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IMPROVING THE CONCEPTUAL UNDERSTANDING OF THE PROCESS OF PHOTOSYNTHESIS TO SECOND YEAR SCIENCE STUDENTS OF ABETIFI PRESBYTERIAN SENIOR HIGH SCHOOL: THE USE OF THE MODEL OF THE LEAF AND ANIMATIONS VIDEOS

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DECLARATION

STUDENT'S DECLARATION

I, Irene Sarpah, declare that this Dissertation, with the exception of quotations and references contained in published works which have been identified and duly acknowledged, is entirely my own work, and it has not been submitted either in part or whole, for another degree elsewhere.

Signature:………………………………..

Date …………………………………….

SUPERVISORS' DECLARATION

I hereby declare that the preparation of this work was supervised in accordance with the guidelines for supervision of Thesis/ Dissertation/ Project as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: ……………………………………………………

SIGNATURE:…………………………………………………………………..

DATE:………………………………………………………………………

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DEDICATION

I dedicate this work to the almighty God for successfully seeing me through the writing of this thesis. Also to my children Delphina Angel Amankwanor and Jeremiah Jude Amankwanor.

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ABSTRACT

Photosynthesis is a biological process which is critical for producing food for all living organisms. The study explores the results of learners' performance with regard to photosynthesis and suggests ways and procedures to help the learners to perform at their maximum level. The targeted group consisted of 30 students in Abetifi Presbyterian Senior High School on the Kwahu Ridge in the Eastern region.

The release of 2013 WASCE examination results, for example, was followed by public outrage as expressed in the newspapers especially concerning poor performance in Biology, and also in other subjects. This was affirmed on the difficulty in understanding most concepts in the area of biology on the parts of students and the teaching methods used in delivering these concepts to students.

And according to Nellist students tend to forget whatever they hear, they remember what they see and whatever they are to do, they understand. Hence it is important to use audio-visual aids (animation and simulation) to bring difficult topics like the concept of photosynthesis to the level of understanding students. This motivated the researcher to find out what aspects of photosynthesis posed conceptual problems for learners.

A pre- and post –test was used to collect data for proper statistical analysis. The test consisted of thirteen questions taken from previous WASCE examination. The questions were analyzed to determine the cognitive demands according to Bloom's taxonomy. The questions were found to be integrated and tested lower and higher order cognitive levels according to Bloom's taxonomy. The learners' achievement scores showed that the test discriminated well among those learners who studied well and those who did not know their work.

The results would then be used to improve the teaching of photosynthesis in the school involved in the study and can extend to other schools on the ridge or to the nation as a whole.

The study addressed questions like, the cognitive level of students, what misconceptions do students have on the concept of photosynthesis, what effect has the use of animation and simulation had on the teaching and learning of the concept of photosynthesis.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter focuses on the background to the study, statement of the problem, purpose and objectives of the study. It also deals with the research questions, significance of the study, limitations and delimitation of the study, operational definition of terms and organisation of the chapters.

1.1 Background to the study

Science education concentrates on the teaching of science concepts, methods of teaching and addressing misconceptions held by learners regarding science concepts.

According to Aina (2013), science education is very important to the development of any nation that is why every nation must take it very serious in all institutions of learning. Many of the developed worlds were able to achieve so much in science and technology because of science education.

Without science education Information and Communications Technology (ICT) would be impossible. Science and technology will not be possible without science education; for instance engineering, medicine and architecture will not be possible if there is no one to teach the students the core subjects needed for these courses (Salau, 2006).

Biology education is very important to any growing economy like Ghana. Many graduates of biology education are self-employed and employers of labour; many owned schools for themselves where people work and earn their living, while some are into fish business (Braimoh & Okedeyi, 2001). There are colleges of education where students of chemistry department are taught how to make dye and chalk; graduates of these departments can establish their own chalk business as soon as they graduate. If supported with funds many schools would not need to buy chalk outside anymore and they can equally produce for other schools.

Despite all the great things science education had accomplished for national development, there are many problems militating against it. Science teaching in Ghanaian schools has been criticised because of the poor performance of Ghanaian students in science subjects relative to their counterparts in other countries. This is evident from the Second International Science Study in which Ghanaian students came last in primary science as well as in secondary science among the participating countries of the world (Olaleye, 2002).

A number of factors have been identified to be responsible for these poor performances in science from the various studies conducted in Ghana. These include the lack of motivation for most teachers, poor infrastructural facilities, in adequate textual materials, attitude of students to learning, lack of teaching skills and competence by science teachers, and lack of opportunities for professional development for science teachers (Braimoh & Okedeyi, 2001; Folaranmi, 2002). Other studies mentioned that poor classroom organisation, lack of management techniques and poorly co-ordinated student activities also reduced the quality of science teaching and learning (Akale & Nwankwonta, 2001). Ivowi, Okebukola & Olodotum(2002) also found the shortage of funds for equipment and materials for fruitful practical work; especially in view of large class size in most schools as a problem. Some other researchers also attributed the low percentage of students who pass examinations in science to dissatisfaction with the syllabus, teachers' qualifications, workload, experience and disposition, general lack of teaching skills, and the ineffective style of delivery of subject matter (Adepoju, 2001; Salau, 2006). Okebukola (2007) painted a gloomy description of science teaching in Ghanaian schools. He was of the view that, teachers of science still use the traditional lecture approach and for that matter has rendered most students to be dissatisfied with science and see the subject to be too abstract and difficult to understand. The chief examiner's report in Biology 2004, 2008 & 2013) attributed students' poor performance in the subject to their inability to read and answer questions that demand inductive and deductive reasoning and thinking. The chief examiner suggested that Biology teachers should use different approaches of teaching that would involve students in the teaching and learning process and would also let them visualize some of the topics that look very abstract for students. It is in line with this that the researcher wants to use the model of a leaf and animated videos to teach process of photosynthesis to see its effect in improving students' performance in photosynthesis.

1.2 Statement of the problem

With the current increasing of the rate of failures in science, it is important to identify and use teaching approaches that can help improve students' conceptual understanding in the process of photosynthesis (Chief Examiner, 2013).

According to the chief examiners report (2004, 2008 &2013), in biology and integrated science, students find it extremely difficult when it comes to the explanation of the process of photosynthesis. Many researchers reported on the difficulty of students having no understanding of the process of photosynthesis. Eisen & Stavy (2003) reported in their research on "secondary students' interpretations of photosynthesis and plant nutrients". They indicated that students show very little understanding of the essential role of photosynthesis in the ecosystem. It seems that most students understand that plants release oxygen and animal absorb it, but there is no understanding of the actual process of photosynthesis. Photosynthesis is perceived as a gas exchange and while there is certain degree of understanding of the gas release, there is very little understanding of autotrophic feeding. They further explained that, many students do not understand that plants absorb carbon dioxide and water to produce organic material.

Lumpe & Staver, (2005), in their article "learning about photosynthesis" stated that, only 23.86% and 19.23% of students gave a correct answer on the concept of energy exchange during photosynthesis and on the process of photosynthesis respectively.

Many teaching strategies have been used to improve the understanding of the process of photosynthesis to students. These include discussions, explanations, questions and answers, and illustrations in diagrams. Though, there was some improvement in students' achievement, it did bring it to an appreciable level as teachers failed to bring the phenomenon to the understanding of the students due to the following factors:

- that the mechanism was not visible in leaves, students found it difficult to understand;
- that the teaching strategies did not give a video on what really took place in the leaves;
- the lack of motivation for most students;
- poor infrastructural facilities;
- inadequate textual materials;
- attitude of students to learning;
- lack of teaching skills and

- competence by science teachers(Martin & Sexton, 2007).

These controversial issues make this research study pertinent to find out the extent to which the use of models and animations influence the performance of secondary school students in the Abetifi Senior High School. In view of this situation, the main problem of the study is to investigate into how the use of models and animated videos affect students' conceptual understanding and improve their academic performance in the process of photosynthesis.

1.3 Purpose of the study

The purpose of the study is to:

Improve understanding of the process of photosynthesis to students in form two at Abetifi Presbyterian Senior High School

1.4 Objectives of the study

The objectives of the study were to:

1. establish the conceptions of students on the concepts of the process of photosynthesis before the use of the models of a leaf and animated videos in the teaching.
2. investigate how the use of the model of a leaf and animated videos improve students' performance in the concept of process of photosynthesis.
3. determine the perception of students about the use of the model of a leaf and animated videos in the teaching and learning of the concepts of the process of photosynthesis.

1.5 Research questions

1. What perceptions do students have about the concept of the process of photosynthesis?
2. What is the extent to which the use the model of a leaf and animated videos improve students' performance on the concept of the process of photosynthesis?
3. What are the perceptions of students about the use of the model of a leaf and animated videos in the teaching and learning of the concept of process of photosynthesis?

1.6 Significance of the study

It is envisaged that when the findings are made accessible, students, teachers and researchers would be the beneficiaries in that:

1. The study will help students on the right way of learning the concept of photosynthesis as well as its importance in life process. In addition to that, it will develop students' ability to understand concepts through the use of models and animations, and again help them to perform better on the topic of photosynthesis.
2. It will help teachers to learn how to use models and animated videos in the teaching of the process of photosynthesis.
3. The study will add to the existing literature on the use of models and animations to teach the process of photosynthesis.
4. Also researchers can use this material as the basis for their further research in photosynthesis.

1.7 Limitation

Students might not truly answer the questionnaire items which might have a negative influence on the results. Also, the researcher being the teacher could not get enough opportunity to collaborate in an intensive way with the other colleague Biology teachers as regards the teaching of the concepts of the concepts of the process of photosynthesis, hence might not have been able to factor their challenges and problems into the intervention. This might also influence the results obtained.

1.8 Delimitation

The scope of the study was all SHS two science students in Kwahu East District, but due to time and money constraints, the study was limited to SHS two science students in Abetifi Senior High School.

1.9 Operational Definitions of Terms

- **Photosynthesis:** In this study photosynthesis refers to a process by which green plants use sunlight, carbon dioxide and water to make their own food. According to Dekker (2001), photosynthesis occurs mainly in green plants. Photosynthesis is the only process in nature by which the radiant energy of the sun becomes available as potential chemical energy for all the reactions that constitute metabolism. A simple equation of photosynthesis according to Mader (2004) is written as:

  $6CO_2 + 12H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$

  Photosynthesis involves the utilisation of sunlight by plants, as well as by the cyanobacteria to convert two inorganic substances, namely carbon dioxide and water, into carbohydrates, with the liberation of oxygen. Pigments such as chlorophyll *a* and *b* in the chloroplast of plant cells act as the energy converters in this reaction. Photosynthesis is a very cost effective process which harnesses sunlight energy to drive the synthesis of carbohydrates. The issue of solar energy is now seen as something that has to be encouraged in our normal lives because both oil and electricity have become extremely expensive. For instance, in South Africa, Eskom, the electricity company, is willing to help people who want to install solar panels in order to heat water instead of using their electricity driven geysers. Hall & Rao (2004) define photosynthesis, literally, as building up or assembling by light. In common terms, photosynthesis is the process by which plants synthesize organic compounds from inorganic raw materials in the presence of sunlight.

- **ATP:** adenosine triophosphate
- **ADP:** Adenosine diphosphate
- **NADPH:** reduced nicotinamide dinucleotide phosphate
- **Science:** In this study the word 'science' refers to the activity of scientists, to the knowledge held (as published material) and to the institutions that practice science. Science is an extension of everyday observations on the nature of the world; it attempts to provide models and to theorize about how things happen. It seeks consensus. It is not essentially good or evil, but can be used to either end. Systematic experimentation and reasoning, induction and deduction, form the core of the scientific method. Science seeks to present nature in the form of laws to which a number of different observations can be fitted. Science is not a static body of dogma. With time models get replaced by new models that fit a wider range of phenomena. Such replacement may be so gradual or the

changes can be so radical that we speak of a conceptual revolution (Brown, 2006). Martin & Sexton (2007) stated that when science is taught holistically, it produces an effective learner and this arises from three important parts of science: attitude, process and knowledge. They further stated that any one part emphasized at the expense of the other too leaves the learners' experience incomplete, hence affecting their academic performance.

- **Concept:**In this study 'concept' means an idea or mental picture of a group or class of object, formed by combining all their aspects (Oxford dictionary, 1999). A slight extension by Martin and Sexton (2007) defined the word "concept" as a general idea or understanding that is derived from specific experiences; a thought, a notion or an idea.

