UNIVERSITY OF EDUCATION, WINNEBA

USING CONCEPT MAPS TO ENHANCE THE LEARNING OF CELL BIOLOGY BY FIRST YEAR STUDENTS OF NIFA AND H'MOUNT SINAI SENIOR HIGH SCHOOLS

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DECEMBER, 2016

DECLARATION

Candidate's Declaration

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

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CHARITY OFOSU

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DATE

Supervisor's Declaration

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

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VICTOR ANTWI (PhD)

…………………………………….

DATE

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DEDICATION

This dissertation is dedicated to the Almighty God for the strength and wisdom given me throughout my course. This work is also dedicated to the Ofosu family especially my nephew Kwaku, who always got serious with his toy computer anytime he saw me busy with my thesis.

Finally, to my husband Dave, whom I kept awake anytime I needed someone to explain something to me. I am most grateful to you all.

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ABSTRACT

This thesis emphasizes an alternative instructional tool called "Concept Map**".** Concept map has been applied in a variety of fields, including instructions, learning, curriculum development, and assessment. Researchers have determined that, concept maps serve as an effective tool in the traditional classroom. The purpose of this study was to investigate the use of concept map to enhance the teaching and learning of Cell Biology in Senior High Schools one students. The research focused on two groups from senior high schools (Nifa and H'Mount Sinai S.H.S) of the Akuapem-North District in the Eastern Region of Ghana.

This study was a pre-test-post-test-2-group comparison study. Both the control and experimental groups were required to take a pre-test before instruction and a post-test at the end of three weeks. The text consisting of 20 questions was used to assess students performance. Student's constructed concept maps were scored using Novak's scoring scheme. Participants included 64 students. The first finding of the study was that, students when exposed to concept maps performed better than when taught with the traditional method. The difference in the learning gains between the experimental and the control group was statistically significant and this was solely due to the use of concept maps in the learning of Cell Biology. The second finding also indicated that, there was no gender disparity among students with the introduction of concept maps, although there were some increases in the mean scores among the females. Nevertheless, the study suggests that, there is a need for future research to improve and strengthen the relationship between Concept Mapping and academic learning, specifically in science.

CHAPTER ONE

INTRODUCTION

Overview

This chapter comprises the background of the study, statement of the problem, purpose of the study, objectives of the study, research questions, the research hypotheses and significance of the study. It further continues with the delimitation, limitation, definition of terms and organization of the study.

Background of the study

The educational system in every nation is a mirror through which the image of the nation can be seen and shaped. Biology is difficult to teach and to learn because it consists of unfamiliar concepts involving complex relations. The highly conceptual nature of Biology makes it particularly difficult for students and the strategies used in the classroom have not sufficiently eased the learning process (Sutherland & Katz, 2005). Rote learning contributes very little at best to knowledge structures, and therefore cannot promote reflective thinking or novel problem solving. To facilitate the process of knowledge transmission, teachers should apply appropriate teaching methods that best suit specific objectives and level exit outcomes. The primary purpose of teaching at any level of education is to bring a fundamental change in the learner (Tebabal & Kahssay 2011) If students can see a clear organized picture of a broad unit covering various concepts, then they would build a deeper understanding and appreciation of these concepts. The development of learning strategy and knowledge tools such as Concept Maps, and others, are all efforts made to improve science education. Similarly, the large number of studies conducted on various aspects of science education is an indication of science educators' search for solutions to the problems facing meaningful learning of scientific concepts and theories.

This study is therefore an attempt to contribute to the solution of the problems facing meaningful learning of scientific concepts and theories. The goal of a study expressed by Nicoll, Francisco and Nakhleh (2001) was to investigate the value of using Concept Maps in Biology and, more particularly, to see if Concept Maps would produce a more interconnected knowledge. Concept Maps would be an excellent strategy to enable the students to think about connections between science terms being learned, organize their thoughts, visualize relationships between key concepts in a systematic way and reflect on their understanding. If Concept Maps are used in instruction and students are required to construct Concept Maps as they are learning, unsuccessful students can become successful in making sense out of science and any other discipline (Abimbola, 2007). Concept Map stresses meaningful learning, and appears to be ideally suited to address Biology content. Concepts Maps play a crucial role in guiding the production of knowledge and meaningful (as distinct from rote) learning (Novak, 2010). Concepts Maps are defined as regularities in events or objects designated by a sign or symbol. A concept is something conceived in the mind. It can be an idea, a general or abstract thought, or notion. Humans create Concepts Maps when they recognize some new regularity in events or objects and assign labels or signs to signify this regularity.

Teachers can facilitate the acquisition of shared meaning with their students regarding the concepts of Biology to produce meaningful learning by making explicit framework of concepts that comprise our contemporary understanding of the regularities manifested by living things. Concept Maps are two-dimensional graphical representations of one's knowledge of a domain (Novak & Gowin, 1984). The idea of Concept Maps is based on Ausubel's, 1978 assimilation theory of cognitive learning. The underlying basis of the theory is that meaningful (as opposed to rote) learning occurs when new knowledge is consciously and purposively linked to an existing framework of prior knowledge. In a Concept Map, concepts are represented by nodes, usually enclosed in circles or boxes, and relationships between concepts are indicated by connecting lines that link them together. The almost 40 years of concept map research in the published literature have focused primarily on the use of Concept Maps in the sciences and found Concept Maps to be an effective tool for knowledge organization, clarification, and retention (Nesbit &Adescope, 2006). The researcher therefore decided to use Concept Maps as an instructional strategy to enhance effective teaching and learning.

Statement of the problem

One of the biggest problem that students are facing in Biology is their inability to communicate what they actually know about the concept either with the teacher or in examination or on a problem set. Their inability to communicate what they know, and receiving a low text score on the material they actually understand undoubtedly frustrated the students even to the extent of sometimes giving up (Jegede, 1987).

The reason for the student's lack of Biology communication skills is simple; they spend very little time in learning, practicing and speaking the language of Biology. Ausubel's theory of meaningful learning is one of the most important expository theories.

It explains how to transform learning from short-term memory to long-term memory (Ausubel, 1978).

According to the theory, meaningful learning occurs when complex ideas and information are combined with student's experiences and prior knowledge with unique understanding. It has therefore become very necessary to study the use of Concept maps as a tool for meaningful learning.

Towards this end, it is instructive that Biology teachers explore a number of alternatives making conceptual connection between representations and developing understanding of underlying concepts for the students to learn Biology. The problem of the students at Nifa S.H.S with regard to Cell Biology is that, they have difficulty in understanding the concept. This has made this study pertinent in finding the effect of the use of Concept Maps on students' performance in Cell Biology at Nifa Senior High School in the Akuapim –North Municipal Assembly in the Eastern Region of Ghana. This is to arouse and sustain the interest of students in Biology lessons, as the teacher uses the appropriate and relevant teaching resources, models and concepts.

Purpose of the Study

The purpose of this study is to find out the impact of Concept Map as an instructional strategy for meaningful learning. Thus, the study will look at the impact of Concept Map on the performance of Biology students.

Objectives of the study

The objectives of the study were to:

1. Determine the performance of students in Cell Biology after the use of Concept Maps.
2. Find out whether there is gender disparity with regard to the understanding of Cell Biology with the use of Concept Maps as the teaching strategy.
3. Examine students' attitude and interest towards the teaching and learning of Biology with the use of Concept Maps.

Research questions

1. What is the performance of students with the introduction of Concept Maps in the teaching of Cell Biology as compared to the use of the traditional lecture application in the learning of Cell Biology?
2. What is the gender disparity in the understanding of Cell Biology with the use of Concept Maps as a teaching strategy?
3. What are students' attitude and interest towards the teaching and learning of Biology with the use of Concept Maps?

Research hypotheses

The research addressed the following hypotheses:

H_{01}: There is no significant difference in the performance of students with the introduction of Concept Maps in the teaching of Cell Biology?

H_{02}: There is no significant difference between males and females in the understanding of Cell Biology when Concept Maps are used as the teaching strategy.

Significance of the Study

It is envisaged that when the findings of this study are made accessible, teachers, students and researchers will benefit due to the following reasons:

- The results of the research would be used to attest to the fact that the use of Concept Map as a teaching strategy could improve students understanding of concepts in science. Hence, teachers could adopt the use of Concept Maps in the teaching of Cell Biology or Science.

- Students could also benefit, in the sense that they could adopt this strategy of Concept Maps in the learning of other topics in Biology or other Science Subjects.
- Lastly, this research would serve as an additional reference material for those willing to work in the field of Concept Maps to improve students' performance in the teaching of Cell Biology or Science in general.

Delimitation of the study

The scope of the study was all first year science students in Nifa Senior High School and H'Mount Sinai Senior High School in the Akuapim –North Municipal Assembly in the Eastern Region of Ghana. However, due to limited time, the study was focused on first year science students of both Nifa Senior High School and H'Mount Sinai Senior High School.

Limitation of the study

The main limitation envisaged will be that of time. The period required for the completion of the work is very short. This is because the work has to be completed in a stipulated academic period. The result of the study cannot be generalized because the study was strictly restricted to science one (1) students of Nifa Senior High School and science (1) students of H'Mount Sinai Senior High School.

Organization of the study

This research is structured into 5 chapters. Chapter 1 constitutes an introductory chapter which contains the background of the study, the statement of the problem, purpose of the study, objectives, the research questions, the research hypotheses, and significance of the research, the delimitation and limitation. Finally, the same chapter provides a definition of concepts and abbreviations used in the study.

Chapter 2 presents a review of the related literature dealing with existing literature on concept maps. The chapter opens up the gaps in the existing literature by reviewing articles and study on Concept Maps. The review looks at the history and definition of Concept Maps, the importance of Concept Maps, Concept Map tools, designing and construction of Concept Maps, the methods of scoring Concept Maps, the Cell Biology and the uses of Concept Maps in the teaching and learning of Cell Biology.

Chapter 3 describes the research methodology. It embodies the research design, the population, the research instruments, the data collection procedure and the tools for data analysis reliability and validity. Chapter 4 presents the results and discussion of the data, while Chapter 5 contains the concluding remarks, the theoretical implications and recommendations.

Definition of Terms

S.H.S.: Senior High School

K.E : knowledge elicitation

WAEC: West African Examination Council

Concept maps: It is a two-dimensional hierarchical diagram that illustrates the interconnections between and among individual concepts.

K.S.I.: knowledge science institute.

SD: standard deviation

df: degree of freedom

CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter review existing literature on concept maps. The chapter opens up the gaps in the existing literature by reviewing articles and study on concept maps. The review looks at the history and definition of concept maps, the importance of concept maps, tools of concept maps, designing and construction of concept maps. Also, the methods of scoring concept maps, the Cell Biology and the uses of concept maps are considered in this chapter.

History of Concept Maps

Concept maps were developed in 1972 in the course of Novak's research programme at Cornell where he sought to follow and understand changes in children's knowledge of science (Novak & Musonda, 1991). During the course of their study the researchers interviewed many children, and they found it difficult to identify specific changes in the children's understanding of science concepts by examination of interview transcripts. The programme was based on the learning psychology of Ausubel (1963; 1968; 1978). The fundamental idea in Ausubel's cognitive psychology is that learning takes place by the assimilation of new concepts and propositions into existing concept propositional frameworks held by the learner. Concept map is an instructional tool that is currently gaining popularity in the field of science education (Abimbola, 2007). The concept and theory of Concept Map had its roots in education and learning (Cañas, Hill & Lott, 2003). It is a product of recent advances in cognitive science and the new philosophy of science innovations that helps individuals to remember learned concepts longer and to be able to use more effectively (Johnson & Raven, 2013). 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 (Novak & Gowin, 1984; Novak, 1990; Mintzes, Wandersee & Novak, 2000). Concept maps are also effective in identifying both valid and invalid ideas held by students. They can be as effective as more time-consuming clinical interviews (Edwards & Fraser, 2004).

Out of the necessity to find a better way to represent children's conceptual understanding emerged the idea of representing children's knowledge in the form of a concept map. Thus was born a new tool not only for use in research, but also for many other uses. Cognitive psychologists and new philosophers of science, view learning as an active internal process of construction of meanings where learners' prior knowledge play a significant role for further conceptual understanding (Ausubel, 1968; Ausubel, Novak & Hanesian, 1978). These educators consider learners to be the architects of' their own knowledge for they construct their own idiosyncratic meanings of concepts and natural phenomena. They also consider learning, to be verbatim repetition of what has been presented to the learner or as a change in behaviour (Ausubel, Novak & Hanesian, 1978).

The new philosophers of science reject the traditional cumulative view of scientific knowledge, and replace it with a conceptual-change as reflected in the works of Kuhn (2012), among others. In general, it is these current ideas of cognitive psychologists with constructivist epistemological views, and the new philosophers of science that formed the cornerstone of concept map. However, it is the work of Ausubel (1963, 1968) and cognitive assimilation of Ausubel, Novak and Hanesian (1978) theory that formed the theoretical foundation of concept map. Novak and Gowin (1984) are the proponents of Concept Maps.

Concept map as a process of constructing web diagrams, involves mapping out logical relationships among concepts in a hierarchical order, using links and nodes such that the most general concepts are at the top of the map, with the most specific concepts at the bottom of the map. Concept Map is a graphical tool that organizes, connect, and synthesize information. Concept maps show concepts in circles or boxes and one can indicate relationships between concepts by connecting lines or linking words.

A concept map, according to Novak (2010), 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 interconnections between and among individual concepts. Concept Maps provide a visual road map showing the pathways that we may take to construct meanings of concept and propositions. According to Novak and Gowin (2010), concept map is both a meta-learning and meta-knowledge tool diagrams that represent organized knowledge in a web and crosslink relationship as a vehicle for knowledge elicitation (KE), and for generating models of domain knowledge. Although originally developed as an evaluation tool, concept map is now widely used in many other aspects as an instructional strategy in education. For instance, it has been used as a tool for curriculum development by Edmondson (2005) and Wallace and Mintzes (1990) and helps to move meaningful information into long-term memory.

In their paper "Concept Maps as a Tool for Meaningful Learning and Teaching in Biology Education", Kiliç & Cakmak (2013) explain why concept maps is superior to other methods of meaningful learning and listed the following reasons;

1. The primary benefit of concept map is that it can be obtained from the visual presentation of ideas.
2. It addresses different forms of learning and individual differences between students. It means same subject or same concepts can be drawn differently for the individuals.
3. It can be used easily for the creation and integration of the scope of the assessment.
4. Concept map is student-centered, active teaching method. It can encourage student-teacher interaction when they create a map together by discussing.
5. It is very useful for showing alternative relationships within a system.
6. After learning this technique, students get used to establish links between concepts rather than recalling concepts separately.
7. It can be used effectively for revision after a topic and students are able to rank topics which they learn.
8. It develops the social aspect (confidence level) of students for being able to speak during construction.
9. Provides clarity of the concept.
10. It is a good way to work and prepare for the examination.
11. It is suitable for many different topics, instructional stage and grade level.
12. It is easy to use for teaching and learning.

The idea of Concept Maps is to determine how meaningful learning increases students' achievement. Concept Maps as a strategy in education is parallel with the movement from teacher to learner and as a result has the power to improve academic achievement (Peterson & Snyder, 2008). Today, educators and researchers are convinced that, most students learn best through personal experience and by connecting new information to what they already believe or know. For this reason students need to personally construct their own knowledge. Sakiyo and Jebson (2008) suggested learner-centered teaching methods which provide adequate learning outcomes rather than teacher-centred approaches which are dominated by the teacher. They also pointed out that, student activities are better than teacher activities in promoting authentic students' learning in secondary schools. Therefore, the recommendations of researchers to involve students in the construction of their knowledge, paved the way to look at Concept Maps teaching method as it relates to students' meaningful learning and achievement.

