map is used to teach	16(31.4)	22(43.1)	8(15.7)	5(9.8)	-
I have opportunity to interact with my mates when concept map is used	22(43.1)	16(314)	6(18.1)	7(13.7)	-
Concept mapping helps me to Contribute to class discussion	16(31.4)	22(43.1)	5(9.8)	7(13.7)	1(2.0)
Concept maps help me study for test	14(27.4)	15(29.4)	10(19.6)	8(15.7)	4(7.8)
I will rather make concept map than take a test	6(11.8)	16(31.4)	12(23.5)	12(23.5)	5(9.8)
I will like concept map to be used in other courses	12(23.5)	14(27.5)	11(21.6)	8(15.7)	6(11.8)

Table 20 (continued)

Perception	SA n /%	A n /%	UN n /%	D n /%	SD n /%
I sometimes use concept map for studying other courses	6(11.8)	16(31.4)	12(23.5)	9(17.6)	8(15.7)

SA = strongly agree D = disagree n = number of students

A = agree SD = strongly disagree (%) = percentage

UN = undecided (neutral)

Table 20 shows that majority of the students exposed to concept mapping responded to ‘strongly agree’ and ‘agree’. However, there were some items that some appreciable number of students responded ‘disagreed’, ‘strongly disagreed’ or ‘undecided’. For instance, 23.5% of students were neutral to the each of the following items ‘concept mapping makes me feel comfortable’, ‘concept map makes me feel relax in classroom environment’, ‘concept mapping has improved my learning’, ‘I will rather make concept map than take a test’ and ‘I will like concept map used in other courses’. Also 27.5% were neutral to ‘I will like to use concept maps more often’. About 25.5% disagreed that ‘constructing concept mapping is not time consuming’, 21.6% disagree that ‘it is easy to construct concept map’, 27.5% also disagree to ‘I enjoy making concept maps’ and 23.5 student showed their disagreement to ‘I will rather make concept map than take a test’. Furthermore, more than 10% responded strongly disagree to the following items ‘constructing concept map is not time consuming’ (13.7%), ‘I will like concept used for other courses’ (11.8%), and ‘I sometimes use concept mapping for studying other courses’ (15.7%). Asan, (2007) also indicated that very low percentage of students responded to ‘disagree’ or ‘strongly disagree’. Bunting et al (2005) also indicated that greater percentage of the students responded to ‘agree’ or ‘strongly agree’. These findings are consistent with this study showing that students have positive perception towards concept mapping. Furthermore, the opinions of the students in the structured interview and questionnaires were put into themes and analysed.

Interest in Concept Mapping

Many of the students interviewed said teaching and learning with concept mapping is interesting. When student A was asked whether he saw concept mapping interesting, he said “Yes. Once something makes you get vivid understanding about a topic you would like it” another student (student C) also answered “Yes. It is very good; it is easy for presenting knowledge and answers. It seems that students developed interest in concept mapping because of how it gave them clear understanding of the Biology content. Student F commented “it is interesting because it’s a new way of learning”. Student B said “it makes you creative, makes you know what you don’t know. The method is good, arrows and propositions make everything like a note”. Student H said “I am happy constructing concept maps”. Student M commented “it is good and nice thing to use. After using you find out that you have a wide collection of information and knowledge of the topic of study”

Concept Mapping for Teaching and Learning Biology

Students initially found the method strange when it was introduced to them. Student D said “it is interesting for teaching, but for learning, no; I am used to writing essay”. Student B commented “at the beginning it was not familiar, but later I found it to be good after practising with it. It makes teaching interesting because concept mapping is sequential…it was clear and created a mental picture” student I also said “ in the beginning I thought it was very difficult, later I found it easier and good, concept mapping is simpler to apply. Other methods used by other teachers are a little difficult”. The other method she was talking about here was the traditional method where teacher just present concepts and give notes. During concept mapping, the discussions between teacher and students and during group works served as ingredients for better explanation of the topic; this is lacking in the traditional method of teaching. This is in consonance with social constructivists approach to learning (Guba & Lincoln, 1994 and Tobin, 1993; Wertsch, 1985) in which learning is considered to be construction of meaning by individuals in a social setting through internal construction of knowledge being driven primarily by social interactions. This ideally involves “negotiating of understanding through dialogue or discourse shared by two or more members of a community of people of shared goals” (Brophy, 2002, p ix). In this contest we see the teacher’s role as a discussion leader, posing questions, seeking clarification, promoting dialogue and helping groups of students to recognize areas of consensus and continuing disagreement

(Good & Brophy, 2000). The aim of all these is to help students to collaborate and to co-construct shared understanding.

About learning with concept map, Student A said “it has improved my learning and organisational work” student B iterated “I was improving; I now learn to understand, no more chew and pour”. By this the student meant no more rote learning. Student P commented “concept mapping has really helped me in Biology, I understand, and would like to use it in my studies in all subjects. I think it should be used in many schools so that it will help many students” Students F and G realized that concept mapping makes learning of concept real. Student G said “I feel comfortable when being taught with and learning with it; it was real, brings more understanding. You ask yourself “what can I add to it?” It makes you creative and makes you to explore”. Student F said “When using it, it is like visualization; like a mental picture. Example, if someone says one acre is 447sqm, it is difficult to understand. But if the person says it is like a football park you are able to understand. That is how concept map is; it makes ideas real.” A key feature of concept maps is that, they are constructed to represent text structure patterns which serve to help students’ mental constructs or schemata of how texts are organized. By mapping ideas into maps designed to model text structure patterns, teachers help students to visualize relationships and learn patterns (Bos and Anderson as cited in Guastello et al, 2000). This indicates that concept mapping result in meaningful learning which leads to students’ improvement in Biology achievement. Bunting et al (2005) also reported that concept mapping influenced students learning.

Concept Map for Summarising, Organising and for Formation of Links between Concepts

In particular, concept mapping was seen as a useful tool for summarizing the large content of notes the teacher gave to students and for organizing their thoughts. Many of the students answering the questionnaire agreed that concept mapping helped them to summarise, organise content and to see links between concepts. Student A in the interview commented "concept mapping bring links and details…as you use links from one concept to another there is logic and sequence making organization perfect." To student B "concept map shows logical and hierarchical presentation from bigger to the least. Student I agreed that "it has improve organization of my works. Student G said "it improves organization of my thoughts" student Q commented "concept mapping gives a summary of a topic". Anderson and Huang (1989) posited that process of concept mapping involves mapping out logical relationships among concepts in an orderly, sequential or hierarchical manner such that the most broad or general concepts are at the top and the most specific ones are at the bottom of the map. Bunting et al (2005) also reported that most of the students in their study commented that concept mapping had helped them to summarise and organise their work.

Construction, Likes and Dislikes of Concept Mapping

Some of the students in the questionnaire agreed that construction of concept maps can be difficult and time consuming. Student G said "It is difficult constructing it. You have to think before you start. It takes time because you have to do rough work before the actual work, however constructing it shows logical, sequential and hierarchical presentation from bigger to the least.” Student D also said “it can be confusing; sometimes you don’t know how to present information on the concept map. Sometimes you find it difficult to present work in hierarchy. However, I am happy constructing it”. However, student F and J indicated it is not difficult constructing concept maps. Student F said “it is not difficult constructing it. If you know what you are about you can easily present it.” Also student K wrote “it is not time consuming and also give easy and faster way of getting concepts about a topic. I wish to use it all the time in studying” It is important to know that students constructed concept maps individually and in group and this provided a ‘hands-on’ activity which facilitated learning. For example, student B said “concept mapping makes you creative and it makes you know what you don’t know”. Student E agreed “sometimes it is time consuming because you have to arrange them sequentially.” student R also commented “…it is cumbersome” Commenting on likes and dislikes student C indicated she likes it because “it is good to use it. It makes your work simpler and presentable” but she dislikes it on the grounds that “it is difficult if you know nothing about the main ideas”. Student A comments “I like the detail representation it gives. It makes understanding easier”. Student B said “what I liked most is the presentation. Anyone can easily understand and know what you mean...the propositions and concepts in the boxes make everything like a note”. Student H had this to say “I like it because it brings out all important ideas; it helps to reduce spelling mistakes and grammatical errors. Student E said “it takes a word or two then you are gone”. Even though, Buntting et al (2005) indicated that most of the students liked concept mapping, they said that a few of the student said they did not like concept mapping because it was time consuming during construction.

Class Participation in Concept Mapping Class

Concept mapping makes student to participate as they contribute to building concept maps. Students and teacher have to reach a consensus about the best sub-concept to add as they build, this make students active learners. This is in agreement to Sizmur (1994) that concept mapping is a discussion task. Putting students into groups also helped them to take up responsibilities and socialize. This is because during group work one may be assigned the scribe, secretary or group leader. Many of the students agreed in the questionnaire that concept mapping helped them to participate in class and also contribute during group work. Student H said "concept mapping helped my class participation". Student A also commented that "it helped in my class participation; it made me sociable as we shared ideas". Student C has this to say "I prefer group work because we bring the knowledge we have and the best is used". To student D "the group was easier because all brought different ideas and we use the one which is best fit. Individually you are alone". This is in line with the findings of Anamuah-Mensah et al (1996) who indicated that individual ideas proposed by group members, generated discussion which led to personal knowledge becoming public knowledge. The agreement by members of a group before a link or proposition is accepted through dialogue is a very important tool for sharing of knowledge.

Actually there was a sense of competition among groups during the presentation as each group wanted to present the best map. Instead of this competition destroying the friendly learning environment concept mapping provides, it rather motivated groups to work as a team in subsequent group works.

Students' questions and answers during the Concept Mapping Class

On the lesson involving photosynthesis, the following discourse took place between the teacher and the students. After the teacher had explained the concept of photosynthesis, the major concepts and sub concepts were written on the board with students input. After the teacher had written photosynthesis in the top box as the major concept, he asked the students "what sub concepts would come after photosynthesis?" student C said "'chemical process', 'definition' and 'requirement". The teacher asked "Now what phrases can link 'photosynthesis' and 'chemical process, 'requirements' by product and products?" Teacher called student J "come and write them". Student K wrote 'has a' between photosynthesis and chemical process, and 'has' between photosynthesis and requirements. But immediately student P raised his hand, and when he was called he said "it would be appropriate if she had written 'is a' between photosynthesis and chemical process, so that it will read 'photosynthesis is a chemical process. The whole class agreed to that. But student L asked "does it mean if you don't get the correct linking word you will get wrong information? The teacher responded "Yes. You need to get the right phrase. But know that, there may be more than one phrase available but, you can use only one of them. Teacher move to the next level and asked "what are the requirements for photosynthesis?" student responded as "water from the soil, CO_2 from the atmosphere and chlorophyll from the leaf" student D answered when he was called. Student S added that "light from the sun is also a requirement for photosynthesis”. Student E wrote ‘water from the soil’ in one box. But the teacher explained “since ‘water’ and ‘soil’ are two concepts they cannot be written in one box. Soil will be below water and then joined by a proposition”. The student asked if he could write two concepts in a box. ‘No you cannot, and you cannot also write sentences in the box, neither can you write sentences as linking words” answered the teacher. Student Q said, “it means you have to take your time and think. Oh, I like this method”. Student O also commented “the whole thing looks like simplified notes”. Through such interactions, a concept map on photosynthesis was constructed (see figure 5).

The teacher finished with the construction of the concept map and asked students question which were to be answered from the map. The teacher asked “what is the use of oxygen from photosynthesis?” student A answered “for respiration”. How did you arrive at the answer” the teacher asked. Student A answered “from the concept map, oxygen is a by-product and it is used for respiration.

Similar interactions occurred in the concept map class during subsequent lessons. This dialogue is typical of discussions between teacher and students, and shows how the teacher tried to elicit views from students when building concept map. Bunting et al (2006) also indicated that such interactions and discourse are prominent in concept map classes. Students are able to ask questions and express their views.

In summary, students considered concept map as helpful strategy to help them see links between concepts, organise their work, improve their learning and classroom participation, ask questions and express themselves in class. Many also indicated that they enjoyed constructing concept maps.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

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

Summary

Overview of the Study

The quasi-experimental design involving two intact classes was used. Two schools were selected randomly from six SHS in the New Juaben Municipality. By random sampling one of the two schools was assigned the experimental group and the other, the control group. SHS 3 students were selected for the study because the topics under consideration are in the SHS 3 syllabus. The experimental group were taught using concept mapping while the control group were taught using the traditional method. Two achievement tests BAT1 and BAT2 were used to assess students. The BAT1 was pretest-posttest. The BAT2 comprised an essay and concept map test items. The two groups were given the same pretest and posttest. The pretest was to identify the entry behaviour of students in the two groups. However the BAT2 was administered to only the experimental group. The interrater reliability of the pretest = 0.99 while that of the posttest = 0.99. The interrater reliability for BAT2A = 0.99 and that of BAT2B (concept map scores) = 0.991.

Key Findings

1. Comparison between the pretest and posttest of each group showed that each group achieve significantly in the posttest. Analysis of the posttest scores using independent sample t-test indicated there was statistically significant difference between the mean scores of the experimental and the control groups after the treatment. The experimental group out scored those in the control group. This implies that the use of concept mapping approach was successful and boosted students' understanding in photosynthesis and internal respiration than the traditional method.
2. There was significant difference between the experimental and control groups on combined dependent variables. There were statistically significant differences between the experimental and control groups for comprehension, application and analysis all in favour of the experimental group. This implies that when concept mapping is used for instruction, students performed at the comprehension, application and analysis levels better than those thought with traditional method.
3. There was significant effect in gender and group interaction. Also there was statistically main effect for sex, and group. The males in the experimental group performed better than the male and females in the control group while females in experimental group also performed better than the males and females in the control group. However, the females in the control group

performed better than their male counterparts. This implies that concept mapping makes males and females achieve higher scores than their counterparts in the control group. However, the males performed better than the females in the BAT1 posttest.

4. There was significant effect in gender and group interaction at the comprehension level. There was also statistical main effect for sex, and for group. Males in the experimental group performed better at the comprehension level than their counterparts in the control group while females in experimental group performed almost the same as their counterparts in the control group. The males in the experimental group performed better than the females in the experimental and control groups. However, the females in the experimental group performed better at the comprehension level than their male counterparts in the control group.
5. At the application level, there was significant effect in sex and group interaction. There was statistical main effect for sex, and for group. The males in the experimental group performed better at the application level than their counterparts in the control group. Also the males in the experimental group performed better than the females in both the experimental and control groups. Females in control group performed better than their counterparts in the experimental group and males in the control group. The females in both the experimental and control groups performed better than the males in the control group.

6. There was statistical main effect for sex and for group. However, sex and group interaction effect did not reach statistical significance. The males in the experimental group performed slightly better at the analysis level than their counterparts in the control group. Females in experimental group also performed almost at the same level as their counterparts in the control group. Both gender had low scores at the analysis level.
7. There was statistically significant difference between males and females exposed to concept mapping. The males scored significantly higher than the females.
8. There was no statistically significant difference between the mean scores of the males and females. This implies that male and female construct concept map alike. It was found out that the ability to draw good concept map is not dependent on the gender of the student.
9. There was a strong positive correlation between students' concept map scores and achievement in Biology, indicating that majority who scored high in the concept map might have also score high in the Biology achievement test.
10. Students had positive perception towards concept mapping. Students indicated that they had interest in concept mapping. Also students indicted that concept mapping helped them to summarise, organise and logically present their work. Also concept mapping helped them to contribute in class, socialize and ask questions in class. However, they indicted that concept mapping was time consuming.

