UNIVERSITY OF EDUCATION, WINNEBA

# USING COMPUTER SIMULATION TO IMPROVE THE TEACHING AND LEARNING OF PHOTOSYNTHESIS IN TWO SELECTED JUNIOR HIGH SCHOOLS.

MICHEAL SAFO-ADU AGYARE

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**MICHEAL SAFO-ADU AGYARE**

**(7140130040)**

**A DISSERTATION IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE EDUCATION, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR AWARD OF THE MASTER OF SCIENCE IN EDUCATION DEGREE**

**DECEMBER, 2016**

# DECLARATION

**Candidate’s Declaration**

I, Michael Safo-Adu Agyare, declare that with the exception of quotations and references contained in published works, which have all been identified and acknowledged, this project is entirely my own original work, and that it has not been submitted, either in part or whole, for another degree elsewhere.

Candidate‟s signature……………………………

Date……………………………….…………..…

**Supervisor’s Declaration**

I, hereby declare that the preparation and presentation of this long essay was supervised in accordance with the guidelines on supervision of research report laid down by the University of Education, Winneba.

Supervisor‟s name: Prof. Yaw Ameyaw

Supervisor‟s signature: …………………..…………

Date……………………………………..……..…..…

## ACKNOWLEDGEMENTS

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I thank Professor Kodjo Donkor Taale and Dr. Nana Annan, who took us through how to conduct research. Special thanks to my family and my course mates for their prayers, support and encouragement in the course of my study.

# DEDICATION

This work is dedicated to my entire family, my wife, Mrs. Matilda Addo Zuta, my daughter, Joana Okoromea Agyare, my mother, Mrs. Victoria Adu, my father, Benjamin Safo-Adu, and my brothers and sisters.

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# ABSTRACT

The study investigated the use of computer simulation to improve the teaching and learning of photosynthesis in two selected Junior High Schools in Prestea Huni-Valley. The research was quasi experimental involving a pre-test and post-test. The total population of the third year Junior High School Students‟ was 2018 students. The sample for the study comprised 136 third year Junior High School students sampled from two public junior high schools in the Western Region of Ghana. The instruments used for the collection of data included students‟ knowledge of photosynthesis Test (SKPT) – pre-test and students‟ Achievement in photosynthesis Test (SKPT) –post-test, which were piloted in a junior high school in the Western Region. The students‟ post-test scores were subjected to statistical analysis using independent-measure t-test. The major findings of the study included: a significantly higher achievement of students exposed to the computer simulation instructional approach compared to those exposed to the traditional instructional approach, significantly higher achievement of the computer simulation instructional approach in cooperative learning settings than those in individualized learning settings. Based on the findings of the study, it is recommended among others that science teachers should employ innovative and more effective learner-centered instructional strategies, such as, computer simulation instructional packages and organize their students into cooperative learning groups to promote meaningful learning of difficult concepts.

# CHAPTER ONE

# INTRODUCTION

## Overview

This chapter deals with the introduction to the study. The background to the study, statement of the problem and the purpose and objectives of the study are discussed in this chapter. The chapter also deals with the research questions that guided the study, research and null hypotheses that were formulated and tested in the study. It further discusses the significance of the study, limitations and delimitations of the study, definition of terms and abbreviations and organization of the study.

## Background to the Study

Experiential evidence obtained through the work of the researcher as a science teacher and an Integrated Science examiner for the West African Examination Council (WAEC) at the Junior High School (JHS) level, suggests that most students perform poorly in Integrated Science probably because they have difficulty in learning some science concepts. This may be because science is taught abstractly, making some of the concepts seem complex and confusing and therefore difficult for students.

The biology aspects of Integrated Science for which students have difficulty, have been investigated by a number of researchers. Johnstone and Mahmoud (1980) for instance, noted that water transport in plant and genetics were among the most difficult biology topics in science to be learnt by students up to the university level.

Finely, Stewart and Yarroch (1982) have shown that photosynthesis, cellular respiration, protein synthesis, Mendelian genetics, mitosis and meiosis, were difficult and important topics for students to learn. Anderson, Sheldon and Dubay (1990) have also indicated that respiration, photosynthesis and gaseous exchange as topics were difficult for students to learn. Again, Abimbola (1998) has noted that Physiology content areas are mostly abstract and microscopic, and involve many fine processes that require proper explanations to enable students understand them. To Abimbola (1998), teachers and students usually find physiology concepts such as photosynthesis, meiosis, cellular respiration, etc., difficult to deal with.

Some teachers also find some biology concept difficult to teach. The study by Finley *et al* (1982) also examined both content importance and difficulty as perceived by some physics, chemistry and biology teachers. They found that most of the important but difficult concepts, to the science teachers were photosynthesis, cellular respiration and Mendelian genetics.

Chromosome theory of heredity and hormonal control of human reproduction are difficult science topics to teach (Finley, *et al.*, 1982). Teachers who find some science concept difficult may teach these concepts poorly. This may explain why students have a difficulty understanding some science concepts.

Tekkaya, Özkan and Sungur (2001) have attributed the possible sources of students" difficulty in learning some science (biology) concepts among others, to the curriculum and the teaching-learning strategies employed by teachers. The researchers believed that the traditional teaching-learning method employed by teachers mainly caused students‟ difficulty and hence their poor academic performance in science (biology) at all levels of science education.

Students‟ poor performance in science (biology) must be addressed if Ghana is to attain its modest aim of becoming an agro-based industrialized and vibrant economy. This is because Rutherford (1985) has noted that the continued progress of the developed countries with respect to economy, security, global status and attractiveness to human society, would continue to be dependent on science education. Brown-Acquaye (2005) has also noted that technological innovations are based on cumulative scientific knowledge for which Science education is the vehicle. Science education, therefore, should be harnessed for the development of Ghana‟s economy.

Literature on studies conducted in countries such as the United Kingdom, the United States of America, Italy, Israel, Taiwan, Ghana, etc. however, provides a glimmer of hope for all who are concerned about the poor performance of students in science. These studies reveal that the use of information and communication technology– ICT (such as computer simulation instructional packages) in the teaching and learning processes has a positive effect on the performance of students in all science subjects. The use of computer simulation instructional package to enhance learning in the science classroom either before or after completion of a didactic unit of instruction has become the focus of most recent research studies (Akpan, 2001). Akpan (2001)

Akpan and Andre (2000) and Coleman (1998) have all opined that computer simulation can be used as extremely effective tools to help students understand difficult science concepts.

Although a number of studies have been conducted on the use of ICT in science education in Ghana, very little is known about the effect of the incorporation of computer simulation instructional packages teaching and learning on students‟ performance in Ghana. This study therefore sought to investigate the effect of computer simulation instructional packages in teaching and learning on the performance of Ghanaian JHS students in photosynthesis.

**Statement of the Problem**

The performance of students in the Basic Education Certificate Examination (BECE) in science has been a worry for many stakeholders in the educational enterprise for some years now. In 2011 for instance, the Chief Examiner‟s report on science, indicated a poor performance in science, compared to the previous year. The trend of poor performance had continued up till now. This abysmal situation has created the perception among most JHS students that "science in general is difficult" and see the study of science as being exclusively for the more gifted or academically well-endowed counterparts. This seems to explain why many students shy away from studying science after their BECE in Ghana.

Students have problems learning some science (biology) concepts meaningfully and therefore, resort to rote-memorizing these concepts. This is because biology is a more interrelated science field with respect to the concepts it covers, than other science fields, (Çibik, Diken & Darçin, 2008).

Johnstone and Mahmoud (1980) have also noted that photosynthesis and respiration in plants are the most confusing biology concepts for students. The complex and confusing nature of photosynthesis may explain why most students perform poorly in answering questions relating to it.

Experimental evidence, gathered through the researcher"s work as a WAEC science examiner and through interactions with other science teachers, indicated that most students have difficulty answering questions relating to photosynthesis correctly, especially those relating to testing for starch and balancing the chemical equation for photosynthesis. The difficulty of students in answering questions relating to photosynthesis may be a contributory factor to the poor performance of JHS students in science.

For some years now, Ghanaian science teachers have used the traditional instructional approaches which involve lecture, demonstration, illustration and discussion in their classroom to deliver their science lessons. This approach has however, proven to be ineffective in helping JHS students to understand complex and confusing concepts in science like photosynthesis. However, Çepni, Taş and

Köse (2006) have found that making use of the Computer-Assisted Instruction Material, a computer simulation instructional package, in the teaching-learning process was very crucial for attaining the application and comprehension levels of cognition in photosynthesis.

The effect of computer simulation instructional packages as a tool for classroom instruction has been noted by a number of researchers. Sahin (2006) for instance has observed that computer simulations are good supplementary tools for classroom instructions and in science laboratories, as they give students the opportunity to observe a real world experience and interact with it. Computer simulations are good tools to improve students" hypothesis construction, graphic interpretation and prediction skills (Sahin, 2006). It therefore seems that the incorporation of computer simulation instructional packages in teaching and learning processes improve the understanding of learners. An investigation into the effect of computer simulation instructional packages in the teaching and learning of complex and confusing science concepts, like photosynthesis, in Ghanaian schools is desirable. Hence, this study in JHSs in the Prestea Huni-Valley District.

**Purpose of the Study**

The purpose of this study was to investigate the extent to which computer simulation instructional approach improves the teaching and learning of photosynthesis in two selected Junior High School students in the Prestea Huni-Valley District.

**Specific Objectives of the Study**

The objectives of the study were to:

1. investigate if there is any difference in the performance between: students exposed to the computer simulations instructional approach and their counterparts treated with the traditional approach to teaching and learning of photosynthesis.
2. find out any difference between students exposed to the computer simulation instructional approach to the teaching and learning of photosynthesis in two different schools in the district.
3. assess the effect of computer simulation instructional model in the teaching and learning of photosynthesis.

**Research Questions**

The study was guided by the following research questions:

1. What differences are there in the performance of JHS 3 students exposed to the computer simulation instructional approach and those exposed to the traditional instructional approach to teaching and learning of photosynthesis?
2. What differences are there in the performance between JHS 3 students exposed to computer simulation instructional approach to the teaching and learning of photosynthesis in two different schools in the district?
3. What differences are in the performance of JHS 3 students exposed to the computer simulation instructional approach to the teaching and learning of photosynthesis in cooperative and individualized learning settings.

## Research Hypothesis

The following were the research hypotheses of the study:

*$H_A$ 1*: There is a statistically significant difference in performance between students exposed to computer simulation instructional approach and those exposed to traditional instructional approach in the teaching and learning of photosynthesis.