1.10 Organisation of the chapters

Chapter one outlines the aim of the study and provides the statement of the problem. This chapter also states the motive behind the study, objectives, research questions, significant of the study, limitation and delimitation of the study.

Chapter two reviews the literature of the importance of photosynthesis. It starts with the theories of teaching and learning in relation to photosynthesis. It further looks at the views of researchers and learners about the teaching and learning of photosynthesis. It also outlines the role of practical work in the teaching and learning of science subjects.

Chapter three discusses the method that was followed to investigate the process of photosynthesis in the schools. Chapter four provides an analysis of responses received from learners. The analysis focuses on learners' age, gender and achievements scores.

Chapter five outlines the entire study, summarises the findings and makes recommendations about how the results of this study could contribute to improving the teaching and learning of the concepts of process of photosynthesis.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter reviews what some scholars say about the topic "improving the conceptual understanding of the process of photosynthesis using models and animation". This includes the idea and theories of teaching and learning, definition of photosynthesis, historical background of photosynthesis, the importance of photosynthetic leaf to the study of photosynthesis, the use of animated videos and other instructional materials in the teaching of the process of photosynthesis.

2.1 Theories of teaching and learning

The way Biology and other learning areas are taught and learned are in line with the work of protagonists who have researched under different perspectives. Different theories will be discussed in relation to the teaching of photosynthesis as a topic.

a) Constructivism and learning

Constructivists see knowledge as actively constructed by individuals, groups and societies but not simply transferred Donald (2002) states that another related and dominant strand to constructivism is the idea that knowledge is not passively received but it is actively constructed. Through engaging in experiences, activities and discussions which challenge them to make meaning of their social and physical environment, learners are actively engaged in building progressively more complex understandings of their world.

b) Characteristics of constructivist theory

Bertram (2001) states that in constructivist theories learners actively construct understanding, new learning depends on present understanding, learning is facilitated by social interaction and meaningful learning occurs within authentic learning tasks. The topic photosynthesis could be presented in the way that would be in line with constructivism especially when learners are given assignments to do some research. They would be actively involved since this is a practical topic where there is experimental work, even though schools without laboratories are affected.

c) Educational implications of Piaget's theory

Donald (2002), states that according to Piaget, the process of cognitive development has three very important characteristics. Each has profound implications for education: Firstly, although we need to take accounts of the effects of inheritance and maturation (Nature) and chances of experience, these factors cannot explain cognitive development. Development does not just happen to us. It is based on our active engagement with and exploration of our physical and social world. The implication of this insight is that teaching and learning also need to be an active, exploration process if we are to optimize the process of cognitive development itself. This means giving students opportunities to 'try things out', to experiment and discover things for themselves; to question and discuss, and to reflect and solve problems for themselves could have positive effect on students learning and understanding.

Secondly, cognitive development is not a slow, even process of gathering more and more bits of information. It happens through an uneven process, but through a fixed sequence of stages, to higher level of organising and of being able to manipulate information. Teachers have tended to interpret Piagetian stages in terms of limitation rather than in terms of progressive potential (Donald, 2002).

Thirdly, the difference between an adult and a child's thinking lies not only in the amount of information that each has. It has to do with differences in the quality of thinking. These differences in the quality of thinking have important implications for understanding not only cognitive development, but also moral, social and emotional development. These aspects relate to children's level of understanding of social relations, and therefore how they understand and deal with moral, social and emotional issues and feelings as they develop. Looking at Piaget's theory, constructivism is rooted in his work because it states active engagement or involvement of the learner while learning. He also highlighted one of the things that educators are practicing which does not help the learners. They focus on the learner's limitations rather than on their progress and potential. Piaget discourages the belief that learners do not want to learn about plants and the saying that the study of plants are boring, must not give room to educators to depart from teaching the topic. They must work on what the learners are able to do and follow, then work on it so as to help them to gain knowledge and develop interest. This is confirmed by (Brophy & Rohrkemper, 2001) who stated that the teachers' language and general socialization style can have strong effect on students' behaviour. Rohrkemper (2001) found that students whose teachers use a behaviour modification style, develop sophistication about behavioural action-reaction linkages but not about the motives and intentions that underlie these behaviours. Teachers who just propound rules and consequences were apt to have less desirable effects on students than educators who also emphasize, model and explain the reasons for rules. Piaget also emphasised that educators need to have a full understanding of children morals, social and emotional development because that helps educators to understand the learner's cognitive development.

d) Behavioural view of learning

This type of learning is based on a model of stimulus and response, as well as some form of reinforcement (Mwamwenda, 2004). Some behaviourist theories are discussed:

i) Classical conditioning

Ivan Pavlov, a Russian physiologist, is credited with having developed a learning theory known as classical conditioning. The word 'classical' means 'of the first type', and seeing that Pavlov's theory is one of the first theories of learning, it is referred to as classical conditioning. Conditioning means learning or modification of behaviour. Classical conditioning may also be referred to as stimulus substitution, because a new stimulus which was originally neutral can take place of a stimulus which elicits a response. Pavlov argued that through association, it is possible for an organism to develop a new set of behaviour. Pavlov did not stop with the positive results of his experiment but proceeded to test other aspects of the dog's behaviour. It was clear to Pavlov that the dog had not acquired a new behaviour, but was also capable of transferring the newly learned behaviour to a similar situation.

One of the factors that were not mentioned when the conditioning of the dog was discussed was that the dog had been deprived of food and therefore hunger was the motive for its subsequent behaviour. Motivation is a very important factor in learning. In Pavlov's experiment, the dog was trained to generalise what it had learned in one situation to a related but different situation.

Looking at Pavlov's theory it is based on behaviour which he says educators can shape. The learner imitates the ways of the educator. If the educator is hardworking and active, his/her learners will take that behaviour. Learners know the educator who does not check whether the homework was done or not and they neglect it. Pavlov also mentioned motivation, learning centres upon intrinsic (internal) and extrinsic (external) motivation. Educators need to be creative so as to motivate learners with interesting ways of teaching. Learners need to be praised for their work so that they can have desire to succeed. Pavlov also mentioned transferring new knowledge to a similar situation. This is in line with Outcome Based Education which encourages learning to be applied in real life situations not to treat knowledge as isolated pieces. This is also in line with how Biology is taught. Learners in some schools are not encouraged to be actively involved and to be able to apply their theory to practical situations which is experimental work.

2.2 Historical background of photosynthesis

The history of the origins of photosynthesis forms interesting reading which can give learners a background to this topic. In the early half of the seventeenth century, the Flemish physician van Helmont grew a willow tree in a bucket of soil, feeding the soil with rain water only (Hall, 2004). He observed that after five years the tree had grown to a considerable size; however the amount of soil in the bucket had not diminished significantly. Van Helmont naturally concluded that the material of the tree came from the water used to wet the soil. In 1727 the English botanist Stephen Hales observed that plants used mainly air as the nutrient during their growth in his book, “Vegetable Staticks”. Between 1771 and 1777 the English chemist Joseph Priestley (who was one of the discoverers of oxygen) conducted a series of experiments on combustion and respiration and came to the conclusion that green plants were able to reverse the respiratory process of animals (Hall, 2004). Priestley burnt a candle in an enclosed volume of air and showed that the resultant air could no longer support burning. A mouse kept in the residual air died. A green spring of mint however, continued to live in the residual air for weeks. At the end of this time Priestley found that a candle could burn in the reactivated air and a mouse could breathe in it. We now know that the burning candle used up the oxygen of the enclosed air, which was replenished by the photosynthesis of the green mint. The history captured in this section consists of ideas that learners can debate in order to understand why a green plant would make a difference in the air present in an enclosed container where there is a living small mammal. Such debates in the classroom would also promote language development for learners who are not first language speakers of English. A few years later in 1779, the Dutch physician, Jan Ingenhousz, discovered that plants evolved oxygen only in sunlight and also that only the green parts of the plant carried out this process (Hall & Rao, 2004). What has been discussed in this paragraph is history of how some stages in the process of photosynthesis have been discovered.

This is part of history of science that is never discussed in many classrooms, but which would give context to what is being studied. This history would help students to understand where science comes from; it would also show that science has a culture. The history of science also shows how different people have collaborated to give us a complete picture of what happens during photosynthesis. It also gives one characteristic of science, that is, it is empirical and consists of knowledge that should be shared among peers. This is unlike indigenous knowledge which is generally not shared openly with peers and this is the culture from which the learners come.

In 1782, Senebier, a Swiss minister, confirmed the findings of Ingenhousz and observed further that plants used carbon dioxides dissolved in water as nourishment. Early in the nineteenth century another, Swiss scholar, de Saussure, studied the quantitative relationship between the CO_2 taken up by a plant and the amount of organic matter and O_2 produced and came to the conclusion that water was also consumed by plants during assimilation of CO_2 (Hall & Rao, 2004). In 1817 two French chemists, Pelletier and Caventou, isolated the green substance in leaves and named it chlorophyll. Another milestone in the history of photosynthesis was the enunciation in 1845 by Robert Mayer, a German physician, that plants transform energy of sunlight into chemical energy. By the middle of the 19^{th} century the phenomenon of photosynthesis could be represented by the relationship shown below:

$CO_2 + H_2O +$ light $+ O_2 +$ organic matter $+$ chemical energy

Accurate determinations of the ratio of CO_2 consumed to O_2 evolved during photosynthesis were carried out by the French plant physiologist. He found in 1864 that the photosynthetic ratio-the volume of O_2 evolved to the volume of CO_2 used up – is almost unity. In the same year, the German botanist, Sachs (who also discovered plant respiration), demonstrated the formation of starch grains during photosynthesis. Sachs kept some green leaves in the dark for some hours to deplete them of their starch content. He then exposed one half of a starch depleted leaf to light and left the other half in the dark. After some time the whole leaf was exposed to iodine vapour. The illuminated portion of the leaf turned dark violet due to the formation of starch – iodine complex; the other half did not show any colour change. These early experiments gave rise to the experiments done in schools where they show that light is necessary for starch to form in leaves.

The direct connection between oxygen evolution and chloroplasts of green leaves, and also the correspondence between the action spectrum of photosynthesis and the absorption spectrum of chlorophyll were demonstrated by the German botanist Engelmann in the 1880. He placed a filament of the green alga *Spirogyra,* with its spirally arranged chloroplasts, on a microscope slide together with a suspension of oxygen requiring, motile bacteria. The slide was kept in a closed chamber in the absence of air and illuminated. Motile bacteria would move towards regions of greater O_2 concentration. After a period of illumination the slide was examined under a microscope and the bacterial population counted. Engelmann found that the bacteria were concentrated around the green bands of the alga filament.

2.3 Why photosynthesis is important?

All forms of life in this universe require energy for growth and maintenance. Algae, higher plants and certain types of bacteria capture this energy directly from the solar radiation and utilize the energy for the synthesis of essential food materials. Mader (2004) states that life on earth is solar powered. The chloroplasts of plants capture light energy that has travelled 160 million kilometres from the sun to convert it to chemical energy stored in sugar and other organic molecules. Described accurately plants should be called photoautotrophic because they use light as a source of energy to synthesize organic substances. During photosynthesis, carbon dioxide is absorbed and oxygen released. Oxygen is required by organisms when they carry on cellular respiration. According to Campbell & Reece (2005) oxygen released in photosynthesis also rises in the atmosphere and forms the ozone shield that protects terrestrial organisms from the damaging effects of the ultraviolet rays of the sun. Animals cannot use sunlight directly as a source of energy; they obtain the energy by eating plants or by eating other animals which have eaten plants. Thus the ultimate source of all metabolic energy in our planet is the sun, and photosynthesis is essential for maintaining all forms of life on earth (Hall & Rao, 2004).

2.4 Why learners seem to show less interest in photosynthesis?

Plants sciences are generally poorly represented in high schools and undergraduate courses (Hershey, 2002). They often receive poor responses, especially from students enrolled in biomedical type course. Students complain that plants sciences are boring. Looking at the central role of the process in Biology, teachers struggle, nevertheless, to promote the relevance and importance of photosynthesis to their students. Photosynthesis is also a conceptually difficult topic, which spans several disciplines Biophysics, Biochemistry, Ecophysiology and Organizational levels including molecules, cells, organisms and ecosystem. Because of these problems of relevance and difficulty, major misconceptions often persist in students' understanding of photosynthesis. Learners seem to be bored when learning about plants because they feel photosynthesis is too abstract. The researcher concurs with Sharon (2004) because learners have a tendency of wanting to learn about something that is interesting in a way that they apply in their daily lives. Even though photosynthesis is a daily thing it is a natural and automatic process that has not much to do with them (Sharon, 2004).