Conclusions

There were statistical differences between the experimental and the control groups in favour of the experimental group. The results of the study showed that concept mapping is more effective for teaching elective Biology at the SHS than the traditional method. Concept mapping has the ability to improve student's achievement in Biology. Also, concept mapping makes students learn meaningfully to improve upon their capacity to answer high order cognitive level questions.

Furthermore, in this study, males in the concept mapping group achieved more than their male counterparts in the traditional method in the three cognitive levels. Females exposed to concept mapping are able to perform better than their male counterparts exposed to traditional method at all the three cognitive levels considered in this study. The females however performed almost at the same level at all the cognitive levels.

From this study, the strong correlation between students' Biology achievement and concept map scores indicates that those who achieve high in Biology are likely to score high in concept map construction. Also, Biology students have positive perception towards concept mapping. Students are able to summarise, organise and logically present their work effectively using concept mapping. Concept mapping helps students to contribute and socialize in Biology class. However, in this study constructing concept map is time consuming for Biology students. In this study males performed better than the females in Biology.

Findings from this study show that concept mapping can be effective for teaching Biology in the classroom, and also assist students to learn meaningfully and achieve significantly in their examination.

Recommendations

Recommendations for Policy and Practice

1. Concept mapping is worth adopting as a teaching method by Biology teachers at the SHS level in the New Juaben Municipality because of its effectiveness.
2. The concept mapping method should be encouraged in many Biology classes since it gives students opportunity to see links between concepts, summarise and organise their works and thoughts logically and sequentially.
3. Both genders must be encouraged to use concept maps for studying Biology.
4. Much attention should be given to students concerning analysis and other high order cognitive level questions.

Suggestions for Further Research

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

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APPENDICES

APPENDIX A

BIOLOGY ACHIEVEMENT TEST (BAT)

BAT1 Time: 2 hours

Answer all questions in this section.

Question 1

a. Explain the roles of chlorophyll, ATP, NADP+ and CO_2 in photosynthesis

b. A farmer believed that the good yield he got from his cassava farm was because the soil was good. Explain to the farmer how the tubers he harvested were formed by the plant.

c. Critically analyse the functions of the chloroplast and mitochondrion

Question 2

a. Explain 4 ways on how the structure of the leaf adapts to its photosynthetic functions.

b. How would you convince a friend that the lives of humans and other living organisms are ultimately dependent on solar energy?

c. In a laboratory diagnostic test, it was found out that Kuma has been exposed to a chemical which inhibits the production of acetyl CoA. Analyse the consequences Kuma is likely to face with respect to his health giving reasons?

Question 3

a. What is the fate of pyruvate under anaerobic conditions and aerobic conditions?

b. Okoto after running the 5000m race look very exhausted. However he was given gluconade to regain his energy to run in the 4 × 400m race in the next 30 minutes. How will this soft drink provide him instant energy?

c. A cassava farmer in the Oyoko complained to his Agric Extension Officer that the yield was very low. When the officer went, he found out that a larger portion of the farm was under a big *Ceiba* tree with a thick canopy. How did this account for the poor yield?

Question 4

a. During the Copenhagen conference on all global warming, world leaders agreed on the importance for the countries in the tropics especially Africa maintaining their forests. How will afforestation help reduce global warming.

b. Mansah was a very good 100m runner. During finals of the 100m event in the recent inter-school athletic competition, Mansah got muscle fatigue and fell on the ground, so she could not complete the race. What might have been the cause of this?

c. Critically analyse the process of anaerobic respiration in the making of bread

BAT 2 Time: 1 hour

Answer all questions

1.

a. What is anaerobic respiration?

b. Construct a concept map to the answer in question 1.a

APPENDIX B

QUESTIONNAIRE ON PERCEPTION OF STUDENTS TOWARDS CONCEPT MAPPING

You are being assured the information you will provide is for purely academic purpose and that your responses will be kept confidential

SPECIAL INFORMATION

Students' Code……………..

Sex…………………………………..Age…………………………………………

Nationality ……………………………..Home Town…………………………….

Residential town………………………district…………………………………….

Former school (JSS)…………………………………………………………...

Location of JSS attended……………………………region………………………

Occupation of parents…………………………………………………………...

Please respond to each of these items in this section by ticking (√) the appropriate response.

Strongly agree (SA) agree (A) disagree (D) undecided (UN) strongly disagree (SD)

Items	SA	A	UN	D	SD
Interest towards concept mapping 1. Concept mapping makes Biology class interesting 2. Concept mapping is fascinating. 3. Concept mapping makes me feel comfortable. 4. Concept mapping makes me feel relax in the classroom environment. 5. Concept mapping stimulates me to learn Biology. 6. I enjoy making concept maps. 7. I would like to use concept maps more often **Usage of concept mapping** 1. Concept map helps me to see the links between concepts.					

Item	SA	A	UN	D	SD
2. Concept mapping helps me summarise concepts. 3. Concept mapping has improved my learning. 4. Concept mapping helps me to understand information better. 5. Concept map makes me organise my thoughts. 6. When teacher uses concept map to explain things, it makes more sense 7. Concept mapping shows me what I know and what I need to learn more about					
Constructing concept map 1. It is easy to construct concept map. 2. Constructing concept map is not time consuming **Anxiety in using concept map** 1. Concept mapping does not scare me. 2. I am not under any terrible strain when concept map is used to teach.					

Item	SA	S	UN	D	SD
Class participation 1. I have the opportunity to interact with my mates when concept mapping is used. 2. Concept mapping helps me to contribute in class discussion					
Concept map and test 1. Concept maps help me study for test 2. I will rather make a concept map rather than take a test.					
Studying other courses with concept map 1. I will like concept mapping to be used in other courses. 2. I sometimes use concept mapping for studying other courses					

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

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APPENDIX C

STRUCTURED INTERVIEW ON CONCEPT MAPPING

1. Did you find teaching and learning with concept mapping interesting?
2. How did you find concept mapping as a teaching method?
3. How did you find your performance in Biology after being exposed to concept mapping?
4. What did you like dislike about concept mapping?
5. How did you find construction of concept mapping?

APPENDIX D

MARKING SCHEMES

Marking scheme for BAT1

Question 1

a. Chlorophyll is a green pigment (1 mark) found in the thylakoids (1 mark) in the chloroplast (1 mark). It traps light energy (1 mark) to excite the electrons (1 mark) as they move through the electron transport chain (1 mark)

Any 2 × 1 = 2 marks

ATP produced in the light stage (1 mark) provides energy (1 mark) for the dark stage for the production of triose phosphate (1 mark)

Any 2 × 1 = 2 marks

NADPHproduced in the light stage (1 mark) reduces glycerate-3-phosphate (1 mark) to triose phosphate/ Phosphoglyceraldehyde used to form glucose (1 mark).

Any 2 × 1 = 2 marks

CO_2 is from the atmosphere, it diffuses into the stroma (1 mark) to react with RuDP (1 mark), a five carbon compound in the Calvin cycle (1 mark) in the presence of the enzyme RuDP carboxylase (1 mark) to form an unsTable six carbon compound which split into glycerate-3-phosphate (1 mark)

Any 2 × 1 = 2 marks

b. The tuber was form as a result of photosynthesis (1 mark). Chlorophyll traps light energy (1 mark) for the production of ATP and Hydrogen atoms (1 mark). The hydrogen is used in the dark stage to form triose phosphate (1 mark). The glucose is converted to glucose (1 mark) and then to starch (1 mark). The starch is stored by the cassava in the tuber (1 mark)

Any 7 × 1 = 7 marks

c. Chloroplast is found in plant cell and in some algae (1 mark). It contains chlorophyll (1 mark) for trapping light. Photosynthesis takes place in the chloroplast (1 mark). The light stage which occurs in the thylakoids (1 mark) uses light energy for the production of oxygen, hydrogen and ATP (1 mark). The dark stage which occur in the stroma leads to the production of starch (1 mark)

any 3 × 1= 3 marks

Mitochondrion is found in all eukaryotic cells (1 mark). It the power house of the cell by producing energy in the form of ATP (1 mark). The energy is produced by Krebs cycle (1 mark) and hydrogen carrier system (1 mark). Krebs cycle occur in the matrix (1 mark) while hydrogen carrier system occurs in the cristae of the mitochondrion (1 mark)

any 3 ×1= 3 marks

TOTAL= 20 marks

Question 2

a. the leaf has broad flat surface giving it a large surface area to allow absorption of light and carbon (iv) oxide/ carbon dioxide/ CO_2 (2 marks)

   the leaf is thin, enabling carbon dioxide/ carbon (iv) oxide/ CO_2 to diffuse easily to the mesophyll cells (2 marks)

   the presence of stomata for exchange of gases. (2 marks)

   presence of large amount of chloroplast in the palisade mesophyll as site for photosynthesis (2 marks)

   presence of spongy mesophylls which are loosely packed allow gases to diffuse easily. (2 marks)

   presence of xylem to transport water to the leaf. (2 marks)

   presence of phloem to transport products of photosynthesis (2 marks)

   arrangement of leaves on the stem allow maximum exposure of leaves to sunlight. (2 marks)

   Any 4 × 2 = 8 marks

b. Plants are autotrophic (1 mark). They produce food using sunlight as source of energy (1 mark). The light energy causes photolysis of water/ breaks water to produce hydrogen (1 mark), and ATP (1 mark) used for the production of glucose, sucrose starch, protein and lipids (1 mark).

These in turn are used by human beings and other animal when they feed on plant either directly or indirectly (1 mark). This means plants cannot survive without the sun (1 mark), hence if plants do not prepare food using light organisms which depend on them cannot survive (1 mark). Therefore human beings and other animal depend on solar energy (1 mark)

Any 7 × 1 = 7 marks.

c. Acetyl CoA is needed for the Krebs cycle to proceed (1 mark). If Krebs cycle does not proceed large amount of energy would be lost from the body (1 mark) this because only little amount of ATP/ energy (1 mark) produce from glycolysis (1 mark) would available to the body of kuma. Therefore organs which require much energy (1 mark) to work would be at a disadvantage. Kuma could be very weak and may die (1 mark).

Any 5 × 1 = 5 marks

TOTAL = 20 marks

Question 3

a. Pyruvate a three carbon compound is produced from glycolysis (1 mark). Under anaerobic condition pyruvate is converted to alcohol (1 mark) in plants or lactic acid (1 mark) in some bacteria and the skeletal muscle (1 mark). Under aerobic condition, pyruvate is decarboxylated to form an acetyl group (1 mark) which is a two carbon compound. This reacts with co-enzyme A to form acetyl coA (1 mark). Acetyl coA enters the Krebs cycle where a series of reactions occur to release large amount of ATP/ energy (1 mark)

Any 2 for anaerobic respiration and any 3 for aerobic respiration 1 × 5 = 5 marks

b. Gluconade contain more glucose (1 mark) which is absorbed into the bloodstream upon drinking (1 mark). The glucose undergoes glycolysis to form pyruvate (1 mark). Pyruvate is also converted to acetyl coA which enter the Krebs cycle to release more energy (1 mark). Thirty eight ATP of energy is produced under aerobic condition for every molecule of glucose (1 mark). Kuma could therefore gain more energy from the gluconade to run again (1 mark).

Any 6 × 1 = 6 marks

c. Light is a limiting factor for the cassava under the thick canopy (1 mark). Since the crops cannot get enough light, it means little amount (1 mark) of hydrogen (1 mark) and ATP (1 mark) would be produced in the light reaction stage (1 mark). This will in turn affect the production of glucose (1 mark) in the dark stage (1 mark). Some of the glucose would be used for respiration (1 mark), hence little starch would therefore be formed for storage by the plant (1 mark). Temperature would also be low under this thick canopy (1 mark). This would affect enzymatic activities (1 mark) in the dark stage leading to production of small amount of starch for storage.

Any 10 × 1 = 10 marks

TOTAL = 20 marks

Question 4

a. Global warming is an environmental problem (1 mark) caused by the inability of the heat of the sun to radiate back to space (1 mark) as a result of the accumulation of carbon (iv) oxide/ carbon dioxide/ CO_2 (1 mark) in the atmosphere. This cause a drastic increase in temperature (1 mark9). Plants use CO_2 for photosynthesis (1 mark), so an increase in the vegetation means increase in the use of CO2 (1 mark) and a decrease in the CO_2 concentration (1 mark) in the atmosphere. Also photosynthesis replenishes the atmosphere with oxygen (1 mark). This means planting more trees will reduce CO_2 concentration (1 mark), thereby reducing global warming (1 mark).

Any $6 \times 1 = 6$ marks

b. The skeletal muscle in the absence of oxygen respires anaerobically (1 mark) to produce lactic acid (1 mark). At rest, lactic acid is oxidized to carbon dioxide and water (1 mark). During vigorous exercise (1 mark) such as running, inadequate oxygen gets the skeletal muscle cells (1 mark) and this leads to the accumulation (1 mark) of lactic acid. This causes muscle fatigue (1mark) which can seize the victim to fall (1 mark).

Any $6 \times 1 = 6$ marks

c. Bread making utilizes alcoholic fermentation (1 mark). Yeast respire anaerobically (1 mark) using glucose from the dough as the substrate (1 mark). The products from this process are CO_2 (1 mark) and alcohol/ C_2H_5OH (1 mark) and small amount of energy (1 mark). As CO_2 escapes

(1 mark), it causes the dough to rise (1 mark). The alcohol produced gives taste to the bread (1 mark).

Any 6 × 1 = 6 marks

Marking scheme for BAT2

Anaerobic respiration does not require the participation of molecular oxygen (2 marks). Anaerobic respiration is also known as fermentation (1 mark) and it produces 2 ATP (1 marks). There are two types of fermentation. These are alcohol fermentation (1 marks) which occurs in yeast (1 marks), and lactic acid fermentation (1 mark) which occurs in the skeletal muscle and in bacteria (1 mark). Pyruvate produced in glycolysis is converted to alcohol and CO_2 (1 mark) in alcohol fermentation; and lactic acid in lactic acid fermentation (1 mark).

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + E$ (2 ATP) (5 marks)

$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3 + E$ (2 ATP) (5 marks)

Both types of fermentation are applied in food processing (1 mark). Alcohol fermentation is used in the breweries to prepare alcoholic beverages such as beer Guinness, pito, palm wine, etc (1 mark); in preparing some foods such as bread, kenkey, gari etc (1 mark). Lactic acid fermentation is used in the preparation of yoghurt and cheese (1 mark). However, accumulation of lactic acid in the skeletal muscle (1 mark) cause muscle fatigue (1 mark) during strenuous exercise; which can cause muscle contraction. This is very painful and can cease the movement of the individual, and fall in the process (1 mark).

Maximum marks = 25 marks

APPENDIX E

SCORING RUBRICS FOR CONCEPT MAPS

1. Concepts: Score 1 point for each concept that is connected to at least one other concept by a proposition.
2. Hierarchy: score 5 points for each valid level.
3. Propositions: for each meaningful valid proposition score 1 point.