Importance of Concept Maps

Concept map increases recall of information in instructions in Biology subject (Hall, 2002). Kinchin (2000a) recommended the use of concept map on instruction and learning in secondary school Biology education. The important point is that the beginning stage of drawing Concept Maps not only needs active participation of the learner in the learning process but also paves way for their understanding of a specific learning area. As a result, such information about learners' understanding empowers facilitators to determine learners' cognitive deficiencies and provide corrective feedback (Nowrezi, Khiabani & Nafissi, 2010). Lambiotte and Dansereau (2001) stated that the students that made concept maps have a broader knowledge base and therefore more able to solve problems compared to those students that learned by rote memorization. Lambiotte and Dansereau also found out that, the students with low prior knowledge learned better with concept map than those taught with lecture method. Concept Map enhances metacognition, thus learning to learn and thinking about knowledge. It also improves language ability (Cambria & Hussain, 2012). Concept Map has also been shown to increase learners' writing ability (Gorjian, Pazhakh, & Parang, 2012). This improvement has been demonstrated in terms of the quantity and quality of producing, arranging and relating ideas (Pishghadam & Ghanizadeh, 2006).

Moreover, giving students more chance to get involved in the learning process through the use of Concept Map skills make them perform significantly better than their counterparts who have been exposed to the teaching using the usual traditional lecture method (Nnamdi & Okechukwu, 2006). Concept Map has also proved to be a useful vehicle to fill the usual gap between theories and practice (Sutherland & Katz, 2005). Access of representation at a given situation in learning is also helped through Concept Map (Bruillard, Baron & G.L, 2000). Concept Map has also proved as useful tools in lesson design, and can determine the key concepts and their relationship, and build the whole curriculum as a content analysis tool in itself (Kaszas &Turcsanyi-Szabo, 2003)

Concept Maps and Gender

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

Kinchin (2000a, b) discussed the positive impact of using Concept Maps on instruction and learning in secondary Biology education. Building on the researches earlier conducted, Kinchin (2000b) demonstrated the relevance of Concept Maps for teacher planning and preparing a lesson and creating an opportunity for meaningful learning on behalf of students. Kinchin (2000b) found a positive effect on students who used Concept Maps to revise and summarize the material.

Markow and Lonning (1998) tested the effect of Concept Map construction on concept understanding in college Chemistry laboratories. They found that students had a strong positive attitude towards using Concept Maps for better understanding of Chemistry laboratory concepts, although multiple choice achievement tests did not reveal any difference in students conceptual understanding between the experimental and control groups.

Many studies have highlighted the importance of Concept Maps in Chemistry teaching. Nicoll, Francisco and Nakhleh (2001) investigated the value of using Concept Map in General Chemistry and, more particularly, to see if Concept Maps would produce a more interconnected knowledge base in students, compared to ordinary instruction. The results showed that the Concept Maps group knew more concepts, had more "useful" linking relationships, and had no more erroneous linking relationships than the non- Concept Map students. Laeary (1993) in her Ph.D. thesis considered the effect of Concept Maps on concept learning and problem solving achievement in high school Chemistry. The study investigated Chemistry achievement among high school students. A significant relationship between concept learning and numerical problem solving was found in the Concept Map group only, thereby supporting the theory behind the Concept Map strategy. Keng (1996) conducted a comparative study of note taking, outline and Concept Map learning strategies on National Taipei Teachers College students' understanding on heat and temperature. The result of the analyses permit the following statements in terms of the overall students' performance as measured by the total examination scores. Students who used either an outlining or Concept Map learning strategy scored significantly better than students who used only a personalized note-taking strategy. Pendley (1994), Francisco, Nakhelh ,Nurrenbern & Miller (2002) investigated the effects of Concept Maps for university student studying Chemistry.

The result shows that Concept Maps is beneficial for university students studying Chemistry. The reviewed studies clearly revealed that Concept Map enhances students' achievement in Chemistry.

Concept Map Tools

Concept Map tools are computer-based, visualizing tools for developing representations of semantic networks in memory (Babkie & Provost 2002). Often it is claimed that Concept Map tools enable the right level of complexity and detail in the students' exploration (Lewis, 2006) and programme such as SemNet, Learning Tool, Inspiration and Mind Mapper have been developed for use as Concept Map tools.

Concept Maps are used as remedial tools and research has shown that these remedial tools will influence the learner's learning skills (Leahy, 2009). In order for the learner to gain meaningful information, the learning process is highly dependent on the ability to reason and to build relationships between information gained. Novak (2010) argues that the main use of Concept Map is as a tool for organising and visualising information, data and knowledge. Concept Maps are seen as a tool to help the learners to learn how to learn in Chemistry (Cullen, 2012). Four studies were conducted

(Asan, 2007) to determine the effect of Concept Map as a tool for the learner's problem solving. The study of Concept Map's effects reached the following conclusions: Concept Map was a helping factor in the learner's selecting, organising and recalling operations. The studies further showed that learners could use thinking and learning skills more effectively in certain situations and contexts. Novak (2008) asserts that Concept Map is a very powerful tool. It can be used as a learning tool, but can also be used as an evaluation tool. This will also lead learners to the meaningful side of learning.

Researchers at the Knowledge Science Institute (KSI) at Calgary had an early interest in the use of Concept Maps and multimedia (Gaines & Shaw, 2010). They have developed a number of demonstration programmes, such as KSI Mapper and CMap. These programmes are not available for purchase, and some of the capabilities have been integrated into Smart Ideas from Smart Technologies. The Calgary group is interested in the use of Concept Maps in multimedia, for education, collaboration, and for the capture of expert knowledge. The primary contribution to date appears to be the development of a Concept library that will assist developers (CMap) and a demonstration programme (KSI Mapper) (Kremer & Gaines 1996; Gaines &Shaw 2010).

Concept Map Tools has been extended to aid the user in the construction of Concept Maps. A Word Net server allows users to navigate through definitions, synonyms and antonyms for any word in a Concept Map (Cañas, Valerio, Lalinde-Pulido, Carvalho & Arguedas, 2003).

Luckie Concept Connector is a software suite currently in development at Michigan State University. This system allows students to build Concept Maps online, and to receive immediate feedback about their maps based on automatic scoring systems that are derived from scoring methods detailed in Novak and Gowin (2010). The Concept Map system is based upon a pre-defined set of concepts and linking phrases. The system is currently being used for online homework and assignments. The software includes an administrator mode in which task characteristics such as arrow types, whether or not participants can add concepts, and the maximum number of concepts, can be specified. The system can also be used to make fill-in maps, to attach multimedia and comments to maps and to prompt the user to specify the strength of a relationship.

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

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

Designing and construction of Concept Maps

The basic premise of concept maps has been representation of knowledge in a hierarchical form. The hierarchical structure as strongly supported by Novak, Gowin,

& Johansen (2006) has been questioned as the only means of linking concepts together. Okebukola's (2012) suggestion has been that the structure of the map should allow the structure of the knowledge and not the other way round. Several types of structures have been proposed such as hierarchy, cyclic chain, spider-maps, and networks that could be used to mentally represent the knowledge embedded in one's long-term memory (Brame 2013). Since the knowledge expressed in the maps is mostly semantic, Concept Maps are sometimes called semantic networks. The two ways of constructing concept maps are the traditional paper and pencil (Babkie, 2002) and the Computer-Assisted Concept Maps Systems (Hibberd, Jones, & Morris, 2002)

Uses of Concept Map

Previous uses of Concept Maps entail that Concept Map has been used as a diagnostic tool to assess students' conceptions (Novak, 1998; Okebukola & Jegede, 1989; Selim & Shrigley, 1983) for clarifying students' understandings and making connections between concepts explicit and also as an alternative science classroom achievement assessment and for assessing learning processes (Nathan, Eilam & Kim 2007; Kelly, 2007). Concept Map has been claimed to be valid in assessing students' conceptual changes. For example in the study of Selim and Shrigley (1983), Concept Map was used as both a pre-test and a post-test, and the capability of Concept Map to identify students' conceptual change due to the treatment effect (concurrent validity) was studied. They found students' Concept Maps were substantially different in complexity and propositional structure of the knowledge base from the pre-test to the post- test and concluded that Concept Map is a valid tool to document students' conceptual change.

Jegede (1987) investigated the use of Concept Map as an "advance organizer" for eight-grade students in a science unit. Jegede reported significant differences in performance of a Concept Map group at the end of the unit over a control group that did not use Concept Map.

Nathan, (2007) investigated the effect of Concept Map construction in college chemistry laboratories. They reported that students had a strong positive attitude towards the use of Concept Maps despite the lack of difference in performance on multiple choice assessment tests between the experimental and control groups. Udeani (2012) investigated the effects of concept and view mappings on students' cognitive achievement in ecology and genetics. A total of 808 tenth grade students were involved in the study. The results showed that the experimental groups performed better than the control group.

Okebukola and Jegede (2012) investigated the effect of using the Concept Map strategy in teaching on the achievement of fifth graders in science. The result of the study showed that Concept Map strategy results in higher achievement. Two studies compared the use of Concept Maps to other forms of knowledge representation with respect to learning new material. Lynch and Peterson (1980) compared Concept Maps to lists and outlines such as those used for lecture aids, and assessed differences in students' recall of the presented material. They reported no significant difference between the effect of Concept Map and the other two lecture aid forms. Contrary to this result, Kinchin (2000b) reported a significant difference in the recall of material presented in the form of a Concept Map when compared to a normal text presentation for only one of the two subject domains tested. Studies on what constitutes a Concept Map raise more questions than they answer, especially regarding the usability and suitability of Concept Maps in different contexts. Conflicting conclusions have been produced while inconsistent results have also been reported in the literature on the effect of Concept Map strategy on students' learning outcomes.

A related research has been carried out by Novak (2010) in which they claim that the low correlation between Concept Map scores and Traditional test scores demonstrates that Concept Maps and Traditional tests measure different attributes of students' abilities. More specifically, they claim that Concept Maps assess higher-order abilities (analysis, synthesis and evaluation) while Traditional assessment assesses lower-order abilities (knowledge, comprehension and application). This claim, according to McClure (2008) is not convincing because the contents and formats of the Traditional tests were not described in the paper.

Concept Maps have gained increasing support for use in distance learning courses because of their effectiveness in visually depicting the relationship between complex concepts (Cardellini, 2004). They have numerous educational applications, and are particularly useful for facilitating critical thinking and problem solving among students in asynchronous learning environments (Freeman & Jessup 2004; Chang, Sung,Y.-T., & Lee 2003; Prestera & Moller 2001) At the same time, their impact on learning outcomes in diversity courses offered online has not been emphasized.

In science education, Concept Map have been widely recommended and used in a variety of ways. It has been used to help teachers and students build an organized knowledge based on a given discipline or on a given topic (Blackwell & Pepper, 2008). It has also been used to facilitate middle level students' learning of science content (Novak & Gowin, 1994; Adlaon, 2002; Dhaaka, 2012). Findings from these studies indicate that Concept Map is an effective tool for aiding students' comprehension of science materials.

From the numerous literatures cited above much of the study on the use of Concept Map is concentrated on chemistry teaching and learning. There is therefore the need to have a study into the impact of Concept Map on the performance of Biology students.

Methods of Scoring Concept Maps

Although it has been over thirty years since Novak proposed the idea of a Concept Map in 1971, researchers are still impressed by its versatility in curriculum design (Edmondson, 2000), teaching strategy (Schmid & Telaro, 2014) and evaluation of teaching (Beyerbach & Smith, 1990; Goldsmith, Johnson, & Acton, 1991; Novak & Gowin, 1984; Ruiz-Primo & Schavelson, 1996). A Concept Map consists of a set of propositions, which are made up of a pair of concepts (nodes) and a relation (link) connecting them, although many researchers have reported that a Concept Map is a useful tool for learning and instruction.

Generally speaking, there are three major approaches (Ruiz-Primo & Shavelson, 1996) for the scoring of the Concept Maps in science. The first one is scoring a student's map component, like propositions, hierarchy, cross links and examples in Novak and Gowin's (1984) scheme. The second approach is using a criterion map and comparing students map with that criterion map. The closeness index used in Goldsmith, Acton, and Johnson, (2000) is a typical example. The third approach combines both the component of a generated map and a criterion map.

Although scholars have proposed various scoring schemes for assessing and scoring Concept Maps, closeness index is that type of the weighted scheme of scoring that takes into account a number of students and teachers instructional needs. Teachers need to determine the importance of each proposition based on their professional knowledge, and each proposition is given a weight ranging from 0 to 1.

Cell Theory

Cell theory refers to the idea that cells are the basic unit of structure in every living thing.

Development of this theory during the mid-17th century was made possible by advances in Microscopy. This theory is one of the foundations of Biology.

This Cell theory became necessary for this study as a result of its major component it occupies in the development and understanding of General Biology. It is also an aspect of the Senior High School Biology syllabus that students normally find it difficult to understand. The observations of Hooke, Leeuwenhoek, Schleiden, Schwann, Virchow, and others led to the development of the Cell theory. The Cell Biology is a widely accepted explanation of the relationship between cells and living things.

The Cell theory states that:

- All living things or organisms are made of cells.
- New cells are created by old cells dividing into two.
- Cells are the basic building units of life.

The Cell theory holds true for all living things, no matter how big or small, or how simple or complex. Since according to research, cells are common to all living things, they can provide information about all life. And because all cells come from other cells, scientists can study cells to learn about growth, reproduction, and all other functions that living things perform. By learning about cells and how they function, you can learn about all types of living things. Schwann (1938) and Schleiden (1838) suggested that cells were the basic unit of life. Their theory accepted the first two tenets of modern Cell Biology. However the Cell theory of Schleiden differed from modern Cell theory in that it proposed a method of spontaneous crystallization that he called "Free Cell Formation". Virchow (1858) concluded that all cells come from pre-existing cells, thus completing the classical Cell Biology.

Classical interpretation

1. All living organisms are made up of one or more cells.
2. Cells are the basic unit of life.
3. All cells arise from pre-existing cells. (***omni cellulae e cellula***)
4. The cell is the unit of structure, physiology, and organization in living things.
5. The cell retains a dual existence as a distinct entity and a building block in the construction of organisms.

Modern interpretation

The generally accepted parts of modern Cell theory include:

1. The cell is the fundamental unit of structure and function in living organisms.
2. All cells arise from pre-existing cells by division.
3. Energy flow (metabolism and biochemistry) occurs within cells.
4. Cells contain hereditary information (DNA) which is passed from cell to cell during cell division.
5. All cells are basically the same in chemical composition in organisms of similar species.
6. All known living things are made up of one or more cells.

7. Some organisms are made up of only one cell and are known as unicellular organisms.
8. Others are multicellular, composed of a number of cells.
9. The activity of an organism depends on the total activity of independent cells.

Exceptions

1. Viruses are considered alive by some, yet they are not made up of cells. Viruses have many features of life, but by definition of the Cell theory, they are not alive.
2. The first cell did not originate from a pre-existing cell. There was no exact first cell since the definition of cell is imprecise.
3. Mitochondria and chloroplasts have their own genetic material, and reproduce independently from the rest of the cell.

The genetic continuity of organisms includes not only the cell as a whole but some of its smaller components such as chromosomes and genes present inside the nucleus. The genetic material in all cases consists of nucleic acids. The basic structure of the cell membranes and their properties are also common. The mechanism of aerobic respiration is strikingly uniform. Nucleic acids and proteins follow the same principle during synthesis. These fundamental similarities speak in favour of unity among all living organisms

Instead of considering its cellularity, he described the living organisms as the aggregation of unity of plan, unity of function and unity of composition. In order to build the diversity of living systems, a large number of building blocks have been utilized. The problem of diversity of structures and functions, the problem of heredity, and the problem of diversification of species have been solved by the use of a small number of building blocks organized into specific macromolecules, which are further associated with a specific function.