Students fail to understand that the cereal they consume for breakfast is a product of photosynthesis. An end to photosynthesis would probably mean death to all living organisms.

Hence learners seem to show less interest in photosynthesis because it a conceptually difficult topic to comprehend, very abstract, as the instructors often fail to let the students visualise the process that go on with the process of photosynthesis.

2.5 Challenges in teaching photosynthesis

One of the fundamental challenges of teaching in areas such as Biochemistry and Biophysics is that, these areas involve the comprehension of objects and process that cannot be seen or experienced. Topics that are taught in biochemistry includes structure and functions of proteins, membrane, electron transport and light harvesting from indirect observations using measuring systems and analytical methodologies, which a lot of biology teachers, without a solid chemistry background skip the biochemistry topics that would lay a foundation to understand photosynthesis. Knowledge about the nature of these invisible entities evolves, punctuated by controversy and consensus about the actual structure and the characteristics that define them. Regardless of the sophistication of our understanding as teachers, and its fit with empirical data, we visualise these objects and process using imagination, models and metaphors. Our challenges in teaching are how to communicate our vision of objects and process in such a way that we generate understanding and excitement while avoiding misconceptions. (Robinson & Russell, 2001). Pedagogical content knowledge (PCK) is important in teaching difficult topics like photosynthesis. It is a concept introduced by Shulman (2000) who started that different topics require very different ways of being taught if they are to be understood. There is the need for new teaching materials and approaches that present photosynthesis in all its complexity, but in a way that stimulates the interest and excitement of students and promotes deep and accurate understanding. According to Moore and Miller (2006) multimedia has the potential, in combining written and spoken word with dynamic pictures and models, to bring abstract concepts and invisible objects and process to life, and to do so in a flexible and reliable way which increases retention and learning. The interactive, user friendly format and excellent graphics, models and animation should improve students' satisfaction and attention, and their learning outcomes. The problem of learners in rural and other poverty stricken areas is lack of proper resources to enhance learning as well as poorly trained educators who reinforce misconceptions because of their poor understanding of the subject's content. Combination of written and spoken word with dynamic pictures, models and animations should suit a range of students and learning styles, including the visually oriented (Beakes, 2003). In spite of less interest in learners, educators need to be very innovative so as to arouse learner's interest. Educators need to develop their strengths in teaching photosynthesis through changing learner attitudes. Educators need to try learner centredness where possible in teaching photosynthesis so that learners will own the self-discovered knowledge and also have interest in developing it while educators present it. We can use innovative teaching methods like the use of models and animation to help students understand the process of photosynthesis.

2.6 Students Misconceptions in Photosynthesis

Photosynthesis is often de-emphasized in Biology curricular, because of the tendency to focus on plant, rather than animal process. Conceptual challenges of understanding this multi–faceted process including electron transport, factors affecting photosynthesis and carbon dioxide fixation is also a problem in understanding this whole process. Netherwood and Robinson (2001) and a number of authors are supporting the statement that, major misconceptions often persist in students' understanding of photosynthesis (Haslams & Treagust, 2000).

According to Heshey (2002) in his article entitled "Avoid misconceptions when teaching about plants". Other misconceptions are: The 'dark reactions' of photosynthesis are a misnomer that often leads students to believe that carbon fixation occurs at night. It is better to use the Calvin Cycle. Plants get most of their food from the soil (which is why they need fertilizer), not from the sun. Photosynthesis is the simple conversion of CO_2 and water to carbohydrates and O_2 regardless of stages involved. Plants photosynthesize during the day and respire at night. Chlorophyll molecules in the light harvesting complexes transfer excited electrons to the reaction centre. Plants are green because they absorb green light.

Robinson (2004) states that these major misconceptions, students may become familiar with words and descriptions of process such as electron transport, light harvesting, oxygen evolution and carbon fixation, but may have only very shallow, and in some cases, flawed understanding of what these process really mean. Although they may be able to develop these concepts sufficiently to pass exams in early years of school, their literacy in this area is likely to remain at a low level (Uno & Bybee, 2004), and they may have to unlearn and relearn this material at higher levels as flaws in their understanding begin to compromise their progress in this area (Robinson, 2004). This is usually seen in students who learn in a foreign language and not in their mother tongue. Memorization of the terms does not mean conceptual understanding. The researcher feels that photosynthesis need to be taken step by step by introducing it at an early stage of education so that learners get deeper understanding with it as they progress to higher levels of education. It is hoped that at their learning levels they will have clear understanding of concepts and terminologies.

By so doing we will be promoting students with deeper insight in Biology, particularly in complex topics like photosynthesis.

2.7 What must be done to overcome learners' misconceptions?

In recent years many scientific researchers have focused on the student's comprehension of scientific concepts. It was determined in these studies that, student's constructions of a concept on a subject are different from the experts of that subject. The students' different perceptions of the concepts have to be dealt with in a manner known as 'Conceptual Change Approach'to remove the misconceptions. According to the Conceptual Change Approach, which was developed by Sahin (2000), the concepts should be comprehensible and logical to remove the students' misconceptions. However, taking into account the fact that the scientific concepts are mostly abstract and this field has microscopic facts, the perception of these concepts by the sense organs are limited. For this reason, the students' realization of the scientific concepts and events in their mind is important to make the scientific concepts comprehensible and logical. In science education, meaningful learning can be obtained by using analogies to teach the concepts and events that are difficult to understand. However, sometimes analogies are also limited and may introduce other misconceptions. Meaningful learning depends on the success of creating and finding relationships between pre – knowledge and newly learned content and one of the ways of finding such relationships is to create and use the analogies (Sahin, 2000). Science concepts can be taught better by using similar events that people meet in daily life e.g. watching a video player. When the active participation of the students is secured and the connection between the analogy and the behaviour is set, students' misconceptions are reduced (Brown, 1992; Silverstein, 2000).The analogies are generally classified into two groups as individual and visual analogies. In individual analogies the student has an active role and realizes these events in his/her mind. In visual analogies, the concepts which are difficult to understand are tried to be comprehended by students through using some diagrams and pictures, which are mostly accompanied by oral explanations. This type of analogy helps students making resemblances between pictures and the concepts. Analogies are the most important tools, which accelerate conceptual change in scientific judgment in learning and teaching (Duit, 1991). Instead of giving them handy analogies, the students' creation of their own analogies makes the conceptual changing process of the students most useful (Wong, 2003). Sahin (2000) emphasized that for developing analogies the students should also have adequate knowledge about the analogies and individual talents which are effective to develop analogies. In addition, developing analogy requires both the desire and capability to do so.

2.8 Who should be taught and what aspect of photosynthesis?

Science national curriculum for England states that all pupils aged 11–14 should be taught that plants need carbon dioxide, water and light for photosynthesis, and produce biomass and oxygen (Haslam & Treagust, 2007). The syllabus also states that the students should also know that: photosynthesis can be summarized as a word equation- nitrogen and other elements, in addition to carbon, oxygen and hydrogen, are required for plant's growth. Pupils at this age are also taught that plants carry out aerobic respiration. These ideas are revisited between the age of 14 and 16 in slightly more details. At this stage the curriculum states that pupils should be taught "The reactants and products of photosynthesis", for instance:

- how the product of photosynthesis are utilized by the plant.
- the importance to healthy plant growth of the uptake of mineral salts.
- in addition they should be taught that the rate of photosynthesis may be limited by light intensity, carbon dioxide concentration and temperature.

Because of the overlapping of the curriculum between ages 11 to 14 and 14 to 16, it was possible to design a teaching sequence which could be used across both age ranges (Haslam & Treagust, 2007).This is the reason for choosing the senior high school of the age range between 14 - 18 since their syllabus include the topic photosynthesis. In the West African School Certificate Examination(WASCE) syllabus, the Ministry of Education requires the learners to study:

- the process of photosynthesis, a simple outline
- practical investigation of the – starch test.
- factors that influence photosynthesis – practical investigation of light, chlorophyll, carbon dioxide, oxygen, temperature and water.
- the two phases of the process of photosynthesis i.e. the light phase and dark phase.
- the products of photosynthesis.

Whitmarsh & Govindjee (2005) on their website on high school Biology lesson plan (http://www.courseworld.com) give a very simple outline of what high school students should be taught on photosynthesis. The work covered is as follows:

The authors first stated that at the end of the study the learners should be able to:

- describe the energy transformations that occur in a chloroplast as light energy is converted to the chemical bond of energy of carbohydrate.
- draw a sketch of a chloroplast and indicate where these energy transformations take place.

- list the inputs (raw materials) and outputs (products) of the light reactions and the Calvin Cycle.
- describe the role of enzymes in the process of photosynthesis.
- explain what the plant does with the carbohydrate that is produced by photosynthesis.

Secondly, the authors put a brief outline of the areas one needs to deal with in teaching about photosynthesis. These topics are shown as:

1. Chloroplast Structure

- Outer membrane
- Inner membrane systems
- Thylakoid membranes
- Thylakoid space (within the thylakoids)
- Granum a stack of thylakoid membranes
- Stroma (the liquid area outside the thylakoid membranes)

2. The Photochemical Light Reactions

- Capture of light energy
- Thylakoid membranes
- Photosystems II and I
- Chlorophyll and accessory pigments.

3. Light absorbance and Photosynthesis

- Energy transformations

- Flow of Electrons
- Splitting of water molecules Release of oxygen
- Accumulation of H+ in thylakoid spaces
- Reduction of NADP to NADPH
- Production of ATP
- ATP synthase
- ADP + Phosphate = ATP

4. The Biochemical Reactions: The Calvin Cycle

- "Fixing" CO_2
- Cyclic series of enzyme reactions Ribolus phosphate (the enzyme that fixes CO_2)
- Stoma and CO_2 availability
- Addition of CO_2 to a 5-carbon compound
- Production of Carbohydrates
- Energy input from ATP
- Addition of H+ and energy
- Production of carbohydrates for storage, transportation, and biosynthesis
- Recycling of 5 carbon compound to fix more CO2.

Many teachers are poorly qualified and have problems understanding at what depth they should be teaching. The outline presents a very good example of what concepts teachers at high school level should be unpacking with the learners. Looking for such material also helped the research to reflect at how she has taught the topic and how she could enrich future teaching by giving learners a holistic picture of the process.

2.9 Students' perceptions on photosynthesis

A review of the literature on teaching and learning about plant nutrition was conducted by (Driver & Barker, 2003). The following characteristic patterns in students reasoning were identified:

- A view of nutrition, based on animal nutrition, as the ingestion of 'food' and the idea that 'food' is absorbed from the soil through the roots of a plant.
- A lack of differentiation between photosynthesis and respiration (the idea that photosynthesis is the plant equivalent of respiration, that sugar provides energy not biomass).
- The idea that sunlight is a reagent, not a source of energy. A lack of recognition of the chemical basis of biological process, and those simple ingredients such as water and carbon dioxide can be combined (through chemical reactions) to produce more complex materials.
- A difficulty in accepting that gases can be a source of biomass.
- A lack of recognition that mass/matter is conserved in biological process.
- A lack of recognition of the site of biological process within an organism.

Based on the conceptual analysis of the curriculum, and these characteristic of students' reasoning, learning demands were identified and teaching goals developed. The teaching goals for the teaching sequences were outlined as follows by (Driver, 2003).

a) ***To open up*** the students own ideas about food (what it is, where it comes from, what it is needed for) to encourage students to discuss and question these to develop an explicit understanding of the distinction between source of food and functions of food.

b) ***To make the implausibility of the scientific explanation***. Explicitly, to problematize the simple scientific explanation that carbon dioxide combines with water to produce sugar in photosynthesis.

c) ***To demonstrate that apparently implausible physical process do indeed happen***:

- That carbon dioxide gas does have mass.
- That a gas and a liquid can combine to produce a solid.
- That simple molecules (water and carbon dioxide) can combine to produce a complex molecule (sugar)
- That matter is conserved in chemical change processed.

d) ***To develop a simple model of photosynthesis***

- Based upon the above physical principles, and to make this model plausible, demonstrating how sugar is produced in the leaf ***To show how this sugar can be converted into different food*** types and assimilated into the biomass of plants, making explicit the role of minerals in the soil:
- Glucose molecules can combine to produce different types of carbohydrate
- Glucose molecules can combine in different ways to produce fats
- Glucose molecules can combine with magnesium to produce chlorophyll.
- Glucose molecule can combine with nitrogen to produce proteins.

f) ***To assess and consolidate the learning*** by revisiting the source and function of food in plants and animals.