Penalty

Score zero (0) for the following;

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

Concept map on importance of photosynthesis

Concepts…………………………………………. 1 × 18 = 18 marks

Hierarchy…………………………………………..5 × 5 = 25 marks

Propositions………………………………………..1 × 23 = 23 marks

Crosslink………………………………………………10 × 1 = 10

Total ………………………………………………….76 marks

Concept map on anaerobic respiration

Concepts……………………………………………..1 × 17 = 17 marks

Hierarchy …………………………………………….5 × 5 = 25 marks

Propositions………………………………………..1× 22 =22 marks

Crosslink………………………………………………10 × 1 = 10

Examples……………………………………………….1 × 4 = 4

Total…………………………………………………… 78 marks

APPENDIX F

CONCEPT MAP DIAGRAMS

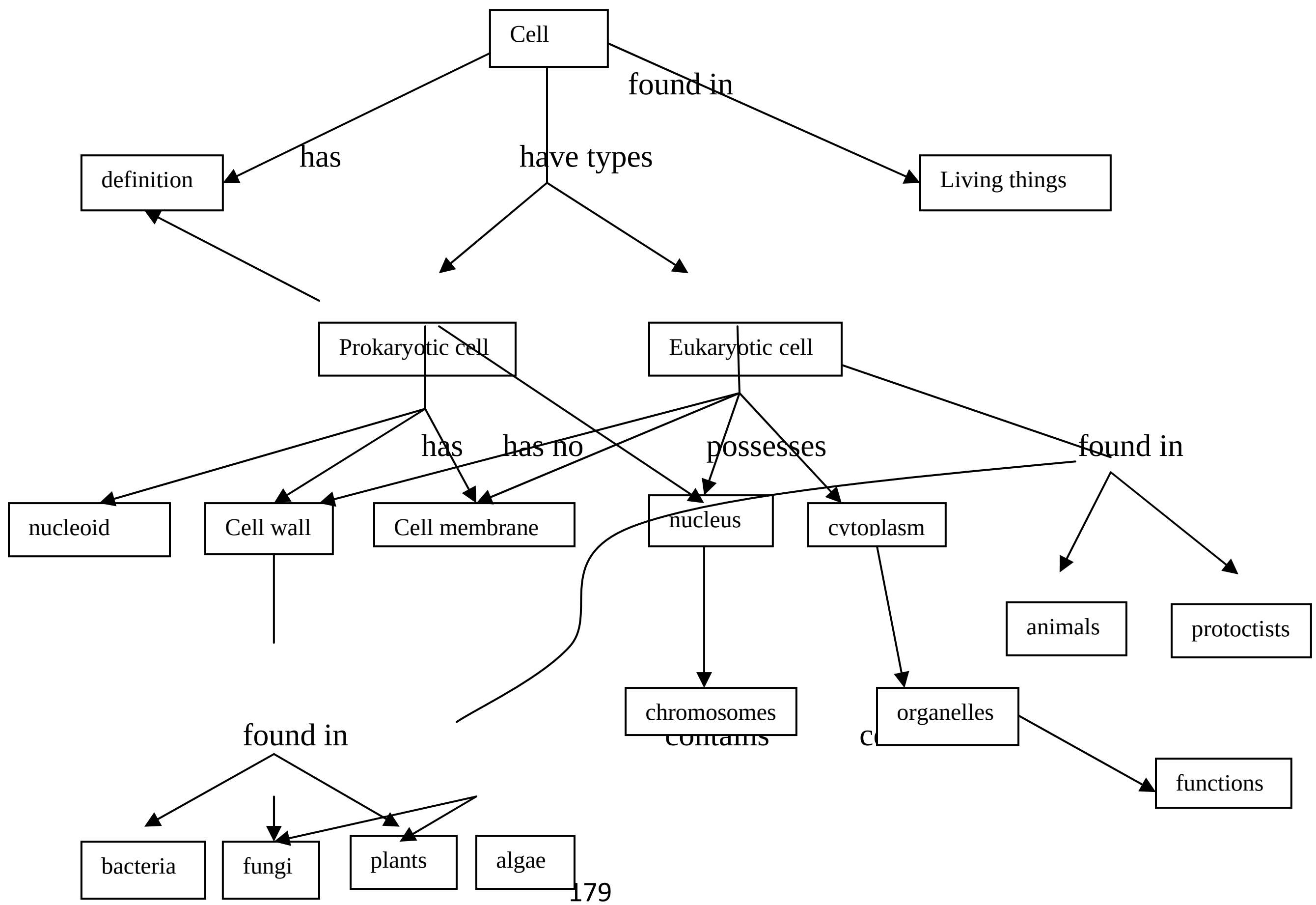
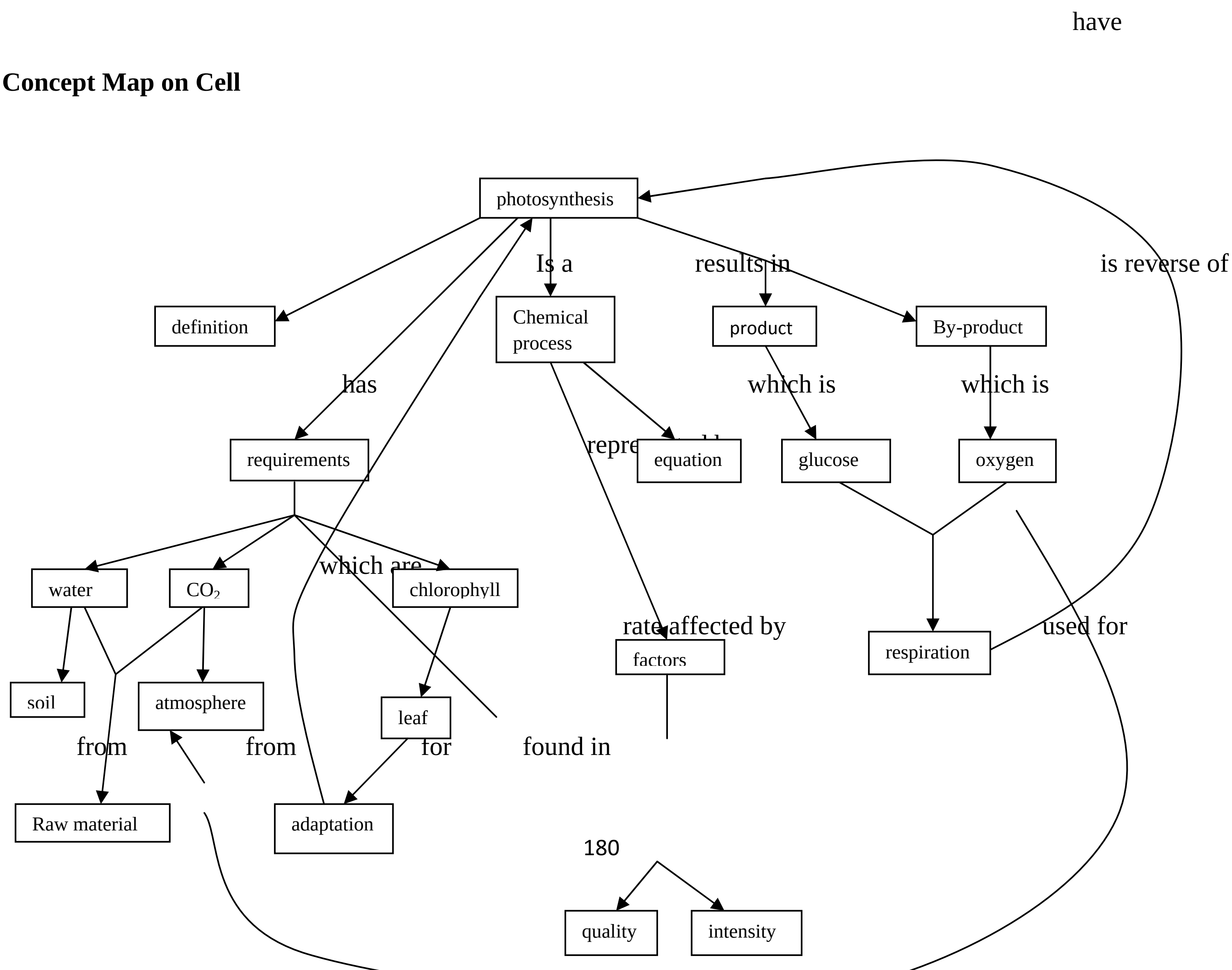


Figure 4: Concept Map on Cell



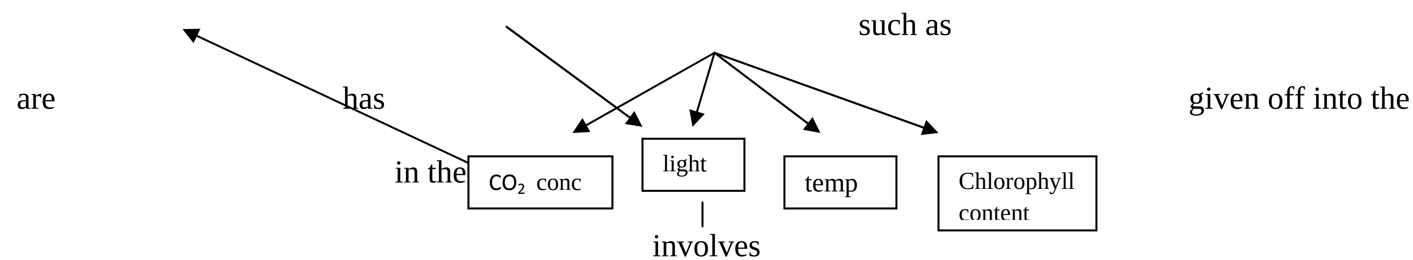
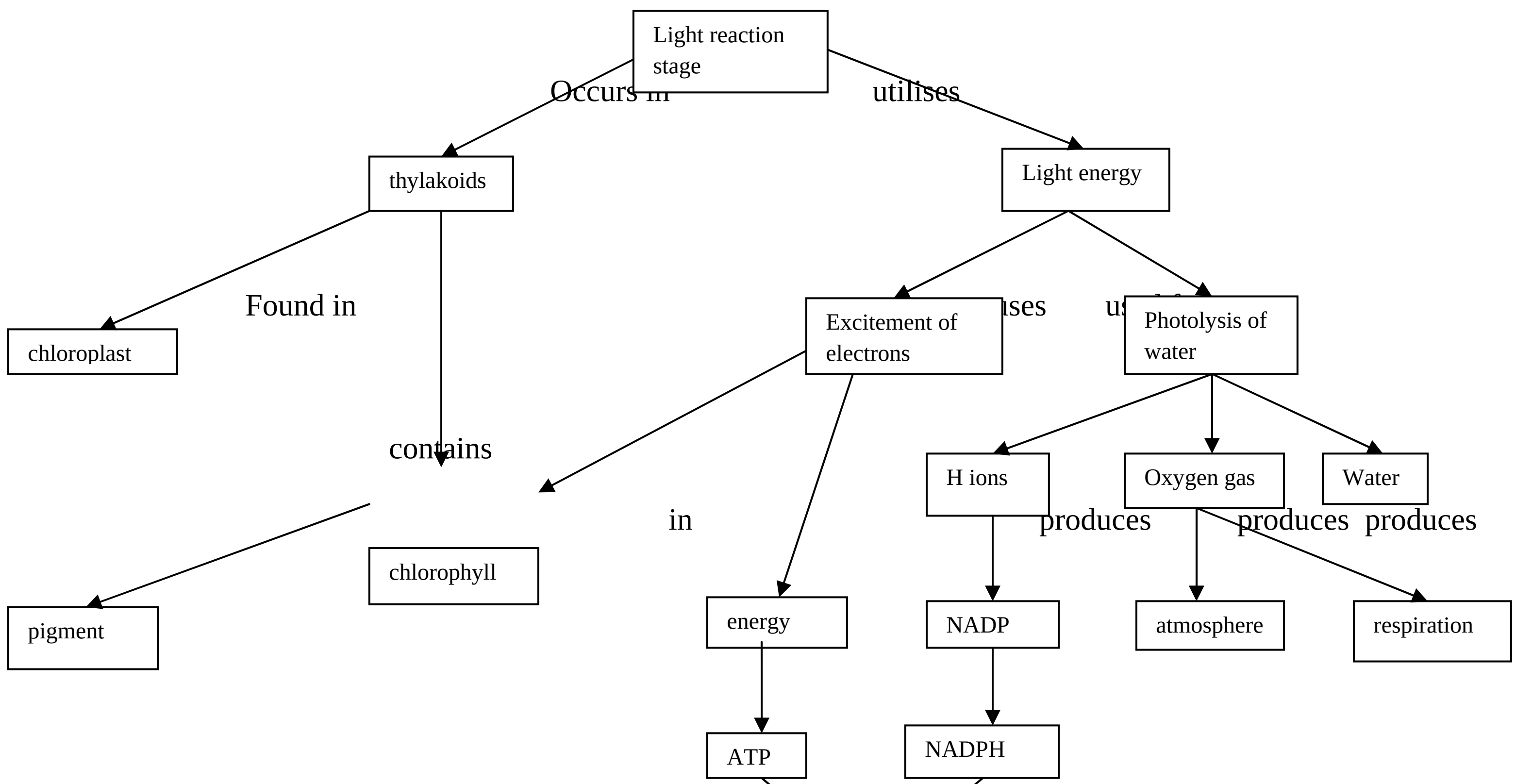


Figure 5: Micro Concept Map on Photosynthesis



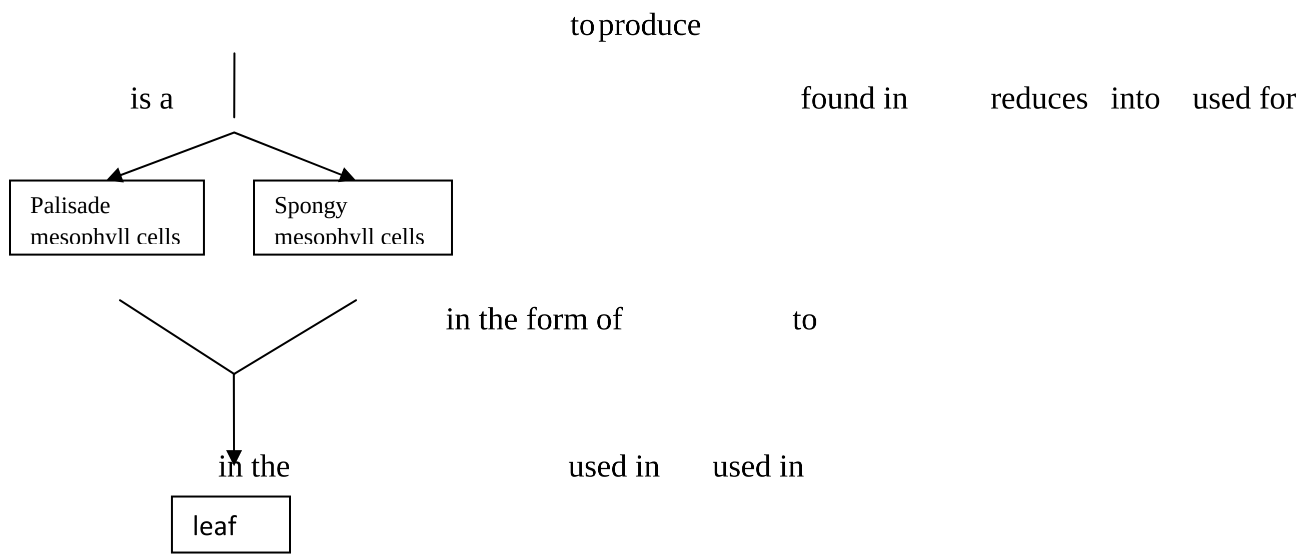
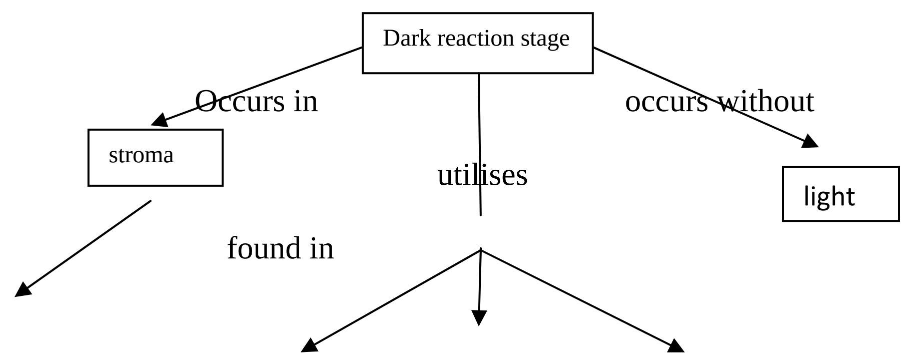