*$H_A$2*: There is a statistically significant difference in the performance of students in the two different schools in the district exposed to the computer simulation instructional approach to the teaching and learning of photosynthesis.

*$H_A$ 3*: There is statistically significant difference in performance of students exposed to computer simulation instructional approach to the teaching and learning of photosynthesis in cooperative learning settings and those in individual learning settings.

## Null Hypothesis

The following null hypotheses ($H_o$) were therefore tested in this study:

*$H_O$ 1*: There is no significant difference in performance of students exposed to the computer simulation instructional approach and those exposed to the traditional instructional approach to the teaching and learning of photosynthesis.

*$H_O$* 2: There is no significant difference in the performance of students in the two different schools in the district exposed to the computer simulation instructional approach to the teaching and learning of photosynthesis.

*$H_O$ 3*: There is no significant difference in the performance of students exposed to the computer simulation instructional approach to the teaching and learning of

photosynthesis in cooperative learning settings and those in individual learning settings.

## Significance of the Study

The study has produced a document that report on the effect of computer simulation instructional packages in teaching and learning on the performance of students in science concepts like photosynthesis.

It was hoped that the study would transform the teaching of science from the traditional instructional approach of lecture, discussion, demonstration and illustration to a situation where computer simulation instructional packages would be incorporated into the teaching and learning of science. This would lead to increased learning gains in science for students. This will thus help to improve the teaching and learning of science at the JHS level and help science teachers realize the importance of incorporating computer simulations instructional packages in the instructional process.

Again, study would empower administrators or heads of schools in procuring the appropriate computer hardware and software for their schools. This will help to improve teaching and learning of science in schools.

Furthermore, this study would be a reference document for the Ministry of Education (MoE), Ghana Education Service (GES), Curriculum Research and Development Division (CRDD) and other stakeholders concerned with science education to make instructional changes in science education and push for the incorporation of computer simulation instructional packages in the teaching and learning of science in Ghana. The Ministry of Education (MoE), Ghana Education Service (GES) will also have the empirical evidence to back any increased budgetary allocation earmarked for the procurement of appropriate ICT facilities and software packages to improve science education in Ghanaian Schools.

Finally, the study would be a reference material for other researchers who would wish to conduct research studies into the same or similar topic area.

**Delimitations of the Study**

The study was delimited to Nana Amoakwah Model JHS and Damang D/A JHS located at Damang in the Prestea Huni – Valley District. This study was also delimited to only JHS 3 students in the two schools. The study was additionally delimited to an aspect of Integrated Science and Information Communication Technology, that is biology and focusing on photosynthesis as a topic in the JHS integrated science syllabus (Section 4, Unit 1).

**Limitations of the Study**

The entire research was a great success, but few incidence which were beyond the control of the researcher influenced the study. First inconsistency of the pupils attendance to school was a problem since the researcher had to repeat lessons in order to have effect on all the students. Also lack of resource centers in the school made the intervention slow since the researcher had to improvise materials for the study.

**Definition of Terms and Abbreviations**

AME - African Methodist Episcopal

SKPT - Students Knowledge of Photosynthesis Test

SAPT - Students Achievement of Photosynthesis Test

CBI - Computer Based Instruction

CAI - Computer Assisted Instruction

JHS - Junior High School

ZPD - Zone of Proximal Development

GES - Ghana Education Service

MOE - Ministry of Education

ICT - Information Communication & Technology

DA - District Assembly

DO - Dissection-Only

SO - Simulation-Only

DBS - Dissection-Before-Simulation

SBD - Simulation-Before-Dissection

**Organization of the Chapters**

The study was organized in five chapters. Chapter one outlined the background to the study, statement of the problem, purpose of the study, significance of the study, delimitation of the study, limitation of the study, definition of terms and abbreviations and organization of the study. Chapter two dealt with review of literature related to the study. Chapter three outlined the methodology (various approaches that were followed to gather data for the study). Chapter four focused on results and discussion of findings. Chapter five dealt with summary, conclusions and recommendations.

# CHAPTER TWO

# LITERATURE REVIEW

## Overview

The review of literature focused on work done by researcher in related fields. The topical issues reviewed in the literature include;

1. The theoretical and conceptual frameworks of the study. The chapter discusses, among others, the theories of Jean Piaget and Lev Vygotsky upon which the study was hinged.
2. The concept of computer simulations in science teaching and learning have also been discussed in the literature.
3. In addition, the literature discussed cooperative learning in science teaching and learning. 4. Finally, students‟ difficulty with some science concepts, and with photosynthesis in particular, as well as the issue of gender and computer simulations in science teaching have been dealt with in this chapter.

## Theoretical Framework of the Study

The theoretical framework that underpinned the study was hinged on Jean Piaget‟s theory of cognitive development and Lev Vygotsky‟s social constructivism theory. To Piaget (1954), the cognitive development of children towards formal thought could be facilitated through three cognitive processes: assimilation, accommodation and reorganization or equilibration. According to Piaget (1945), when children assimilate, (they perceive new objects and events) according to their existing schemata, (mental models or cognitive structures). The mental models of children, formed by their prior knowledge and experience, therefore, control how they incorporate new information into their minds. This may occur when the new experiences of children align with their existing schemata, (mental models or internal representations of the world) or as a result of their failure to change a faulty understanding (Piaget, 1954). Sometimes, when children‟s experiences contradict their existing schemata, they may change their perceptions of the experiences to fit their internal representations.

Accommodation however, results as children reframe or modify their existing schemata to fit their new experiences for learning to occur (Piaget, 1954).

Hence, as children exercise existing mental structures in particular environment, accommodation-motivating disequilibrium results and the children construct new mental structures to resolve the disequilibrium (Piaget, 1954). The state of disequilibrium and contradiction arising between the existing schemata and the more sophisticated mode of thought for the new experience therefore, has to be resolved via equilibrium process.

Equilibrium maintains the balance between new knowledge and assimilated knowledge with previously gained knowledge. Knowledge is therefore, not a mirror of the world but is created or „constructed‟ from the individual‟s continuous revision and reorganization of cognitive structures in conjunction with experience (Piaget, 1954). Thus in the view of Piaget, students are actively involved in the construction of their own knowledge. It is therefore, argued that knowledge is constructed through active reflection on objects and events till they eventually achieve an adult‟s perspective. Piaget (1954) hence posited that the process of intellectual and cognitive development is similar to a biological act, which is adaptation to environmental demands. To Vygotsky (1978), every function in the child‟s cultural development appears twice: first, the social level, and later, on the individual level. First, between people (intrapsychological) and then inside the child (intrapsychological). According to Vygotsky (1978), children are capable of performing at higher intellectual levels when asked to work in collaborative situations then when asked to worked individually.

Vygotsky (1978) also believed that less skillful individuals are better able to develop more complex levels of understanding and skill through collaboration, direction, or help of an expert or a more capable peer than they could independently. Social interaction extends a child‟s zone of proximal development, which is the difference between a child‟s understanding and potential to understand more difficult concepts (Vygotsky, 1978).

Thus with Vygotsky, children are capable of constructing their own knowledge through collaboration, direction or help in constructing their own knowledge. This is what has been termed „social constructivism‟. Social constructivism not only acknowledges the uniqueness and complexity of the learner, but also actually encourages, utilizes and rewards it as an integral part of the learning process (Wertsch, 1997).

Vygotsky‟s ideas concerning the Zone of Proximal Development (ZPD) provide a strong support for the inclusion of cooperative learning strategies in classroom instruction. Research studies have clearly indicated the effectiveness of cooperative learning methods over individual learning methods in the development of higher-order thinking skills as well as the achievement of greater learning outcomes (Johnson & Johnson, 1985). For instance, Stahl and Vansickel (1992) have noted that every cooperative learning strategy, when used appropriately, enables students to move beyond the text memorization of basic facts and learning levels skills. Also, Ajaja and Eravwoke (2010) have opined that cooperative-learning strategies result in cognitive restricting, which leads to an increase in understanding of all students in a cooperative group.

Simulations can be considered a variant of cognitive tools, that is, they allow students to test hypothesis and more generally "what-if" scenarios and enable learners to ground cognitive understanding of their action in a situation (Thomas & Milligan, 2004; Laurillard, 1993). According to Thomas and Milligan (2004), simulations, in this respect, are compatible with a constructivists‟ view of education. Light and Mevarech (1992) have pointed out that since the early 1980s there has been growing interest in the potentialities of both cooperative learning and of computers as facilitators of students learning. In the view of Newberry (1999), the claims made for each in some respects, are rather similar, for both emphasize the role of students‟ interactions in enhancing a wide range of school outcomes, including academic achievements, cognitive processes, meta-cognitive skills, motivation towards learning, self-esteem and social development. This seems to indicate that both computer simulations and cooperative learning strategies have a positive influence on students‟ academic achievements.

**Conceptual Framework of the Study**

Based on the theories of Jean Piaget and Lev Vygotsky, a conceptual model (Figure 1) was developed by Laringtey and was adopted and modified for the study. When students are exposed to confusing or complex concepts, they are thrown into a state of disequilibrium. Computer simulation instructional packages (administered in cooperative or individualized learning setting) enable students to develop cognitive structures (mental models) or reorganized their already existing ones to better understand confusing and complex science concepts such as, photosynthesis. Gardner (1993), and Pintrich, Marx and Boyle (1993) have noted that, the constructivists‟ position that students should have access to multiple viewpoints and representations for information, is partially satisfied by well-constructed simulations.