2.10 The role of practical work in teaching science subjects

Bently & Watts (1989), states that for teachers in the Beatty Woolnough survey, practical work had many aims. The five most important of which were to:

- Rouse and maintain interest;
- Encourage accurate observation and description;
- Promote a logical reasoning method of thought;
- Make phenomena more real through experience;
- Be able to comprehend and carry out instructions;

The purpose of practical experience in the senior high school, then, is to encourage enthusiasm and excitement about science.

Students should be given the opportunity to engage in experimental work in which a variety of practical and investigative skills are developed. Practical work, then, is being seen as a way to encourage skills development and enable youngsters to test out their ideas about science.

2.11 The relevance of the knowledge of the cross–section of a leaf in improving the understanding of photosynthesis

In most plants, the leaves are the principal sites for photosynthesis. Thus the leaves can be thought of as photosynthetic machines (Wolin, 2010).

Farabee (2007) explains that a cross-section of a leaf showing the anatomical features is important to the study of photosynthesis.

The importance of the anatomy of the leaf with regard to the study of photosynthesis is also highlighted by Mader (2007) saying, photosynthesis occurs primarily in leaves. A cross section of the leaf reveals that the palisade and spongy mesophyll tissue which forms the bulk of the leaf contains numerous chloroplasts, which contains chlorophyll; the green pigment that absorbs the energy from sunlight needed to combine water and carbon dioxide to form glucose during photosynthesis. This knowledge about the leaf as the ''photosynthesis machine'' may therefore inform the choice of a leaf's anatomy as a suitable material to enhance the understanding of the concept of photosynthesis. It may however be difficult to show students the cross section of a real leaf revealing the internal arrangement of tissues, perhaps unless it is viewed under the microscope which may not even be clear enough for better understanding. It will therefore be prudent and more convenient to use an improvised model of the cross section of the leaf.

Tamakloe, Amedahe & Atta (2004) explain that "a model is a recognizable imitation of an object". Models are one of the principal instruments of modern science. In the use of idealized models, there is a deliberate simplification of something complicated with the perspective of making it more traceable (Hattman, 2006). This statement about the use of models in science coupled with the role of the leaf in photosynthesis explains the need for the researcher to use a model of the cross section of the leaf showing the entry point of raw materials and actual sites of reactions, to facilitate the teaching and learning of photosynthesis for better understanding.

2.12 Practical work in teaching and learning

Millar (2004) states that the term 'science' can be used to refer to a product (a body of knowledge), a process (a way of conducting enquiry) and an enterprise (the institutionalised pursuit of knowledge of the material world).The distinctive characteristic of scientific knowledge is that it provides material explanations for the behaviour of the material world, that is, explanations in terms of the entities that make up that world and their properties .The aims of science education might then be summarised as:

- To help students to gain an understanding of the established body of scientific knowledge as is appropriate to their needs, interest and capacities,
- To develop students understanding of the methods by which this knowledge has been gained, and our ground for confidence in it.
- To claim to know something, it is not enough simply to believe it to be the case, but also necessary to have adequate evidence to support the claim. One has to be able to explain not only what causes change but, also why things happen in different ways. That is where hands-on activities come into display.

In an example of a practical work using models and animations relevant to photosynthesis cited at the site (http://teachingtoday.glencoe.com) the author illustrates an activity on the role of plant pigments in photosynthesis. The outcomes of this activity are that students should be able to:

- Relate the basic principles of photosynthesis
- Use paper chromatography to evaluate a hypothesis regarding plant pigments.
- Understand the role of chlorophyll and other pigments in photosynthesis.

The learners go through the process of separating colours of chlorophyll using chromatography. What was interesting about the lesson is that the following strategies are used to meet the needs of different learners:

- **Varying academic levels:** uses mixed-ability groups to allow learners to learn from one another, small and whole group participation.
- **Visual learners:**incorporates images related to photosynthesis, written guidelines, and journal writing.

- **Auditory learners:** uses discussion and direct inquiry to review concepts related to photosynthesis and discuss results of the experiment.
- **Kinesthetic learners:** engages students in an experiment to prove or disprove their hypothesis.

Before the practical begins learners are asked to think about why the leaves of some trees change colour in the fall. They are asked whether they believe that the red, yellow, and orange colours are present in the leaf when the leaf is green, or whether these colours are formed in the leaf only during the fall. The questions set the learners thinking and coming up with their hypotheses. In this experiment learners have to be shown how to do chromatography because this is a new technique, but learners interpret their own results and reject or accept their hypotheses. This gives the learners a chance to work like scientists. Some of the features of the open ended experiments as follows:

1. The experiment asks a broad question and the design of the method is frequently left to the learner. The guidance from the teacher is of course crucial so that learners do not waste time fumbling about.

2. The learner generally does not know the answer to the question before the experiment.

2.13 How to break down misconceptions

Although vernacular and factual misconceptions can often be easily corrected, even by the students themselves, it is not effective for a teacher simply to insist that the learner dismiss preconceived notions and ingrained nonscientific beliefs. Recent research on students' conceptual misunderstandings of natural phenomena indicates that new concepts cannot be learned if alternative models that explain a phenomenon already exist in the learner's mind (McDermott, 2001). Although scientists commonly view such erroneous models with disdain, they are often preferred by the learner because they seem more reasonable and perhaps are more useful for the learner's purpose. These beliefs can persist as lingering suspicions in a student's mind and can hinder further learning (McDermott, 2001).

Before embracing the concepts held to be correct by the scientific community, students must confront their own beliefs along with their associated paradoxes and limitations and then attempt to reconstruct the knowledge necessary to understand the scientific model being presented. This process requires that the teacher:

Identify students' misconceptions prior to teaching.

- Provide a forum for students to confront their misconceptions.
- Help students reconstruct and internalize their knowledge, based on scientific models.

2.14 Identifying misconceptions

Before misconceptions can be corrected, they need to be identified. Many researchers and teachers have compiled lists of commonly encountered misconceptions. A number of professional societies have developed conceptual tests which allow teachers to identify learners' misconceptions.

Hake(2002) used introductory laboratory exercises to help students test their conceptual bases for understanding motion. Essay assignments that ask students to explain their reasoning are useful for detecting students' misconceptions. These essays and discussions need not be used for grading, but rather can be used as part of the learning process to find out what and how students are thinking.

Misconceptions can occur in students' understanding of scientific methods as well as in their organization of scientific knowledge. For example, students in a science class will often express disappointment that an experiment did not work. They do not fully understand that experiments are means of testing ideas and hypotheses, not of arriving at an expected result. To the scientist, an experiment yields a result which needs to be interpreted. In that sense, each experiment "works," but it may not work as expected.

2.14.1 Helping learners to confront their misconceptions

It is useful to review and think about possible misconceptions before teaching a class or laboratory in which new material is introduced. It is better to use questions and discussion to probe for additional misconceptions. Students will often come with the variety of their preconceptions. Teachers have to listen closely to their answers and explanations. You can help students by asking them to give evidence to support their explanations and by revisiting difficult or misunderstood concepts. Misconceptions are often deeply held, largely unexplained, and sometimes strongly defended. To be effective, a science teacher should not underestimate the importance and the persistence of these barriers to true understanding of content. Confronting them is difficult for the learners and the teacher. Some misconceptions can be uncovered by asking learners to sketch or describe some object or phenomenon. For example, one might ask learners to sketch a structure of an atom before doing so on the board. By asking them to firstly draw their own model and then asking some students to share their answers with the class, a teacher can identify pre-existing models and use them to show the need for new models.

2.14.2 Helping learners to overcome misconceptions

Strategies for helping students to overcome their misconceptions are based on research about how we learn (Arons, 1990). The key to success is to ensure that learners construct or reconstruct a correct framework for their new knowledge. One way of establishing this framework is to have learners create "concept maps". With this technique, learners learn to visualize a group of concepts and their interrelationship.

2.15 Process of Photosynthesis

The leaves contain a substance called chlorophyll which is responsible for capturing the Sun's energy. The chlorophyll is what gives the leaves and stem their green color. The plant will use the energy the chlorophyll takes in to make its own food in a process called

photosynthesis. Photosynthesis is the food-making process of all plants. In this process, the plant uses water, carbon dioxide (CO_2) and the energy from the Sun to create sugars and oxygen (O_2). The plant takes in the water from its roots, the carbon dioxide from the air and captures the Sun's energy using the chlorophyll. The plant will use some of the sugar that it created in photosynthesis. It will burn the sugars to get energy in a process called respiration. In this process, the plant takes oxygen and sugars and combines them to release energy and the waste products carbon dioxide and water. Any sugars that the plant does not need for energy will be stored in its root, or stem or leaves.

2.15 What is animation?

Animation is the process of making the illusion of motion and change by means of the rapid display of a sequence of static images that minimally differ from each other. Illusion in motion pictures in general is thought to rely on the phenomenon (William & Richard, 2001).

Computer animation is the process used for generating animated images by using computer graphics. The more general term computer generated imagery (CGI) encompasses both static scene and dynamic images while computer animations only refer to moving images. Lin and Hsieh (2006) stated that, ". . . multimedia has become a mainstream information platform adopted in most computer-aided training systems". In today's age, instruction that is transferred through computers is often presented using this means of information transfer. The technology allows for differentiation as information can be transferred visually, audibly, and even kinesthetically to meet the needs of unique learners and specific desired outcomes.

Multimedia can be especially beneficial to English language learners and students with disabilities or special needs (Cisco Systems, Inc., 2008).

Additionally, Aragon and Zibrowski (2008) found that instructional videos were beneficial in allowing students to view fine details of procedures. Many times in live-instructor demonstrations, students need to be divided into groups to view the instruction from a decent distance. However, it is still difficult for students to view the intricate details of the steps in this

way. Students often have to take turns viewing close-ups of the procedures during live demonstrations, and thus, it is not possible for each of them to view the entire procedure adequately. With instructional videos, all learners can view the demonstration from an up-close perspective. This is also ideal for students with visual disabilities as images and text can be enlarged on a computer screen (Lam, 2005).

Nevertheless, if students are put into groups to ensure that each individual is able to view the demonstration from a decent distance, the instructor must repeat the process over again to each group. With instructional videos, the demonstration is required to be conducted and recorded once, and can be distributed to a number of people on a number of occasions. As a result, time is saved for both the instructor and students (Aragon & Zibrowski, 2008). The videos also allow the students to be independent learners as they can often access these applications when and where it is convenient for them, granted that the exercises are posted online or shared in another manner. This gives the students control to go through the process at their own pace with the option of repeating the activity. Ultimately, instructional videos support both teaching and learning as instructors do not have to repeat themselves, and students can learn in a way that meets their needs(Lam, 2005). "The animations provide opportunities for students to take greater control of their learning. They can be played step-by-step and they can be replayed until they are fully understood. Interactive models are used to help make abstract concepts more tangible" (Bradley & Boyle, 2004, Pedagogical Design section).

2.16 What is a model?

According to Fond and Andrew (2009), model is not the real world but merely a human construct to help us better understand real world systems. They continued to say that "in general all models have an information input, an information processor and an output of expected results.

2.16.1 Importance of models and animation to the teaching of science

In science education, computerized modeling and animations are used for describing, explaining, and predicting scientific process. Abstract scientific phenomena occurring in the macroscopic level (such as the movement of planets) or in the microscopic level (such as molecules and atoms) can be attractively illustrated by animated movies. Animations are employed for enhancing the transitions from abstract to concrete mental operations and vice versa (Barak & Dori, 2005; Barak & Rafaeli, 2004; Dori & Belcher, 2005). The use of animated movie was found to have a positive effect on students' learning motivation and thinking skills (Rosen, 2009). Thinking skills and cognitive operations are associated with Bloom and colleagues (1956). According to their taxonomy, 'knowledge' and 'understanding' are examples of lower order cognitive operations, or thinking skills, whereas analysis, synthesis, and evaluation are considered as higher order thinking skills. Among the various higher order thinking skills, reasoning ability is essential for the development of learners' critical thinking and argumentation skills (Barak & Dori, 2009). In our study, we examined students' lower order thinking skills – understanding of scientific concepts, and higher order thinking skills - their reasoning ability, as they studied science with the use of animated movies.