The study and understanding of Cell Biology has been a major problem to many students of which the students from Nifa and H'Mount Sinai Senior High Schools are no exception. From the literature, it has been established that the use Concept Maps in the teaching of Cell Biology could go a long way to help students appreciate the concept, as it has been able to help students in other disciplines, such as Chemistry. Hence this is the more reason why in this research, the use Concept Maps are going to be used in the teaching of Cell Biology to measure its effects on students' performance

CHAPTER 3

METHODOLOGY

Overview

This chapter focuses on the research methodology used. It looks at the research design, population and sampling procedure, instrumentation, reliability and validity, data collection and data analysis.

Research Design

Action research design was used for the study. Both qualitative and quantitative data were used. It utilized a pre-test and post-test study. The pre-test and post-test were similar. The pre-test consisted of 20 multiple choice questions which were similar to the post-test, and the post-test also consisted of 20 multiple choice questions. The pre-test was administered to all the 64 elective science students offering Biology at Nifa Senior High School, Adukrom-Akuapem and H'Mount Sinai Senior High School, Akropong –Akuapem both in the Eastern Region of Ghana. Their scores were used as a baseline data for the two groups (experimental and control).

The research design made use of Concept Maps as an intervention on the Cell Biology. The post-test was used to determine students' performance after the use of the intervention in relation to their performance in the pre-test score. The use of the questionnaire helped the researcher to identify the students' perception (the Experimental Group) about the effectiveness of the use of the Concept Map in the instructional process of the Cell Biology.

Similarly, the post-test scores of the experimental group and control group were compared after they had been introduced into the instructional approach of Concept Maps and Traditional Lecture respectively.

The discussion and analysis on the effectiveness of the use of Concept Maps in the teaching and learning of Cell Biology was based on the scores of the pre-test and post-test of the experimental and control groups.

Population

Population is defined by McMillan and Schumacher (2001) as group of elements or cases, whether individual, objects or events that conform to specific criteria in research. The population of the study constitutes 64 first year elective Biology students of which 30 is from Nifa Senior High School and 34 is from H'Mount Sinai Senior High School, all in the Akuapem- North District in the Eastern Region of Ghana.

Sampling Procedure and Sample Size

Kothari (2004) defines sampling technique as a selection of some part of an aggregate or totality of what the population is made. Sampling procedures are techniques that are to determine the number of respondents that are involved in the study to provide the necessary knowledge.

Purposive and convenience sampling techniques were used in selecting the sample of the study. Babbie (2004) defines purposive sampling technique as the one which enables a researcher to select a sample based on his /her knowledge of population, research elements and objectives. Purposive sampling is also based on researcher's judgment and purpose of the study. In Nifa Senior High School Form One 'B' Science students were used as the experimental group. They comprised 30 students. It was purposive due to the fact that they had difficulty in understanding the Cell Biology. Also, the researcher was the class teacher of Form One 'B' Science class and teaches Biology in that class, hence it was convenient to use that class for the study.

Form One 'B' Science students comprising Thirty-four (34) students were also chosen as the control group from H'Mount Sinai Senior High School. They also had difficulty in understanding of Cell Biology and the Biology teacher to that class was a colleague to the researcher who agreed to help in the study. Thus in all the sample size was 64 students: 30 students as the experimental group from Nifa Senior High School and 34 students as the control group from H'Mount Sinai, all in the Akuapem-North District in the Eastern Region of Ghana. Nifa Senior High School and H'Mount Sinai Senior High School have similar characteristics. For example, they are both Grade B schools with almost the same population. The results of both schools are also alike. Out of the 64 students, 14 (22%) of females and 50 (78%) were males. The ages of the students ranges from 14-17 years.

Instrumentation

The instruments used for the research were questionnaire, pre-test and post-test. These were developed by the researcher. The purpose of these instruments was to help obtain the needed information for the analysis of the problem for appropriate intervention to improve students' performance in the study of Cell Biology.

Description of the questionnaire items

According to Leedy and Ormrod (2005), questionnaire offers participants the advantage of answering questions with the anonymity for their responses. The questionnaire consisted of two main parts; A and B. The A consisted of two (2) items that were used to seek information on the background of the respondents. It included; gender and age. The B part consisted of items that sought information on respondents' perception of Concept Map on the teaching and learning of Cell Biology.

Questionnaire is a more common mode of data collection in research. Although it has advantages of using it, it also has some disadvantages, which are that, some people may not be willing to answer the questions, invite people to lie and answer questions vaguely.

The researcher used close- ended questionnaire in the research. The questionnaire is attached as Appendix A.

Scoring the closed ended questionnaire items

A Likert scale with five options which include; Strongly Agree (SA) =5, Agree (A) =4, Neutral (N) =3, Disagree (D) =2, and Strongly Disagree (DA) =1 were used to score the questionnaire items. The items on the questionnaire were positively and negatively worded in order to minimize participants satisfying responses. Likert scale is easier to construct, interpret and also provide the opportunity to compute frequencies and percentages as well as statistics such as mean, median, standard deviation of scores and do t-test analysis (Franenkel & Wallen, 2000; Muijus, 2004).

Description of Pre-test and Post-test

The pre-test consisted of 20 multiple choice questions with options lettered A-D on Cell Biology and the post-test also consisted of 20 multiple choice questions with options lettered A-D. The pre-test and post-test were similar. The pre-test was administered to the Form One Science students from Nifa Senior High School and H' Mount Sinai Senior High School. The post-test was again administered to the experimental group and the control group after the use of the Concept Maps as an instructional approach on the experimental group and the Traditional Lecture as the medium of instruction for the control group. Students were given 30 minutes to answer the pre-test questions and another 30 minutes for the post-test questions after the intervention. Two science teachers from each school assisted the researcher in conducting the tests.

Scoring of Pre-test and Post-test

The pre-test was scored over 20 marks. The post-test was also scored over 20 marks. Thus, one correct answer attracted a score of one (1) mark.

Reliability of the Instrument

The quality of a research instrument or a scientific measurement is determined by both its validity and reliability (Cresswell, 2005). The responses of a questionnaire that are reliable are consistent, but if it does not measure the content it is intended to measure then it becomes invalid. The pre-test and post-test items on Cell Biology were selected from the Biology and Integrated Science GAST (Ghana Association of Science Teachers) textbooks, and other relevant Biology textbooks. The pre-test and post-test, and the questionnaire items were given to a Form One Science students from Nifa Senior High School and H'Mount Sinai Senior High School in the Akuapem- North District

Validity of the instrument

Validity of a research instrument is how well it measures what it is intended to measure (Patton, 2007). The content materials as well as the Concept Map instructional strategy packages were examined by experienced Biology and Integrated Science teachers who have taught for a number of years. The instrument was looked at thoroughly by the researcher's supervisor to determine the extent to which the test could measure what it is supposed to measure with respect to the Cell Biology topics.

Data Collection Procedure

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

The researcher was the teacher who had to use the Concept Map in her instruction of Cell Biology in Nifa Senior High School, which was the experimental school/group. A colleague Biology teacher was the one who taught the Form One 'B' Science Students in H'Mount Sinai Senior High School using the Traditional Lecture Approach. She is a Biology teacher to that particular class.

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

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

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

Contextualization: Involved defining the context for the Concept Map. This was done by constructing a focus question for each of the topics. The focus question for the Cell Biology was, "What is a cell?"

Brainstorming phase: In this phase, students were asked to write on small pieces of paper, the terms they knew in the topic types of cell. Examples of concepts students wrote included; plant cell, animal cell, eukaryotic and prokaryotic.

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

Finalizing the concept map: In this phase specific examples were given below concepts to solidify meaning. Students during this stage were now asked to put their Concept Map into a permanent form.

During these lessons, the experimental group of students were made to individually construct micro-concept maps on the content of each lesson. Each student's concept map was checked for accuracy and completeness at the end of the activity. Students were also told they could modify their concept maps at any time. The same procedure was done for the succeeding lessons.

Lesson one: The cell

The first lesson was given after the first Concept Map was analyzed. This lesson covered the history and parts and functions of the cell. And all the concepts included in the concept bank. All the students in the experimental group were involved in the lesson. A summary of the lesson is represented with a Concept Map below.

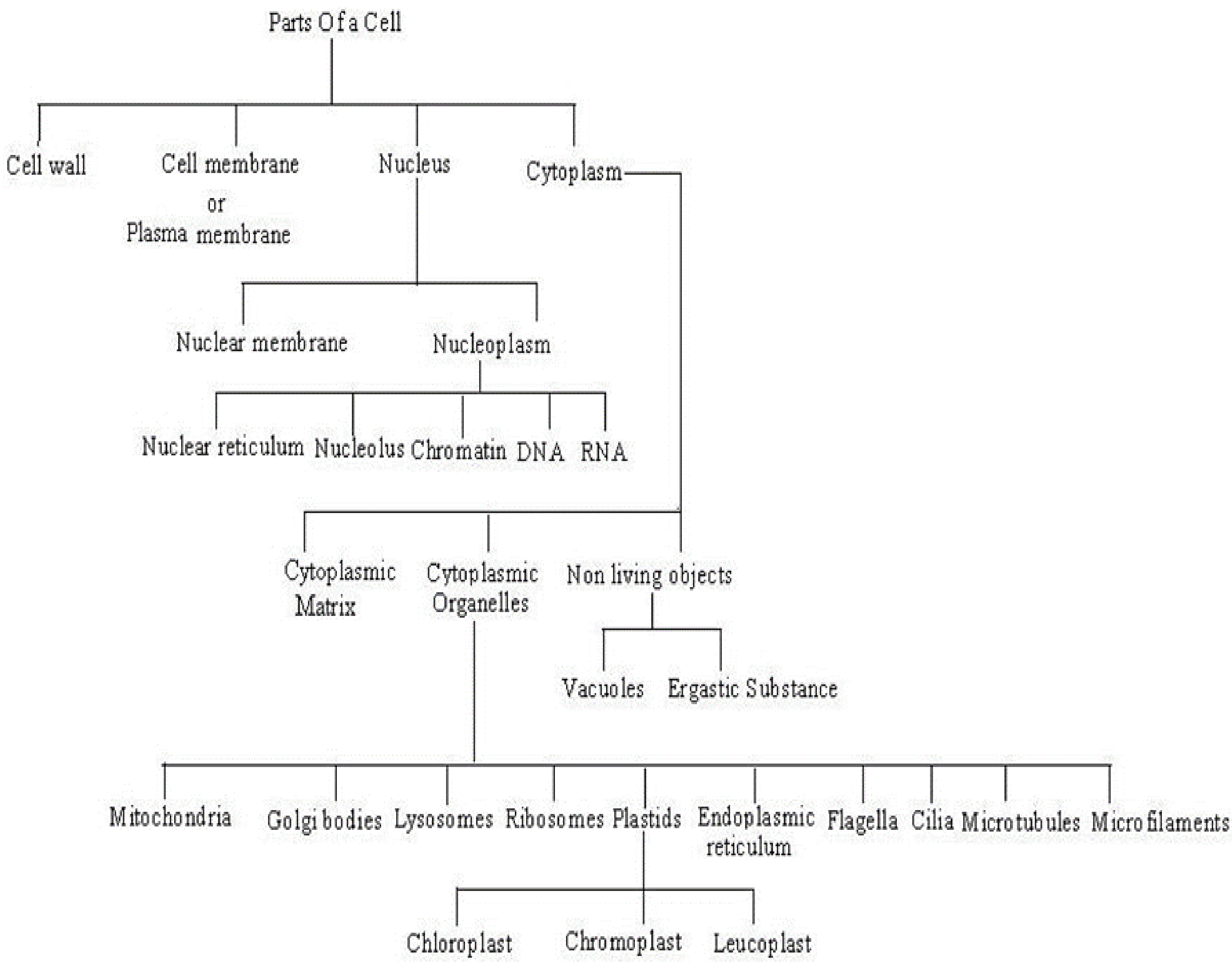

Figure 3.1: A Concept Map showing the various parts of a cell

From Figure 1, students realized that, there were four major parts of a cell (plant cell). These are the cell wall, cell membrane or plasma membrane, nucleus and cytoplasm. The nucleus has two features in it. These are the outer layer of the nucleus called the nuclear membrane and the inner part which contains the nucleoplasm. The nucleoplasm contains the genetic materials like the DNA (Deoxyribonucleic acid), RNA (Ribonucleic acid), chromatin, nucleolus and nuclear reticulum.

In the cytoplasm are also found other organelles like vacuoles and ergastic substance which are regarded as non-living objects. It also contains substances like cytoplasmic organelles and cytoplasmic matrix. Cytoplasmic organelles consists of mitochondria, Golgi bodies, lysosomes and ribosomes, plastids, endoplasmic reticulum, flagella, cilia, micro tubules and micro filaments.

The plastids contain three major substances. These are the chloroplasts, chloroplasts and leucoplasts.

Lesson two: The types of cell

Lesson two was given after the second Concept Map was analyzed. This lesson covered the two major types of cell, that is, Eukaryotic and Prokaryotic cells and all the surrounding concepts. This lesson also included an individual follow-up discussion with participants. A summary of the lesson is represented with a Concept Map in Figure 2:

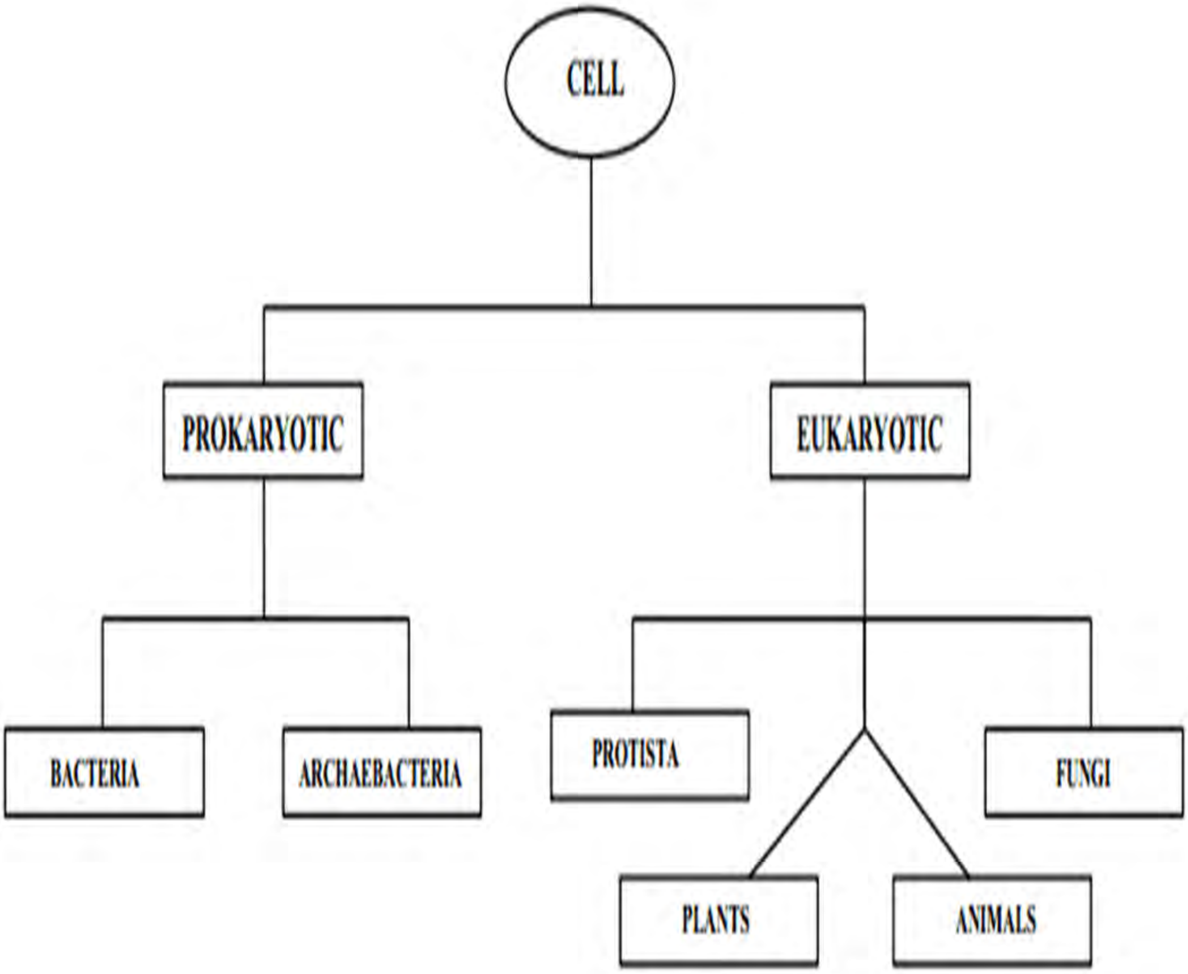

Figure 3.2: A Concept Map showing the main divisions of the cell

From Figure 3.2, students learnt or understood that there are two basic types of organisms based on cell type, Prokaryotic and Eukaryotic. The Prokaryotic cells are divided into the domains Bacteria and Archaea and are the smallest forms of life that can live independently and the most familiar prokaryotes are bacteria. The archaea are also quite diverse, but resemble the bacteria in general appearance. Some prokaryotes, mainly in domain Archaea, can live in extreme environments. Prokaryotes have been utilized as sources of enzymes that work under extreme condition unlike Prokaryotes, Eukaryotic cells are the type of living cells that form the organisms of all of the life kingdoms except monera. Protista, fungi, plants and animals are all composed of eukaryotic cells. Examples of specific types of eukaryotic cells could also be given as, muscle fibres, leucocytes and neuroglia which are types of animal cells, and parenchyma cells, collenchyma cells and sclerenchyma cells, which are types of plant cell. Prokaryotic cells are more primitive than eukaryotic cells, eukaryotic cells are generally larger and much more sophisticated than prokaryotic cells due to the presence of a complex series of membranes that divide a typical eukaryotic cell into compartments and also due to the many different types of specialized organelles present in most eukaryotic cell.