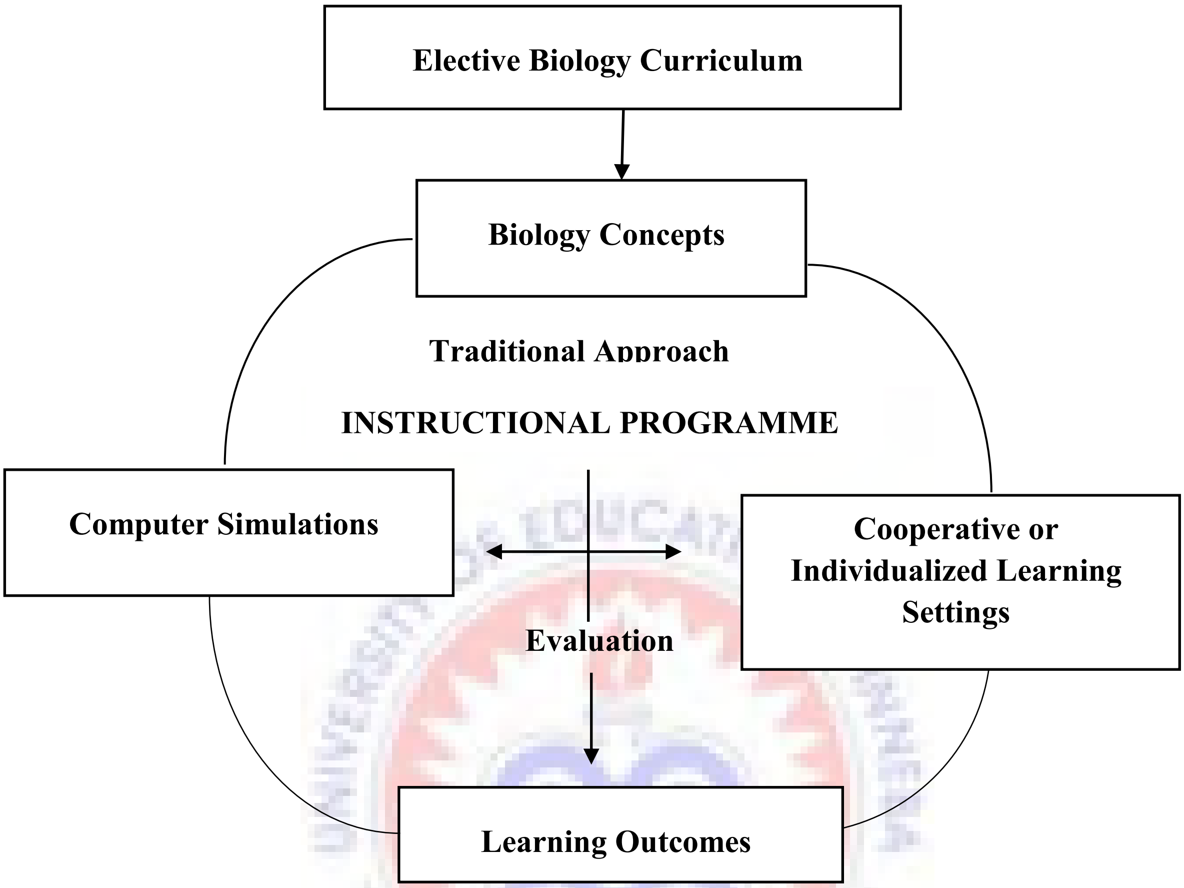


**Figure 1: Conceptual Model of the Study (Laringtey, 2014)**

Ramasundarm, Grunwald, Mangeot, Comerford and Bliss (2005) and Cholmsky (2003) have also observed that, simulations have the potential to make learning of confusing, complex and difficult concepts more interactive, authentic and meaningful. Computer simulation instructional packages therefore, seem to give students experiences that facilitate conceptual development leading to increased understanding.

Also, with dynamic group support in cooperative environments, students seem to perform at higher intellectual levels, which enable them to better comprehend complex, confusing or abstract science concepts. This is because Newberry (1999) opined that, the claims made for computer simulations and cooperative learning strategies in some respects are rather similar. For according to Newberry (1999), they both emphasize the role of students‟ interactions in enhancing a wide range of school outcomes, including academic achievements, cognitive processes, meta-cognitive skills, motivation towards learning, self-esteem and social development. Computer simulations instructional packages (either alone or in cooperative learning settings) therefore, seem to provide students with experiences that facilitate conceptual development, which leads to increases understanding of difficult concepts. Evaluation of the instructional processes however, reveals learning outcomes, which could serve as evidence of the attainment of the curriculum objectives or basis for the need to refine the curriculum objectives.

**Concept of Computer Simulation**

Computers have been used in teaching and learning for several years now and are used in many ways in teaching sciences. Teachers have been using computers for many purposes beyond word processing (Sahin, 2006). Akpan and Andre (1999) and Lazarowitz and Huppert (1993) have observed that computers can play important roles in classroom and science laboratory instructions. According to Sahin (2006), one type of computer application is simulations. With simulations, teachers can potentially better focus students‟ attention on learning objectives, because with simulations the real-world environments are simplified, causality of events are more clearly visualized and unnecessary cognitive tasks are reduced (De Jong & Van

Joolingen, 1998). Sahin (2006) has also observed that computer simulations give students the opportunity to observe a real world experience and interact with it. Therefore, worthwhile goal for science education is to develop simulation pedagogies that maximize student learning (Lindgren & Schwartz, 2009).

Thompson, Simonson and Hargrave (1996) have defined a simulation as a representation or model of an event, object or some phenomenon. According to Akpan (2001) and Miller and Castellanos (1996), a simulation is a dynamic execution of the processes within a relational model system of an object.

Broadly defined therefore, computer simulations could be seen as computer-generated dynamic models that present theoretical or simplified models of real-world components, phenomena or processes (Trundle & Bell, 2010). According to Akpan and Andre (1999), a computer simulation in science education is the use of the computer to simulate dynamic systems of objects in a real or imagined world.

**Types of Computer Simulations**

There are many different forms and types of computer simulations. To Sahin (2006), computer simulations take many different forms from two or three dimensional simple shapes to highly interactive, laboratory experiments and inquiry environments. According to Trundle and Bell (2010), computer simulations can include animations, visualizations and interactive laboratory experiences.

Computer simulations have some positive effects on students. Computer simulations according to Strauss and Kinzie (1994) are useful for labs that are impractical, expensive, impossible, or too dangerous to run. Simulations can contribute to conceptual change in students (Stieff & Wilenskyl, 2003; Zietsman & Hewson, 1986) and provide problem – solving experiences (Howse,1998; Woodward, Carnine & Gersten 1988) and tools for scientific inquiry (Dwyer & Lopez, 2001; White & Fredericksen, 2000). Science simulations can be extremely effective tools in helping students understand and experience practical applications of scientific thinking (Akpan, 2001; 1999; Akpan & Andre, 2000; Coleman, 1998).

Thomas and Hooper (1991) have classified computer simulations in four categories; experiencing simulations, informing simulations, reinforcing simulations and integrating simulations.

Experiencing simulations are used to set the cognitive or affective stage for future learning and their use precede the formal presentation of the material to be learned. Sahin (2006) has noted that informing simulations are used to transmit information to the students and are more appropriate when incorporated in a supporting environment, such as, regular classroom or laboratory work. Reinforcing simulations are for strengthening specific learning objectives (Thomas & Hooper, 1991). According to Thomas and Hooper (1991), the most common format for reinforcing simulations is drill and practice, in which a sequence of stored or generated exercise is presented for students to complete. These simulations can be designed to adjust to the students‟ knowledge level and to track the students‟ progress (Thomas & Hooper, 1991). Integrating simulation, however, seem to be most prevalently used simulations for the acquisition of diagnostic skills, where students first learn the required factual information and principles and then used the simulations to relate and apply that knowledge (Thomas & Hooper, 1991).

De Jong and Van Jooling (1998) have also indicated that computer simulations could be divide into two main categories: simulations containing a conceptual model, and those based on an operational model. Conceptual models hold principles, concepts and facts related to the systems being simulated; while operational models include sequences of cognitive and non-cognitive operation procedures that can be applied to the simulated systems (De Jong & Van Jooling, 1998).

Gredler (1996) however, distinguishes between two main types of simulations: symbolic and experiential simulations. The student in an experiential simulation takes on a serious role in an evolving scenario and experiences the privileges and responsibilities of that role in attempting to solve a complex problem or realize a goal (Gredler, 1996). Experiential simulations therefore, immerse the students in a complex, changing environment in which the student is a functional component. Experiential simulations allow students to execute multidimensional problem-solving strategies as part of their role in the programme and provide them with opportunities to develop their cognitive strategies by organizing and managing their own thinking and learning (Sahin, 2006).

According to Sahin (2006), experiential simulations may be cooperative or individualized exercise due to the nature of the participants‟ roles and the types of decisions and interactions in the exercise.

Gredler (1996) has stated that the four essential components of an experiential simulations are a scenario of a complex task that unfolds in part response to learner actions, a serious role taken by the learner in which he or she executes the responsibilities of the positions, multiple plausible paths through the experience and learner control of decision making. Gredler (1996) has recognized four major types of experiential simulations. These include data management, crisis management, diagnostic and social-process exercises. Of these, crisis management simulations are developed to meet pre-established criteria regarding the nature of the crisis and expected student reactions (Gredler, 1996). According to Gredler (1996), symbolic simulations on the other hand, are dynamic representations of a universe, system or process of phenomenon by another system, in which the behavior that is simulated involves the interaction of at least two variables over time. To Gredler (1996), the student interacts with symbolic simulation from the outside, unlike with experiential simulation. In symbolic simulations therefore, the student is not a functional component of the programmed environment. The types symbolic simulations according to Gredler (1996) are data universe, system, process and laboratory-research simulations.

Sahin (2006), on the other hand, viewed computer simulations in two broad perspectives: reflecting constructive and instructive pedagogies. Constructive simulations provide learners with a contextual environment in which they take place and play roles (Sahin, 2006); examples include Exploring the Nardoo and Bioworld. Constructive simulations may include integrated simulations, experiential simulations, and conceptual simulations (Sahin, 2006). Instructive simulations, on the other hand, include learners as external players on the provided conditions (Sahin, 2006). The photosynthesis Advanced was the computer simulation instructional package used in this study. According to Sahin, (2006) instructive simulations may include information simulations, reinforcing simulations, experimenting simulations, symbolic simulation and operational simulations. Therefore, the computer simulations instructional package used in the study is a process or an instructive simulation, which uses symbols to represent the interactions of unobservable variable in naturally occurring phenomena like photosynthesis, cellular respiration, cell division: mitosis and meiosis, protein synthesis, Newton‟s law of motion, complex atomic reactions, and the like.

**Elodea Photosynthesis Simulation Laboratory**

Pineda (2013) used simulation laboratory to produce oxygen as a plant photosynthesized. He placed Elodea, an aquatic plant commonly used in aquaria, in water with baking soda to provide carbon. The plant was then exposed to various treatments. Oxygen was measured by the counting the number of bubbles produced by the plant during a specific time interval.

In this experiment, investigation was done on how four factors influence the rate of photosynthesis. The factors are carbon dioxide availability, light intensity, temperature and light colour.

Pineda, (2013) kept two variables always constant in the experiment and concluded that simulation always provide opportunity for students to interact therefore enhancing effective teaching and learning.