2.17 Summary and conclusion

This chapter discusses in detail the theories of teaching and learning because these help to understand the nature of the learners and how they should be treated to make schooling a useful and beneficial experience. The historical background of photosynthesis was also discussed. The importance of this process and the reasons why it must be taught at schools are also discussed at length. Challenges faced by educators and learners are also discussed. The researcher also researched widely on strategies used by teachers internationally to enhance the learning/teaching of photosynthesis. The role of practical work (using models and animations) in teaching this topic was also discussed and the emphasis was on that practical work should not be conducted like a cookbook recipe but must be inquiry orientated. Tips and ways of dealing with misconceptions are also discussed. Towards the end of this chapter the researcher discussed what animation is, what models are and importance of animation and models in the teaching and learning of science.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter reflects on the research design, population, sample and sampling techniques. Also research instruments which will be used for data collection will be looked at. The chapter ends with the summary of how the data will be summarized.

3.1 Research design

The study was an action research. It involved the diagnosis of a specific academic problem in the classroom situation. The researcher gathered data to support the reality of the problem diagnosed. Also information was gathered to answer the questions that were set for the study.

3.2 Population

The target population of the study consisted of all form two science students of Abetifi Presbyterian Senior High School. The total population was 1200 students.

3.3 Sample and sampling technique

The sample used was form two science students with a class size of 30. All the 30 students were used in the study. Out of the 30 students 11 were females and 19 were males.

Purposive and convenience sampling techniques were used for the study. Thus, the form two science class was selected because it was the class that seems to have the difficulty in understanding the process of photosynthesis. Also the researcher teaches the class, so using the entire class in the study was quite easy.

3.4 Research instruments

Two different instruments were used in the collection of data during the study. These include questionnaire and test (pre and post).

3.4.1 Questionnaire

One of the instruments used was questionnaire (Appendix C). The questionnaire was chosen because the instrument guides students to give a precise, concise and diverse answers to a question asked. It also provided opportunities for clarifying of questions and responses for better understanding.

The questionnaire gathered information on students' knowledge about the topic of photosynthesis understudy. Most of the questions posed on the questionnaire were structured in such a way that students come out openly to the problems in learning the concept of photosynthesis. The questions were meant to get a general idea as to whether students understand the concept of photosynthesis or not, know whether students were aware of the adaptations of the leaf for the process of photosynthesis and to make concept of photosynthesis look real to students.

3.4.2 Tests (pre-test and post–test)

This was administered in two stages. The pre intervention stage test (pre-test) and the post intervention stage test (post-test). The pretest (Appendix A) was a diagnostic test designed to identify students' strengths and weaknesses in explaining the concept of photosynthesis under the following headings; raw materials for photosynthesis, the adaptations of the leaf for photosynthesis, and the importance of photosynthesis to the sustenance of life on earth. The pre-test was similar to the post test.

The post-test (Appendix B) was an assessment and evaluation test used to measure student's level of understanding of the concept of photosynthesis after the intervention. Student's performance in the pre intervention test was compared to that of the post intervention test.

3.5 Reliability and Validity

Reliability according to William (2006) refers to consistency or 'dependability' of the measurement or the extent to which an instrument measures the same way each time it is used under the same condition with the same subjects. Validity on the other hand determines whether the research truly measures that which it was intended to measure or how truthful the research results are (Joppe, 2000).

To check for the validity of the pretest and posttest questions, the items were approved by experts in the Department of Biology Education, University of Education, Winneba, with the questions and wordings being appropriate and suitable at the level of the students were used. Biology students who were not part of the sample were made to answer the test items twice within a week. It was realized that majority of the students (about 97%) reproduced the same answers. This showed a high reliability level of the test items.

The questionnaire items were given to experts in the Department of Biology Education to look at the content validity. Thus whether the content refers to the extent to which a measure represents all facets of a given social construct. The questionnaire items were composed using words that were easy to understand and unambiguous. The corrections were made before they were administered to the respondents.

3.6 Data collection procedures

The researcher initially observed some specific attitudes that were expected. The researcher observed students during the lesson on subsequent topics under photosynthesis. Data gathered from the observations indicated that:

1. most students were not attentive throughout the lessons.
2. Only few students were able to ask questions. The inability of students to ask questions could be attributed to lack of interest and enthusiasm.
3. Some few students too were confident to answer questions posed by the teacher. However, most students appeared to rely on the whispered answers from colleagues.
4. It was also observed that, most of the students lacked the interest to contribute to the lesson, instead they were rather interested in listening to the teacher.

After these observations, the researcher administered questionnaire to the students. Feedback from the questionnaire showed that most of them find Biology lessons boring because the teaching of Biology, for them had always been a 'chalk and talk' style. They yearned to see the realities of biological phenomenon during lesson delivery. Students wished they could at least see an animated video of the process of photosynthesis in order to fully understand and appreciate the phenomenon. It was also revealed that students had no knowledge at all on the cross section of the leaf showing the internal arrangement of tissues and structures as well as how these contributes to the process of photosynthesis.

3.6.1 Pre-test

Finally, the researcher constructed and administered a pre-test to establish the level of students understanding of the concept of photosynthesis and its importance to life. The students used 30 minutes to answer the questions. The researcher supervised the students to take the pre-test. The performance of the students in the pre-test was recorded.Their performance was very poor. The weaknesses identified in the questionnaire were confirmed.

3.6.2 Intervention design

An intervention was designed to address the problem identified during the pre-intervention data analysis. The Strategies designed included;

(1) The Construction of a model of the cross-section of a photosynthesis leaf.

(2) Using the constructed model with Microsoft students Encarta video clip on photosynthetic leaf, to re-teach lessons on photosynthesis.

(3) Animation on the concept of photosynthesis from you tube.

Implementation of intervention

(1) Construction of the model of a cross-section of a leaf.

Using the pictorial illustration of the leaf's cross- section shown in Figure 3.1, the students and the researcher, from Abetifi Presbyterian Senior High School constructed a model of the cross section of the leaf, from local materials.

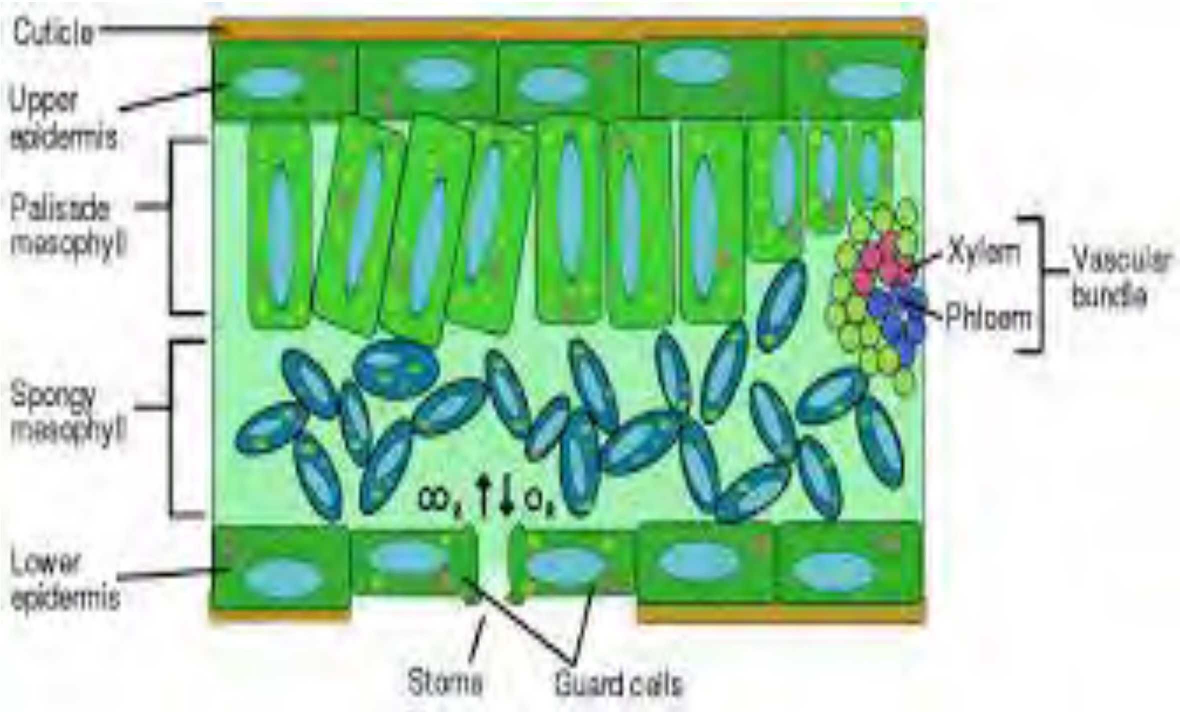

Fig 3.1: model of a cross - section of a leaf

(2) Re-teaching the lesson on photosynthesis using the constructed model.

With the help of the constructed model of the cross-section of the photosynthesis leaf, the lessons on photosynthesis were re-taught. The lesson topic was broken down into the following sub-headings:

a) Raw materials of photosynthesis and how they reach the photosynthetic cells

b) The process of photosynthesis and its products and

c) The importance of photosynthesis to life

Each lesson was taught separately. The major instructional material used was the model of the cross section of a photosynthetic leaf. Other teaching methods employed were questioning and answering, demonstration, discussion with analogies and the usage of videos on animation and simulation of the process involved in the process of photosynthesis.

Lesson One (1)

This lesson was under the sub-topic, **raw materials of photosynthesis.** The teaching and learning material (TLM) used was the model of leaf's cross-section. After successfully naming the conditions necessary for photosynthesis, students were guided to identify the major cells in the leaf as shown by the mounted model. The adaptation of the leaf was then discussed. On the leaf's adaptation, emphasis was laid on the broad nature of a leaf's surface, the presence of the chlorophyll in the palisade mesophyll cells, the spongy mesophyll cells, the guard cells and leaf vein, as well as the fact that leaves are arranged in a regular pattern on the stem or branch to minimize shadowing. The respective roles of each of the organs and cells stated were discussed thoroughly.

The movement of water, carbon (IV) oxide and sunlight energy was further explained using an animated video. The Students could easily compare the constructed model of the leaf's cross-section with that shown in the video, Students' interest grew deeper and their attention and participation was satisfactory.

Lesson Two (2)

The process of photosynthesis

The next lesson was on the mechanism of photosynthesis. The balanced chemical equation that summarizes the process of photosynthesis was used as a guide to discuss the mechanism of photosynthesis.

$$6CO_2 + 6H_2O \xrightarrow[\textbf{Chlorophyll}]{\textbf{Sunlight}} C_6H_{12}O_6 + 6O_2$$

The use of the chlorophyll

These are molecules located in the thylakoids in the grana of the chloroplast and it absorbs solar energy. The light energy absorbed increases the energy of the electrons in the chlorophyll molecule and so electrons are transferred through a series of electron carriers and finally returned to the chlorophyll molecule. During the passage of the electrons through the electron transport chain from one carrier to the other, energy is extracted and used to synthesize Adenosine Tri-phosphate from Adenosine di-phosphate and inorganic phosphate and water molecules is given as a by- product. An animated video on the process of photosynthesis was shown to students so to make it look real for easy understanding www.youtube.com

The use of sunlight in the process of photosynthesis

Sunlight as the source of energy then splits the water molecules called photolysis to produce hydrogen and oxygen with the oxygen being released into the atmosphere and hydrogen being used to reduce carbon dioxide in the dark reaction Nicotiamide Dinucleotide Phosphate (NADP) to reduced Nicotiamide Dinucleotide Phosphate (NADPH). Again an animated video from the internet was used to explain further about the process of the use of sunlight in the process of photosynthesis. (www.youtube.com)

The use of Adenosin Triphosphate (ATP) and Reduced Nicotiamide Dinucleotide Phosphate (NADPH) in Calvin cycle

This reaction occurs in the ground fluid filled substance of the chloroplast known as stroma. Atmospheric carbon dioxide diffuses into the leaf and it is accepted by a five-carbon compound called ribulose -1,5-bisphosphate to become an unstable 6-carbon sugar. This is broken down into two forming glycerate-3-aldehyde by an enzyme (ribulose carboxylase). The reduced Nicotiamide Dinucleotide Phosphate (NADPH) react with glycerate-3-aldehyde to form phosphoglyceraldehyde or triose - phosphate by ATP (Adenosin Triphosphate). This undergoes series of reactions to regenerate ribulose-1,5-bisphosphate to ensure the continuity of the process. The rest of the triose is used to produce glucose, sucrose, amino acid, fructose and starch.