Lesson three: Plant and Animal Cell

Lesson three was given after the third concept map was analyzed. This lesson covered both plant and animal cells, the parts and function of the various parts. The lesson is summarized with a Concept Map in Figure 3.

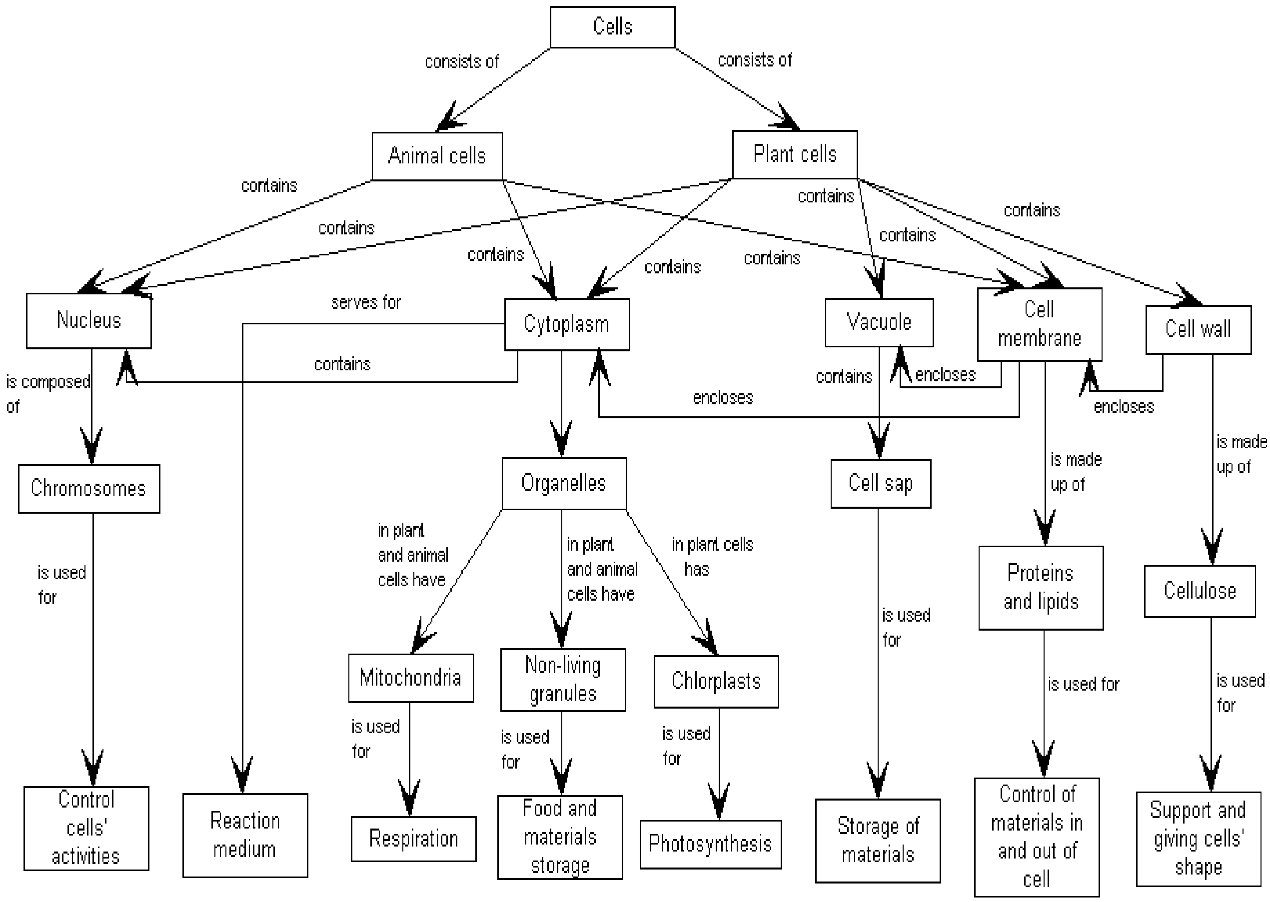

Figure 3. 3: A Concept Map showing the various component of plant and animal cell

From Figure 3.3, students learnt that, the cell consist of both plant and animal cell. The animal cell contains, nucleus, cytoplasm and cell membrane. The nucleus is composed of chromosomes which is used for the control of cell activities. The cytoplasm also contains organelles which consist of mitochondria, non-living granules and chloroplast. The mitochondria is used for respiration, the non-granules is used for food and material storage and the chloroplast is used for photosynthesis.

The plant cell also consist of the nucleus, cytoplasm, vacuole, cell membrane and cell wall. The vacuole which is enclosed in the cell membrane contains cell sap and it is used for the storage of materials. The cell membrane is made up of proteins and lipids, used for the control of materials in and out of cell. The cell wall is also made up of cellulose which is used for support and giving cells shape.

Post intervention

After this treatment, a post- test was conducted in both groups (experimental and control) to assess students' progress and their understanding of the subject matter of the Cell Biology. The students from the experimental group and control group were further asked to construct detailed linkages/relationships in hierarchical order, branching, cross links and patterns of the Cell Biology that they had treated. These were checked for accuracy and completeness at the end of the activity.

Data Analysis

The data analysis from the questionnaire was quantitative. That is, it was in numerical form. The data was checked for consistency and organized in tables.

For the purpose of this research the traditional method of Concept Map scoring proposed by Novak and Gowin (1984) was used in the assessment process of the students' micro concept maps on Cell Biology that they drew. This method is based on the components and structure of the Concept Map.

SCORING SCHEME

Valid relationship (13 x 1) =13

Hierarchy levels (4 x 1) = 4

Branching (1st level) = 1

2nd level x 3 = 3

3rd level x 3 = 3

4th level x 3 = 3

Crosslinks (4 x 2) = 8

Pattern (General to specific) = 5

Example (2 x 1) = 2

Novak and Gowin's system assigns points for valid propositions (1 point each), levels of hierarchy (1 point for each level), branching (1 point for the first branching where two or more concepts are connected to the proceeding concept), pattern (maximum 5 points if the map shows general to specific pattern), crosslinks (1 point for each valid cross-link), and specific examples (1 point for each example). The number of hierarchical levels addresses the degree of subsumption, the number of branching indicates progressive differentiation, and the number of cross-links indicates the degree of integration of knowledge. This scoring technique has proven to be time-consuming, but it does give a great deal of information about the creator's knowledge structure.

The teachers in this study employed the same scoring scheme as proposed by Novak and Gowin in all the Concept Maps created by the students.

The pre and post- test mean scores of both the control and the experimental groups were analyzed using quantitative t-test analysis as well as descriptive statistical tool such as the mean, and the standard deviation to determine the impact of Concept Maps on students' performance in Cell Biology. The high, average and low-scoring students' performance were calculated and analyzed using t-test statistical tool for the testing of the hypothesis of the study.

CHAPTER 4

RESULTS AND DISCUSSIONS

Overview

The results are divided into two sections. The first section describes and analyses the pre-test scores of students in both schools; Nifa SHS and H'Mount Sinai SHS. The second section describes the findings from the investigation into the influence of Concept Map on students' performance in Science, and their ability to construct Concept Maps using Cell Biology as presented and discussed in relation to the three research questions. The research questions are discussed with the use of t-test statistical tool, scoring scheme techniques and descriptive analysis of the pre-and post-test mean scores as well as the responses from the questionnaire of the students. The findings of the study are discussed based on the research questions.

Comparing Pre-test Scores

Before instruction, the pre-test was administered to Nifa SHS and H'Mount Sinai SHS. To compare and verify if the pre-test scores of the control and the experimental groups were statistically the same, a two-tailed t-test was run. The result of the test is shown in Table 4.1.

Table 4.1: Table 1: Summary of the t-test statistics on the Pretest Scores of students from Nifa SHS (Experimental) and H'Mount Sinai SHS (Control)

Group	N	Mean	SD	variance	t-value	p-value
Control	34	12.47	4.04	16.32	2.00	0.85
Experimental	30	12.30	3.25	10.56		

From Table 4.1, the mean score for the control group was 12.47, while that of the experimental group was 12.30. The calculated t-value was 2.00 and p-value was 0.85, which means that there is no significant difference between the mean pre-test scores of the control and experimental groups ($p > 0.05$). This establishes that the two groups were comparable on their initial knowledge of the concept taught.

Findings Related to the Research Questions

Research question one (1)

What is the performance of students with the introduction of Concept Maps in the teaching of Cell Biology?

After 3 weeks of instruction, a post-test was given to the experimental and the control groups.

Comparing the pre-test and post-test of experimental and the control groups

The pre-test and post-test mean scores of the experimental group and the control group were compared to see the influence of the use of Concept Maps in the teaching of Cell Biology on students from Nifa Senior High School. The outcome is shown in Figure 4.1.

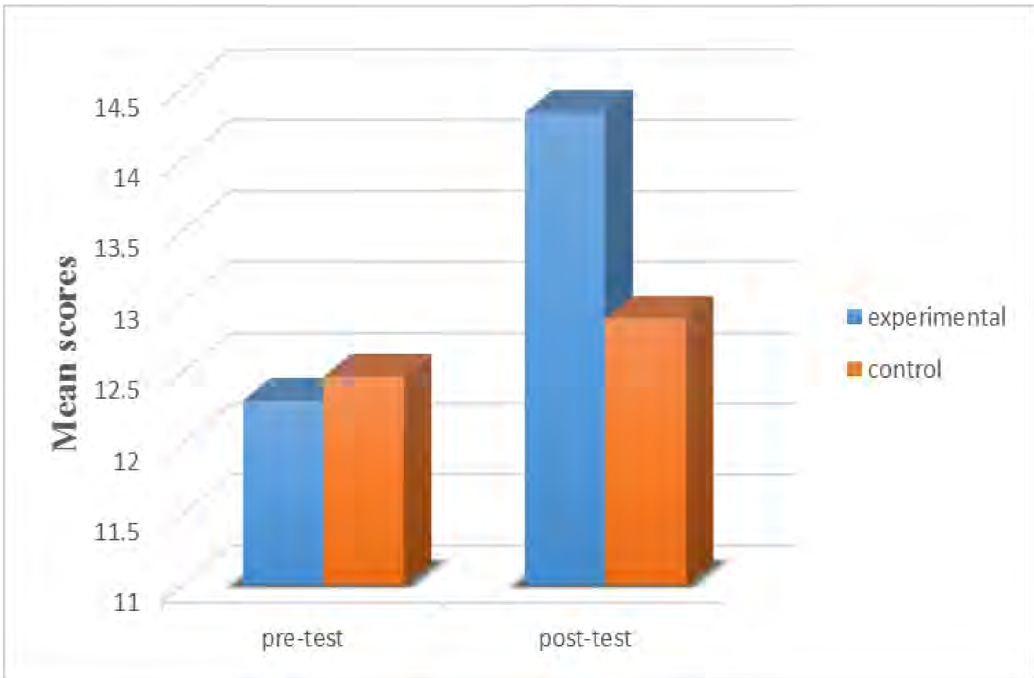

Figure 4.1: Comparison of pre-test and post-test mean scores between the experimental group and the control group

Figure 4.1 shows the comparison of the experimental and the control groups' pre-test and post-test mean scores. The control group attained a post-test mean score of 12.88 with the use of Traditional Lecture approach as the instructional approach, after they had a mean score of 12.47 in the pre-test. This implies the control group had a small gain of 0.41 in their post-test and pre-test mean scores. The experimental group had a pre-test mean score of 12.30. However, after the introduction of the Concept Maps as the instructional approach on the experimental group, the students' post-test mean scores significantly improved to 14.33, a gain of 2.03. Based on this result, it can be said that, students in the experimental group (Nifa Senior High School) seem to display a considerable improvement in their score from pre-test to post-test.

Comparison of Pre-test and Post-test Mean Scores between the experimental group and the control group using t-test statistical analysis

To determine if there was a statistically significant difference in the performance of students with the introduction of Concept Maps to the experimental group and the Traditional Lecture approach to the control group, a t-test was employed. Table 4.2 shows a summary of the analysis conducted.

Table 4.2: Comparison of Pre-test and Post-test Mean Scores between the experimental group and the control group

Groups	Type of test	N	Mean scores	S. D	t-value	p-value
Control	Pre-test	34	12.47	4.03	2.00	0.66
	Post-test	34	12.88	3.76		
Experimental	Pre-test	30	12.30	3.25	2.05	0.00
	Post-test	30	14.33	3.41		

From Table 4.2 a t-value of 2.00 and a p-value of 0.66. ($t=2.00$; $p > 0.05$) for the control group was displayed. This means, there is no significant difference between the pre-test and post-test mean scores of the control group, though there is a marginal increase in the mean scores. A t-value of 2.05 and a p-value of 0.00 ($t=2.05$; $p < 0.05$) for the experimental group, renders a decision that the difference is statistically significant. One possible reason for that could be due to the fact that the learners were facile with constructing Concept Maps which gave an indication that the interest gained in creating maps from the scratch might have improved their learning. Students caught up with the Concept Maps process of instruction to such an extent that less time was devoted to using the Concept Maps for its intended purposes of organizing thoughts and visualizing concepts.

Testing null hypothesis one (1)

H_{01}: There is no significant difference in the performance of students with the introduction of Concept Map in the teaching of Cell Biology

Comparing the mean scores of the pre-test and post-test Scores of the experimental group. To determine if the difference in the pre-test and post-test mean scores of the experimental group is statistically significant, a statistical t-test analysis was employed.

Table 4.3 shows a summary of the analysis conducted.

Table 4.3: Comparing the experimental group's pre-test and post-test mean scores

Type of test	N	mean	SD	variance	df	t-value	p-value
Pre-test	30	12.30	3.25	10.56	29	2.05	0.00
Post-test	30	14.33	3.41	11.61	29		

A p-value of 0.00 renders a decision that the difference is statistically significant based on the 95% confidence level. This means that, there is a significant difference in the performance of students with the introduction of Concept Maps instructional strategy. Therefore, the null hypotheses is rejected. One possible reason for that could be, learners gained interest in constructing Concept Maps which gave an indication that the introduction of Concept Maps has promoted learning. The mean test scores of pre- and post-test of the Experimental group students had a high significant increase which indicates that, the experimental group demonstrated a better conceptual understanding of Cell Biology with the use of Concept Maps. This is reflected in their post-test mean score value after the intervention (Concept Maps).