**Cooperative Learning in Biology Teaching**

Cooperative learning has been defined by Johnson and Johnson (1978) as an approach that engages students in working together noncompetitively towards a common goal. Cooper and Mueck (1990) also described cooperative learning as a structured, systematic instructional strategies in which small groups work together towards a common goal. The goals of cooperative learning are to enhance students‟ learning and to develop student‟s social skills like decision making, conflict management and communication (Bonewell & Eison, 1991). The cooperative learning methods used in contemporary education have evolved over the last 30 years (Handelsman, Houser & Kriegel, 2002) and proponents of cooperative learning have developed classroom strategies that emphasize small groups of students working together in a structured process to solve academic task (Newberry, 1999).

Cooperative learning tends to be more carefully structured and delineated than most other forms of small-group learning (Newberry, 1999). According to Borich (2004), in cooperative learning, interaction among students is intense and prolonged and students gradually take responsibilities for each other‟s learning. Cooperative learning is thus, the instructional use of small groups so that students work together to maximize their own and each other‟s learning.

Five critical elements make cooperative learning successful such factors are positive interdependence, individual accountability, face-to-face promotive interaction, social skills, and group processing (Johnson & Johnson, 1999). The first of the five critical elements is positive interdependence. Positive interdependence is the process of linking students together so that they cannot succeed unless their teammates do (Johnson & Johnson, 1999). Positive interdependence is, thus, the act of working together to benefit on another. To ensure positive interdependence, teachers must develop bonding and group trust, use group roles and structure content areas (Gibbs, 2001).

Individual accountability is the second element of cooperative learning. Individual accountability ensures individual and group assessments (Johnson & Johnson, 1999). Parveen, Mahmood and Arif (2011) have noted that individual accountability exists when the performance of each individual member is assessed, the results are given back to the individual compared against a standard of performance and the member is held responsible by group-mates for contributing his or her fair share to the group‟s success. Johnson and Johnson (1999) therefore, suggest that teachers give individual test, randomly select students work and have each student explain what he or she learned to facilitate individual accountability during cooperative learning. In individual accountability, each student within a group must, thus, be held accountable for mastery of the instruction presented to the group.

The third critical element of cooperative learning, according to Johnson and Johnson (1999), is face-to-face promotive interaction. Face-to-face promotive interaction is individual supporting each other in a cohesive group in which they promote each other‟s success by sharing resources, helping, assisting, supporting, applauding each other‟s effort to achieve and encourage one another. Also, in face-to-face promotive interaction, students teach and encourage one another during the exercise to ensure that any team member randomly chosen will be prepared to answer for the group.

There are important cognitive activities and interpersonal dynamics that can only occur when students promote each other‟s learning (Johnson & Johnson, 1999). This includes orally explaining how to solve problems, teaching one‟s knowledge to others, checking for understanding, discussing concepts being learned and connecting present with past learning (Johnson & Johnson, 1999). Lampe, Rooze and Tallent-Runnels (1998) have stated that peer interaction is central to the success of cooperative learning as it relates to cognitive understanding and facilitated comprehension. During cooperative learning therefore, the feedback, reinforcement and support come from student peers in the group. This implies that science teachers dividing their students into groups of four or five, working together in physical closeness promoted by a common task, will encourage collaboration, support feedback from the closest and most immediate source – one‟s peers (Ajaja &

Eravwoke, 2010). According to Ajaja and Eravwoke (2010), science teachers should therefore, model their instructions to enforce student-student interaction. In a cooperative learning classroom therefore, the teacher must specify both the academic and social skills objectives, explain the task and goal structures, assign roles within the groups to facilitate learning.

The fourth critical element of cooperative learning, according to Johnson and Johnson (1999), is social skills. To promote effective cooperative learning, Johnson and Johnson (1999) suggested that students must be taught social skills, such as leadership, decision making, trust building, communications, and conflict management, as purposeful and precise as academic skills. Vermette, Harper and DiMillo (2004) have found that conflicts do arise between students in cooperative learning groups. However, they need to be resolved in a healthy manner for effective cooperative learning. Students cannot be placed together in a group situation and expected to cooperate, they must, be taught the skills needed for collaboration, and they must be motivated to use them (Slavin, 1995; Johnson & Johnson, 1985).

The fifth and final critical element of cooperative learning is group-processing. According to Parveen *et al.* (2011), group processing may be defined as reflecting on group session to describe which member‟s actions were helpful or unhelpful and take decisions about which actions should continue or change. Continuous improvement of the processes of learning results from the careful analysis of how members are working together and determining how group effectiveness can be enhanced (Johnson, Johnson & Holubec, 1993). To Johnson and Johnson (1999), group members discuss how well they are achieving goals and maintaining effective relationships while discovering how well each member performs and adjusts to change.

Dentler (1994) has noted that cooperative-learning approaches empowers students, bolstering their self-esteem and confidence. Nelson (1996) speaks convincingly of the need to alter philosophies and practices and advocates a switch to alternative, non-lecture based pedagogies, such structured group work. Dentler (1994) concludes:

> *when we ask our urban community college students to find answers on their own and share them, non-competitively with their classmates, we empower them in a way that wasn't even necessary for my generation of college students. When our students work with their peers on research projects, we are literally inviting them to participate in the system. For many, this is the first time the system welcomes them at the table* (p.11).

Millis and Cottell (1998) have noted the close affinity and links between cooperative learning and technology by asserting that cooperative learning and technology (such as computer simulations) are natural partners. This is because the use of technology involves human dimensions of caring, community and commitment (Yusuf & Afolabi, 2010). Accordingly, using technology in ways that promote sequenced learning within groups can lead to more in-depth processing of course content and hence, more retention of information (Newberry, 1999). Barron and Orwig (1997) have also opined that technology can be used to enhance and encourage cooperative learning in our schools through small groups using a single computer, network-based instructional programmes or collaborative projects on the internet.

**Empirical Evidence of the Study**

A number of studies have indicated that the use of computer simulations instructional packages has positive influence on the achievement of students in science. Kiboss, Wekesa and Ndirangu (2006) for instance, assessed the effects of a computer-based instruction simulation (CBIS) programme on students‟ understanding and perception of cell theory in school biology. The CBIS programme was developed for the teaching of school biology, as part of a classroom innovation for science instruction to improve students‟ understanding and perceptions of cell theory. Kiboss *et al*. (2006) found that CBIS programme positively affects the development of students‟ understanding and perception of cell division lessons in school biology.

Okoro and Etukudo (2001) in a paper entitled "Computer Assisted Instruction (CAI) versus Extrinsic Motivation based traditional methods: It‟s Effect on Female Genders‟ Performance in Chemistry" presented at 42nd STAN Annual Conference in Ilorin, noted that students exposed to the CAI performed significantly better than those exposed to the extrinsic motivation based traditional method. Akour (2006) in a study on the effects of computer-assisted instruction on Jordanian college students‟ achievements in an introductory computer science course, noted that students taught using traditional instruction combined with the use of computer performed significantly better than their counterparts taught using traditional instruction.

Huppert, Lomask and Lazarowitz (2002) also investigated the impact of computer simulations on the development of higher-level inquiry skills. They found that high school students using a simulated yeast cell lab outperformed those completing a hands-on lab. Additionally, Akpan and Andre (2000) investigated the effectiveness of computer simulation and hands-on frog dissection. Akpan and Andre (2000) found that students receiving simulation-before-dissection (SBD) and simulations-only (SO) learned significantly more in anatomy than students receiving dissections-before simulations (DBS) and dissection-only (DO).

Furthermore, a study by Cavalier and Klein (1998) compared the effects of cooperative learning versus individual learning during computer-based instruction (CBI). The study examined, among others, the effect of learning strategy and orienting activities on intentional and incidental post-test performance.

Cavalier and Klein (1998) concluded that students who received instructional objectives throughout the programme performed significantly better on intentional post-test items than students who received either advance organizers or no orienting activities. Cavalier and Klein (1998) also indicated that cooperative settings that have experience working in groups are likely to be more efficient with their learning than students working alone with the computer.

Finally, Crooks and Klein (1998) investigated the effects of cooperative and individual learning during learner-controlled computer based instruction. However, the results indicated that although students in the cooperative learning condition performed better than their counterparts in individual learning condition on the post-test, the difference in performance was not statistically significant.

**Students' Difficulty with the Concepts of Photosynthesis**

Çibik et al (2008) have observed that biology is a more interrelated science field with respect to the concepts it covers, compared to other science fields.

As a result, students have problems learning some biology concepts meaningfully and therefore, choose to rote memoirze these concepts.

Johnstone and Mahmoud (1980) also found that photosynthesis and respiration in plants are the confusing biology concepts for students. Furthermore, photosynthesis, cellular respiration, protein synthesis, Mendelian genetics, mitosis and meiosis, have been shown by Finley *et al*. (1982) to be difficult and important topics for student to learn whereas Anderson *et al*. (1990) have indicated that photosynthesis, respiration and gaseous exchange are difficult for students to learn.

Photosynthesis is one of the most fundamental concepts in biology and is traditionally taught in several fields of biology, such as, cell biology, plant physiology, ecology and botany, etc. The process of photosynthesis, according to Çibik *et al* (2008), is indeed complicated and knowledge in chemistry and physics.

The complex and confusing nature of photosynthesis and some other biology concepts may explain why most students perform poorly in it.

# CHAPTER THREE

# METHODOLOGY

## Overview

This chapter deals with the research methodology employed in the study. It discusses the study area, research design adopted for the study, population sample and sampling procedures used in the study. The data collecting, instruments, and their validity and reliability, procedure data collection data procedure analysis have also been presented in this chapter. The study was done in two JHSs in the Prestea Huni-Valley District in the Western Region of Ghana.

## Research Design

The study employed the quasi-experimental research design. This is because quasi-experiments are exceptionally useful in instances, such as evaluating the impact of public policy changes, educational interventions or large scale health intervention, where it is not erasable or desirable to conduct an experiment or randomized control trial (Shadish, Cook & Campbell, 2002). Quasi-experimental research design involves selecting groups, upon which a variable is tested without any random pre-selection processes (Shuttleworth, 2008). Shadish *et al* (2002) have identified several types of quasi-experimental designs. According to them, quasi-experimental research designs include, but are not limited to: the one-group post testonly design; the one-group pre-test post-test design; the removed-treatment design; the case-control design; the non-equivalent control groups design; the interrupted design, time-series design and the regression discontinuity design.