The lesson was summarized with an animated video on photosynthesis showing the light and dark stages. At the end of the lesson, students were able to express satisfaction from their countenance that they had enjoyed the lesson.

Lesson Three (3)

The last lesson was under the heading "the **significance of photosynthesis to the sustenance of life".** The lesson was centred on discussion and characterized by effective questioning and answering techniques. The students were guided through the use of questions to identify the significance of photosynthesis to life.

Pictorial illustrations of the exchange of carbon (IV) oxide (**CO_2**) and Oxygen (**O_2**) between animals including man and green plants were used as study materials.

Each of the thirty (30) students was provided with the copy of the pictorial illustration. Students were instructed to study the illustration of the exchange of **CO_2**

and O_2 gases and give their comments. The importance of photosynthesis was not restricted to the manufacture of food and oxygen for respiration but further emphasis was placed on the fact that the use of carbon (IV) oxide as a raw material for photosynthesis eventually results in the regulation of CO_2 in the atmosphere, though the following were discussed with the students;

1. Produces raw materials for the formation of proteins and fats
2. Provides food for animals
3. Provides a substrate for respiration

Students were therefore made aware of the need to encourage afforestation and ensure the protection of the green vegetation.

3.6.3 Post-test

After the intervention, students were made to answer the post-test which was similar to the pre-test. The students used 30 minutes to answer the questions. It was supervised by the researcher. The sheets of students were collected, marked and the scores were kept for analysis.

3.7 Data analysis

The responses and marks obtained from the study were collated. The outcomes of the questionnaires and test results were analyzed qualitatively and quantitatively and presented in tables. The detailed analysis and discussion follow in the next chapter.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Overview

This chapter focuses on presentation, interpretation and discussion of the findings. The chapter first reported on the data of the background characteristics of the respondents and then followed with the data in response to the research questions. With the analysis, both descriptive and inferential statistics were adopted. To clearly illustrate results for meaningful interpretation and discussion, results were presented in tables.

4.2 Demographic Data of Respondents

Students Demographics

This portion deals with the demographic information obtained from respondents. This was to know the calibre of students involved in the study. Therefore, background characteristics of the students were examined in terms of their age and sex

Table 4.1: Age distribution of students

Year group	frequency
15-16	6
17-18	19
19-20	5
Total	30

From Table 4.1, it is indicated that majority of the respondents fall within the age group of 17 – 18 years. Thus nineteen of the respondents (63.3 %) fell within the age 17-18. Six (20.0 %) of the students were within the age group of 15 – 16 years and five (16.7 %) were within the age group of 19 – 20 years.

4.3 Gender of students

The gender distribution of students is presented in Table 4.2.

Table 4.2: Gender of students

Gender of students	**Frequency**
Male	19
Female	11
Total	30

Table 4.2 reveals that most of the respondents were males. The number of males were 19 indicating (63.3 %), were higher than the number of females which were11respondents (36.7 %). This ratio of greater number of males to females may be due to the higher number of males in secondary education as compared to their counterpart females.

Analysis of Research Question 1

Research Question 1: What perceptions do students have about the concepts of the process of photosynthesis?

The main aim of this research question is to find out the perceptions of students in the concept of the process of photosynthesis prior to the introduction of the treatment (intervention). To get the perceptions of students, pre-test items 14 and 15 were used to solicit their perceptions and these have been outlined in Table 4.3.

Table 4.3: Students' perceptions on the concepts of photosynthesis

Perception question	N	Students' perceptions	
14. What perceptions do you have about the concepts of the process of photosynthesis?	30	Twenty-seven of the students were of the view that the concepts of process of photosynthesis are very abstract and difficult to understand.	Three of the students had the perception that the process of the photosynthesis cannot be seen, and the teachers cannot portray exactly what happens to their understanding.
15. Why do you think the concepts of the process of photosynthesis is difficult?	30	Twenty-five of the students attributed the difficulty of the concepts of process of photosynthesis to the teaching style of the teachers. They were of the view that the teachers used the lecture method and as a result do not allow them share their views, opinions or complaints of where they find it difficult to understand.	Five of the students also claimed that the textbooks in the library do not expatiate more on the process of the photosynthesis. Hence they do not get enough reading materials to boost their understanding after what they receive from the class teachers. However, the class teachers also do not usually give further and detail explanation on that.

From Table 4.3, twenty-seven (27) of the students were of the view that the concepts of process of photosynthesis are very abstract and difficult to understand. However, three (3) of the students had the perception that the process of the photosynthesis cannot be seen, and the teachers cannot portray exactly what happens to their understanding. Meanwhile, with item 15 which seek to know why students think the concepts of the process of photosynthesis are difficult, twenty-five (25) of the students attributed the difficulty to the concepts of process of photosynthesis to the teaching style of the teachers. They were of the view that the teachers use the lecture method and as a result, do not allow them share their views, opinions or complaints of where they find it difficult to understand. Again, five (5) of the students also claimed that the textbooks in the library do not give detail explanation on the process of the photosynthesis. Hence they do not get enough reading materials to boost their understanding after what they receive from the class teachers.

Analysis of Research Question 2

Research Question 2: What is the extent to which the use of a model of a leaf and animated videos improve students' performance on the concepts of the process of photosynthesis?

The main aim of this research question is to find out how the use of a model of a leaf and animated videos affect the learners performance in the concepts of the process of photosynthesis. To answer this question, the pretest and posttest (questions 1 to 13) scores were used (Tables 4.4 and 4.5).Descriptive analysis was run on these scores to make meaning out of them.

Table 4.4: Analysis of Pre-test

Pre-test questions	N	Right answers	Wrong answers
1	30	15	15
2	30	12	18
3	30	10	20
4	30	11	19
5	30	7	23
6	30	14	16
7	30	13	17
8	30	12	18
9	30	9	21
10	30	2	22
11	30	12	18
12	30	14	16
13	30	12	18

Results from Table 4.3., indicates that 15 students had question 1 of the test items correct as well as 15 students giving wrong responses. This means that students had fair knowledge on the raw materials needed for the mechanism of photosynthesis to take place.

Also question numbers 2, 3, 4, 5 and 6 of the pretest recorded 12, 10, 11, 7 and 14 of the correct responses respectively. The number of students who got these test items wrong were 18,20,19,23 and 16 respectively.

It was also observed that question 7 of the test items got 13 correct responses as to 17 wrongs from the respondents while in question 8, 12 students gave correct responses as against 18 wrong responses. In question 9, 9 students got the test item correct with 21 students giving wrong responses.

Furthermore, it was realised from the pretest that questions number 10,11 and 12 obtained 2,12 and 14 correct responses respectively and on those same test items,22,18 and 16 students gave wrong answers respectively.

Finally, in question 13the outcome was that 12 students gave correct responses while 18 students had it wrong. These results indicate that there were a greater number of wrong responses to correct answers due to the misconception that the process of photosynthesis is abstract and difficult.

From Table 4.3, it was shown that students could not perform very well and the understanding of the process involved in photosynthesis was difficult to comprehend hence the poor performance in the pretest.

Table 4.5: Analysis for post test

Post-test questions	N	Right answers	Wrong answers
1	30	25	5
2	30	28	2
3	30	23	7
4	30	22	8
5	30	21	9
6	30	30	0
7	30	24	6
8	30	22	8
9	30	29	1
10	30	25	5
11	30	27	3
12	30	26	4
13	30	30	0

Results from the posttest presented in Table 4.4 indicate that more of the respondents got most of the questions correct. Questions 1, 2 and 3 documented 25, 28 and 23 correct responses as to 5, 2 and 7 wrong responses respectively. Also, question 4 had 22 correct responses and 8 wrong responses from the students, question 5 got 21 correct responses and 9 wrong responses while in question 6, all the students gave correct responses. With question 7, recording 24 correct responses and 6 wrong answers. It is also clearly represented in Table 4.4 that students performed well during the posttest paper. The number of students who got correct responses for questions 8, 9, 10 and 11 during the posttest were 22, 29, 25 and 27 respectively. Their respective wrong answers were 8, 1, 5 and 3.This trend continued through to questions 12 and 13 of the posttest as they also recorded 26 and 30 of correct responses respectively. Four students got items 12 wrong and none of the students had test item 13 wrong.

It is sufficient to say that the number of students who got most of the test items wrong during the posttest have reduced drastically. It can boldly be said that, the use of the model of a leaf and the animated video has enhanced better understanding of the process of photosynthesis hence, the improvement in the performance of students in the post-test after the intervention.

To ascertain whether there was a significant change in the students' knowledge of the concept of photosynthesis prior to the introduction of the treatment and after the introduction of the intervention, paired sample t-test analysis was used. This is presented in the Table 4.6.

Table 4.6: Paired sample t-test on pretest-posttest scores

Group	N	Mean	S .D	Mean Difference	T	P
Pre test	30	18.8	4.644	13.3	13.147	0.000
Post test	30	32.5	7.263			

From Table 4.6, it can be seen that the mean difference between the two tests was 13.3. This mean value produced a t-value of 13.147 and a p-value of 0.000. P-value is less than 0.05 and therefore means there is a statistically significant difference between the two tests. This goes to show that the use of the intervention of the model of the leaf and animated videos in the teaching of the process of the photosynthesis has had positive impact on students' performance in the posttest.

Analysis of Research Question 3

Research Question 3: What are the perceptions of students about the use of models and animations in the teaching and learning of the concepts of process of photosynthesis?

This question sought to determine the perceptions of students about the use of model of a leaf and animated videos in the teaching of the process of photosynthesis. Though questionnaire items 4 to 9 were used, items 6 and 7 answered the research question.

Table 4.7: Students perceptions on the use of models and animations (N = 30)

Item		
4. Do your science teachers use models and animated videos in teaching the concept of the process photosynthesis?		
	Frequency	**Percentage**
Yes	5	16.7%
No	25	83.3
5. How often do your science teachers use models and animated videos in teaching the concepts of the process of photosynthesis?		
	Frequency	**Percentage**
Very often	0	0.0%
Often	5	16.7%
Not at all	25	83.3%
6. Is it important to use models and animations to teach concept of photosynthesis?		
	Frequency	**Percentage**
Yes	30	100.0%
No	0	0.0%
7. (a) Reasons for choosing yes	**Frequency**	**Percentage**
It helps in the understanding of abstract and complex concept	26	86.7%
It helps in easy recall of concepts	4	13.3%
(b) Reasons for choosing no		
Not applicable	30	100.0%
8. Name some models use in teaching science concepts.		
	Frequency	**Percentage**
Charts	4	13.3%
Illustrative diagrams	5	16.7%
9. Should models or animations be used frequently in the teaching and learning of science concepts?		
	Frequency	**Percentage**
Yes	30	100.0%
No	0	0.0%

Observation from Table 4.7 shows that 25 (83.3 %) of the students indicated that their teachers do not use models and animated videos in the teaching of concepts of process in photosynthesis while only 5 (16.7 %) indicated otherwise. Thus according to 16.7 % of the students, teachers do use models and animated videos in the teaching of the process of photosynthesis concepts. The five (5) students (16.7%) did indicate that the teachers who use models and animated videos in teaching the concepts of process in photosynthesis do not use them very often. Twenty-five (25) students representing (83.3%) of the students still maintained that the science teachers do not use models and animated videos in teaching of the process of photosynthesis.

Talking about perceptions of students on the use of models, all the students who took part in the study, 30 (100.0 %) agreed to the fact that models and animated videos are important materials that help in teaching the concepts of photosynthesis. Hence all the 30 students chose “Yes”. Moving on to the reasons why the students chose “Yes”; 26 (86.7 %) of them said it is important to use models because it helps in the understanding of abstract and complex concepts. Again, 4 representing 13.3% of the students said, it helps in easy recall of concepts. None of the students was against the use of models and animated videos in the teaching of the concepts of the process of photosynthesis.