Figure 6: Micro concept map on light stage of photosynthesis



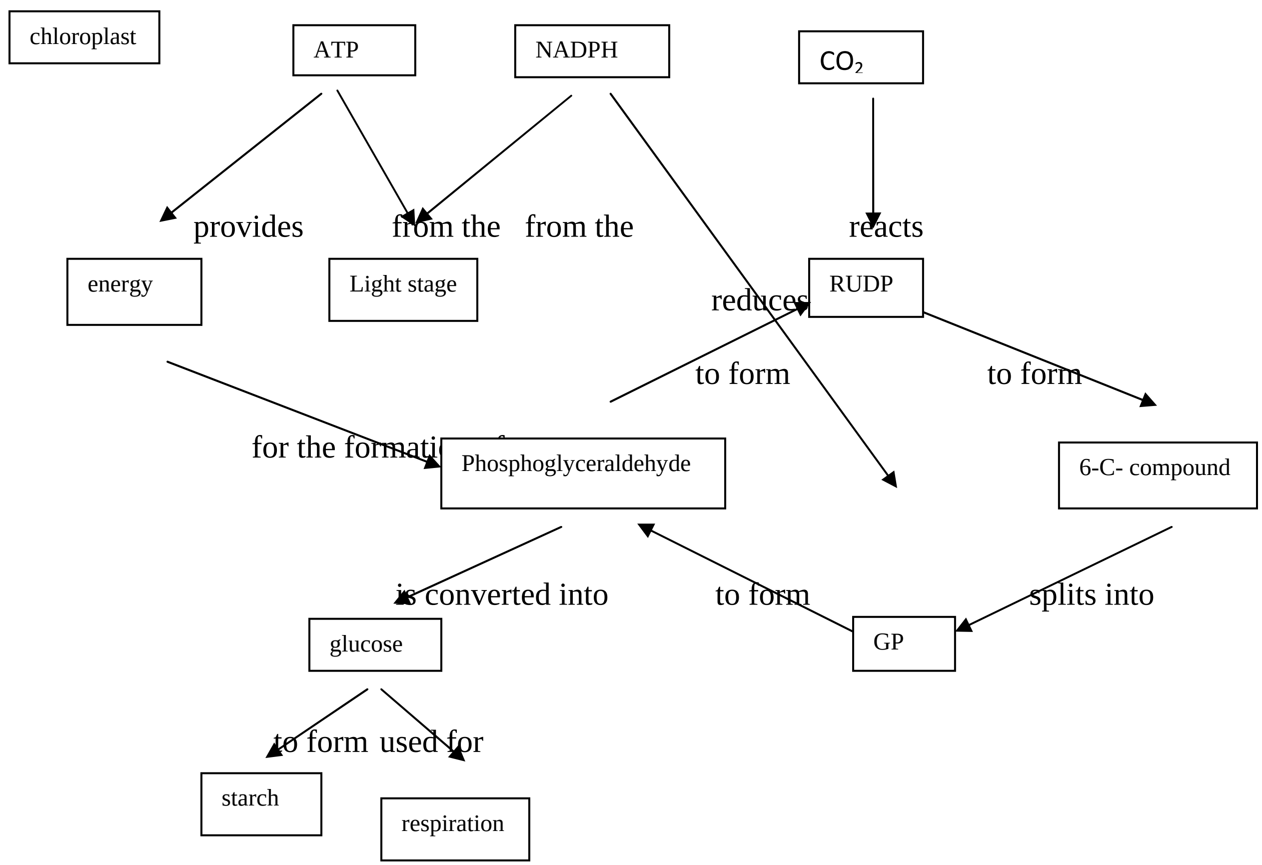
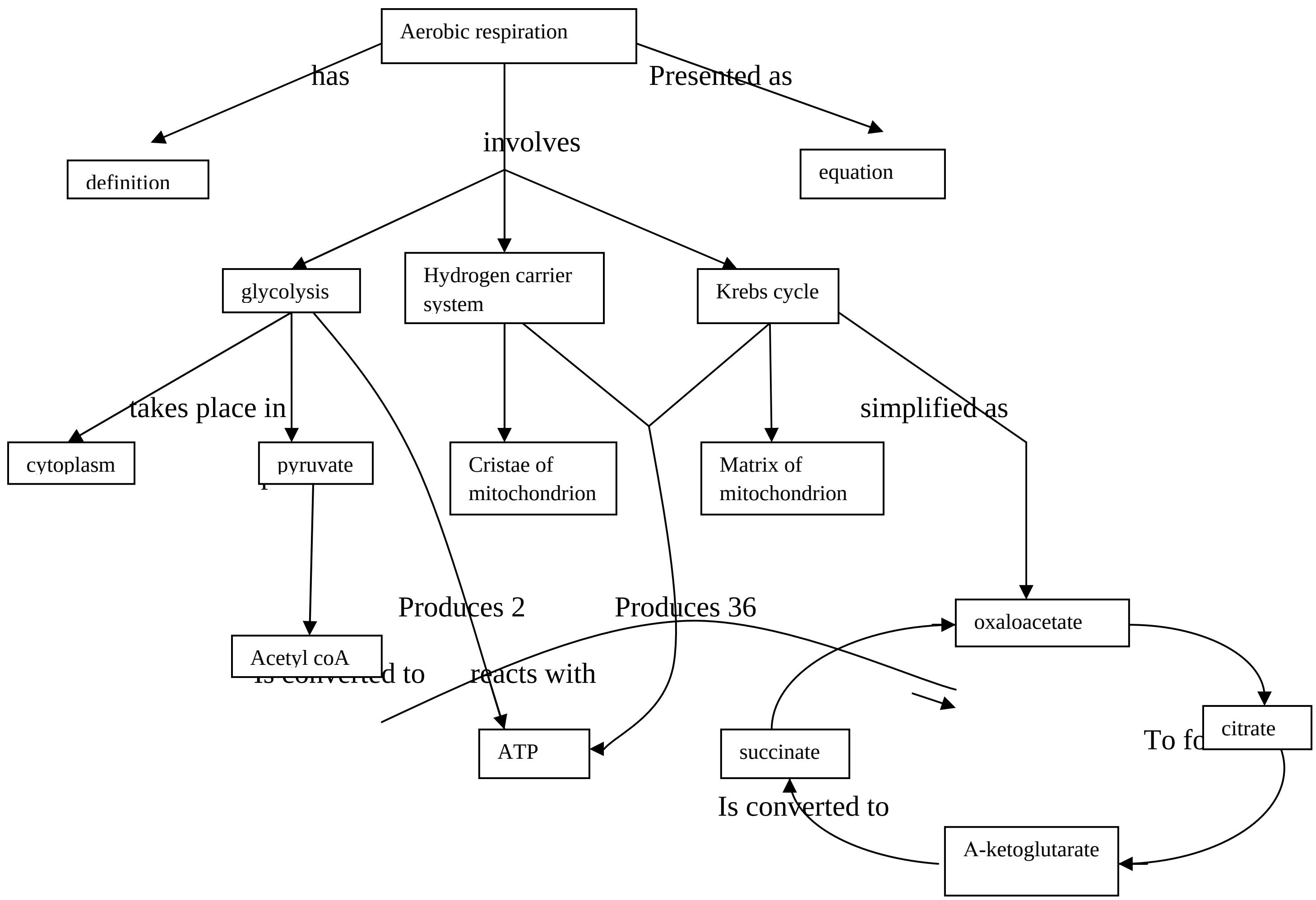


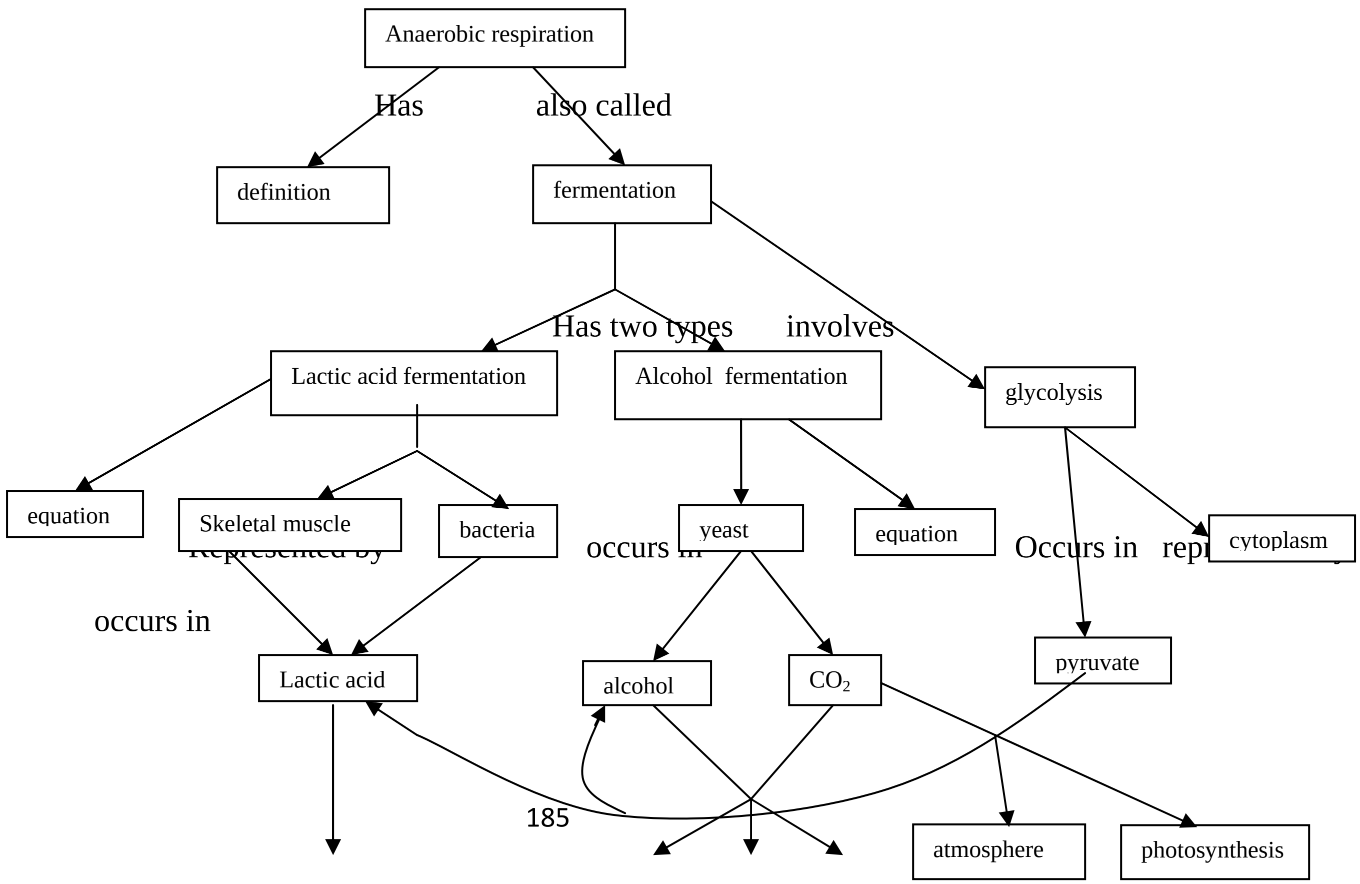
Figure 7: Micro Concept Map on Dark Reaction Stage of Photosynthesis


Aerobic respiration
has
Presented as
involves
definition
equation
glycolysis
Hydrogen carrier system
Krebs cycle
takes place in
simplified as
cytoplasm
pyruvate
Cristae of mitochondrion
Matrix of mitochondrion
Produces 2
Produces 36
oxaloacetate
Acetyl coA
Is converted to
reacts with
ATP
succinate
To fo
citrate
Is converted to
A-ketoglutarate