According to Gribbons and Herman (1997), the frequently used types of quasi-experimental research designs include the post-test only nonequivalent control group design, time series designs and pre-test-post-test nonequivalent control group design. Time series designs refer to the pre-testing and post-testing of one group of subjects at different intervals, the purpose of which might be to determine long term effect of treatment. In time series designs therefore, several assessments (or measurements) are obtained from the treatment group as well as from the control group, which occurs prior to and treatment (Gribbons & Herman, 1997). Therefore, according to Gribbons and Herman (1997), in time series design, many observations are made over time; both without intervention and with intervention (Gliner & Morgan, 2000). The multiple observations, according to Zelenka (2010), are used to establish a baseline that shows an ideally stable level of the outcome of interest over time. Again, according to Zelenka (2010), multiple observations are made during intervention, ideally showing a change due to intervention, the treatment may be withdrawn, in an attempt to isolate the relationship of treatment to observed outcome. This may be used with or without a control group (Zelenka, 2010). In pre-test-post-test nonequivalent control group where an experimental group is compared, the groups are chosen and assigned out of convenience rather than through randomization (Heffner, 2004). To Leedy (1997), this design is one of the strongest and most widely used quasi-experimental designs, which differs from experimental designs because test and control group design involves administering an outcome measure to two groups or to a programme or treatment group and a comparison made (Gribbons & Herman, 1997).

This study employed pre- and post-tests only non-equivalent control group design of the quasi-experimental research design. Such a design was used because the study used intact classes which did not permit random selection and assignment of participants. Post test only non-equivalent control group design of quasi-experimental design was also used because the study investigated the effect of two teaching approaches: computer simulation teaching and the traditional teaching approach, on experimental and control groups (students), which have not been equated by randomization (Cohen, Manion & Morrison, 2008) in two JHSs in the Prestea Huni Valley District in the Western Region of Ghana. One of the schools, Nana Amoakwah Model JHS is a performing school in BECE and Damang DA School which is a non-performing school in BECE, in the same District.

**Population**

The target population for the study was all public JHSs in the Prestea Huni – Valley District in the Western Region of Ghana. The target population for the study was 2018 JHS 3 students in the district. The accessible population for the study, however, comprised Nana Amoakwah Model JHS and Damang DA JHS selected from the target population. These two JHS were chosen based on their candidates" performance in BECE, willingness of the school heads and science teachers to participate in the study; and proximity of such schools to the researcher.

**Sample and Sampling Procedures**

The sample for this study was made up of students in two intact JHS 3 classes in each of the selected JHSs. The sample size used for the study was 136 students. Seventy-four (74) students were chosen from Nana Amoakwah School. Sixty-two (62) students were from Damang D/A JHS. They were further grouped into control and experimental groups. Both JHSs included in the study were selected by purposive sampling. Purposive sampling is when a researcher selects participants that will purposely help him to achieve his objectives. Therefore, the two schools and the classes were selected for this study.

Third year JHS students were used in the study because "Photosynthesis" is taught during the third of the JHS integrated science programme as contains the JHS integrated science syllabus. Participants in this study were all of similar educational background as they have been taught Photosynthesis at the primary school level and they have basic knowledge of the concept.

The participants were categorized into the experimental groups and the control group based on the performance of the intact classes on a pre-test instrument, "students" knowledge of Photosynthesis Test" – SKPT used in the study. The pre-test instrument was administered to all participants in each selected JHS in their respective classrooms at the same time in each school. Mean scores obtained by the intact classes on the SKPT, were used as the basis of the categorization of participants into the experimental and control groups. The classes that obtained the lower mean scores were designated as the control groups. This was alone to investigate whether the performance of the classes with the lower mean scores would improve much more with the computer simulation instructional approach than that with the highest mean score, which were taught with the traditional instructional approach.

The total sample size for the study was 136 students from both schools. This was made up 74 students from Nana Amoakwah Model School and 62 from Damang DA JHS. The control group was JHS 3 students from Nana Amoakwah Model JHS (consisted of 25 boys and 15 girls) while the experimental group 3 in the same school (consisting of the 4 boys and 33 girls). The two experimental groups in Damang DA JHS were 16 boys and 14 girls in group 1; while group two was made up of a single boy and 31 girls. The total sample size was taken from two streams in each of the selected schools (that is, A and B) from Nana Amoakwah; and, A and B streams from Damang DA School.

**Research Instrument**

The date collecting instruments were paper and pencil test of comparable standard, developed by Laringtey. This was adopted and modified by the researcher to collect quantitative data from all participants. The test instruments were named "Students Knowledge of Photosynthesis Test" – SKPT and "Students Achievement in Photosynthesis Test" – SAPT . „„Which were adopted and modified from Laringtey (2014)"". The SKPT and SAPT were used as the pre-test and post-test instruments respectively. The SKPT was used to assess the participants" knowledge and difficulty with the concept of „Photosynthesis" in order to have a baseline about all the participants before the implementation of the interventions. The SAPT was however, designed to measure participants" achievement after the implementation of the interventions. The SKPT and SAPT were both 20 item paper and pencil tests, which were made up of three sections – A, B and C in appendices A1 and A2 Preceding section A of each test instrument was a portion that briefly stated the purpose of the test and also asked participants to provide personal data, such as identification number (ID), gender, class and school. This portion also contained general instructions to answering items in all three sections of the test instruments. Additionally, each section of the SKPT and SAPT begins with specific instructions regarding how to respond to items in that section.

Section A of the SKPT and SAPT were both made up of 10 multiple-choice objective items, numbered as items 1 to10. Each of the multiple choice items on the SKPT and SAPT has a stem (about an aspect of the concept of photosynthesis) followed by four plausible answers, comprised one correct answer (key) and three plausible distracters. Each correct answer circled or chosen was awarded one mark, resulting in total score of 10 marks for section A of both SKPT and SAPT.

Section B was made up of five true – false test items, which appeared as items 11 to 15 on the SKPT and SAPT. Each of the five true – false items has a statement about an aspect of the concept of photosynthesis followed by True or False. Participants were required to circle *true* if they agreed with a statement or *false* if they disagreed with it. Each correct option circled was awarded one mark, giving a total score of five marks for section B of both SKPT and SAPT.

Section C was made up of five short essay shot – answer items numbered as items 16 to 20 on the SKPT and SAPT. All participants‟ responses to one short essay or short – answer items were scored before scoring participants‟ responses to the next short essay or short – answer items. This helped to keep one frame of references and one set of criteria in mind while scoring responses to a particular short – answer or short essay item. It also prevented carrying over impressions formed while scoring the response of a participant to the participants‟ next response(s). Also, to ensure uniformity in the scoring of all items, marking guides and scoring schemes were prepared for the marking and scoring of the SKPT and SAPT. Items in sections C had maximum score of two, three, four or five mark giving total scores of 20 marks for the SKPT and SAPT respectively. The SKPT and SAPT therefore, had overall scores of 30 marks respectively.

**Validity of the Instrument**

To ensure that participants‟ score from the SKPT and SAPT make sense, are meaningful and enable good conclusions to be drawn from the sample studied to the research population (Yeboah 2012 cited in Laringtey, 2014), both test instruments were presented to one senior biology lecturer in the biology education department of the University of Education, Winneba; to two SHS elective biology teachers and to two Integrated science teachers at the JHS level who had considerable teaching experience Integrated Science for their comments and suggestions on the instrument ( SKPT and SAPT).

**Reliability of the Instruments**

In order to ensure that the research instruments produced scores that are stable consistent and their test items are devoid of any ambiguities (Creswell, 2008) as much as possible, the SKPT and SAPT were pilot-tested using AME Zion JHS 3 students in the Prestea Huni – Valley District of the Western Region of Ghana. Data from the pilot test were statistically analysed to determine the reliability of the test instruments using the Spearman-Brown prophecy formula since all items on both SKPT and SAPT were dichotomously scored. The analysis yielded reliability coefficients of 0.59 and 0.62 for the SKPT and SAPT respectively. According to Ary, Lucy and Asghar (2002), if the measurement results are to be used for making a decision about a group or for research purposes, or if an erroneous initial decision can be easily corrected, then scores with modest reliability coefficients in the range of .50 to. 60 may be acceptable. The above reliability coefficients for the SKPT and SAPT therefore, signify that both research instruments are considerably reliable.

**Data Collection Procedure**

The data collection procedure was divided into three phases: pre-treatment phase, treatment phase and post-treatment phase. This is illustrated diagrammatically below:

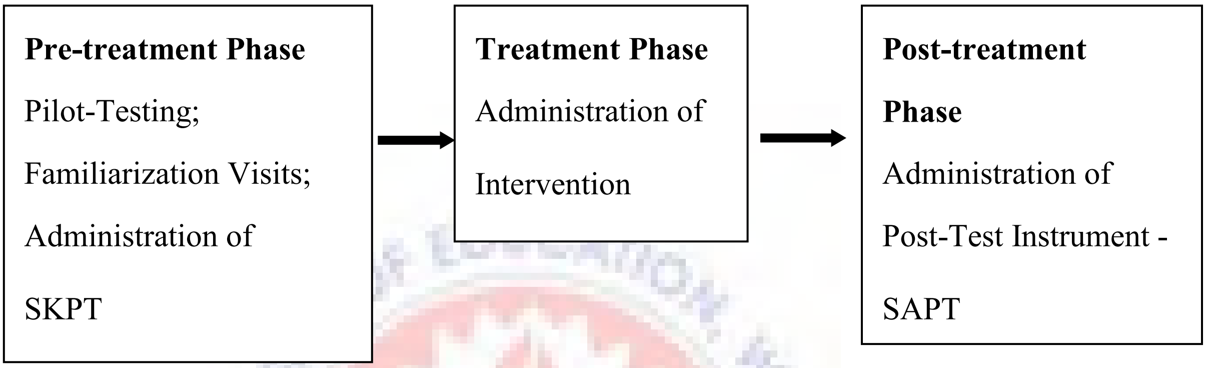


**Figure 2: Data collection process (adopted from Laringtey, 2014).**

**Pre-Treatment Phase**

This phase of the study lasted for one week in each of the selected schools. Three familiarization visits were undertaken to each selected school for the formal introduction of the researcher to the appropriate school heads. This was done to ensure effective data collection. Prior to undertaken the familiarisation visits, the researcher pilot-tested the SKPT and SAPT on 29 JHS 3 students in African Methodist Episcopal Zion in the Prestea Huni – Valley District in the Western Region of Ghana.

During the first visit to each of the schools, permission was sought from school heads to conduct the study in their schools, after a discussion was held with them about the nature of the study, its expected duration and the benefits their students, teachers and schools, as a whole, would derive from the study. The school heads subsequently informed the respective subject teachers about the study in order to solicit their cooperation and assistance for the study.