In tabulating results from students on the models used by science teacher during the teaching and learning process, four (4) of the students representing 13.3% proposed that the popular model used by science teachers were charts while 5 (16.7%) indicated illustrative diagrams were mostly used by their teachers.

To answer the question on whether models and animated videos should be used by teachers frequently in the teaching and learning of science concepts, all the 30 students representing

100% gave a positive response that models and animated videos should be used frequently in the teaching and learning of science concepts.

4.4 Discussion of Results

From the results of research question one, majority of the students were of the view that the concepts of process of photosynthesis were very abstract and difficult to comprehend. They gave a number of reasons why they consider it to be difficulty; for instance, one of the reasons was the traditional lecture method that has been adopted by most Biology teachers. Students complained that they are not allowed to ask questions, contribute their quota towards the topic or participate in any other way. Perhaps, the only contributions they make are the few questions that the teacher would ask them. This makes the studying of the process of photosynthesis to be boring and difficult. This is confirmed by Hershey (2002) and Sharon (2004) that most Biology teachers are not able to teach topics on plants to attract students' attention. They teach such topics on photosynthesis to the boring of the students and make it very difficult for students to understand. Again, students did indicate that the process of the photosynthesis cannot be seen, and the teachers themselves though may give out their best, it is not enough to let them see what exactly what happens with regard to the process of photosynthesis. They find it difficult to form a mental picture of the process involved. Another opinion of the students was that the available textbooks in the library do not give detail explanation on the process of the photosynthesis. Hence they do not get enough reading materials to boost their understanding after what they receive from the class teachers.

From the results to research question two, one can say that "Students knowledge level has improved in the right direction about the concepts of photosynthesis". Students really benefitted from the use of models and animated videos in the teaching of the concepts of the process of photosynthesis." Thus, in the pretest, students recorded a mean score of 18.8 out of 60 marks. This however has increased to 32.5 out of 60; given us a difference of 13.3 marks. In education, adding 13.3 marks to your previous score cannot happen on a silver platter and one can vividly say that the student's knowledge level has improved. This goes to confirm what Adcock (2003) stated that the teacher cannot assume that students, though they may have a number of years of science instruction, possess the prior knowledge that is crucial to truly understanding photosynthesis. Adcock continued to say that the teacher must consider students' background knowledge about every topic he/she teaches in class. Likewise, in this study, the researcher conducted a pretest to obtain an insight into students' entry level prior to the introduction of the treatment. With the use of the paired samples t-test, it has been shown that there was a significant contribution by the treatment introduced. A t-value of 13.147 gave a p-value of 0.000. The implication of this is that, the use of models should be encouraged since it produces positive significant change in the knowledge and comprehension level of students. A segment from the video series "A Private Universe" by Schneps and Sadler (1987), reveals that students, even those with an extensive science background, may not truly understand photosynthesis unless they get aided by models or animated videos for students to visualise. This is a confirmatory statement on results obtained from this study.

Research question 3 wanted to obtain information on students' perception on the use of models and animations. To this regard, 30 (100.0 %) of the students ascertained that it is important to use models and animations to teach the concept of photosynthesis. Thus one can attest to the fact that all the students have positive mind towards the use of models and animated videos. A similar result was shared by Ören & Meriç (2014), when their students were more attentive and active in the teaching and learning process when the teacher made use of cartoons to illustrate a concept. A view of a student in their study was that “I was very excited when I saw it had illustrations, I liked it.” Another student did indicate that “I understood this lesson would be very enjoyable. Firstly, I was very excited when I saw the cartoons and we had very entertaining lessons.” The excitement students had in the study of Ören and Meriç is reflected in the reasons students gave when they were asked if the use of models is important in the teaching of photosynthesis concepts. In this study, 26 (86.7 %) of the students indicated that the use of models and animations helps in the understanding of abstract and complex concepts while another 4 (13.3 %) said it helps in easy recalling of concepts learnt. Students realised that they understand concepts of photosynthesis more when it is presented with the help of models and animated videos.

4.5 Implications

The findings in this study have some implications for the Ministry of Education, Parents Teachers Associations, School Management Committees and the various stakeholders of education in Ghana. Most importantly, since it has been exposed that students learnt better and therefore perform better in photosynthesis lessons where concepts are taught using models and animated videos, schools that lack these facilities and resources might not be able to deliver information to their students to take advantage of the benefits that this instructional technology brings to students.

Moreover, students acknowledged that the use of models and or animations by their science teachers in teaching them help them recall concepts taught and that concepts become clear to them. This presupposes that students must and should be given the opportunity to witness this type of teaching environment to improve upon their learning process.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This part of the research presents the summary, conclusion and recommendations drawn from the study. It also includes the implications and main findings of the study. Nowadays, we find ourselves surrounded with different types of classroom environments with modern ways of presenting information to learners. Research on the human brain has shown that not all students learn by one particular strategy (Cowles, 1997). Therefore, when both visual and verbal modalities are used to process the information, the encoding simplifies and results in better retrieval. If the information is actively processed by the learner at the moment of instruction, it may be passed on to the long term memory. One the major ways to achieve this in complex science lessons such as photosynthesis is by the use of models and animations. This will help solve the confusing and misconceptions that arise from students' comprehension of complex science concepts. Teachers and students for that matter need to take into consideration procedures that involve the use of models and animations; it will help create variety of teaching and learning experiences. Students also reported a number of benefits of using models and animations as an integral technology in ameliorating the understanding rate of students in complex science topics. They also made reference to the materials that they have come across in the classroom during the learning sessions.

5.1 Summary

The use of models and animations has been noted to have a lot of advantages if employed by teachers in the delivery of lessons. The main purpose of this study was to inculcate the use of models and animation and simulation, to improve on students' knowledge for better understanding of concept of photosynthesis and its importance to mankind. Also, the study aimed at arousing students' interest in the learning of photosynthesis by encouraging teachers to make conscious effort to bring difficult concepts like photosynthesis to light for students to comprehend, thus, by using models and animations. This has adopted a conceptual framework that opined that students must be taught using variety of methodology but not only the traditional or conventional way of teaching and learning. Base on this, the study explored ways of improving the conceptual understanding of the process of photosynthesis to second year science students taking into consideration the use of models and animations. With this, the study aimed at obtaining the impact of models and animations on students' performance.

On the whole, a total sample size of 30 students comprising of 19 males and 11 females, took part in the study. The setting of the study was at Abetifi Presbyterian Senior High School in the Eastern Region of Ghana. The instruments used were made of pretest-posttest and a questionnaire for students. The beginning part of the questionnaire contained background characteristics of the respondents while the later part made use of items that helped to answer the research questions that guided the study. For the analysis, frequencies and percentages and tables were used to represent the biographic data and research questions 1, 2 and 3.To answer research question 1 made use of inferential statistics (paired samples t-test) and descriptive statistics (mean and standard deviation).

5.2 Main Findings

The findings of this study revealed that:

1. The knowledge level of students prior to the introduction of the treatment was low. Moreover after the treatment, it was observed that students recorded higher scores, and there was a significant difference between the pretest scores and that of posttest.
2. Students stated that, animations and models were used in teaching photosynthesis and other science related courses offered at Abetifi Presbyterian Senior High School. Student respondents even name some of the models and animations when they were asked through questionnaire.
3. All the respondents of this study hold a positive perception on the use of models and animations in teaching photosynthesis concepts and other concepts in science that may require the use of animations or simulations.
4. The use of models and animations in teaching photosynthesis concepts help reveal the process that come to play, and that also promote students better understanding.

In a nutshell, the findings in this study revealed that respondents agreed to the fact that models and animations yield better results and should be taken as integral part in teaching complex science courses

5.3 Conclusion

In conclusion, the outcomes of this research revealed things that are in line with research previously cited. That is the use of models and animations have a positive impact on students. I t improved the conceptual understanding of students in the process of photosynthesis.

5.4 Recommendations

In the light of the findings of the study, the following recommendations were made:

1. The Ministry of Education, the Ghana Education service, School Management Committees and other stakeholders in education should ensure that all schools are well provided with resources such as models and tools that will help teachers get animations. This if properly implemented would go a long way to help majority of students in Ghana to enhance and improve upon their performance especially in areas where students perennially perform poorly.
2. Headmasters and headmistresses in schools that already have these models and animations should ensure that they are properly used to benefit the students. The models and animations resources should not become white elephant in the school.
3. Further, teachers at all levels of education should be trained with skills to properly use models and animations and make them become integral parts of their lessons. Thus, the government and Ghana Education Service should introduce in-service training for teachers to improve on their skills in the use of models and animations.

5.5 Suggestions for Further Studies

- The findings of this research helped the researcher to make some suggestions for further study. Though this research has undergone a thorough study of second year science students, it is recommended that a more general study should be undertaken in the major course content in senior high schools general science program. The study should make use of all the difficult topics in the general science program so that a more comprehensive generalization could be drawn.

- Further, many studies should be conducted on the methodology employed by teachers in teaching difficult topics. The studies should also take into account the teaching and learning materials used by teachers in teaching a given topic and check if there is a significant increase in the performance of students.
- Also, students' readiness in learning through the use of models or animations and also the teacher confidence in integrating these should be investigated.

References

Adcock, B. C. (2003). *Examining the impact of directly addressing a major misconception about photosynthesis prior to instruction.* Unpublished Master's Thesis, North Carolina State.University, North Carolina.

Aina, J. K. (2012). *Factors affecting students' performance in science in Nigeria Schools*. Retrieved from http://www.amazinees.com/articledetail.cfm? Articleid-4246692.

Akale, M. A., & Nwankwonta N. A., (2001). A study of students' and teachers' perceptions of laboratory/ classroom environment in senior secondary schools. *Journal of the science teachers associations of Nigeria*, *3*(1&2): 13-20.

Amedeker, M, K., (2004). The mode of light. *Everyday science for schools, 3*(1), 15 – 17.

Arons, A.B. (1990). *A guide to introductory physics teaching*. John Wiley, New York.

Aragon, C. E., & Zibrowski, E. M. (2008). Does exposure to a procedural video enhance preclinical dental student performance infixed prosthodontics? *Journal of Dental Education, 72*(1). Retrieved April 1, 2009, from http://www.jdentaled.org/cgi /reprint/72/1/67.pdf

Barak, M. C., & Rafaeli, S. (2004). Online question posing and peer- assessment as means of web-based knowledge sharing. *International journal of human-computer studies*, *61*(1), 84-103.

Barak, M., & Dori, Y. Y., (2005).Enhancing undergraduate students' chemistry understanding through Project- based learning in an IT environment. *Science Education, 89*(1), 117-139.

Barak, M., & Dori, Y. J. (2009). Enhancing higher order thinking skills among in-service science education teachers via embedded assessment. *Journal of Science Teachers Education*, *20*(5),459-474.

Beakes, G. (2003). A picture is worth a thousand words. A personal view of using images in the teaching of the biological sciences.*Bioscience Education E-journal*, 1, available athttp://bio.ltsn.ac.uk/journal/vol1/beej-1-3 (accessed 25 March 2004).

Beck , J. (2004). *Animation Art* : From pencil to pixel. The history of cartoon, Anime & CGI.

Bentley, D., & Watts, D. (Eds.) (1989). *Learning and Teaching In School Science*. Milton keynes, UK : Open University Press.

Bertram, M. F. (2001). Attribution theories: How people make sense of behaviour. In Chadee, D. (Ed.), *The theories in social psychology* (pp.72-95). London: Wiley Blackwell.

Bradley, C., & Boyle, T. (2004). The design, development, and use of multimedia learning objects. *Journal of Educational Multimedia and Hypermedia, 13*.Retrieved June 29, 2009, from http://goliath.ecnext.com/coms2/gi_0199-4316565/The-design-development anduse.html

Braimoh, D.S., & Okedeyi, A. S. (2001). Direction of professional development classroom teachers in effective science, technology and mathematics teaching: matters arising. *Lagos Journal of Science Education, 5*, 33-37.

Brophy, J. E., & Rohrkemper, M. M. (2005). Teacher's specific strategies for dealing with Hostle Aggressive students research series. *The Journal of learning science, 86*, 104-120.

Brown, D. E. (2006). Using examples and analogies to remediate misconception in physics: factors influencing conceptual change. *Journal of research in science teaching*, *29*(1), 17-34.

Campbell, N. A., & Reece, J. B. (2005). *Instructor's Guide to Text and Media in Biology*: University of California, Riverside; ISBN-10:0805371486.