Research question two (2)

What is the gender disparity in the understanding of Cell Biology with the use of Concept Maps as a teaching strategy?

The distribution of the control group and the experimental group in terms of gender is shown in Table 4.4. The overall sample (including both the experimental and control groups) consisted of 64 students.

Table 4.4: Frequency distribution of control and experimental groups categorized in terms of Gender

Group	Frequency	Male	Female
Control	34	26	8
Experimental	30	24	6
Total	64	50	14

The total sample is made up of 78% male and 22% female subjects. The control group consisted of 34 students while the experimental group was made up of 30 students.

To compare and verify if there was a significant difference between the males and females when Concept Maps was used in the teaching of the Cell Biology, a t-test analysis was employed on their pre-test and post-test respectively. The results are shown in Table 4.5.

Table 4.5: Summary of the mean scores of experimental and control groups by gender

Group	Type Of test	Female Mean	Male mean	t-value	p-value
Control	Pre-test	11.75	13.15	2.18	0.33
	Post-test	12.37	13.80		
Experimental	Pre-test	11.17	12.67	2.45	0.27
	Post-test	13.83	14.45		

Table 4.5 indicates that, the control group has a t-value of 2.18 and a p-value of 0.33 ($t=2.18$; $p>0.05$) for the pre-test and post-test for both males and females, while the experimental group had a t-value of 2.45 and a p-value of 0.27 ($t=2.45$; $p>0.05$) for the pre-test and post-test for males and females. This means that, there is no significant difference between the males and females in the control group and the experimental group. This results means that, there is no statistical difference between the experimental and the control groups, though, there is a difference between their mean scores. This goes on to explain that, the males in both groups performed better than the female students in their respective groups.

Testing null hypothesis two (2)

There is no significant difference between males and females in the understanding of Cell Biology when Concept Maps are used as the teaching strategy

To determine if the null hypothesis is true, a t-test was employed on the post–test of the experimental male and female students. This is shown in the Table 4.6.

Table 4.6: Mean scores of the post-test of males and females of the experimental group

Group	N	Mean	t-value	p-value
Male	24	14.45	2.45	0.27
Female	6	13.83		

From Table 4.6, the calculated t-value was 2.45 and p-value was 0.27 ($t = 2.45$; $p>0.05$), was not significant at a probability level of 0.05. It is therefore suggested statistically the null hypothesis is maintained or accepted at 95% confident level. There is no significant difference between males and females in the understanding of Cell Biology after Concept Maps are used as the instruction strategy to teach them.

However, the male students had a slightly higher gain than their female counterpart in their mean scores.

Research question 3

What are students' attitude and interest towards the teaching and learning of Biology with the use of Concept Maps?

To determine the ratings of students from the experimental group on the effectiveness of Concept Maps integration in Biology as an instructional strategy, their responses are illustrated using graphs and charts as shown in Figure 4.2 to 4.9, and Table 4.7.

To determine whether concept maps promote students' interest in learning, figure 4.2 establishes the opinion from students in the experimental group:

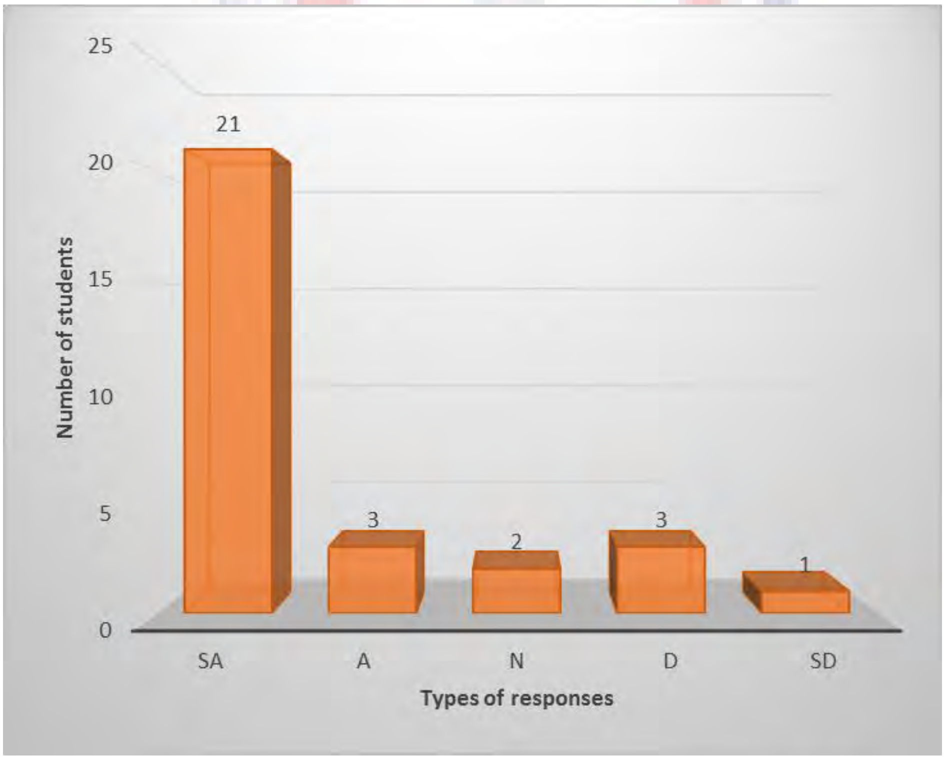

Figure 4.2: Concept Maps promote students interest in learning

Majority of participants (70.0 %, N=21) strongly agree with item 4, which indicates that the: "integration of Concept Maps in Biology teaching will elicit students' interest in Science concepts" and this is graphically shown in Figure 4.2.

Students' opinion on the use of Concept Maps as an effective tool for improving their attitude, ability and knowledge (item 5) is shown i`n Figure 4.3.

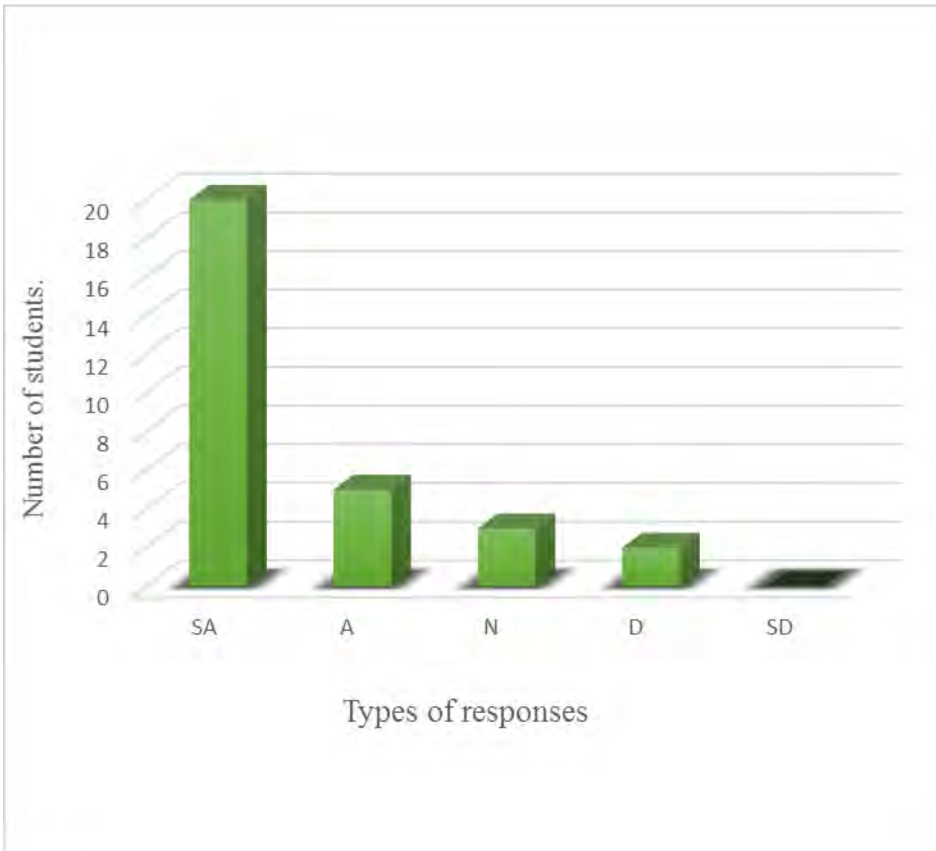

Figure 4.3: Concept Maps promotes students abilities and interest in learning

From Figure 4.3 (item 5), 66.6% (N=20) out of the 30 participants strongly agreed that, Concept Map is an effective tool for improving the attitude, ability and knowledge of students. This was confirmed by two of the participants asserting that, 'Concept Maps can improve the technical abilities of individual students'.

Students' views on the use of the Concept Maps in the teaching and learning of Biology were answered by the use of questionnaire. Students' responses to the questionnaire items were converted to percentages and presented in Table 4.7.

Table 4.7: The effectiveness of Concept maps in the teaching and learning of Biology

Items	SD N(%)	D N(%)	N N(%)	A N(%)	SA N(%)
4. The use of Concept Maps provide aids for expanding what has been taught in class.	1(3.3)	3(10.0)	2(6.7)	3(10.0)	21(70.0)
5. The use of Concept Maps as instructional techniques is an effective Strategy for students of all abilities.	0(0.0)	2(6.7)	3(10.0)	5(16.7)	20(66.6)
6. I was more enthusiastic and motivated during the use of Concept Maps in the teaching and learning of Cell Biology.	4(13.3)	1(3.3)	2(6.7)	4(13.3)	19(63.4)
7. The use of Concept Maps in instruction reduces my personal interaction with my colleagues.	22(73.3)	3(10.0)	2(6.7)	2(6.7)	1(3.3)
8. The use of Concept Map as an instructional strategy would promote students' understanding of concepts and do away with rote learning.	1(3.3)	1(3.3)	1(3.3)	5(16.7)	22(73.4)
9. Concept Maps hinder students' ability with learning tasks (e.g., writing, analyzing data for solving problems).	15(50.0)	7(23.3)	1(3.3)	2(6.7)	5(16.7)
10. The use of Concept Maps instruction is an effective means of helping students to understand the relationships among concepts.	1(3.3)	1(3.3)	1(3.3)	3(10.0)	24(80.1)
11. The use of Concept Maps instruction would make me feel more involved and offer more contributions in the given project.	1(3.3)	2(6.7)	5(16.7)	4(13.3)	18(60.0)
12. The use of Concept Maps for learning almost always reduces the personal undue forgetfulness and recitation of mnemonics as well as acronyms during examinations.	1(3.3)	4(13.3)	4(13.3)	6(20.0)	15(50.0)

13. The use of Concept Maps for instruction would enable me to interact more with my colleagues to promote group discussion.	2(6.7)	2(6.7)	1(3.3)	8(26.6)	17(56.7)
14. I feel the use of Concept Maps for instruction would affect my learning during my private time ina positive way.	1(3.3)	3(10)	2(6.67)	5(16.67)	19(63.3)

From Table 4.7, majority of the students (N = 19 to N = 27) responded positively to most of the items. Thus about 19 to 27 students agreed or strongly agreed to items 4, 5, 6, 8, 10, 11, 12, 13 and 14.

Items 7 and 9 were negatively coded, and 83.3% (N = 22) disagreed or strongly disagreed with the statement 7, while 10% of the participants established that Concept Maps integration reduces their personal interaction with colleagues. Also in item 9, 73.3% (N = 22) disagreed or strongly disagreed with the statement. However, about 23.4% (N = 7) responded that the use of Concept Maps reduces their personal interaction with their colleagues.

Students' response to item 4 on as to whether the use of Concept Map as an instructional strategy would promote students understanding of concepts and do away rote learning or not is represented in Figure 4.4 by the use of a chart.

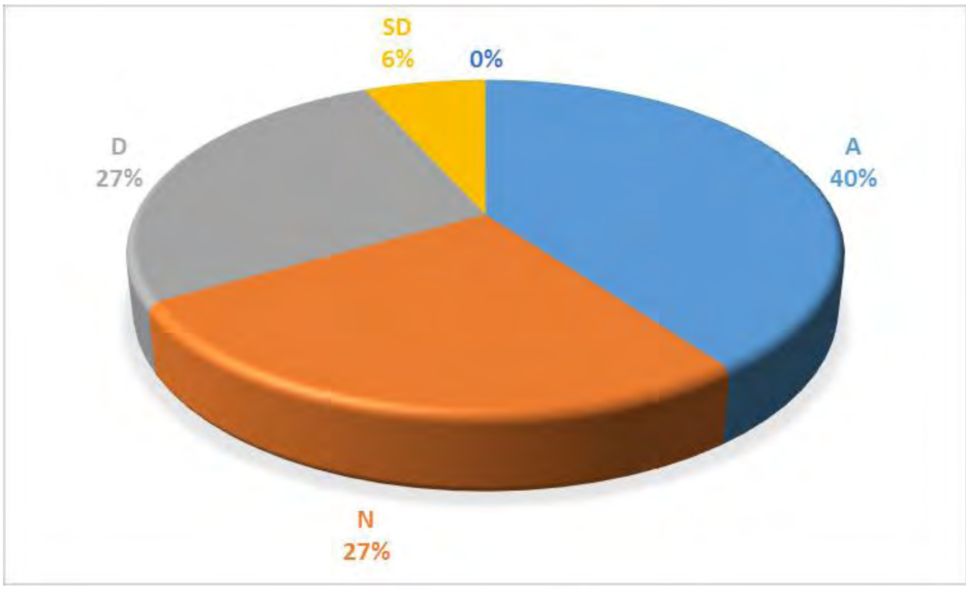

Figure 4.4: Concept Map helps in expanding knowledge

In item 4, 70.0% (N=21) of the participants strongly agreed that, the use of Concept Maps is an effective means of expanding what have been taught in class. Three (3) of the students representing 10% did agree that to the fact that the use of Concept Map helps in expanding their knowledge.

Students' perception on whether Concept Maps as a tool for instruction would promote their understanding of concepts and do away with rote learning and memorization of facts or not (item 8) is shown in Figure 4.5.