On the second familiarisation visit to the selected schools, similar discussions were held with the subject teachers during which copies of their time-tables were obtained. The time-tables enabled the researcher to properly plan the data collection programme in each selected school. Each class sampled in the selected schools had six periods of 40 minutes each per week for science. Also, during these visits, the researcher was introduced to both intact science classes in each selected school by the subject teachers, during which the purpose of the study was explained to all the participants in their respective classrooms.

On the last familiarisation visit, the pre-test instrument – SKPT was administered to the participants in their respective classrooms. The subject teachers, whose classes were used for the study, assisted in the administration of the SKPT. Mean scores obtained by the participants on the SKPT were used to assign the intact classes into the experimental and control groups. The classes that obtained the lower mean scores (9.79) were designated as the experimental groups and those with the highest mean score, as the control group. This was done to find out if the performance of the classes with lower mean scores would be improved than those with the highest mean score after the interventions.

**Treatment Phase**

There were three experimental groups: Experimental groups 1, 2 and 3; and one control group, all for which were intact classes in the JHSs selected for the study. Experimental groups 1 and 2 were in Damang DA School while experimental group 3 and the control group were in Nana Amoakwah Model School. Participants in Experimental group 1 were taught section 4 unit 1 of the third year JHS science syllabus, which deals with „photosynthesis", using computer simulation instructional approach in cooperative learning settings while those in Experimental groups 2 and 3 were taught the same topic of the JHS science syllabus using the computer simulations instructional approach in individualised learning setting. The participants in the control group were however, taught the same topic using the traditional instructional approach.

The computer simulation instructional package used in this study was the "Photosynthesis Advanced", adopted from Goalfinder (2015), which is an ICT company based in Maharashtra – India (web address: www.goalfinder.com), "Photosynthesis Advanced" was produced by Amik Kulshresth. Samples of screen captured pictures of some scenes in "Photosynthesis Advanced" computer simulation instructional package have been provided as Appendices $B_1$ to $B_3$

The treatment phase of the study lasted for five weeks in the first term of the 2015/16 academic year in each selected school. To prevent the Hawthorne effect between the participants in the two schools, the study was not conducted concurrently in the two schools. It lasted from the 2nd to 6th week in Damang D/A JHS and from the 7th to 12th week in Nana Amoakwah Model JHS. The treatment phase was interrupted for one week (the 4th week) because of their Zonal Sports competition organized by the District Education office (Sports Department).

The experimental groups were taught selection 4, unit 1 of the integrated science syllabus (JHS3), which deals with „Photosynthesis". The computer simulation instructional package on photosynthesis was administered in the cooperative learning settings; the experimental group 1, of four students per group.

Experimental groups 2 and 3 were also taught using the same topic. However, the computer simulation instructional package on photosynthesis was administered in the individualised learning settings to experimental groups 2 and 3.

The control group was also taught the same topic using the traditional instructional approach, which involves lecture, demonstration, illustration and discussion.

**Post-Treatment Phase**

The posttest instrument, student"s Achievement in Photosynthesis Test –SAPT, was administered to all participants after experimental groups had been treated with the intervention and the control groups treated with the traditional instructional approach. This is done to assess the effectiveness of the computer simulation instructional package in the teaching and learning of photosynthesis.

The post-treatment phase of the study was done in the last week of data collection period in each of the school. After the implementation of the interventions in each school, the SAPT was administered to all participants in the experimental groups and the control group. Subject teachers whose classes were involved in the study, helped with the administration of the SAPT in their respective classrooms. This was done to assess the effectiveness of computer simulation instructional package on the performance of the students in photosynthesis.

**Data Analysis**

The study collected only quantitative data and employed quantitative method of data analysis. Data obtained from participants in both experimental and control groups on the SAPT were analysed statistically using independent-measures t-test. The independents-measures t-test was used to investigate whether any significant differences in means score existed between experimental and control groups. This was done to answer the research questions and to either reject or fail to reject the null hypotheses formulated for the study. Data analysed were presented in tables.

# CHAPTER FOUR

## RESULTS AND DISCUSSION

### Overview

This chapter presents the results and the analysis of the quantitative data generated from the participants in the experimental and control groups using the Students Achievement in Photosynthesis Test (SAPT). The first part presents the analysis of the data, while the discussion of the finding of the study is dealt with in the second part.

The mean scores on the SKPT of the intact classes included in the study are provided in Table 4.1.

**Table 4.1: Mean Scores on SKPT of Intact Classes Included in the Study**

| School | Class | Group | Mean Score |
|---|---|---|---|
| Damang DA | JHS 3 | Experimental Group 1 | 9.71 |
| | | Experimental Group 2 | 12.55 |
| Nana Amoakwah | JHS 3 | Experimental Group 1 | 11.35 |
| | | Experimental Group 2 | 12.83 |

The distribution of the participants in the sample is summarized in Table 4.2.

**Table 4.2: Summary of Participants in the Study**

| School | Class | Boys (%) | Girls (%) | Total |
|---|---|---|---|---|
| Damang DA | 3 JHS (Exp. Group 1) | 16 (53.33) | 14 (46.67) | 30 |
| | 3 JHS (Exp. (Group 2) | 1 (3.13) | 31 (96.88) | 32 |
| Nana Amoakwah | 3 JHS (Exp. Group 3) | 4 (10.81) | 33 (89.19) | 37 |
| | 3 JHS (Exp. Group) | 12 (32.43) | 25 (67.57) | 37 |
| **Total** | | **33 (24.26)** | **103 (75.74)** | **136** |

**Analysis with Respect to Research Question One**

**RQ1:** What difference is there in the performance of JHS3 students exposed to computer simulation instructional approach and those exposed to the traditional instructional approach to the teaching and learning of photosynthesis?

Descriptive statistics such as means and standard deviations were computed, and used to determine the differences in performance between the control group and the experimental group on the post-test instrument- SAPT. The mean score for the control group exposed to the traditional approach to teaching and learning of photosynthesis, on the SAPT was 15.86 (SD=3.33) while that for experimental group 1, exposed to the computer simulations instructional approach in cooperative learning settings was 21.86 (SD=2.70).

The mean scores for the experimental groups 2 and 3, both exposed to the computer simulation instructional approach, were 17.67 (SD=2.78) and 18.08 (SD=3.66), respectively. The results shown in Table 4.2 reveal that all the experimental groups performed better than the control group.

**Table 4.3: Differences between Experimental Groups and Control Group**.

| Groups compared | Test | Mean | SD | t−value | p− value |
|---|---|---|---|---|---|
| Experimental Group.1 | Post-test | 21.86 | 2.70 | 8.2723 | 7.77E-12 |
| Control Group | Post-test | 15.86 | 3.33 | | |
| Experimental Group.2 | Post-test | 17.67 | 2.78 | 2.4104 | 0.0188 |
| Control group | Post-test | 15.86 | 3.33 | | |
| Experimental Group. 3 | Post-test | 18.08 | 3.66 | 2.7218 | 0.0083 |
| Control Group | Post-test | 15.86 | 3.33 | | |

a= not significant at 0.05; p>0.005 *=significant at 0.00; p>0.05

Independent-measure t-Test analyses showed that the differences in performance between experimental groups 2 and 3, and the control group was statistically significant, t(65)=2.4204, p=0.0188 and t(21)=2.4104 p=0.0082 respectively as indicated in (Table 4.3). There was therefore, a significant difference in performance between JHS 3 students exposed to the computer simulation instructional approach. This signifies that the participants exposed to the computer simulation instructional approach perform better than those exposed to the traditional instructional approach, when they were exposed to concepts of photosynthesis.

Therefore, it was concluded that there was a statistically significant difference in performance between the participants exposed to the computer stimulation instructional approach and those exposed to the traditional instructional approach in the teaching and learning of photosynthesis. The difference was attributed to the use of the computer simulation instructional approach.

**Analysis with Respect to Research Question Two**

**RQ 2:** What difference and there in the performance of JHS 3 students exposed to the computer simulations instructional approach to the teaching and learning of photosynthesis in the two selected schools at the BECE level?

**Table 4.4: Differences between Participant in Performing Schools and Non-Performing Schools**

| Groups Compared | Test | Means | SD | t-value | p-value |
|---|---|---|---|---|---|
| Experimental gp.2 | Post-test | 17.67 | 2.78 | -052602 | 0.6.00662[a] |
| Experimental gp.3 | Post-test | 18.08 | 3.66 | | |

a= not significant at 0.05; P >0.05 *=significant at 0.05; p<0.05

Descriptive statistics such as means and standard deviations were computer and used to determine the difference in performance between experimental groups 2 and experimental groups 3, both exposed to the computer simulation instructional approach to teaching and learning of photosynthesis in cooperative learning settings and experimental groups 2 and 3, both exposed to the computer simulation instructional approach to teaching and learning of photosynthesis in individualized learning setting. The mean score for experimental group on the SAPT was 21.86 (SD = 2.70) and those for experimental groups 2 and 3 were respectively 17.67 (SD = 2.78) and 18.08 (SD = 3.66) as indicated in Table 4.4. The results revealed that JHS 3 students exposed to the computer simulation instructional approach in cooperative learning settings performed better than their counterparts in the individualized, non-cooperative or competitive learning settings.

**Testing of Hypothesis with respect to Research Question Three**

To determine whether the difference in performance groups 2 and 3 were statistically significant; research question 3 was formulated into a null hypothesis and tested.

It was hypothesized that:

Ho 3: There is no statistically significant difference in the performance of JHS 3 students exposed to the teaching and learning of photosynthesis in cooperative learning settings, and those in individualized learning settings.

Independent measures t-Test analysis confirmed that the difference in performance between experimental group 1 and experimental groups 2 was statistically significant, t (65) =6.0394, P = 1.11E- 07 in Table 4.3. Again, independent measure t-Test analysis confirmed that the difference in performance between experimental group 1 and experimental group 3 was also statistically significant, t (65) = -4.9403, P = 5.76E-06 in Table 4.3. This was between JHS 3 students exposed to the computer simulations instructional approach to the teaching and learning of photosynthesis in cooperative learning settings and those in individualized learning settings. This indicates that the participants exposed to the computer simulations instructional packages in the cooperative learning settings had performed better than their counterparts in the individualized learning settings. It was therefore, concluded that there was statistically significant difference in the performance of JHS 3 students exposed to the computer simulation instructional approach in the cooperative learning settings than those in the individualized or non-cooperative learning settings. The difference in performance was attributed to the mode of administrations of the computer simulations instructional package on the participants.