decarboxylated to form

CO_2 removed to form

Figure 8: Micro Concept Map on Aerobic Respiration



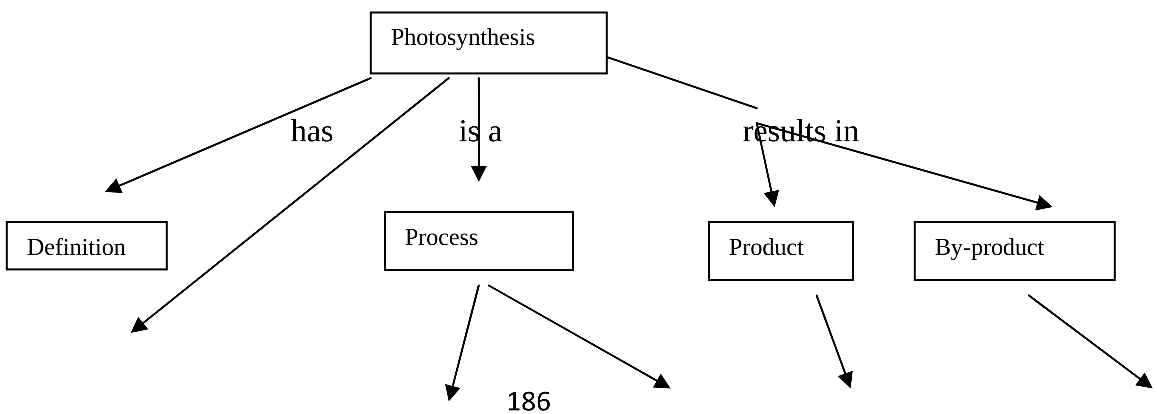
To produce produces

For preparing For preparing

produces Released into used for

yoghurt bread pito kenkey

Figure 9: Micro Concept Map on Anaerobic Respiration



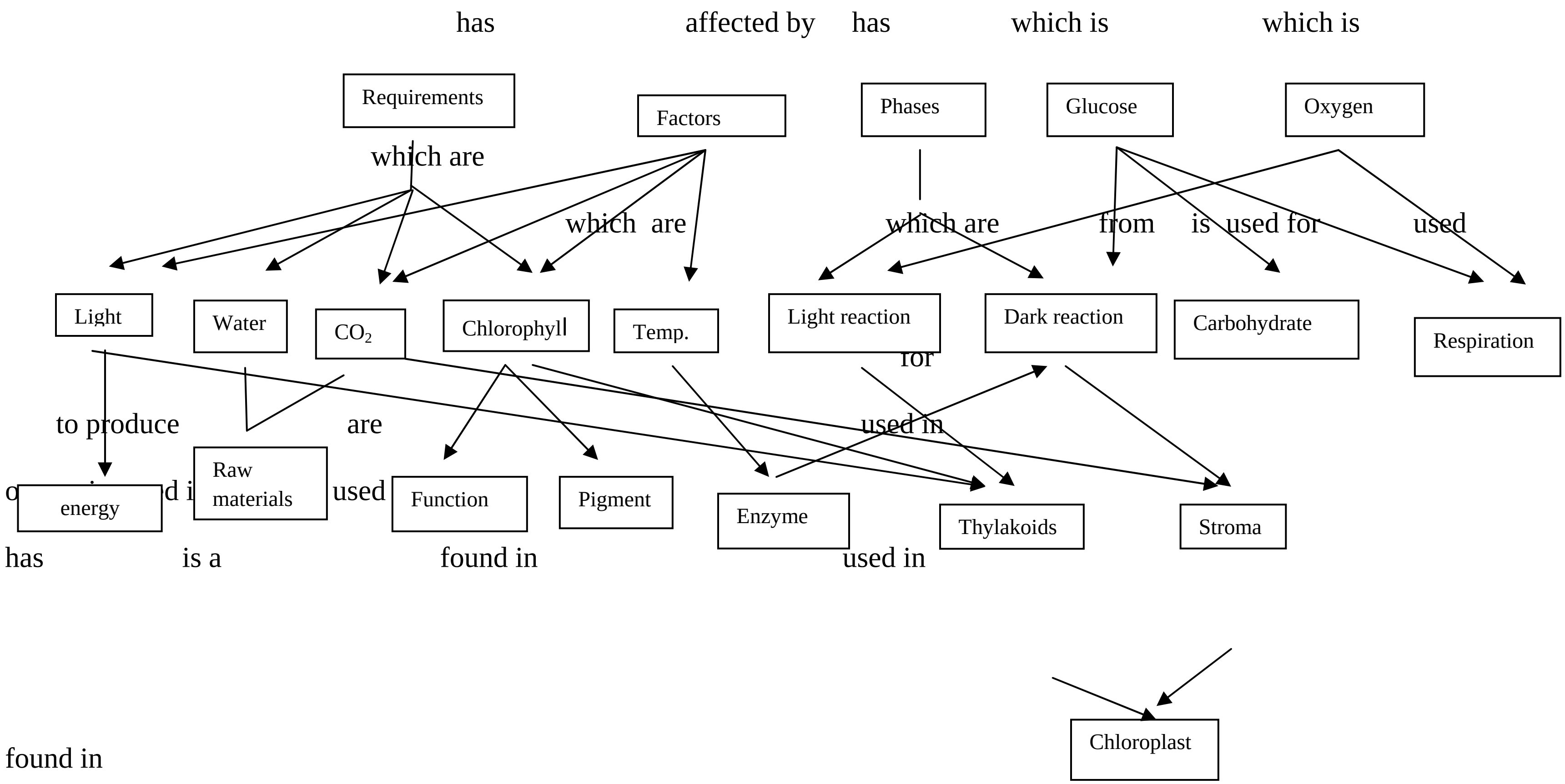


Figure 10: Full Concept Map on Photosynthesis

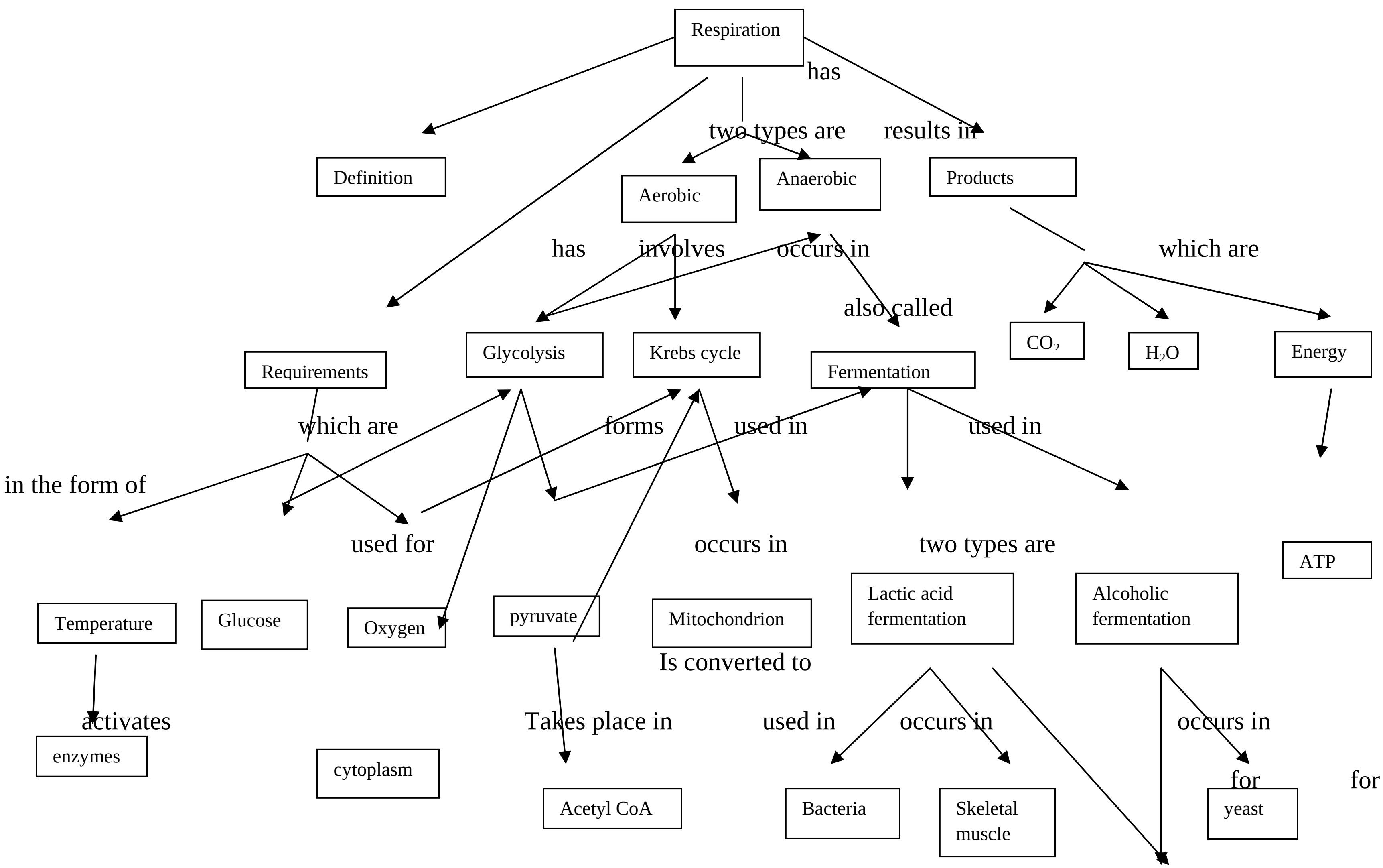
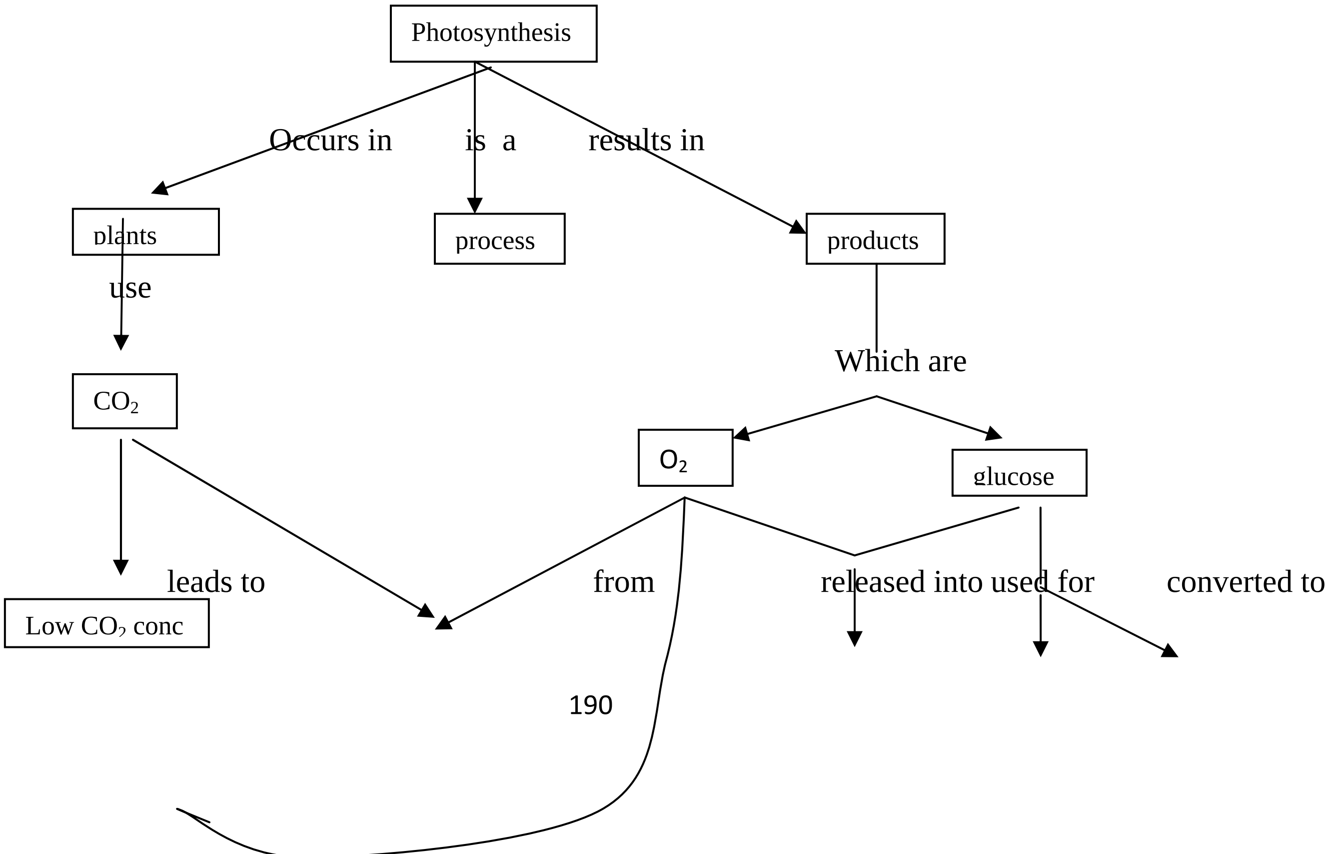

Respiration
has
two types are
results in
Definition
Aerobic
Anaerobic
Products
has
involves
occurs in
which are
also called
CO_2
H_2O
Energy
Requirements
Glycolysis
Krebs cycle
Fermentation
which are
forms
used in
used in
in the form of
used for
occurs in
two types are
ATP
Temperature
Glucose
Oxygen
pyruvate
Mitochondrion
Lactic acid fermentation
Alcoholic fermentation
Is converted to
activates
Takes place in
used in
occurs in
occurs in
enzymes
cytoplasm
for
for
Acetyl CoA
Bacteria
Skeletal muscle
yeast

Figure 11: Full Concept Map on Respiration



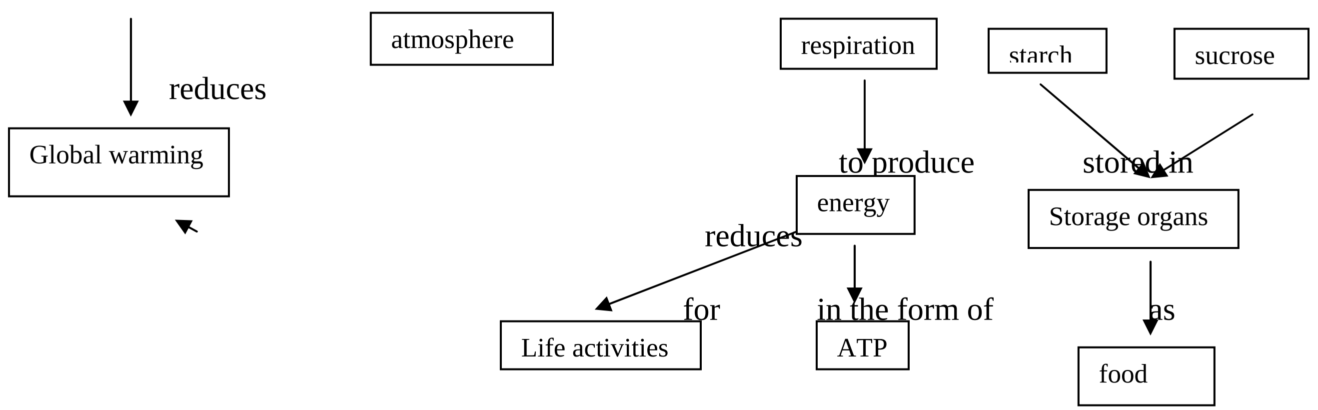


Figure 12: Full Concept Map on Photosynthesis

APPENDIX G

LESSON PLANS FOR THE EXPERIMENTAL AND CONTROL GROUPS

LESSON PLAN 1 FOR TEACHING THE EXPERIMENTAL CLASS USING CONCEPT MAPPING TECHNIQUE

Subject: Biology Date: Duration: 80 minutes Class: SHS 3

Topic: Photosynthesis Time: Place: Classroom Number of students:

Previous knowledge: Students know about autotrophic and heterotrophic modes of nutrition.

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

1. explain the term photosynthesis.
2. list at least three adaptations of the leaf to photosynthesis
3. list at least three factors affecting rate of photosynthesis
4. explain how at least one of the listed factors affect the rate of photosynthesis.

Pre-lesson preparation: Teacher prepares a concept map of photosynthesis, a chart, showing the morphological and anatomical structure of the leaf.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	
Introduction (5 minutes)		Explain concept map and its uses to students. Puts students into groups of	Students listen, write down relevant points and study the map given them.	

		four and give each group a photocopy of concept map of animal cell. (Figure 4 Appendix F) show students how to draws a concept map by constructing one on the board.		

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
<u>Content Development</u> <u>Step I</u> Explanation of		Ask students to explain the term photosynthesis. Lead students to	Students give explanation to photosynthesis. e.g	Photosynthesis is a process whereby green plants (and some algae and bacteria) prepare food

Photosynthesis (10 minutes)		construct micro concept map to explain photosynthesis. Ask students to derive equation from the explanation for the process of photosynthesis	photosynthesis is a process by which plant prepare their food Students participate in the construction of micro concept map. Students try writing equation to represent	(glucose) from carbon (iv) oxide and water in the presence of chlorophyll using energy from light. $6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2$
STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
<u>Step II</u>			photosynthesis in their notebooks and on the board	

Adaptation of the Leaf to Photosynthesis (15 minutes)	A chart showing the morphology and anatomy of the leaf	Show to students a chart of the morphology and anatomy of the leaf. Discuss with students the adaptations of the leaf to photosynthesis	Students look at chart. Students contribute to discussion by answering teacher's question	1.The leaf is broad and flat, giving it a large surface area to allow absorption of light and carbon (iv) oxide 2.The presence of abundant
STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
	.	through questioning. E.g why do you think the palisade mesophyll	Expected answer: because they are closer to the upper surface of the	chloroplast in the palisade mesophyll cells to trap light energy.