Chief Examiner (2002). *The West African Examination Council, Accra: Senior Secondary School Certificate Examination. Annual Report 2004.* Accra, Ghana: Ghana Publishing Corporation.

Chief Examiner (2004). *The West African Examination Council, Accra: Senior Secondary School Certificate Examination. Annual Report 2004.* Accra, Ghana; Ghana Publishing Corporation.

Chief Examiner (2008). *The West African Examination Council, Accra: Senior Secondary School Certificate Examination. Annual Report 2004.* Accra, Ghana; Ghana Publishing Corporation.

Chief Examiner (2013). *The West African Examination Council, Accra: Senior Secondary School Certificate Examination. Annual Report 2004.* Accra, Ghana; Ghana Publishing Corporation.

Cisco Systems, Inc. (2008). *Multimodal learning through media: What the research says?* Retrieved June 3, 2009, from http://www.cisco.com/web/strategy/docs/education/ Multimodal-LearningThrough-Media.pdf

Cowles, S. (1997). Technology melts classroom Walls. *Focus on Basics*, 11-13.

Dekker, M. (2001). *The inverse Gaussian distribution: theory, methodology and applications*; Inc. NewYork, NY,USA:0-8247-7997-5.

Donald J. G. (2002). *Motivation for higher order learning*. *New direction for teaching and learning*, (78), 27- 35.

Dori, Y. J., & Belcher J. W. (2005). How does technology enable active learning affect students understanding of scientific concepts. *The Journal of learning science, 14*(2), 243-279.

Driver, R. (2003). *Making sense of Secondary science support materials for teachers*. London; New York: Routledge. Retrieved from http://search.ebscohost.com.

Duit, R. (1991). *On the role of analogies and metaphors in learning science*. Science education. 75(6):649-672.

Esien, Y., & Stavy, R. (2003). How to Make the Learning of Photosynthesis More Relevant. *International Journal of science education, 4,* 23-35.

Farabee, M. J. (2007). *Atoms and Molecules.* Retrieved from http://www.emc.maricopa.educ/faculty/farabee/BIOBKCHEMI.HTML.

Folaranmi, B. A. (2002). The Teaching of Sciences in our Schools: What Hope Do We Have For The Future, Bright Or Bleak? *Journal of science and movement Education*, *4*, 132-142.

Fond, K., & Andrew, M. (2009). *Modeling the environment* (Ed). Washington DC: Island Press.

Govindje-Kem J. F. Messinger, J., & Whitmarsh J. (2010). Photosystem II: Encyclopedia of life. Science (ELS). Chicester: John Wiley & Sons.

Hake , R. R., (2002). *Relationship Of Individual Student Normalised Learning Gained In Mechanics With Gender High School Physics And Pretest Score On Maths And Spatial Visualization*. Paper Presented At Physics Education Research.

Hall, D. O., & Rao, K. K. (2004). *Photosynthesis.* Great Britain: Press of the University of Cambridge.

Hall, H., (2004). Chiropratic information in a public library. *Scientific review of alternative medicine 7*(2), 78-86.

Haslam, F., & Treagust, D. F. (2007). Diagnosing Secondary Students Misconception of Photosynthesis and Respiration in Plants Using a Two Tier Multiple Choice Instrument. *Journal of Biology Education, 6(*2), 54-66.

Hattman, S., Kenny, K., & Berger, C. (2006). Comparative Study of DNA Methlylation in three Unicellular Eukaryotes. *Journal of Bacteriol, 135*(3), 1156-1157.

Hershey, D. R. (2000). Making plant Biology Curricula Relevant. *Bioscience, 42*(3), 188-191.

Hershey, D. R. (2002). Plant nutrient solution pH changes. *Journal of Biological Education*, *26*, 107-111.

Ivowi, U. N. O., Okebukola, A. O., & Olodotum, J. S. O. (2002). *Raising the standard of performance in public Examination.* STM,STAN position paper No.4, Ibadan, STAN.

Jope, R. (2007). Trends in Biochemical Science. *Journal of Biological Education, 32*(9), 407-414.

Lam, R. (2005). *Effective use of instructional video. ITE Teacher's Conference*. Retrieved
March 19, 2009, fromhttp://edt.ite.edu.sg/ite_conf/edu_tech/tc05et02.pdf

Lin, D-Y. M., & Hsieh C-T .J. (2006). The role of multimedia in training the elderly to acquire operational skills of a digital camera. *Gerontechnology Journal, 5*(2), 68-77. Retrieved April 15, 2009,
fromhttp://www.gerontechnology.info/Journal/main.php?p=12&art=322

Lumpe, A. T., &Staver, J. R. (1995). Peer Collaboration and Concept Development: Learning About Photosynthesis. *Journal of Research in Science Teaching, 32*,71-98.

Mader, S. S. (2004). *Biology*. Boston: Mc Grew- Hill.

Mader, S. S. (2007). *Biology.* Boston: Mc Grew- Hill.

Martin, R., & Sexton, E. (2007). *Teaching Science for all Children. Instructors Manual, Transparency Masters and Text Bank.* London: Allyn and Bacon.

Martin, S., Wagner, P., & Gerlovich, S. (2007). *Teaching science for all children.* Boston: Ally & Bacon.

McDermott, K. B. (2001). The rise and fall of false recall: The impact of presentation duration. *Journal of memory and language. 45*(1). 160-176.

Miller, L. M., & Castellanos, J.(2006). Use of teaching technology for science and mathematics collaborative teaching. *School science and mathematics, 96*(2),58-62.

Miller, R. (2004). *The role of practical work in the teaching and learning of science*. Washington DC: National Academy of science.

Moore, R., & Miller, I. (2006). How the use of multimedia affects student retention and learning. *Journal of College Science Teaching*, *25*, 289-293.

Mwamwenda, T. S. (2001). *Education Psychology*. South Africa: Part Print Heinemann Publishers (PTY) Ltd.

Mwamwenda, T. S. (2004). *Education Psychology*. South Africa: Part Print Heinemann Publishers (PTY) Ltd.

Okebukola, P. A. O. (2007). Computers and the learning of biological concepts: attitude and Achievement of Nigerian students. *Science Education, 75*(6), 701-706

Olaleye, S. B., Onasanwo, S. A., & Elegbe R. A. (2002). Analgesic and anti-inflammatory activities of the root extracts of securidacalongipeunculata (fres).

NISEB. *Journal the official publication of the Nigerian society for experimental biology,2*(1), 157-164.

Ören, F. Ş., & Meriç, G. (2014). Seventh Grade Students' Perceptions of Using Concept Cartoons in Science and Technology Course .*International Journal of Education in Mathematics, Science and Technology*, *2*(2), 116–136.

Robinson, J. (2004). The world of cities. *The British Journal of Sociology, no. 4*(2004): 569-578.

Rosen.Y. (2009). *The effect of an animated based online learning environment on higher order thinking skills and on motivation for science learning: The 4th chais conference.* Raanana: The open university of Israel.

Russell, W., Robinson, S., & Netherwood, A. (2001). *Photosynthesis in silico*. Overcoming the challenges in photosynthesis.Education using multimedia CD-ROM. *Bioscience education, 2*(3), 41-52.

Sahin, F., Guarda, A., & Ave Berkem, M. L. (2000). *A Research on a Meaningful Learning of Psychological Concepts*:*4th congress of science Education.* Hacettepeuniversity, faculty of Education, M.E.B. and Pedagogische Hchschule, Heidelberg. Germany, 6-8 September,2000, Ankara, 17-23.

Schneps, M. H.,Ruel, J., Sonnert, G., Dussault, M., Griffin, M., &Sadler, P.M., (2014). Conceptualising Astronomical Scale: Virtua Simulation on Handheld Tablet Computers Reverse Misconception. *Computers & Education, 70*, 269-280.

School Certificate Examination. Annual Report 2004 Accra, Ghana*;* Ghana Publishing Corporation .Science Classroom. *Journal of Science Education and Technology*, *1*, 67-79.

Sharon, F. Gurdal, A., & Ave Berkem, M. L. (2004). *A research on meaningful learning of psychology concepts*:*4th congress of science education.* Hacettepe University, faculty M.E.B. and PedagogisheHoschule, Heidelberg Germany,6-8 September, 2000, Ankora, 17-23.

Shulman, L. S. (2000). Those who understand knowledge growth in teaching. *Educational Research, 6*, 4-14.

Silverstein, S. (2000). The science training. *Educational Leadership, 64*(4), 24-29.

Uno, G. E., & Bybee, R. W. (2004). Understanding the dimension of biological literacy. *Bioscience, 44*, 553-557.

Williams, R. (2006). *Animator's survival kit*. Faber and Faber, ISBN 978- 0571-20228-7.

Wolin, J. (2010). Songs for teaching. *Computers & Education, 8*, 269-280

Wong, E. D. (2003). Self- Generated Analogies as a tool for constructing and Evaluating Explanations of scientific phenomena. *Journal of research in science, 9,* 53-61.

Appendix A

Abetifi Presbyterian senior high school

Elective biology f 2D1

Pre – test

Name …………………………………………………………………………………..

Answer all questions

1.What are raw materials needed for photosynthesis?

……………………………………………………………………………………………….

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2. What are the end products of photosynthesis?

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3.Write down the chemical formular for photosynthesis.

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4. What is the use of the energy in a form of ATP (Adenosine Triphosphate) in the process the process of photosynthesis?

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5. Is the light stage of photosynthesis important in this process? Why?

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6. What is another name for the dark stage of photosynthesis?

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7. Briefly explain the dark stage of photosynthesis.

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8. Mention three internal structures of the leaf.

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9. State one function each of the structures above.

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10. How do plants tap up carbon dioxide into the leaf?

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11. In which part of the leaf does the light stage of photosynthesis take place?

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12. When light splits water molecules in its components, how is it called?

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13. Which compound in the leaf accepts carbon dioxide in the leaf?

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14. What impression do you have about the concept of photosynthesis?

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15. Why do you think that the concept of photosynthesis is difficult?

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Appendix B

Abetifi Presbyterian senior high school

Elective biology F 2D1

Post test

Name ………………………………………………………………………………..

Answer all questions

1. What are raw materials needed for photosynthesis?

…………………………………………………………………………………………….

……………………………………………………………………………………………

2. What are the end products of photosynthesis?

…………………………………………………………………………………………………..

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3. Write down the chemical formula for photosynthesis.

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4. What is the use of the energy in a form of ATP (Adenosine Triphosphate) in the process the process of photosynthesis?

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5. Is the light stage of photosynthesis important in this process? Why?

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6. What is another name for the dark stage of photosynthesis?

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7. Briefly explain the dark stage of photosynthesis.

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……………………………………………………………………………………………
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8. Mention three internal structures of the leaf.

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9. State one function each of the structures above.

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10. How do plants tap up carbon dioxide into the leaf?

……………………………………………………………………………………………

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11. In which part of the leaf does the light stage of photosynthesis take place?

…………………………………………………………………………………………..

12. When light splits water molecules in its components, how is it called?

……………………………………………………………………………………………

13. Which compound in the leaf accepts carbon dioxide in the leaf?

…………………………………………………………………………………….............

14. What perceptions do you have about the concept of the process of photosynthesis?

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15. Why do you think that the concept of the process of photosynthesis is difficult?

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Appendix C

QUESTIONNAIRE FOR STUDENTS

This study is purely for academic purposes. Kindly provide honest responses to each item below. The information you will provide would be treated with confidentiality.

Please tick (√) the appropriate box and write clearly where spaces are provided.

Thank you.

SECTION A: **Personal information**

1. Age: 15-16 years [ ]

17-18 years [ ]

19-20 years [ ]

21-22 years [ ]

2. Sex: Male [ ]

Female [ ]

3. Form: ………………..

SECTION B: **Students views on animations**

4. Do your science teachers use animations /models in teaching the concept of the process of photosynthesis?

Yes ☐ No ☐

5. How often do science teachers use models /animations to teach the concept of photosynthesis
6.

Very often ☐ Often ☐ Not at all ☐

7. Is it important to use models/animations to teach the concept of photosynthesis

Yes ☐ No ☐

8. If yes or no ,briefly give your reason
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9. Name some models used in teaching science concepts
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10. Should models or animations be used frequent?

Yes ☐ No ☐

11. Why do you think animation should be used to teach photosynthesis?
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