**Discussion of Findings**

The study set out to find the effect of computer simulation instructional approach on the performance of JHS 3 students on the concept of photosynthesis. It yielded some information about the effect of computer simulation instructional package on photosynthesis on students" performance at the JHS level. In the earlier part of this chapter, findings were mainly presented and analyzed based on the specific research questions with only brief comments on them. In this part however, the findings have been discussed in details in the research.

Findings with respect to research question one were positive in that, the performance of JHS 3 students exposed to the computer simulation instructional approach was better than traditional approach to the teaching and learning of photosynthesis. The findings of this study thus supported the research hypothesis that there is a statistically significant difference in performance between JHS3 students exposed to the computer simulation instructional approach than those exposed to the traditional approach to the teaching and learning of photosynthesis. The independent measures t-Test analysis results have been presented in Table 4.1.

The findings reaffirm the previous studies of Kara and Kahraman (2008); Kara and Yesilyurt (2007); Kiboss *et al*. (2006); Akour (2006) and Akpan and Andre (2000), conducted in biology, which indicated that the achievement scores of students exposed to computer simulation instructional programmes were higher than those exposed to traditional, conventional or regular methods of instruction. For instance, Kiboss *et al.* (2006) investigated the effect of a computer based instruction simulation (CBIS) programme on students understanding of cell theory in school biology and observed that the CBIS programme positively affected the development of students understanding and perceptions of cell division lessons in school biology.

Akour (2006) has also observed that students taught using traditional instruction combined with the use of computer performed significantly better than students taught using the traditional instruction in a college setting. Again, Akpan and Andre (2000) examined the prior use of simulation of frog dissection in improving students, learning frog anatomy and morphology. The study of Akpan and Andre (2000) indicated that students receiving simulation before dissection and simulation only learned significantly more anatomy than students receiving dissection only.

The findings are also congruent with those of Mweir, Too and Wando (2011) and Udousoro (2000) in Mathematics; Bayrak (2008); Karamustafaoglu, Aydin and Ozmen (2005) and Kiboss and Ogunnyi (2003) in physics and Okoro and Etududo (2001) in chemistry. These studies confirmed that computer simulation instructional approach has been effective in enhancing students" performance than the traditional or conventional classroom instruction in subjects other than biology. For example, in a study to investigate the effects of computer simulation programmes on university students‟ achievements in physics, Bayrak (2008) affirmed that students in the experimental group who were exposed to computer assisted instruction were more successful than students in the control group who were exposed to face-to –face instruction.

However, the findings of the study contradict that of Owusu, Monney, Appiah and Wilmot (2009); Strauss and Kinzie (1994) and Duhrkopf and Kramer (1991). These studies indicated that students‟ achievements in biology were not improved significantly by means of the computer simulations instructions. Owusu *et al.* (2009) for instance, investigated the effects of computer Assisted instruction (CAI) on performance of SHS students in Ghana. The findings of Owusu *et al*. (2009) indicated that students instructed with the traditional approach, performed better on the post–test than those instructed with the computer assisted instruction (CAI).

Hence, the effect of computer simulation instructions on students‟ performance seems to be mixed. However, based on the strength of the findings of the study a strong case can be made in favour of incorporating computer simulation instructional packages in biology as well as science teaching and learning in Ghana.

With respect to research questions two, the findings of the study concur with the null hypothesis that there is no statistically significant difference in the performance between JHS 3 students exposed to the computer simulation instructional approach in performing and non-performing schools at the BECE level.

Participants in both performing and non-performing schools selected were of mixed abilities. Generally, however, the students in performing schools are usually high achievers while those in non-performing school are low achievers.

This situation is attested to by the mean scores and standard deviations of the participants in the performing and non-performing schools on the SKPT is statistically significant t(131) =1.9986; p=0.02]. This helps in the placement system in Ghana, whereby high achievers and place category A or B schools and low achievers are placed in C or D schools.

In this light of the findings of the study, the computer simulation instructional package on photosynthesis seems to benefit equally the students in performing and non-performing schools at the BECE level.

This is however, not in keeping with the findings of Owusu *et al*. (2009) and Mevarech (1993). The study of Owusu *et al*. (2009) for instance, also showed in their study that the performance of the low achievers within the experimental group was better after they were instructed with the computer assisted instruction (CA1). Mevarech (1993) also examined the effects of computer assisted instruction in individualized (one child to a computer) and cooperative (a pair of children to a computer) situations on amount of invested mental effort (AIME), in math achievement acceptance of high and low achievers. According to Mevarech (1993), the analyses of AIME showed that "low achievers" who worked individually gradually decreased AIME over time, while the "low achievers" who worked with partners gradually increased AIME. However, "high achievers" proved at approximately the same rate in both conditions (Mevarech, 1993).

However, the findings of the study with respect to research questions two are inconsistent with the conclusion of the study of Hativa and Becker (1994), which noted that the computer –based integrated learning system had shown large benefits for high achievers than low achievers.

Mevarech (1993) also cited a number of studies that give mixed results. Some of these studies according to Mevarech (1993) showed that high achievers in computer-assisted instruction (CA1) classrooms had rate of progress double that of low achievers.

Finally, with respect to research question three, the study hypothesized that there is statistically significant difference in the performance between JHS 3 students exposed to the computer simulation instructional approach to the teaching and learning of photosynthesis in cooperative learning settings than those in individualized learning settings.

The findings of the study have shown that the performance of JHS 3 students exposed to the computer simulation instructional approach in cooperative learning settings was better than those in the individualized, non-cooperative or competitive settings. The findings were congruent with those of Yusuf and Afolabi (2010); Abdullah and Abbas (2006); Newberry (1999) and Cavalier and Klein (1998), which affirmed that the performance of students exposed to the computer simulation instructional approach or computer based instruction in cooperative learning settings was better than those in individualized or non-cooperative learning settings. Yusuf and Afolabi (2010) for examples have noted that students exposed to computer assisted instructional packages in cooperative learning settings did better than those in individualized learning settings. Furthermore, Newberry (1999), also found that students in elementary and high schools do tend to show an improvement academically when using cooperative activities and computer-based instruction. However, according to Newberry (1999) the results were not as positive for college students.

On the basis of the findings of the study and other related ones, administration of computer simulation instructional packages in cooperative learning settings have maximum effect on student‟s achievement. The study demonstrated that computers simulation instructional approach had a favourable effect on JHS 3 students‟ achievement or performance in photosynthesis. It has also indicated that the computer simulation instructional package has no significant effects on the performance of either high or low achieving students. It further showed that, computer simulation instructional approach administered in cooperative learning settings has a greater effect on the students" performance than when administered in individualized, non-cooperative or competitive learning settings.

# CHAPTER FIVE

# SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER STUDY

## Overview

This chapter is devoted to the summary of the findings of the study and conclusions drawn from findings of the study. Additionally, the recommendations based on the findings of this study and suggestions for further studies have also been discussed in this chapter.

## Summary of Findings of the Study

It deals with the summary of the differences in performance between: the experimental and control groups, students taught with computer simulation instructional approach and those taught with the traditional approach, students in cooperative and individualized learning settings.

### 1. Differences in Performance between Experimental and control Groups

The performance of the experimental groups was significantly better than that of the control group on the SAPT, signifying that JHS3 students exposed to the computer simulation instructional approach performed significantly better than those exposed to the traditional instructional approach. This indicates that the computer simulation instructional packages appear to have a positive influence on the learning of photosynthesis.

2. **Differences in Performance between students taught with computer simulation instructional approach and those taught with traditional approach.**

Students who were taught from the two schools with the computer simulation instructional approach performed better.

This indicates that the computer simulations instructional approach on teaching and learning of photosynthesis equally favoured students in performing and non-performing schools.

3. **Differences in Performance between students in the cooperative and individualized learning settings.**

The performance of JHS students in the cooperative learning settings was significantly better than those in the individualized learning settings. This indicated that the computer simulation instructional package administered in cooperative learning settings had a greater positive influence on students‟ conceptual understanding of photosynthesis than in the non-cooperative learning settings.

**Conclusions**

The results of the study imply that students from the two selected schools in the Western Region exposed to the computer simulation instructional approach to the teaching and learning of photosynthesis performed significantly better than those exposed to the traditional instructional approach, which is in keeping what.

Aslan Efe, Oral, Efe and Owner Sünkür (2011) also found in their study. The study has also shown that the positive effect of the computer simulation instructional package on students" performance is however, greater when administered in cooperative learning settings, as shown by Yusuf and Afolabi (2010); Abdullah and Abbas (2006) in their studies. Furthermore, the results of the study seem to indicate that the computer simulation instructional package equally favoured students in both performing and non-performing schools at the Basic Education level, who were generally high achieving and low achieving students respectively. This is however incongruent with what Owusu *et al* (2009) found in their study.

Finally, the effects of gender on the use of the computer simulations instructional approach in the teaching and learning processes was not an object of this study as the has been the focus of researchers, such as Yusuf and Afolabi (2010), Barner and Dori (1999), Choi Genner (1987), Huppert *et al* (2002), Bello (1990) and spencer (2004). These researchers did not find any statistically significant gender difference in the performance of students exposed to computer simulation instructional packages.

**Recommendations**

Based on the findings of this study, the following recommendations are made in the teaching and learning of photosynthesis:

1. Innovative and more effective learner-centered instructional packages, should be used by science teachers to promote meaningful learning of difficult

science concepts like photosynthesis. Appropriate computers simulation instructional packages should therefore, be developed or adopted for use in the Ghanaian schools.

2. Since the findings of the study showed that students exposed to the computer simulation instructional packages in cooperative learning settings, performed better than those in individualized learning settings, students should be encouraged to develop social interaction in the use of computer simulation instructional packages. This implies that the science teachers should model their instructions to enforce student-student interaction. This in addition to the computer simulation instructional packages, will further enhance students" performance in difficult science concept like photosynthesis.
3. Curriculum planners and developers should be empowered by the findings of the study to introduce innovative instructional strategies, such as, computers simulation instructional approach, in the science programme to encourage science teachers incorporate computer simulation instructional packages or programme in their classroom instructions to enhance students" performance in science.
4. Curriculum Research and Development Division (CRDD) of the Ghana Education Service (GES) should also consider learners" prior knowledge but not only the structure of the subject and design, and develop science curriculum materials for basic schools. This will stimulate learners to construct their own knowledge and improve conceptual understanding of

science. This means they should supply basic schools with science basic equipment.

5. The Ministry of Education (MOE), GES and other stakeholders involved in science education should organize regular workshop and in-service training lessons for science teachers on the effective use of computer simulation instructional packages to enhance the effective application of the computer simulation instructional packages especially in cooperative learning settings in the classroom.
6. The MOE, GES, CRDD and other stakeholders associated with science education should also push for structural modifications in science educations to promote the use of computer simulation instructional packages by providing computers and computers laboratories at the basic school level to help the teaching and learning of science.