Step III Factors Affecting the Rate of Photosynthesis.		cells have more chloroplast? Ask students the following question. what are some of the	leaf, they have to be many to trap maximum amount of light	Presence of stomata for gaseous exchange CO_2 concentration, temperature, light, pollution, chlorophyll concentration are

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
(20 minutes)		factors affecting the rate of photosynthesis discuss with students	Students answer teacher's question. Expected answer: CO_2	factors affecting rate of photosynthesis. Limiting factor of a

		through question and answers how these factors affect rate of photosynthesis. See APPENDIX 5 E.g. How does CO_2 concentration affect rate of photosynthesis?	concentration, light, temperature, pollution and chlorophyll concentration Expected answer: when CO_2 concentration in the atmosphere increase rate of photosynthesis increase	process is the factor present in its minimal value and a change in its value affects the whole process when there is high chlorophyll concentration in the leaf, rate of

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
			and low CO_2 concentration decrease the rate of	Photosynthesis increases, and a decrease in chlorophyll content in a leaf reduces the rate of

Application (5 minutes)		Ask students the following question. E.g. A cassava farm was situated under a big tree with a thick canopy.	photosynthesis. Students respond to the question. Expected answer: because the cassava plants were getting	photosynthesis, hence chlorosis affect rate of photosynthesis,

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	
		When the cassava was harvested at the end of the crop season the	Minimum amount of light, rate of photosynthesis was low, hence few starch was	

Closure Evaluation (20 minutes)		yield was very low. How do you explain this? Arrange students for group work to construct concept map on photosynthesis.	available for storage hence the low yield. Students work in groups to construct concept maps by: 1. Arranging concepts	Concepts for constructing concept maps are: photosynthesis, definition,

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
		Ask students to present concept maps. Allocate 5 marks for	Hierarchically. 2. using arrows to show linkages along	equation, requirements, product, process, by-product, factors light, temperature, CO_2 concentration,

		each hierarchy, 1 mark for every valid proposition, no mark for invalid proposition, and no mark for missing labels.	and across hierarchies 3. writing linking word and phrases on each arrow	chlorophyll content, glucose, oxygen, respiration, Water, light, CO_2, chlorophyll, raw materials, soil, atmosphere, sun, leaf, adaptation,

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
		Give feed back to students on their concept maps	Students submit their maps for scoring.	

closure summary (5 minutes)		constructed Summarise lesson by going through the constructed map	Students listen to teacher	

Assignment:

1. Explain how the following affect rate of photosynthesis
   i. carbon (iv) oxide concentration
   ii. light
2. Using concept mapping explain the factors which affect photosynthesis

References:

Nyavor, C. B. & Seddoh, S. (2006). *Biology for senior secondary schools* (3rd ed.). London: Macmillan Publishers.

Mader, S (2000). *Biology* (7th ed.). New York: Macmillan Publishers.

Stone. R.H. (1985). *New Biology for West African Schools*. London: Longman Group, UK. Ltd.

Remarks:

LESSON PLAN 2 FOR TEACHING THE EXPERIMENTAL CLASS USING CONCEPT MAPPING TECHNIQUE

Subject: Biology Date: Duration: 80 minutes Class: SHS 3

Topic: light and Dark Reaction stages of Photosynthesis Time: Place: Classroom Number of students:

Previous knowledge: Students can explain at least one of the factors which affect the rate of photosynthesis.

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

1. explain the steps involved in the light reaction stage of photosynthesis
2. explain the steps involve in the dark reaction stage of photosynthesis
3. explain the fate of products of photosynthesis.

Pre-lesson preparation: Teacher prepares a concept map of light and dark reaction stages of photosynthesis (figures 6 and 7), and procures chart showing the light and dark reaction stages of photosynthesis.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
Introduction (5 minutes)		Revise previous concept map through questions	Students contribute to discussion by answering	

		using researcher made concept map. E.g which of the concepts on the map are broad? (Figure 5). Puts students into groups of five.	teacher’s question. Expected answer: photosynthesis, requirement, factors and product. Students organize themselves into five groups	

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS’ ACTIVITY	

STAGE/STEP/ CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATETGIES TEACHER ACTIVITY	INSTRUCTIONAL STRATETGIES STUDENTS' ACTIVITY	MAJOR IDEAS
<u>Content development</u> <u>Step I</u> Light Reaction Stage of Photosynthesis (20 minutes)	A chart showing the light reaction stage of photosynthesis	Use a chart to explain the light stage of photosynthesis. Write chemical equations involved with the reaction on the board. Use students' idea to construct micro concept maps on the light reaction stages of photosynthesis using questions (figure 6). e.g list the	Students look at chart and ask questions at some stages of delivery of lesson. Expected questions: 1. how does photolysis occur? 2. What is the use of the ATP produced?	Light reaction stage occurs in the thylakoids. Chlorophyll molecules in the thylakoids absorb light energy. This causes the electrons to be excited and release energy in the process. This energy is used in the synthesis of ATP. Some of

step I Light Reaction Stage of Photosynthesis	A chart showing the light reaction stage of photosynthesis	concepts involved in a hierarchical order. Answer: 1. It occurs by water splitting in to its component units using light energy. 2. ATP is used to drive the dark stage of photosynthesis	Students contribute towards construction of micro concept maps. Expected contribution: the concepts are : photosynthesis, thylakoids, chlorophyll, light, energy, molecules, ATP, photolysis, water, oxygen, H atom, NADP	the light energy is used in photolysis of water. $H_2O \rightarrow OH^- + H^+$ $4OH^- \rightarrow 2H_2O + O_2$ $2H^+ + NADP \rightarrow NADPH + H^+$ ATP and NADPH are used in the dark reaction stage of photosynthesis.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	

<u>step II</u> The Dark Reaction Stage of Photosynthesis (20 minutes)	A chart showing the dark reaction stage of photosynthesis	Use chart to explain to students the dark reaction stage of photosynthesis. Answer: the reaction was first discovered by Calvin. Use students idea to construct micro concept map on the dark reaction stage	Students look at chart, listen to teacher and ask questions. Expected question: why is the cycle called Calvin Cycle? Students contribute to the construction of micro concept	Dark reaction stage of photosynthesis occurs in the stroma of the chloroplast. Dark stage utilizes NADPH and ATP from light reaction stage and CO_2 from the atmosphere. CO_2 enters the Calvin cycle and reacts with a five carbon compound Ribulose Diphosphate (RuDP) to form an unsTable six carbon compound in the presence of the enzyme RuDP carboxylase. The unsTable compound splits into two molecules of
STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	

step II The Dark Reaction Stage of Photosynthesis (20 minutes)	Chart showing the dark reaction stage of photosynthesis	of photosynthesis	maps. Expected contribution: the linking phrase between dark stage and light is 'occurs without'	glycerate-3-phosphate (three carbon compound). Glycerate-3-phosphate (GP) is the first product of photosynthesis. GP is reduced by reacting with NADPH to form phosphoglyceraldehyde (triose phosphate). Energy used is provided by ATP. Triose phosphate undergoes a series of reaction to form RuDP. The rest of the triose phosphate is used to form glucose.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	

step III The Fate of Products of Photosynthesis (5 minutes)		Discuss with students the fate of the products of photosynthesis using questioning and response. E.g. How is starch formed from glucose?	Students contribute to discussion. Expected answer: starch is formed by polymerization of glucose.	The main product of photosynthesis is glucose. Glucose is converted to starch, sucrose for storage. Glucose is converted to protein by addition of sulphur, and nitrogen. Glucose is also converted into cellulose and lipids to form the structure of cell wall and protoplasmic component. Glucose is metabolized to prelease energy. Oxygen, as a bi-product is used for respiration.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	

<u>Application</u> (5 minutes)		Pose a question to students. A maize plant situated under a street light by a roadside grew tall and greenish. Irrespective of this when it was due for harvest there were very few corn on the cob. How do you explain this by photosynthesis?	Students answer question. Expected answer: Since there is light available throughout the day and night, there is continuous photosynthesis. There is accumulation of products of photosynthesis in the leaf and this prevents more starch to be formed. Hence little starch is produced for storage.	

STAGE/STEP/CONTENT ITEM (ESTIM;ATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	

- <u>Closure</u> <u>Evaluation</u> (20 minutes)		Put students into groups of five to construct concept map on the lesson. Ask students to present their work.	Students construct concept maps in groups of five. Students present their maps for discussion.	The concepts for construction of concept maps are: Light reaction stage ,dark reaction stage, thylakoids, chloroplast chlorophyll, electrons, light energy, photolysis, ATP, NADPH, CO_2, RuDP, RuDP carboxylase, GP, Phosphoglyceraldehyde, glucose, starch, protein, sucrose.

STAGE/STEP/CONTENT ITEM (ESTIM;ATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	

- Closure summary (25 minutes)		Summarise the lesson by going over the concept map constructed	Students listen to teacher.	

Assignment:

1. What is your view on the statement that all living organisms depend on the sun for survival?
2. How is the protein stored by the ground-nut plant formed?
3. Use concept mapping to represent the answer produce for question

References:

Nyavor, C. B. & Seddoh, S. (2006). *Biology for senior secondary schools* (3rd ed.). London: Macmillan Publishers.

Mader, S (2000). *Biology* (7th ed.). New York: Macmillan Publishers.

Stone, R. H. (1985). *New Biology for West African Schools*. London: Longman Group, UK. Ltd.

Remarks:

LESSON PLAN 3 FOR TEACHING THE EXPERIMENTAL CLASS USING CONCEPT MAPPING TECHNIQUE

Subject: Biology	Date:	Duration: 80 minutes	Class: SHS 3
Topic: Respiration	Time:	Place: Classroom	Number of students:

Relevant Previous knowledge: Students can explain that they have to eat to get energy for various activities.

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

1. explain the term respiration.
2. analyse the process of aerobic respiration

Pre-lesson preparation: Teacher prepares a concept map (figure 8) and chart on respiration.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	

Introduction (5 minutes)		Lead class discussion using questions to revise concept map of previous lesson using researcher’s map. E.g. How do we begin the construction of concept map?	Students participate in class discussion by answering teacher’s question. Expected answer: we begin with the broadest concept at the top of the map.	
Content development step I Explanation of the Term Respiration (5 minutes)		Ask students to explain respiration in their own words. E.g. how do you explain respiration in your own words?	Students attempt to explain respiration in their own words. Expected explanation: this a process in living organisms which	Respiration is the sum total of the chemical processes that release energy from food

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS' ACTIVITY	MAJOR IDEAS
step II Aerobic Respiration (5 minutes)		Ask students the following question: what is aerobic respiration? Mention to students that the two stage of aerobic respiration are	leads to the production of energy through the oxidation of food. Students answer question. Expected answer: aerobic respiration requires molecular oxygen to break down food to release energy.	substances within cells, with or without the participation of molecular oxygen. Aerobic respiration involves molecular oxygen. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + Energy$ The two stages of aerobic respiration are Glycolysis and Krebs cycle (Tricarbocylic Acid

STAGE/STEP/ CONTENT ITEM	TEACHING- LEARNING	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER	STUDENTS'	

(ESTIMATED TIME)	MATERIALS	ACTIVITY	ACTIVITY	
		are gycolysis and Krebs cycle	Students listen and write in their notebooks.	Cycle) And The Hydrogen carrier system
<u>step II</u>I Glycolysis (I5 minutes)		Explain steps in gycolysis using a chart. Write the steps on the board.	Students listen to teacher and writes steps of glycolysis in to their notebooks	Glycolysis occurs in the cytoplasm of a cell. No oxygen is used. Glycolysis is common to both aerobic and anaerobic respiration. Steps in glycolysis. 1. glucose is converted to glucose

STAGE/STEP/CONTENT ITEM	TEACHING-LEARNING	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER	STUDENTS’	

(ESTIMATED TIME)	MATERIALS	ACTIVITY	ACTIVITY	
step III Glycolysis. (15 minutes)				phosphate. 2.Glucose phosphate is converted to fructose phosphate. 3. Fructose phosphate is converted to fructose diphosphate. 4. Fructose diphosphate is converted to pyruvate. Pyruvate is used in Krebs Cycle.
step IV The Krebs Cycle (20 minutes)	Chart of Krebs Cycle	Explain Krebs Cycle to students using chart	Students pay attention to teacher and write steps of the Krebs Cycle	Krebs Cycle occurs in the matrix of mitochondrion. Requires the use of oxygen. Pyruvate is converted to an acetyl compound (a two-carbon compound) which

STAGE/STEP/ CONTENT ITEM	TEACHING- LEARNING	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS'	

(ESTIMATED TIME)	MATERIALS		ACTIVITY	
<u>step IV</u> Krebs Cycle (20 minutes)				reacts with Co-enzyme A to form acetyl CoA. Acetyl CoA enters the Krebs Cycle and reacts with oxaloacetate (a four-carbon Compound) to form citrate (a six-compound). This is the first product of the Krebs cycle. Citrate is oxidised to α-ketoglutarate (five-C-compound). This is also oxidised to succinate (four-C-compound). Succinate is converted
STAGE/STEP/ CONTENT ITEM	TEACHING- LEARNING	INSTRUCTIONAL STRATEGIES TEACHER ACTIVITY	STUDENTS’ ACTIVITY	MAJOR IDEAS

(ESTIMATED TIME)	MATERIALS			
<u>Application</u> (5 minutes)		Teacher poses the following problem: In a diagnostic test, a chemical which interferes with the production of the acetyl group was found in the	Students attempt to explain the results of problem posed by teacher. Expected answer: since formation of the acetyl is prohibited, acetyl CoA is not formed hence the stages of the Krebs cycle cannot proceed. This means little energy (2 ATP) produced in glycolysis is what will be	to oxaloacetate to begin the Krebs cycle

STAGE/STEP/ CONTENT ITEM	TEACHING- LEARNING	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	

(ESTIMATED TIME)	MATERIALS			
		blood of Akua. Explain the consequences kweku will face.	available to Akua for metabolism. This will affect the physiology of organs which require energy. Akua may have weakness in the body.	
<u>Closure</u> evaluation (20 minutes)		Put students into groups of five to construct concept map on aerobic respiration. Let students to present their	Students construct concept maps in group by: 1. arranging concepts hierarchically	Concept on aerobic respiration includes: aerobic respiration, glycolysis, Krebs cycle,

STAGE/STEP/CONTENT ITEM	TEACHING-LEARNING	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER	STUDENTS ACTIVITY	

(ESTIMATED TIME)	MATERIALS	ACTIVITY		
		Their group concept maps. Allocate 5 marks for each hierarchy,1 mark for every valid proposition, 0 mark for invalid	2. using arrows to show linkages along and across hierarchies. 3. writing explanatory notes on each arrow. Students submit their maps for scoring.	hydrogen carrier system, equation, definition, cytoplasm, pyruvate, mitochondrion, acetyl CoA, ATP, oxaloacetate, citrate, α-ketoglutarate, succinate.

STAGE/STEP/CONTENT ITEM	TEACHING-LEARNING	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	

(ESTIMATED TIME)	MATERIALS			
Summary (5 minutes)		proposition, and 0 mark for missing labels Summarise lesson by going through the concept map constructed on the board (Figure 8).	Students submit their maps for scoring. Students listen to teacher.	reacts with, produces 38,

Assignment:

1. Using illustrations, explain how ATP is produced by the Krebs cycle.
2. Describe the stages of glycolysis.
3. Using concept mapping, explain the importance of glycolysis

References:

Nyavor, C. B. & Seddoh, S. (2006). *Biology for senior secondary schools* (3rd ed.). London: Macmillan Publishers.