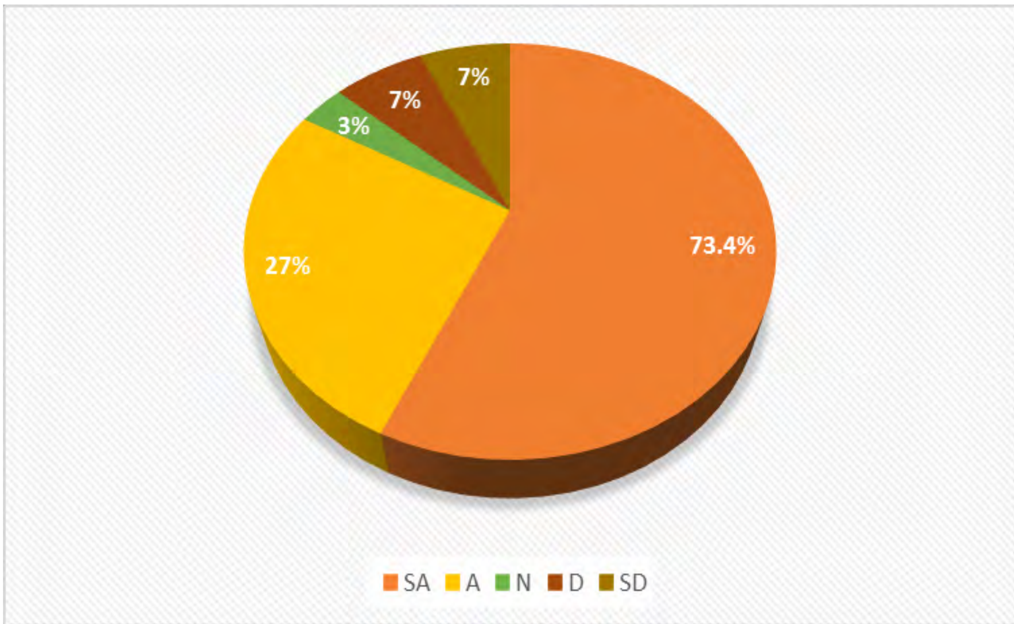

Figure 4.5: Concept Maps prevents rote learning and memorization of facts

In Figure 4.5 **(**Item 8), 73.4% (N=22) of the participants strongly agreed that, they perceived that Concept Maps as a tool for instruction would promote the students understanding of concepts and do away with rote learning and memorization of facts. This was indicated by one of the participants that: *"using Concept Maps for instruction would promote our understanding of concepts and do away with rote learning and memorization of facts during examinations and tests in schools. This will arouse our cooperation and confidence in the study of Biology in class."*

Students' idea on whether Concept Maps enhances students learning ability in science instruction through writing, and analysing of data for problem solving or not is represented Figure 4.6:

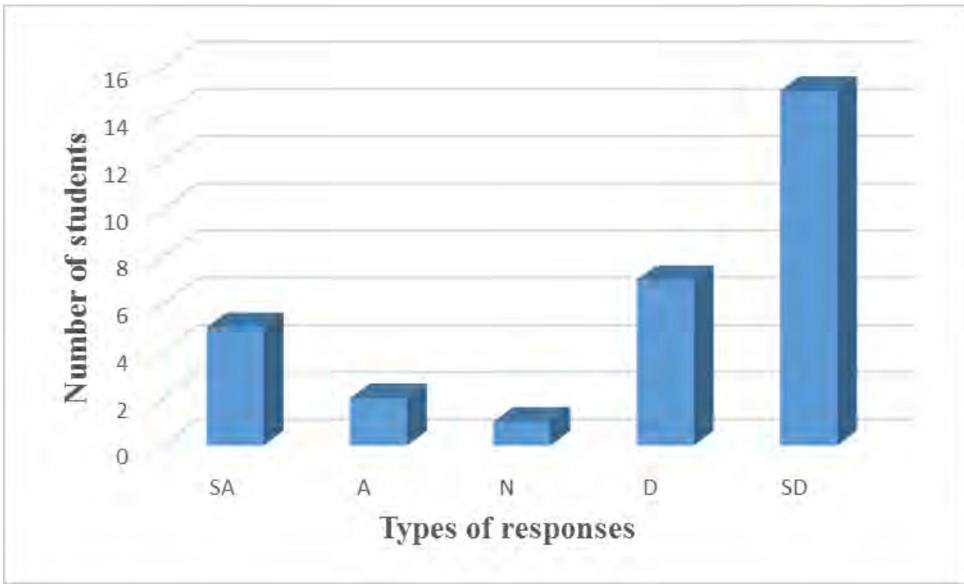

Figure 4.6: Concept Maps enhances students ability in science instruction

Item 9 was negatively coded with 50% of the respondents' strongly disagreeing (item 9). This shows that, half of the respondents perceived that, Concept Maps enhances students learning ability in science instruction through writing, and analysing of data for problem solving.

Students' perception on the use of Concept Maps for learning almost always reduces the personal undue forgetfulness and recitation of mnemonics as well as acronyms during examinations (item 12) is represented in Figure 4.7:

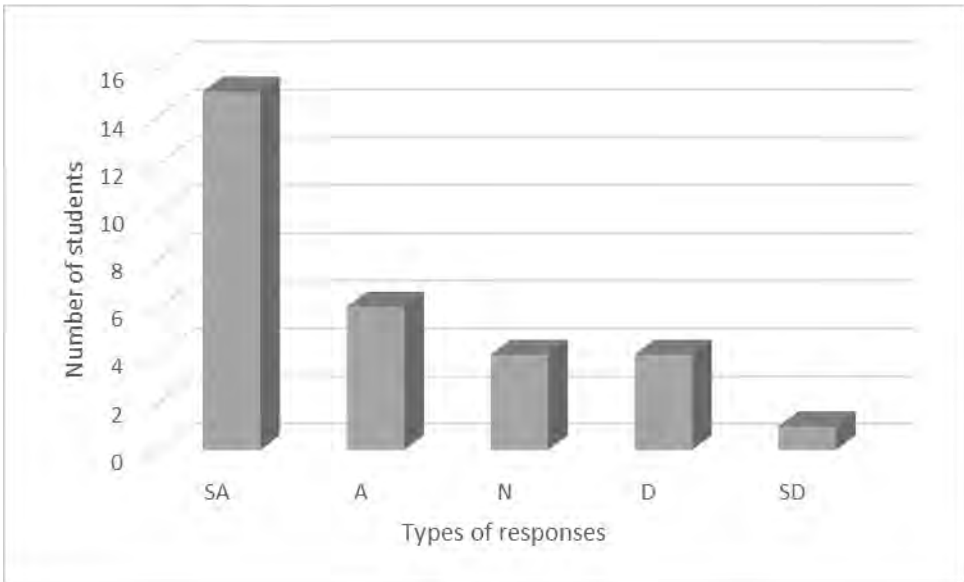

Figure 4.7: Concept Map can reduce forgetfulness and recitation in examination

As indicated in Figure 4.7, 50% (N=15) of the participants that is item 12, strongly agreed that the use of Concept Maps for learning almost always reduces the personal undue forgetfulness and recitation of mnemonics as well as acronyms during examinations. One of the participants indicated that *"Concept Map is a tool for quick revision and remembrance."*

Item 13 was to find from the students their response on whether the use of Concept Maps for instruction would enable them to interact more with my colleagues to promote group discussion or not. Their response is represented in Figure 4.8:

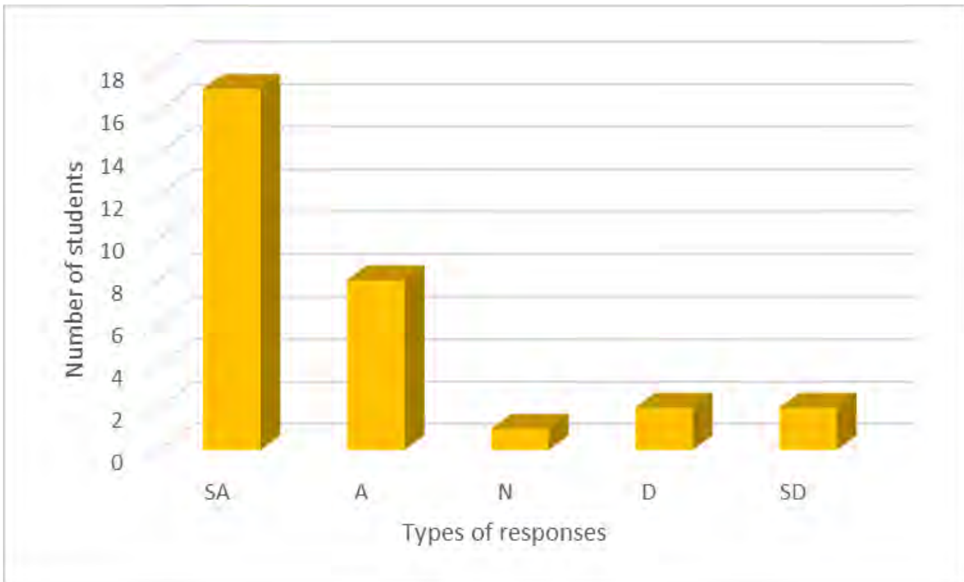

Figure 4.8: Concept Maps help students in their private studies

For item 13, 17(56.7%) out of 30 participants strongly agreed, which indicates that most of the participants perceived Concept Map tools to enable them interact with their fellow students to promote group discussion.

Also, about half of the respondents perceived that the use of Concept Maps will capture their attention and, that the use of Concept Maps for instruction would positively affect their learning during their private revision time, as one of the participants indicated: *"Concept Maps enforcement and integration will enhance the teaching and learning of science as we are actively involved in the teaching and learning process. It will also enhance our analytical and critical thinking skills."*

The overall mean score on the effectiveness of Concept Maps integration in the enhancement of Biology instruction is 3.56 (standard deviation 0.16), which indicates that, the students have a positive perception towards the integration and enforcement of Concept Maps in Biology instruction.

Discussions

The use of Concept Maps in the teaching of Cell Biology positively affects students learning by improving their performance. This is shown in the post-test mean score value of 14.33 as against their pre-test mean score of 12.30 with the experimental group for whom Concept Map was used as their instructional approach. This was not observed with the control group who had a post-test mean score of 12.88 as against their pre-test mean score of 12.47. This goes to show that the use of Concept Maps in the teaching of Cell Biology (Biology) helps students to improve their performance in Biology. This is in agreement with Hall (2002) and Kinchin (2000), as they were of the view that the use of Concept map increases recall of information in instructions in Biology subject which will in effect improves students' learning. (Hall, 2002).

The use of concept maps as an instructional approach also improves students' understanding of concepts and do away with rote learning and memorization of facts, and as such prevents undue forgetfulness and quick revision and remembrance in students. Keng (1996) also had a similar view when he conducted a comparative study of note taking, outline and Concept Map learning strategies on National Taipei Teachers College students' understanding on heat and temperature. Keng's result indicated that Students who used either an outlining or Concept Map learning strategy scored significantly better than students who used only a personalized note-taking strategy.

Students from Nifa Senior High School (experimental group) whom the Concept Maps were used as their instructional approach improved in their writing abilities and analyzing data for solving problems. These skills were also achieved by Cambia and Hussain (2012), and Gorjian, Pazhakh and Parang (2002) who in their studies also found out that their students language, writing and solving problem abilities have been improved.

Though significant researches have indicated that gender plays a role in students' academic achievement particularly in Biology and Science in general with the use of Concept Map instructional approach (Okeke, 2007; Offor, 2007), in this study it was observed that the use of Concept Map to improve students' performance in Cell Biology (Biology) did not depend on gender as there was no significant difference between males and females performance of male and female with respect to their post-test mean scores.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Overview

This chapter comprises the summary of findings and significant ideas, conclusion and educational implications for the teaching of Biology and further studies. It then continues with the recommendations of the research study.

Summary

The main purpose of this study was to investigate the use of Concept Map to enhance the teaching and learning of Cell Biology for S.H.S. one (1) elective Biology students of Nifa Senior High School and compare it with the Traditional Lecture method of instruction. In this study, Concept Map was used as an instructional strategy. The independent variables were the frequency and quality of Concept Mapping students employed in their self-studies. The dependent variable was the resulting change in students' understanding of Cell Biology concepts, as demonstrated by comparison between the pre-test and post-test results of the experimental and the Control groups. The research questions addressed in the study were as follows:

1. What is the performance of students with the introduction of Concept Maps in the teaching of Cell Biology?
2. What is the gender disparity in the understanding of Cell Biology with the use of Concept Maps as a teaching strategy?
3. What are students' attitude and interest towards the teaching and learning of Biology with the use of Concept Maps?

To investigate these questions, experimental and control groups were assigned.

The results of the present study showed that, the pre-test mean scores of the students in the experimental and control group were not significantly different. This indicated that, the two groups used in the study showed comparable characteristics.

Post-test results were also compared and the results obtained were that, there was a significant difference between the experimental group and the control group. The students from the experimental group had a higher mean score value than their counterparts in the control group after the post-test. Thus the experimental group performed considerably better than the students from the control group.

With regard to the gender disparity with reference to the use of Concept Map as an instructional strategy in the teaching of Cell Biology, the difference between the males and females was not statistically significant. Thus, the males did not perform better than the females, but the results showed that the pre-test mean score and post-test mean score of the two groups were virtually similar. This finding goes on to suggest that, the effective use of Concept Map in the teaching of Biology will go a long way to help female students to achieve comparable results as their male counterparts.

The findings also indicated that, the null hypotheses for research question two which stated that, there is no significant relationship between male and female after the introduction of the Concept Mapping should not be rejected.

The deductions made from the responses to the questionnaire items (4-14) suggested that, most experimental group students support the view that, the integration of Concept Map in education is useful in:

1. Promoting students keen interest in the teaching and learning of Biology.

2. Enhancing cooperative work among students during science projects and practical works.
3. Providing suitable learning environments that appeal to a variety of learning styles of students.
4. Helping students to expand and apply what has been taught in class so as to give them courage to exercise control over the environment.
5. Minimizing the personal undue forgetfulness and recitation of mnemonics as well as acronyms during examinations.
6. Assisting students to acquire the basic quick revision skills in Biology education needed for their future advancement.

Conclusion

The results of the study suggest that, using Concept Map as an instructional approach in Cell Biology promotes higher level of thinking in students and allow instructors insights into the thought processes and understanding held by their students. The data showed a significant difference between the mean scores of the pre-test and post-test of the experimental group when Concept Map is used as an instructional strategy, whereas the use of the Traditional Lecture approach did promote enough gain in terms of students' performance.

This goes to show that, the use of Concept Maps in the teaching of Cell Biology really helped the students to improve in their performance.

The findings also showed that, there is no gender disparity in the understanding of concepts when Concept Map is used as a tool for learning. The post-test mean scores of the females and the males in the experimental group were similar, indicating the effectiveness of Concept Map in enhancing conceptual understanding among all ability levels in a mixed sexes' environment.

To conclude, results of this study shows that, the probability of achieving gender equality in science education is based on hard work on the part of female students and the use of appropriate teaching strategy, which is seen in the use Concept Map as an instructional strategy. This is because, Concept Map brings about meaningful conceptual understanding of science to students of different achievement levels and not limited to any achievement level or sex.

Educational implications of the study for Biology Teaching

Numerous researchers have investigated Concept Mapping since its inception as a graphic memory and learning as an instructional strategy to improve knowledge acquisition. Concept Map may be used by any area of academic endeavour at any developmental level (Canas & Novak, 2000). However, the inclusion of Concept Map should be an element that is considered and committed over time, giving the individuals who could potentially benefit from their use the time necessary to adequately prepare for their successful use. Some research indicates that, the use of Concept Maps fosters the development of higher level thinking and problem solving by presenting relationship between concepts in a manner that can be readily understood by learners (Ifenthaler, 2012). Concept Maps have the potential of positively influencing the teaching of science especially, the teaching of Biology. When used properly it will promote higher level critical thinking and communication skills which are crucial elements needed in the academic environs or work place.

Limitation of the study

The number of students for this study was limited to 64. Hence the result achieved cannot be generalized to all S.H.S. one students in Ghana.

Also, some of the students might decide not to choose the appropriate response with regard to the answering of the questionnaire, which might influence the results obtained in one way or the other.

The researcher was also the teacher of the experimental group, hence her biasness might affect the results in some way.

Recommendations

The purpose of this study was to investigate the use of Concept Map to enhance the teaching and learning of Cell Biology. Recommendations resulting from this study suggest a need for future research to improve and strengthen the relationship between Concept Map and academic learning specifically in science. In light of these findings;

1. The researcher recommends that, teachers must flip the study groups to provide fair evaluating of attitudes and responses towards the Concept Map methodology.
2. Enough time must be allotted to teach the Concept Map technique with consideration to the students' psychological reactions to increasing levels of difficulty and demands of complexity.
3. Teachers practice caution in incorporating Concept Map in instruction and in using proposition-based scoring methods as they can be time consuming and require human judgement.

4. Future studies of this nature dealing with Concept Maps should include both genders over a long period of time and begin with the younger ages in an effort to preclude interference resulting from prior learning or familiarization with other graphic organizers.
5. Teachers are to use Concept Maps as instructional strategy when a subject matter of a unit is hierarchical and basically conceptual and that this strategy be used for one unit at a time to lessen the cognitive load and demands of the Concept Map technique.