Mader, S (2000). *Biology* (7th ed.). New York: Macmillan Publishers.

Stone, R. H. (1985). *New Biology for West African Schools*. London: Longman Group, UK. Ltd.

Remarks:

LESSON PLAN 4 FOR TEACHING THE EXPERIMENTAL CLASS USING CONCEPT MAPPING TECHNIQUE

Subject: Biology   Date: Duration: 80 minutes   Class: SHS 3

Topic: Anaerobic Respiration   Time: Place: Classroom   Number of students:

Relevant Previous knowledge: Students can explain how glycolysis and Krebs cycle release energy.

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

1. explain how energy is produced by the Hydrogen Carrier System.
2. analyse the process of Anaerobic respiration

Pre-lesson preparation: Teacher prepares a concept map and chart on Hydrogen Carrier System and Anaerobic Respiration.

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS' ACTIVITY	MAJOR IDEAS
Introduction (5 minutes)		Revise previous lesson's concept map by asking students to construct concept map on the light reaction stage of photosynthesis (Figures 6 and 7). question: using concept map describe the light stage of photosynthesis	Students individually construct concept map on the light reaction stage of photosynthesis.	

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS' ACTIVITY	MAJOR IDEAS
<u>Content Development</u> <u>Step I</u> Hydrogen Carrier System (15 minutes)	A chart of the hydrogen carrier system	Show students chart of the hydrogen carrier system and build a micro concept map to explain the process. Answer: hydrogen carrier system occurs in the cristae of the mitochondrion.	Students look at chart, listen to teacher and ask questions when necessary. Expected question: where does hydrogen carrier system occur? Students write relevant points and study the map	Pairs of hydrogen atoms removed from substrates during glycolysis and Krebs cycle are accepted by NAD (hydrogen acceptor). Electrons from hydrogen pass through the electron transport system eg cytochrome to produce ATP. Each pair of hydrogen atom produces three ATP
STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES		

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS' ACTIVITY	MAJOR IDEAS
<u>step II</u> Anaerobic Respiration (5 minutes)		Ask students the following question: 1.what is anaerobic respiration? 2. what is the other name of anaerobic respiration	Students answer question. Expected answer: 1. This is a type of respiration which does not require the use of molecular oxygen. 2. Fermentation	Anaerobic respiration involves only glycolysis. Anaerobic respiration is the same as fermentation

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
<u>step III</u> Process of Anaerobic Respiration (20 minutes)	A chart showing process of anaerobic respiration	Use chart to discuss the process of anaerobic respiration. Using question. 1. What are the products of alcohol and lactic acid fermentation? 2. What are the uses of alcohol and yeast?	Students listen and answer question. Expected answer: 1. alcohol and carbon dioxide; and lactic acid. 2.alcohol fermentation is used for preparing bread, gari beer, pito while lactic acid	Alcohol fermentation occurs in yeast. $C_6H_{12}O_6 \longrightarrow C_2H_5OH + CO_2 + E$ Lactic acid fermentation occurs in the skeletal muscle and in some bacteria. $C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3 + E$ accumulation of large amount of lactic acid leads to muscle fatigue in sportsmen. Yeast fermentation is used in food processing and

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
step III Process of Anaerobic Respiration (20 minutes)	A chart showing process of anaerobic respiration		fermentation is used in preparing yoghurt	Breweries. Lactic acid fermentation is also used in food processing e.g. yoghurt.
Step IV Uses of energy produced from respiration		Discuss the uses of energy produced from respiration with students using questioning. E.g. what are	Students contribute to discussion by answering question. Expected	Energy from respiration is used for biosynthesis e.g. protein, muscular
STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES		

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS' ACTIVITY	MAJOR IDEAS
Content development step V Uses of Energy from Respiration (10 minutes)		uses of the energy produced from respiration?	answer: for movement, metabolism, and reproduction	Contraction, heat production, active transport, and transmission of nerve impulse
Application (5 minutes)		Pose the following problem: during the inter-school athletic competition Owusu, a 100m runner fell down during the race due to	Students give answer to cause of problem. Expected answer: as Owusu runs vigorously, oxygen debt occurs in	
STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES		

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS' ACTIVITY	MAJOR IDEAS
<u>Application</u> (5 minutes)		muscle fatigue. What might account for this?	the muscles leading to lactic acid accumulation. This causes muscle fatigue. This make the muscles to contract and the athlete feel pains and falls down.	
<u>Closure</u> <u>evaluation</u> (20 minutes)		Make students to construct concept map on anaerobic	Students work individually to construct concept maps by 1. arranging concepts hierarchically	Concepts for building concept map are: Anaerobic respiration, fermentation,
STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES		

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS' ACTIVITY	MAJOR IDEAS
Evaluation (20 minutes)		respiration individually ask students to present their concept maps. Allocate 5 marks for each hierarchy,1 mark for every valid proposition, 0 mark for invalid proposition, and 0 mark for missing labels	2. using arrows to show linkages along and across hierarchies. 3. writing explanatory notes on each arrow. Students submit their maps for scoring.	Alcohol fermentation, lactic acid fermentation, Pyruvate, glycolysis,yeast, bacteria, lactic acid, alcohol, food processing, muscle fatigue.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
summary (5 minutes)		Summarise the lesson by going through the concept map constructed on the marker board. (Figure 9)	Students listen to teacher.	

Assignment:

1. List three local foods processed by fermentation.
2. Explain how one of the foods mentioned in question 1 is processed using fermentation.
3. Use concept map to explain the importance of respiration

References:

Nyavor, C. B. & Seddoh, S. (2006). *Biology for senior secondary schools* (3rd). London: Macmillan Publishers.

Mader, S (2000). *Biology* (7th ed.). New York: Macmillan Publishers.

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Remarks:

LESSON PLAN 1 FOR TEACHING THE CONTROL CLASS USING THE TRADITIONAL METHOD

Subject: Biology | Date: | Duration: 80 minutes | Class: SHS 3

Topic: Photosynthesis | Time: | Place: Classroom | Number of students:

Previous knowledge: Students can explain autotrophic mode of nutrition.

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

1. explain the term photosynthesis.
2. list at least three adaptations of the leaf to photosynthesis
3. list at least three factors affecting rate of photosynthesis
4. explain how at least one of these factors affect the rate of photosynthesis

Pre-lesson preparation: Teacher prepares a chart showing the morphological and anatomical structure of the leaf.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
Introduction (5 minutes)		Revise students' previous knowledge through questions and introduces the lesson for the day Questions: 1. What is autotrophic mode of nutrition?	Students answer teachers' questions. Expected answers 1. Autotrophic mode of nutrition is a mode of nutrition exhibited by organisms which prepare their own food.	

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
		2. What is heterotrophic mode of nutrition? 3. Mention one example each of organisms which exhibit each of these mode of nutrition	2. This is a type of nutrition exhibited by organisms which depend directly or indirectly on the auototrophs for their food. 3. Example of an autotroph is green plant; example of heterotroph is man.	

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
Content Development Step I Explanation of Photosynthesis (10 minutes)		Ask students to explain the term photosynthesis. Question: in your own words explain the term photosynthesis. Write main ideas on board. Teacher ask students to derive equation from the explanation for the process of photosynthesis	Students give explanation to photosynthesis. Expected answer: photosynthesis is a process by which plants prepare their food. Students write equation in their notebooks	Photosynthesis is a process whereby green plants (and some algae and bacteria) prepare food (glucose) from carbon (iv) oxide and water in the presence of chlorophyll using energy from light (sunlight). $6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2$
STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES		

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
<u>step II</u> Adaptation of the Leaf to Photosynthesis (25 minutes)	A chart showing the morphology and anatomy of the leaf	Show to students, a chart of the morphology and anatomy of the leaf. Use questioning to discuss with students the adaptations of the leaf to photosynthesis. E.g why do you think the palisade mesophyll cells have	Students look at chart and answer question. Expected answer: because they are closer to the upper surface of the leaf, they have to be many to trap maximum amount of	1. The leaf is broad and flat, giving it a large surface area to allow absorption of light and carbon (iv) oxide 2. The presence of abundant chloroplast in the palisade mesophyll cells to trap light energy. 3. Presence of stomata for gaseous
STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES		

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
step III Factors Affecting the Rate of Photosynthesis. (30 minutes)	.	more chloroplast? Ask students to the following question. e.g. what are the factors which affect the rate of photosynthesis? Explain to students how these factors affect the rate of Photosynthesis.	Light Students answer question. Expected answer: CO_2 concentration, light, temperature, and pollution	exchange Factors affecting rate of photosynthesis are: CO_2 concentration, temperature, light, pollution, chlorophyll concentration. Limiting factor is the factor present in its minimal value and a change in its value affects the whole process

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
<u>Application</u> (5 minutes)		Ask students the following question. A cassava farm was situated under a big tree with a thick canopy. When the cassava was harvested at the end of the crop season the yield was very low. How do you explain this?	Students respond to the question. Expected answer: because the cassava plants were getting minimum amount of light, rate of photosynthesis was low, hence few starch was available for storage hence the low yield.	

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
<u>Closure</u> <u>Summary and evaluation of lesson</u> (5 minutes)		Teacher summarises the lesson using questions. 1. What is photosynthesis? 2. List three adaptation of the leaf to photosynthesis 3. List three factors which affect photosynthesis. 4.explain how one of these factors affect rate of photosynthesis	Student answer questions orally. Expected answers. 1. Photosynthesis is a process by which plant prepare their food from water and carbon dioxide. 3.presence of chlorophyll for trapping light energy, presence of stomata for gaseous exchange, presence of xylem	

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
		3. List three factors which affect photosynthesis. 4.explain how one of these factors affect rate of photosynthesis	transporting water 3. Temperature, CO_2 concentration, and chlorophyll content. 4. Low temperature affects enzymatic activities hence low rate of rate of photosynthesis while high temperature increases rate of photosynthesis. But very high temperature will deactivate enzymes resulting in low rate of photosynthesis.	

Assignment:

1. Explain how the following factors affect the rate of photosynthesis

i. carbon (iv) oxide concentration

ii. light

References:

Nyavor, C. B. & Seddoh, S. (2006). *Biology for senior secondary schools* (3rd ed.). London: Macmillan Publishers.

Mader, S. (2000). *Biology* (7th ed.). New York: Macmillan Publishers.

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Remarks:

LESSON PLAN 2 FOR TEACHING THE CONTROL CLASS USING THE TRADITIONAL METHOD

Subject: Biology Date: Duration: 80 minutes Class: SHS 3

Topic: Light and Dark Stages of Photosynthesis Time: Place: Classroom Number of students:

Previous knowledge: Students can explain at least one of the factors which affect rate of photosynthesis.

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

1. explain the steps involved in the light reaction stage of photosynthesis
2. explain the steps involve in the dark reaction stage of photosynthesis
3. explain the fate of products of photosynthesis

Pre-lesson preparation: Teacher procures chart of light and dark reaction stages of photosynthesis.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	
Introduction (5 minutes)		Revise students' previous knowledge using questioning. E.g. What is a limiting factor in the process of photosynthesis?	Students answer teacher's question. Expected answer: this is a factor short in supply or minimum in value and a change in this factor affects the rate of photosynthesis.	

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
<u>Content development</u> <u>Step I</u> Light Reaction Stage of Photosynthesis (30 minutes)	A chart showing the light reaction stage of photosynthesis	Use chart to explain the light stage of photosynthesis. Write chemical equations involved with the reaction and respond to students questions. 1. Water is broken down to its components using light energy. 2. To provide energy for	Students look at chart and ask questions at some stages of delivery of lesson. Expected questions: 1. how does photolysis occur? 2. What is the use of the ATP produced? Students write main ideas	Light reaction stage occurs in the thylakoids. Chlorophyll molecules in the thylakoids absorb light energy. This causes the electrons to be excited and release energy in the process. This energy is used in the synthesis of ATP. Some

STAGE/STEP/	TEACHING-	INSTRUCTIONAL STRATEGIES	

CONTENT ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
step I Light Reaction Stage of Photosynthesis		dark stage of photosynthesis	into their notebooks.	of the light energy is used in photolysis of water. $H_2O \longrightarrow OH^- + H^+$ $4OH^- \longrightarrow 2H_2O + O_2$ $2H^+ + NADP \longrightarrow NADPH + H^+$ ATP and NADPH are used in the dark reaction stage of photosynthesis

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
<u>step II</u> The Dark Reaction Stage of Photosynthesis (30 minutes)	A chart showing the dark reaction stage of photosynthesis	Use chart to explain to students the dark reaction stage of photosynthesis. Write main ideas on marker board. Answer: because this reaction was discovered by Calvin	Students look at chart, listen to teacher and ask questions. Expected question: why is the cycle called Calvin Cycle? Students write main ideas	Dark reaction stage of photosynthesis occurs in the stroma of the chloroplast. Dark stage utilizes NADPH and ATP from light reaction stage and CO_2 from the atmosphere. CO_2 enters the Calvin cycle and reacts with a five carbon compound Ribulose Diphosphate (RuDP) to form an unsTable six carbon compound in the presence of the enzyme RuDP carboxylase. The unsTable compound splits into two molecules of
STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES		

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
step II The Dark Reaction Stage of Photosynthesis (25 minutes)	A chart showing the dark reaction stage of photosynthesis			glycerate-3-phosphate (three carbon compound). Glycerate-3-phosphate (GP) is the first product of photosynthesis. GP is reduced by reacting with NADPH to form phosphoglyceraldehyde (triose phosphate). Energy used is provided by ATP. Triose phosphate undergoes a series of reaction to form RuDP. The rest of the triose phosphate is used to form glucose.

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
<u>step III</u> The fate of products of photosynthesis (10 minutes)		Explain to students the fate of the products of photosynthesis Expected response: sulphur and nitrogen are added to glucose through a series of reactions.	Students listen and ask questions when necessary. Expected question: how is protein form from glucose?	The main product of photosynthesis is glucose. Glucose is converted to starch and sucrose for storage. Glucose is converted to protein by addition of sulphur, and nitrogen. Glucose is also converted into cellulose and lipids to form the structure of cell wall and protoplasmic component. Glucose is metabolized to release energy. Oxygen which is a product

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
				is used for respiration
<u>Application</u> (5 minutes)		Pose the following question to students. Question: a maize plant under a street light by a roadside grew tall and greenish. Irrespective of this when it was due for	Students answer question. Expected answer: Since there is light available throughout the day and night, there is continuous photosynthesis. There is accumulation of products of photosynthesis in the leaf and this	

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES		

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
Closure summary and evaluation (5 minutes)		harvest there were very few corn on the cob. How do you explain this by photosynthesis? Summarise lesson through questions 1. explain the steps involves in light stage of photosynthesis. 2. Explain the step involved in the dark stage of photosynthesis. 3. Explain what is meant by the fate of photosynthesis	prevents more starch to be formed. Hence little starch is produced for storage. Students answer questions verbally	

Assignment:

1. What is your view on the statement that all living organisms depend on the sun for survival?
2. How is the protein stored by the ground-nut plant formed?

Reference:

Nyavor, C. B. & Seddoh, S. (2006). *Biology for senior secondary schools* (3rd ed.). London: Macmillan Publishers.

Mader, S (2000). *Biology* (7th ed.). New York: Macmillan Publishers.

Stone, R. H. (1985). *New Biology for West African Schools*. London: Longman Group, UK. Ltd.

Remarks:

LESSON PLAN 3 FOR TEACHING THE CONTROL CLASS USING THE TRADITIONAL METHOD

Subject: Biology Date: Duration: 80 minutes Class: SHS 3

Topic: Respiration Time: Place: Classroom Number of students:

Relevant Previous knowledge: Students can explain how they have to eat to get energy for various activities.

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

1. explain the term respiration.
2. analyse the process of aerobic respiration

Pre-lesson preparation: Teacher prepares a chart on respiration.

STAGE/STEP/CONTENT	TEACHING-	INSTRUCTIONAL STRATEGIES	

ITEM (ESTIMATED TIME)	LEARNING MATERIALS	TEACHER ACTIVITY	STUDENTS ACTIVITY	MAJOR IDEAS
Introduction (5 minutes)		Revise student previous knowledge through a story and continues to introduce the topic	Students listen attentively.	
<u>Content development</u> <u>step I</u> Explanation of the Term Respiration (5 minutes)		Ask students to explain respiration in their own words. Question: explain respiration in your own words.	Students attempt to explain respiration in their own words Expected answer: is a process whereby living thing produce energy from oxidation of food	Respiration is the sum total of the chemical processes that release energy from food substances within cells, with or without the participation of molecular oxygen.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	
step II Aerobic Respiration (5 minutes)		Ask students a question. Question: what is aerobic respiration? Mention to students the two stages of aerobic respiration	Students answer question expected answer: aerobic respiration requires molecular oxygen to break down food to release energy. Students listen and write main ideas into their notebooks.	Aerobic respiration involves molecular oxygen. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$ The two stages of aerobic respiration are Glycolysis and Krebs Cycle (Tricarbocylic Acid Cycle

STAGE/STEP/ CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	
<u>step III</u> Glycolysis (25 minutes)	A chart showing stages of glycolysis	Explain steps in gycolysis using chart. Write the steps on marker board.	Students listen to teacher and writes steps of glycolysis	Glycolysis occur in the cytoplasm of a cell. No oxygen is used. Glycolysis is common to both aerobic and anaerobic respiration. Steps in glycolysis. 1. glucose is converted to glucose phosphate. 2. Glucose phosphate is converted to fructose phosphate. 3. Fructose phosphate

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	
step III Glycolysis. (25 minutes)				Is converted to fructose diphosphate. 4. Fructose diphosphate is converted to pyruvate. Pyruvate is used in Krebs Cycle.
Content development step IV The Krebs Cycle (30 minutes)	A chart of the Krebs cycle	Explain Krebs Cycle to students using chart	Students pay attention to teacher and write steps of the Krebs Cycle into their notebooks	Krebs Cycle occurs in the matrix of mitochondrion. Requires the use of oxygen. Pyruvate is converted to an acetyl (two carbon compound) which reacts with CoA to form acetyl CoA. Acetyl CoA enters the Krebs Cycle and reacts with oxaloacetate (four-C-compound) to form citrate

STAGE/STEP/ CONTENT ITEM (ESTIMATED TIME)	TEACHING- LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
<u>step IV</u> Krebs Cycle (30 minutes)				(six-C-compound). This is the first product of the Krebs cycle. Citrate is oxidised to α-ketoglutarate (five-C-compound). This is also oxidised to succinate (four-C-compound). Succinate is converted to oxaloacetate to begin the Krebs Cycle

STAGE/STEP/ CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	
Application (5 minutes)		Teacher poses a problem. E.g: In a diagnostic test a chemical which interferes with the production of the acetyl group was found in the blood of Akua. Explain the consequences Akua will face.	Students attempt to explain the results of problem posed by teacher. Expected answer: since formation of the acetyl is prohibited, acetyl CoA is not formed hence the stages of the Krebs cycle cannot proceed. This means little energy (2 ATP) produced in glycolysis is what will be available to Akua for metabolism. This will affect the physiology of organs which require energy. Akua may have weakness in the body.	

STAGE/STEP/ CONTENT ITEM (ESTIMATED TIME)	TEACHING- LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	
<u>Closure</u> Summary and Evaluation (10 minutes)		Teacher summarises lesson through question 1. What is respiration? 2. Analyse the process or aerobic respiration	Students answer questions verbally. Expected answer: Respiration is the sum total of the chemical processes that release energy from food substances within cells, with or without the participation of molecular oxygen.	

Assignment:

1. Using illustrations, explain how ATP is produced by the Krebs cycle.

2. Describe the stages of glycolysis.

References:

Nyavor, C. B., & Seddoh, S. (2006). *Biology for senior secondary schools* (3rd ed.). London: Macmillan Publishers.

Mader, S. (2000). *Biology* (7th ed.). New York: Macmillan Publishers.

Stone, R. H. (1985). *New Biology for West African Schools*. London: Longman Group, UK. Ltd.

Remarks:

LESSON PLAN 4 FOR TEACHING THE CONTROL CLASS USING THE TRADITIONAL METHOD

Subject: Biology Date: Duration: 80 minutes Class: SHS 3

Topic: Anaerobic Respiration Time: Place: Classroom Number of students:

Relevant Previous knowledge: Students can explain how glycolysis and Krebs cycle release energy.

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

1. explain how energy is produced by the Hydrogen Carrier System.
2. analyse the process of Anaerobic respiration

Pre-lesson preparation: Teacher prepares a chart on respiration.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
Introduction (5 minutes)		Introduce lesson by revising previous lesson through question. E.g why is pyruvate important in energy production in the body?	Students answer teacher's question. Expected answer: pyruvate is converted to acetyl CoA which is needed for Kreb Cycle where a lot of ATP is produced. Hence without pyruvate Krebs cycle cannot proceed.	

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
Content Development Step I Hydrogen Carrier System (20 minutes)	A chart of the hydrogen carrier system	Show students a chart of the hydrogen carrier system explain the process to students. Answer: in the cristae of the mitochondrion.	Students look at chart, listen to teacher and ask questions when necessary. E.g. where does hydrogen carrier system take place? Students write relevant points into their notebook.	Pairs of hydrogen atoms removed from substrates during glycolysis and Krebs cycle are accepted by NAD (hydrogen acceptor). Electrons from hydrogen pass through the electron transport system eg cytochrome to produce ATP. Each pair of hydrogen atom produces three ATP

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
<u>step II</u> Anaerobic Respiration (5 minutes)		Ask students the following question: what is anaerobic respiration?	Students answer question. Expected answer: this is a type of respiration which does not require the use of molecular oxygen.	Anaerobic respiration involves only glycolysis. Anaerobic respiration is the same as fermentation Anaerobic respiration does not require molecular oxygen.

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
<u>step III</u> Process of Anaerobic Respiration (30 minutes)	A chart showing process of anaerobic respiration	Use chart to explain the process of anaerobic respiration. Answer: yeast respires anaerobically to produce alcohol and some bacteria also respire anaerobically to produce lactic acid	Students listen and ask question when necessary. Expected question: which organisms can respire anaerobically?	Alcohol fermentation occurs in yeast. $C_2H_{12}O_6 \longrightarrow C_2H_5OH + CO2 + E$ Lactic acid fermentation occurs in the skeletal muscle and in some bacteria. $C_2H_{12}O_6 \longrightarrow C_3H_6O_3 + E$ accumulation of large amount of lactic acid leads to muscle fatigue in sportsmen. Yeast fermentation is used in food processing and

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
step III Process of Anaerobic Respiration (30minutes)	A chart showing process of anaerobic respiration			Breweries. Lactic acid fermentation is also used in food processing e.g. yoghurt.
Step IV Uses of energy produced from respiration (10 Minutes)		Discuss the uses of energy produced from respiration with students using question. e.g. what the uses of energy	Students contribute to discussion by answering question. expected answer: cell division, movement and	Energy from respiration is used for biosynthesis e.g. protein, muscular contraction, cell division, heat production

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS' ACTIVITY	
step III Uses of Energy from Respiration (10 minutes)		Produced from respiration?	Reproduction	Contraction, heat production, active transport, and transmission of nerve impulse
Application (5 minutes)		Ask students question. E.g. during the Inter-School Athletic Competition Owusu, a 100m fell during the race due to muscle fatigue.	Students answer question. Expected answer: as Owusu runs vigorously oxygen debt occurs in the	

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	
Application (5 minutes)		What might account for this?	skeletal muscles of the legs leading to lactic acid accumulation. This causes muscle fatigue. This make the muscle to contract and the athlete feel pains and falls down.	
Closure summary and evaluation (5 minutes)		Teacher summarises lesson through questions 1. How is ATP produced	Students answer questions in their class exercise book	

STAGE/STEP/CONTENT ITEM (ESTIMATED TIME)	TEACHING-LEARNING MATERIALS	INSTRUCTIONAL STRATEGIES		MAJOR IDEAS
		TEACHER ACTIVITY	STUDENTS ACTIVITY	
		In the hydrogen carrier system? 2. How is energy produced by anaerobic respiration?		

Assignment:

1. List three local foods processed by fermentation.
2. Explain how one of the foods mentioned in question 1 is processed using fermentation.

References:

Nyavor, C. B. & Seddoh, S. (2006). *Biology for senior secondary schools* (3rd). London: Macmillan Publishers.

Mader, S (2000). *Biology* (7^{th} ed.). New York: Macmillan Publishers.

Stone, R. H. (1985). *New Biology for West African Schools*. London: Longman Group, UK. Ltd.

Remarks:

APPENDIX H

BAT SCORES

Table 21: BAT 1 scores for Experimental Group

		Experimental Group			
Gender	Pretest	Posttest	Comprehension	Application	Analysis
M	16	58	22	1	15
F	10	18	8	7	3
F	9	23	9	4	10
F	15	41	16	14	11
M	21	47	22	19	6
F	6	22	12	2	8
M	8	33	12	15	6
F	7	16	8	3	5
M	16	55	21	17	17
M	5	32	16	7	9
F	10	31	11	12	8
M	8	23	11	7	5

Table 21 (continued)

			Experimental Group		
Gender	Pretest	Posttest	Comprehension	Application	Analysis
M	10	31	11	12	8
M	14	36	20	8	8
M	18	44	20	12	12
F	13	40	19	14	7
M	4	17	7	8	2
F	11	38	19	10	9
M	19	38	19	10	9
M	20	55	25	14	19
M	13	35	19	8	8
M	23	52	20	19	13
M	12	27	13	9	5
M	4	21	12	4	5
M	14	37	12	16	9
F	7	14	3	8	3
M	7	46	23	11	12
M	15	43	17	16	10
M	16	46	16	14	16

Table 21 (continued)

			Experimental Group		
Gender	Pretest	Posttest	Comprehension	Application	Analysis
M	18	38	8	10	10
F	17	38	18	13	7
M	25	42	14	18	10
M	12	46	19	16	10
F	4	33	13	9	11
F	8	23	11	5	7
F	6	14	8	2	4
F	5	18	11	2	5
F	16	41	13	16	12
M	27	65	24	21	20
F	22	50	19	18	13
F	11	18	6	6	6
F	8	26	6	10	10
F	12	43	20	10	13
F	5	27	9	10	8
M	9	32	14	9	9
M	13	27	9	9	9

Table 21(continued)

			Experimental Group		
Gender	Pretest	Posttest	Comprehension	Application	Analysis
M	17	44	18	16	10
M	12	41	13	13	15
M	1	39	16	13	10

M = Male F = Females

Maximum scores:

Pretest = 80 comprehension = 27 analysis = 26

Posttest = 80 application=27

Table 22: BAT Scores for Control Group

			Control Group		
Gender	Pretest	Posttest	Comprehension	Application	Analysis
F	16	27	9	10	8
F	19	37	17	14	6
F	9	36	18	11	7
M	8	17	8	4	5
M	16	42	20	4	8
M	15	24	9	8	7
M	24	36	18	7	11
M	22	25	9	10	6
M	16	33	13	10	10
M	11	20	10	9	1
M	26	30	14	10	6
M	19	28	11	9	8
M	5	33	16	8	9
M	10	24	11	7	6
M	1	5	3	2	0
M	4	10	4	4	2
M	11	22	7	8	7

Table 22 (continued)

Control Group					
Gender	Pretest	Posttest	Comprehension	Application	Analysis
F	8	16	7	4	5
F	6	21	10	10	1
F	8	20	7	7	6
F	6	23	10	7	6
M	8	8	2	3	3
M	7	17	6	5	6
F	15	40	15	16	9
F	7	29	13	11	5
F	23	44	18	14	12
F	4	2	0	1	1
F	11	22	7	8	7
F	6	14	2	7	5
F	12	20	8	4	8
F	18	26	8	10	8
F	21	36	19	12	5
F	8	24	10	11	3
F	17	31	14	9	8

Table 22 (continued)

Control Group					
Gender	Pretest	Posttest	Comprehension	Application	Analysis
F	14	30	14	11	5
F	8	30	7	14	9
F	5	28	13	10	5
F	5	8	8	5	5
F	9	11	4	2	5
M	16	37	15	12	10
F	13	37	15	13	9
M	24	37	17	9	11
M	15	21	9	5	7
F	14	26	15	6	5
F	11	12	6	4	2
F	10	25	7	11	7
F	2	10	6	2	2
F	19	43	21	12	10
F	15	28	16	5	7
F	17	35	16	9	10
F	6	21	6	10	5

Table 22 (continued)

Control Group					
Gender	Pretest	Posttest	Comprehension	Application	Analysis
F	10	26	6	10	5
F	34	41	18	15	8
F	15	29	13	9	7

M = Male F = Females

Maximum scores: Pretest = 80 Posttest = 80

comprehension = 27 analysis = 26 application = 27

Table 22: Scores of BAT2

Gender	BAT2A	BAT2B	Gender	BAT2A	BAT2B
M	16	52	M	25	64
F	10	42	M	14	58
F	23	28	M	12	9
F	21	34	M	25	49
M	12	50	M	12	16
F	20	46	M	25	26
M	11	48	M	7	40
F	12	43	M	13	48
M	15	60	M	23	60
M	15	44	M	20	59
M	11	21	M	16	46
F	10	41	M	9	35
M	17	42	M	13	40
M	2	1	M	20	6
M	24	46	F	5	33
M	9	23	F	8	34
M	14	50	F	12	34

Table 23 (continued)

Gender	BAT2A	BAT2B	Gender	BAT2A	BAT2B
F	15	42	F	11	43
M	6	1	F	18	48
F	22	64	M	25	35
F	16	33	M	14	33
F	0	25	M	8	30
F	10	25	M	10	37
F	12	50	M	8	26
F	16	28	M	7	31

BAT2A = 25 BAT2B = 78 M = Male F = Females

APPENDIX I

FORMULAE FOR CALCULATION OF EFFECT SIZES

Formula for Calculating Effect Size for Dependent Sample T-Test

$$d = \frac{t}{\sqrt{N}}$$

Where d = effect size

t = t value from SPSS output

N = Number of students

Formula for Calculating Effect Size for Independent Sample T-Test

$$d = t\sqrt{\frac{N1+N2}{N1\ N2}}$$

Where d = effect size

t = t value from SPSS output

N1 = Number of students in the experimental group

N2 = number of students in the control group