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APPENDICE

STUDENTS' QUESTIONNAIRE

Appendix A; TEACHING WITH CONCEPT MAPS STRATEGY

INSTRUCTIONS

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

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

A. **Background information**

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

1. Gender [ ] Female [ ] Male

2. Age ………………years

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

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

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

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

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

Statement	SA	A	N	D	SD
4. I was more enthusiastic and motivated during the use of Concept Maps in the teaching and learning of Cell Biology.					
5. The use of Concept Maps as instructional techniques is an effective strategy for students of all abilities.					
6. The use of Concept Maps strategy in instruction reduces my personal interaction with my colleagues.					
7. The use of Concept Maps provides a means of expanding and applying what has been taught in class.					
8. When using Concept Maps to explain un-grasped concept to a colleague, my role will be as a facilitator of theirs learning.					
9. The use of Concept Maps instruction would promote the student understanding of concepts and do away rote learning memorization of facts.					
10. The use of Concept Maps instruction is an effective means of helping students to understand relationships among concepts.					
11. The use of Concept Maps instruction would make the student feel more involved and to cooperate more on projects.					

12. The use of Concept Maps for learning almost and always reduces the personal undue forgetfulness and recitation of mnemonics as well as acronyms during examinations.					
13. Concept Maps for instruction would enable me to interact more with other students to promote group discussion.					
14. I feel the use of concept maps for instruction would affects my learning during my private time in a positive way.					

APPENDIX B

Pre-intervention test for the study.

Please answer each of the following questions to the best of your knowledge by choosing the correct answer from options (A-D).

1. This structure serves as the outer boundary of the eukaryotic cell;
   a) Cell membrane
   b) Flagella
   c) Capsule
   d) Cytoskeleton
2. Which of the following are not found in plant cell?
   a) Golgi apparatus
   b) Mitochondria
   c) Glyoxysomes
   d) Centrosomes
3. Plasma membrane is composed of
   a) Cellulose
   b) Lipids
   c) Proteins
   d) Protein and lipids
4. Sara would like to film the movement of chromosomes during cell division. Her best choice for a microscope would be;
   a) Light microscope, because of its resolving power.
   b) Transmission electron microscope, because of its magnifying power.
   c) Scanning electron microscope, because the specimen is alive.
   d) Transmission electron microscope, because of its great resolving power
5. The electron microscope has been particularly useful in studying bacteria, because
   a) Electrons can penetrate though bacteria cell walls.
   b) Bacteria are so small
   c) Bacteria move so quickly they are hard to photograph
   d) With few organelles present, bacteria are distinguished by differences in individual macromolecules.

6. The nucleus of a cell

   a) Is the region of the cell where ribosomes are degraded

   b) Contains DNA and controls cell activities

   c) Is contained inside the nucleolus.

   d) Is surrounded by a single layer of membrane.

7. Organelles found outside a eukaryotic cell and usually involved in movement of the cell or movement of substances past the cell are called

   a) cilia and flagella

   b) Cell walls and plasmodesmata

   c) Nucleus and nucleolus

   d) cytoplasm and endoplasm

8. Food is converted to energy in

   a) Chloroplast

   b) Nucleus

   c) Mitochondria

   d) Nucleolus

9. Cell Biology states that;

   a) All cells are living

   b) Cells are fundamental structural units of plants and animals

   c) All cells have nuclei

   d) Cells reproduce by mitosis and meiosis

10. Prokaryotic cell does not possess

   a) Cytoplasm

   b) Nuclear membrane

   c) Plasma membrane

   d) Cell wall.

11. The photosynthetic pigment of a cell is known as

   a) Chloroplast

   b) Nucleus

   c) Mitochondria

   d) Cytoplasm

12. The function of mitochondria is

   a) Intracellular transport of proteins.

   b) Photosynthesis.

c) Intracellular digestion.
d) cellular respiration (ATP synthesis

13. Extra nuclear DNA is found in
a) chloroplast
b) endoplasmic reticulum
c) ribosomes
d) nucleus

14. He advanced the Cell Biology with his conclusion that cells could only come from other cells;
a) Anton Van Leeuwenhoek
b) Rudolph Virchow
c) Theodor Schwann
d) Robert Hooke

15. Rough endoplasmic reticulum
a) Contains ribosomes for protein synthesis
b) creates an enormous surface area for cell metabolism
c) contains a compartment to transfer and modify products of metabolism
d) all of the above

16. In eukaryotic cells, internal membranes
a) provide additional area where many metabolic processes occur
b) Form membranous compartments called organelles.
c) Contain proteins essential for metabolic processes.
d) All of the choices are correct.

17. When a cell is deprived of oxygen, its lysosomes tend to burst and release their contents into the cell. (This statement is true.) As a result of this, that cell would be expected to
a) Undergo self-digestion and die.
b) Recycle damaged organelles.
c) Produce additional ER.
d) Undergo cell division

18. Of the following organelles, which group is involved in manufacturing substances needed by the cell?
a) Lysosome, vacuole, ribosome

b) Ribosomes, rough ER, smooth ER

c) Vacuole, rough ER, smooth ER

d) Smooth ER, ribosome, vacuole

19. In a cell, the organelle for water storage is called

a) Cytoplasm
b) Mitochondria
c) Vacuole
d) Nucleus

20. Materials transportation and packaging in the cell is done by

a) Nucleus
b) Cytoplasm
c) Mitochondrion
d) Golgi bodies

APPENDIX C

Post-intervention test for the study

Please answer each of the following questions to the best of your knowledge by choosing the correct answer from the options (A-D), provided below.

1. Who was the first person to see cells under the microscope and give them a name?
   a) Anton van Leeuwenhoek
   b) Robert Hooke
   c) Theodor Schwann
   d) Matthias Schleiden
2. He discovered that all plants were made of cells, which contributed to the development of the Cell Biology.
   a) Anton van Leeuwenhoek
   b) Robert Hooke
   c) Theodor Schwann
   d) Matthias Schleiden
3. Bacterial cell are prokaryotic; in comparison to a typical eukaryotic cell they would
   a) Be smaller.
   b) Have a smaller nucleus.
   c) Lack a plasma membrane.
   d) Have a greater variety of organelles
4. This structure serves as the outer boundary of the eukaryotic cell:
   a) flagella
   b) cytoskeleton
   c) cell membrane
   d) capsule
5. Unlike eukaryotes, prokaryotes do not have:
   a) DNA
   b) cytoplasm
   c) cell walls
   d) a membrane bound nucleus
6. Which of the following is NOT one of the main components of the Cell Biology?

a) Cells must contain DNA

b) all living things are made of cells

c) cells can only come from other cells

d) cells are the basic unit of life

7. The photosynthetic pigment of a cell is known as?

a) Chloroplast

b) Cytoplasm

c) Nucleus

d) Mitochondrion

8. Which of the following is not an organelle of the cell?

a) Vacuole

b) Cytoplasm

c) Nucleus

d) Mitochondrion

9. Packaging and transport of materials in the cell is carried out by?

a) Golgi bodies

b) Cytoplasm

c) Nucleus

d) Mitochondrion

10. Which of the following are not found in plant cell

a) Mitochondria

b) Glyoxysomes

c) Centrosomes

d) Golgi apparatus

11. The main difference between plants and animal cell is that

a) Animal cell lack rigid cell wall

b) Animal cells have vacuoles

c) Plant cell lack rigid cell wall

d) Plants cells have small vacuoles

12. Extra nuclear DNA is found in

a) Chloroplast

b) Endoplasmic reticulum

c) Ribosomes

d) Nucleus

13. Cell Biology states that,

a) All cells have nuclei

b) All cells are living

c) Cell reproduce by mitosis and meiosis

d) Cells are fundamental structural units of plants and animals.

14. The water storage (in the form of sap) organelle in the cell is known as?

a) Vacuole

b) Cytoplasm

c) Nucleus

d) Mitochondrion

15. Which of the following organelle is not permanent in animal cell?

a) Vacuole

b) Cytoplasm

c) Nucleus

d) Mitochondrion

16. Prokaryotic cell does not possess

a) Cell wall

b) Nuclear membrane

c) Cytoplasm

d) Plasma membrane

18. Plasma membrane is composed of

a) Protein

b) Lipids

c) Cellulose

d) Protein and lipids

19. Ribosomes help in

a) Protein synthesis

b) Photosynthesis

c) Respiration

d) Lipid synthesis

20. Food is converted to energy in

a) Nucleus

b) Nucleolus

c) Chloroplast

d) Mitochondria

APPENDIX D

Examples of students constructed Concept Maps

APPENDIX D1

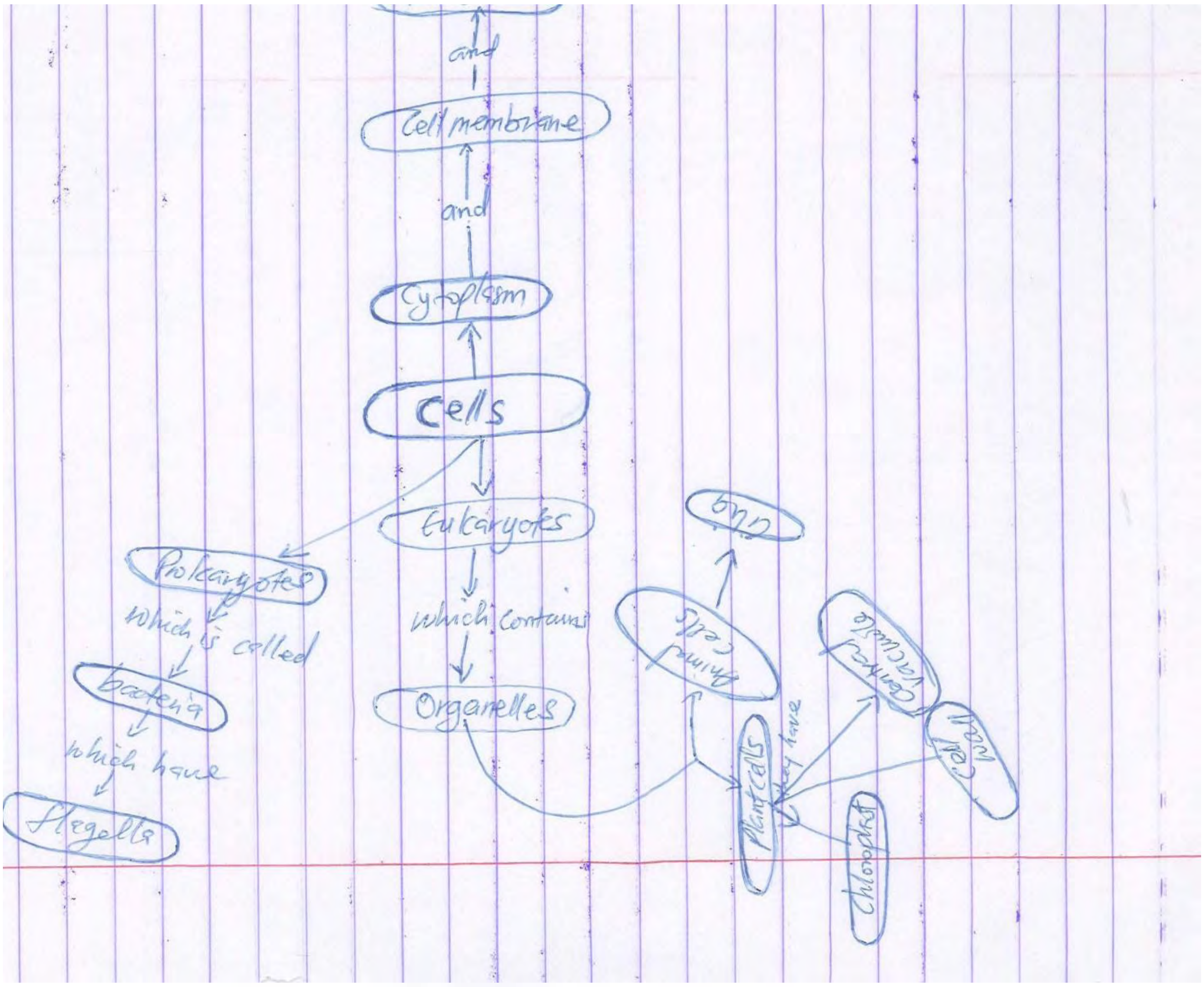

Fig.13; Student's constructed Concept Map.

APPENDIX D2

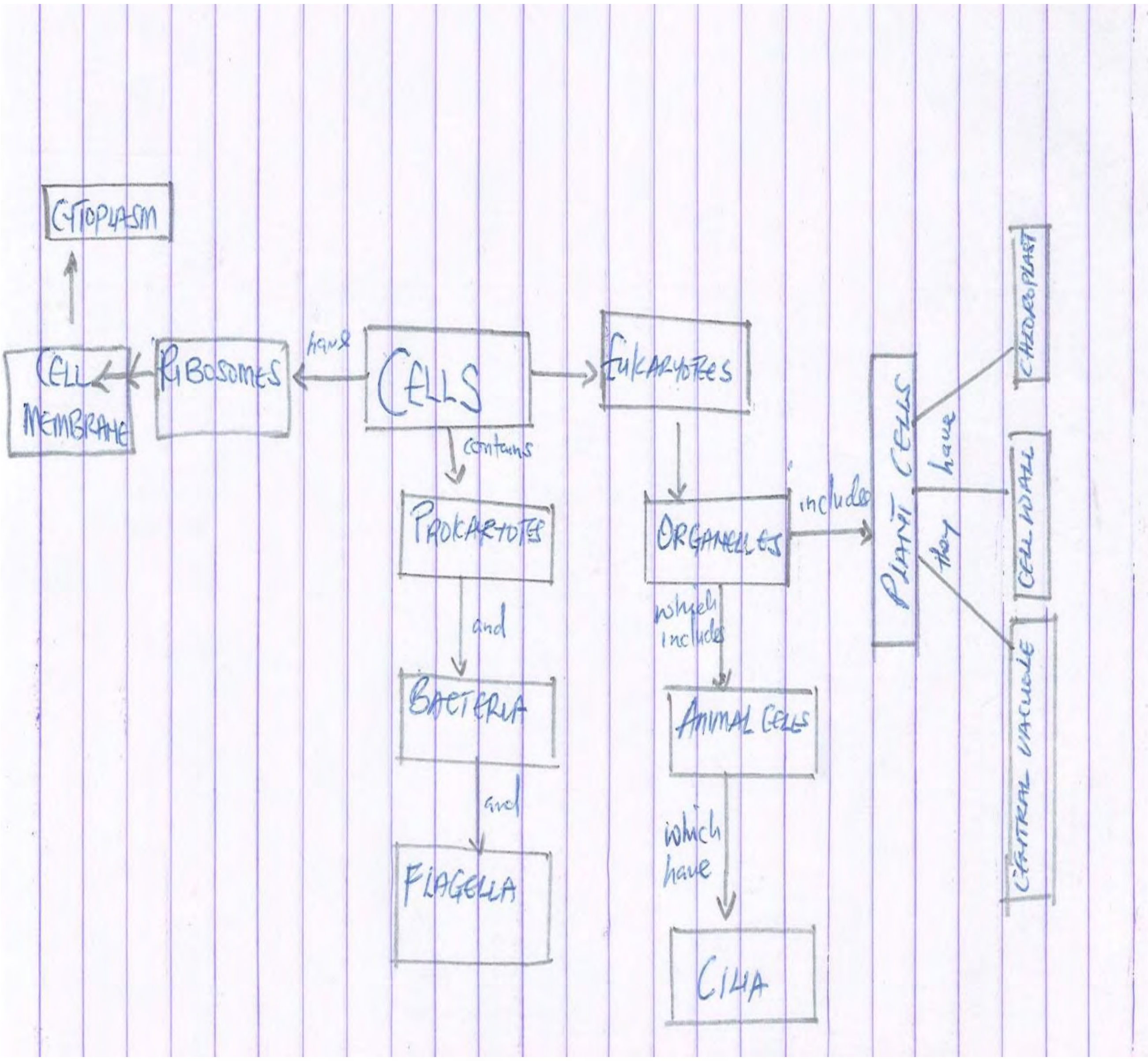

Fig.14; Student's constructed Concept Map.

APPENDIX D3

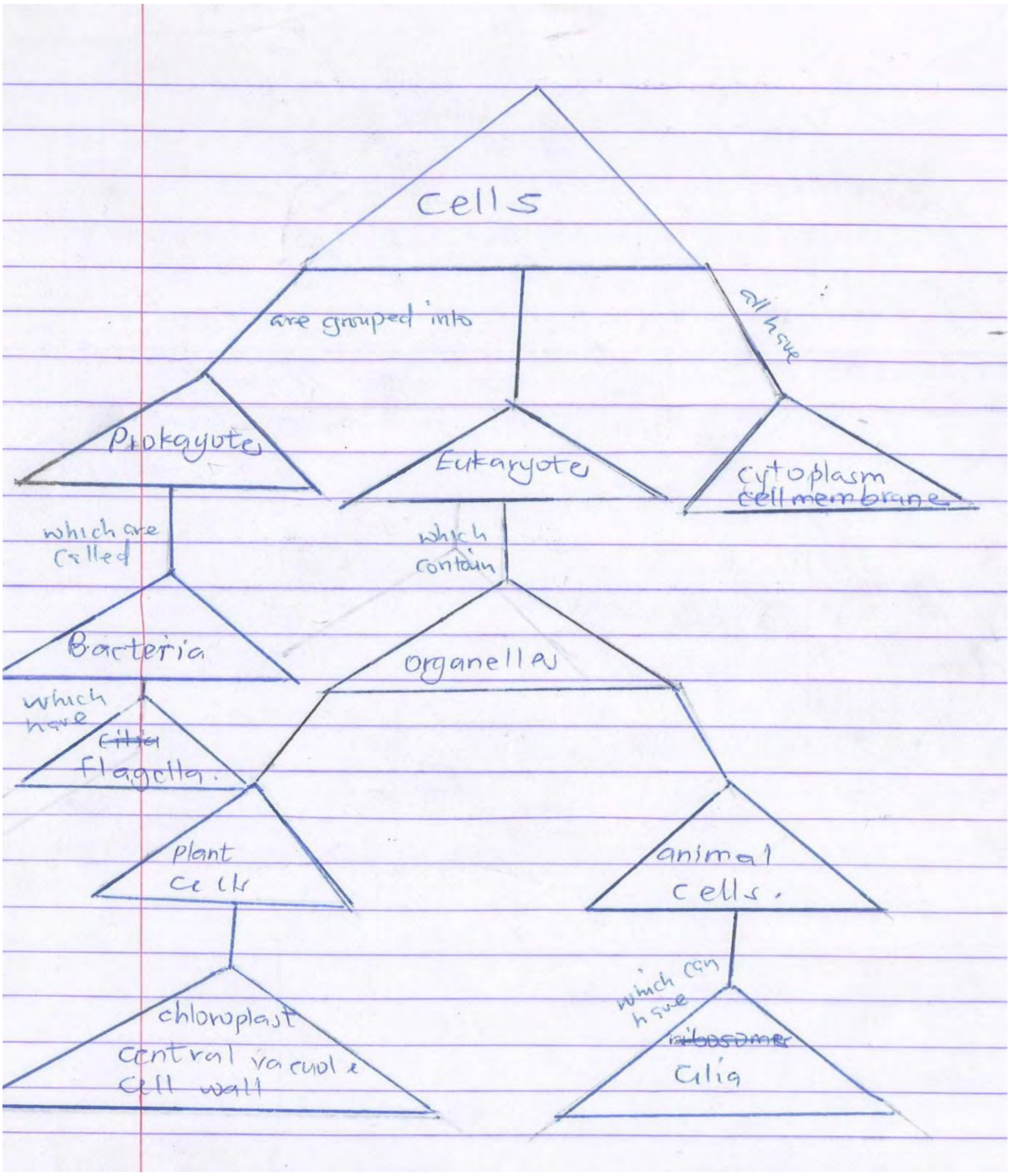

Fig.15; Student's constructed Concept Map

APPENDIX D4

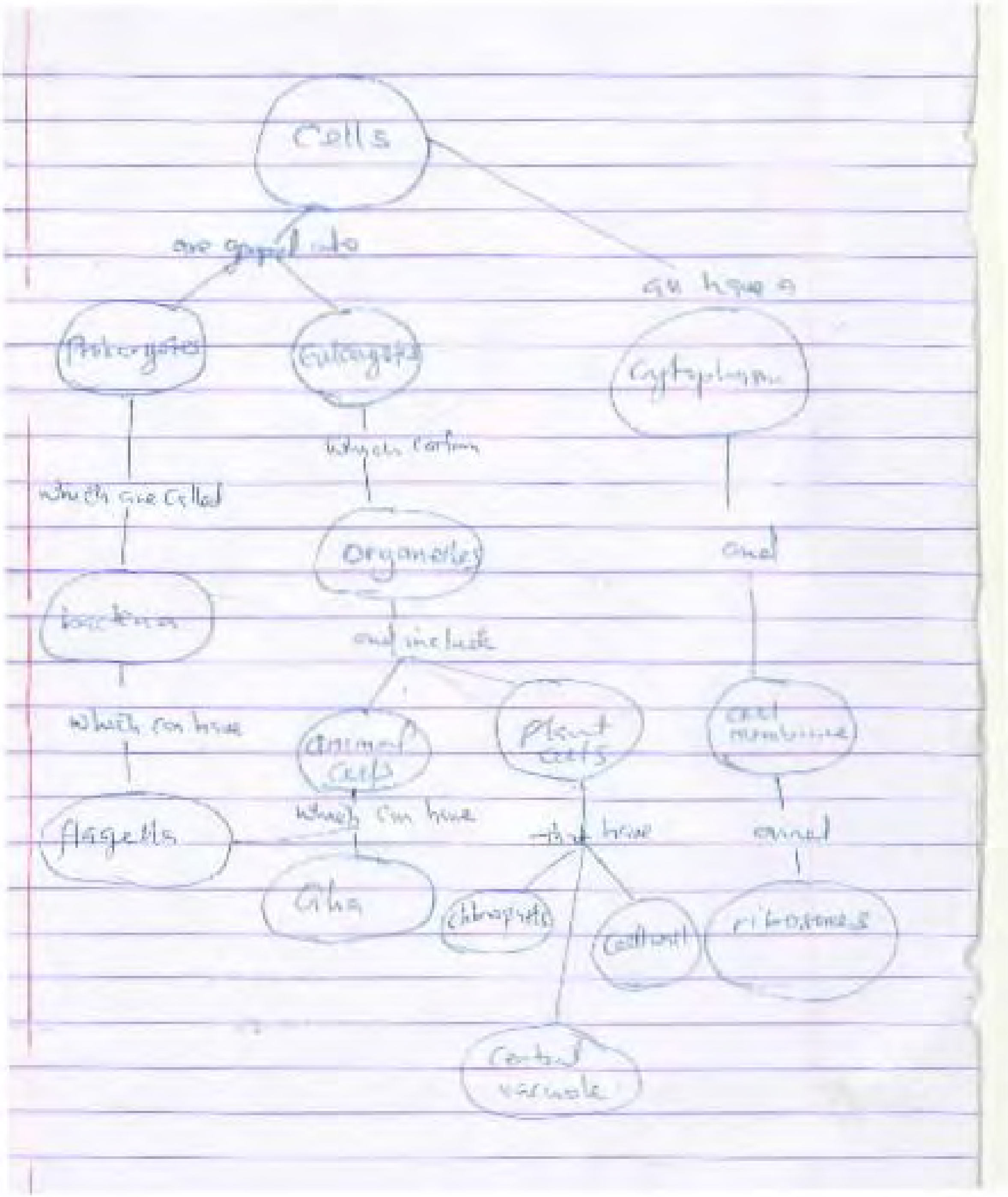

Fig.16; Student's constructed Concept Map

APPENDIX D5

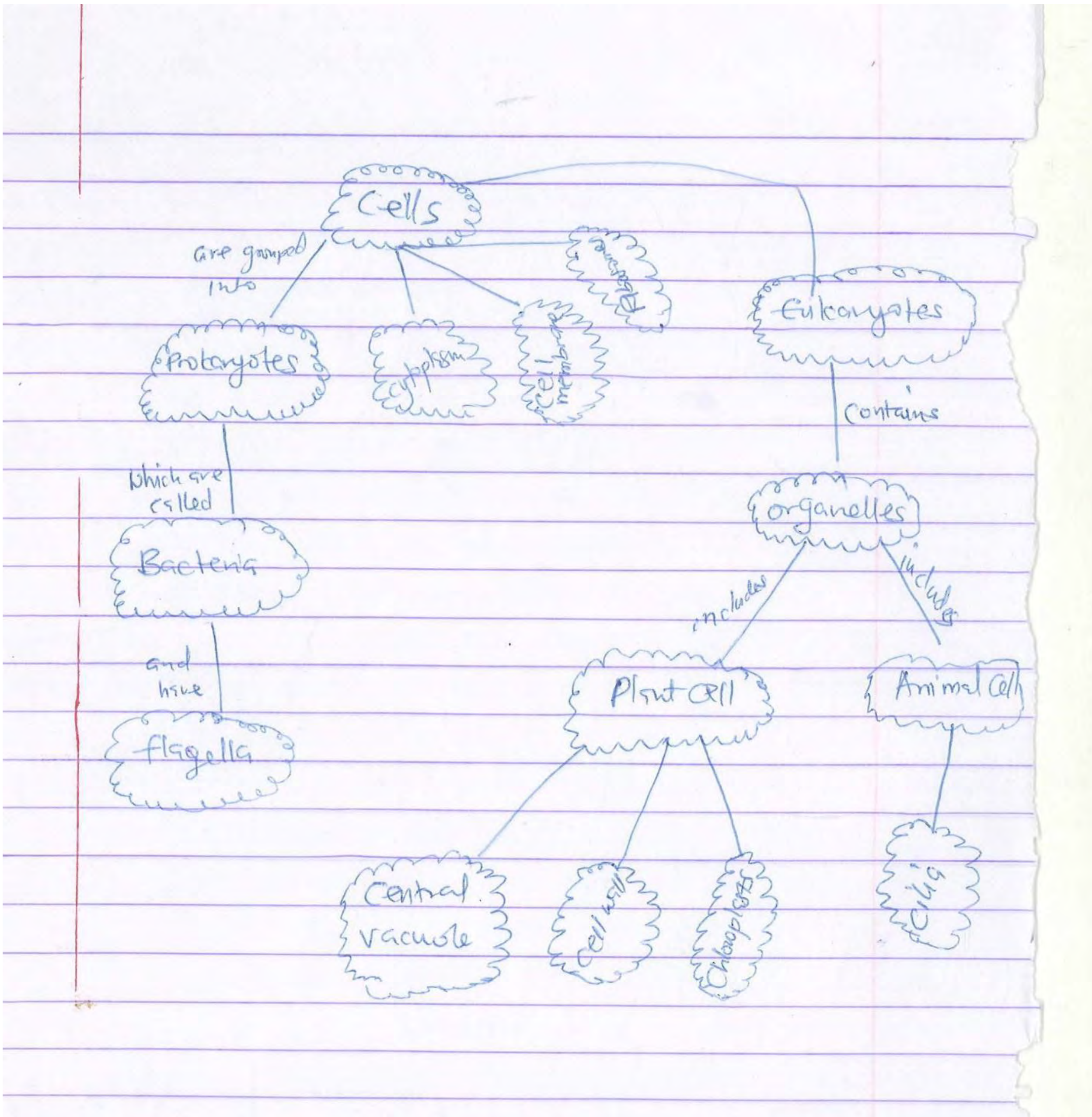

Fig.17; Student's constructed Concept Map

APPENDIX D6

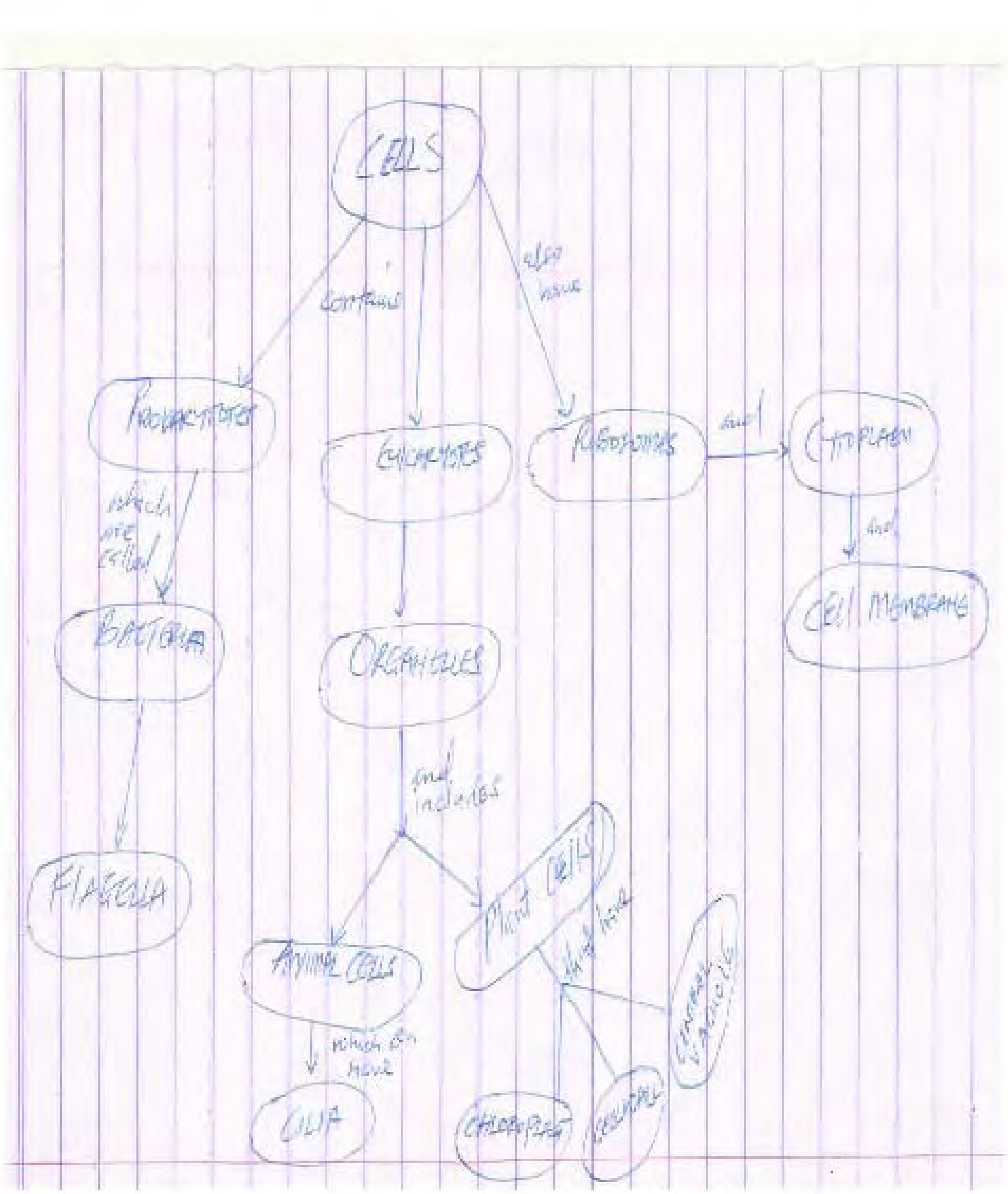

Fig.18; student's constructed Concept Map.