**Suggestions for Further Studies**

In light of the findings of the study and their educational implications, the following suggestions are made for further research with respect to the use of computer simulation instructional packages in the teaching and learning of science:

1. It is suggested that the study be replicated using computer simulation packages on other difficult science concepts, such as, respiration in humans, digestions in humans, and reproduction in humans, feeding in animals and reproduction in humans etc.

This would also provide a basis for greater generalization of the conclusion drawn from the findings of the study.

2. Additionally, it is suggested that the study be replicated using large samples to provide a basis for more generalization of the conclusions drawn from findings of the study about the effectiveness of computer simulation instructional packages in the teaching and learning of photosynthesis.
3. Also it is recommended that a similar study should be conducted with large sample using qualitative data from both teachers and students to find their attitudes towards the use of computer simulation instructional packages of the teaching and learning processes.
4. Finally, similar empirical studies should be carried out on the use of computer simulation instructional packages on other subjects at different levels to provide the basis for the integrations of computer simulation instructional packages in Ghanaian schools.

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# APPENDICES

## APPENDIX A$_I$

## UNIVERSITY OF EDUCATION, WINNEBA

## SCIENCE EDUCATION DEPARTMENT

## PRE−TEST DATA COLLECTING INSTRUMENT-STUDENTS' KNOWLEDGE OF PHOTOSYNTHESIS (SKPT)

**Student's ID**……………………………………………………………………………

**Gender of Participant**………………… **Class of Participant**…………………….

**School of Participant**……………………………………………………………………

**GENERAL INSTRUCTIONS**: This test contains fifteen (15) questions grouped in three (3) sections, namely sections A, B, and C. Please answer all questions in all three (3)

## SECTION A

**INSTRUCTIONS**: The questions are followed by four (4) options lettered A and D. Find out the correct options and circle A, B, C or D to indicate your answer.

1. The energy needed for photosynthesis to occur is obtained from

    A. Water

    B. Sunlight

    C. Chlorophyll

    D. Soil

2. Photosynthesis occurs in green plants because they contain….
    A. Water
    B. Energy
    C. chlorophyII
    D. stem
3. Which gas is needed for photosynthesis
    A. carbon dioxide
    B. nitrogen
    C. oxygen
    D. neon
4. Water for photosynthesis is from the….
    A. Atmosphere
    B. Sun
    C. Rocks
    D. Soil
5. Photosynthesis takes place in which part of the plant?
    A. Stem
    B. Roots
    C. Leaves
    D. Branches

**SECTION B**

**TRUE/FALSE**

6. Glucose is a by-product of photosynthesis

    A. True

    B. False

7. Chlorophyll is found in the chloroplast

    A. True

    B. False

8. Sugar solution is used to test for starch

    A. True

    B. False

9. Carbon dioxide and water are the main materials for photosynthesis

    A. True

    B. False

10. Photosynthesis help reduce the amount of oxygen in the air

    A. True

    B. False

## SECTION C

## ESSAY QUESTIONS

**INTRUCTION**: Answer **ALL** questions in this section.

11. What is photosynthesis?

12. State two importance of photosynthesis

13. Write the equation for photosynthesis

14. Describe how photosynthesis occurs in green plants

15. How do we test for starch?

# APPENDIX $A_2$

## UNIVERSITY OF EDUCATION, WINNEBA

## SCIENCE EDUCATION DEPARTMENT

## POTST-TEST DATA COLLECTING INSTRUMENT

### STUDENTS'ACHIEVEMENT OF PHOTOSYNTHESIS TEST (SAPT)

**STUDENT ID………………………………………………………………**

**Gender of Participant: ………………Class of Participant …………………**

**School of Participant: ..…………………………………………………..**

**GENERAL INSTRUCTIONS:** This test contains twenty (20) questions grouped in three (3) sections, namely Sections A, B, and C. Please answer ALL questions in ALL three (3) sections of the test.

### SECTION A

### TRUE / FALSE QUESTIONS

1. Glucose is a by-product of photosynthesis

   A. True

   B. False

2. Chlorophyll is found the chloroplast

   A. True

   B. False

3. Sugar solution is used to test for starch

   A. True

B. False

4. Carbon dioxide and water are the main materials for photosynthesis

A. True

B. False

5. Photosynthesis help reduce the amount of oxygen in the air

A. True

B. False

## SECTION B

## MULTI CHOICE QUESTIONS

**INSTRUCTIONS:** the following questions are followed by four (4) options lettered A to D.

Find out the correct options and circle A, B, c or D to indicate your answer.

6. The energy needed for photosynthesis to occur is obtained from

A. Water

B. Sunlight

C. Chlorophyll

D. Soil

7. Photosynthesis occur in green plants because they contain…...

A. Water

B. Energy

C. Chlorophyll

D. Stem

8. Which gas is needed for photosynthesis to occur?

   A. Carbon dioxide

   B. Nitrogen

   C. Oxygen

   D. Neon

9. Water for photosynthesis is from the……….

   A. Atmosphere

   B. Sun

   C. Rocks

   D. Soil

10. Photosynthesis takes place in which part of the plant?

    A. Stem

    B. Roots

    C. Leaves

    D. Branches

## SECTION C

## ESSAY QUESTIONS

**INSTRUCTIONS**: Answer **ALL** questions in his section

11. What is photosynthesis?
12. State two importance of photosynthesis
13. Write the equation for photosynthesis
14. Describe how photosynthesis occur in green plants
15. How do we test for starch?

# APPENDIX $A_5$

## MARKING GUIDE FOR PRE-TEST (SKPT) ITEMS

### SECTION A

1. B
2. C
3. A
4. D
5. C

### SECTION B

6. True
7. True
8. False
9. True
10. False

***Section A and B, 1mark for each question 1x 10. Sub-Total = 10***

### SECTION C

11. Photosynthesis is the process by which green plants manufacture their own food using carbon dioxide and water in the presence of sunlight producing oxygen as a by product. ***3marks.***

12. How photosynthesis occur

    a. The sun‟s energy is trapped by chlorophyll. ***1mark.***

    b. Carbon dioxide enters the leaves through the stomata. ***1mark.***

    c. Root and stem transport water from the roots to the leaves. ***1mark.***

d. Carbon dioxide and water are converted into by the leaves. ***1mark.***

e. The sugar is then converted into starch as plant food. ***1mark***

***If Any 5 x 1 = 5***

13. (i). It helps plants to manufacture their own food. ***1mark.***

(ii). It helps reduce the amount of carbon dioxide in the atmosphere. ***1mark.***

14. (a). Carbon dioxide + water $\xrightarrow[\text{Chlorophyll}]{\text{Sunlight}}$ glucose + oxygen. ***2marks.***

(b). $6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O6 + O6 + 6O_2$ ***3marks.***

15. (a). A leaf which has received more sunlight is put into boiling water for five minutes. ***1mark.***

(b). Remove the leaf and dip in alcohol warmed in hot water bath.

***1 mark.***

(c). The leaf is then washed in cold water. ***1 mark.***

(d). The leaf is dipped in iodine solution. ***1 mark.***

(e). The leaf turns blue black if starch is present. ***1 mark.***

***Any 5 x 1 = 5***

***Grand Total = 30marks.***

## APPENDIX $A_6$

## SCORING GUIDE FOR POST-TEST (SAPT) ITEMS

### SECTION A

16. True
17. True
18. False
19. True
20. False

### SECTION B

21. B
22. C
23. A
24. D
25. C

***Section A and B, 1mark for each question 1x 10. Sub-Total = 10***

### SECTION C

26. Photosynthesis is the process by which green plants manufacture their own food using carbon dioxide and water in the presence of sunlight producing oxygen as a by product. ***3marks.***

27. (i). It helps plants to manufacture their own food. ***1mark.***

    (ii). It helps reduce the amount of carbon dioxide in the atmosphere. ***1mark.***

***Any 5 x 1 = 5***

28. (a). Carbon dioxide + water $\xrightarrow[\text{Chlorophyll}]{\text{Sunlight}}$ glucose + oxygen. ***2marks.***

(b).$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O6 + 6O_2$ . ***3marks.***

29. How photosynthesis occur

f. The sun"s energy is trapped by chlorophyll. ***1mark.***

g. Carbon dioxide enters the leaves through the stomata. ***1mark.***

h. Root and stem transport water from the soil to the leaves. ***1mark.***

i. Carbon dioxide and water are converted into sugar by the leaves. ***1mark.***

j. The sugar is then converted into starch as plant food. ***1mark***

*30.* (a). A leaf which has received more sunlight is put into boiling water for five minutes. ***1mark.***

(b). Remove the leaf and dip in alcohol warmed in hot water bath. ***1 mark.***

(c). The leaf is then washed in cold water. ***1 mark.***

(d). The leaf is dipped in iodine solution. ***1 mark.***

(e). The leaf turns blue black if starch is present. ***1 mark.***

***Any 5 x 1 = 5***

***Grand Total = 30marks.***

# APPENDIX $C_1$

t-Test: Two- Assuming Unequal Variances

**t- Test Analysis with Respect to Research Question One**

| | *EXPERIMENTAL GROUP 1* | *CONTROL GROUP* |
|---|---|---|
| *Mean* | *21.875* | *15.86486* |
| *Variance* | *7.274194* | *11.12012* |
| *Observations* | *32* | *37* |
| *Hypothesized Difference* | *0* | |
| *Df* | | |
| *t Stat* | *8.272255* | |
| *P(T<=t) one-tail* | *3.89E-12* | |
| *t Critical one-tail* | *1.667916* | |
| *P(T<=t) two-tail* | *7.77E-12* | |
| *t Critical two-tail* | *1.996008* | |

# APPENDIX $C_2$

## t- Test Analysis with Respect to Research Question One

### t-Test: Two-Sample Assuming Unequal Variances

| | *EXPERIMENTAL GROUP2* | *CONTROL GROUP* |
|---|---|---|
| *Mean* | *17.66667* | *15.86486* |
| *Variance* | *7.747126* | *11.12012* |
| *Observations* | *30* | *37* |
| *Hypothesized Difference* | *0* | |
| *Df* | | |
| *t Stat* | *2.410383* | |
| *P(T<=t) one-tail* | *0.009387* | |
| *t Critical one-tail* | *1.668636* | |
| *P(T<=t) two-tail* | *0.018774* | |
| *t Critical two-tail* | *1.997138* | |

# APPENDIX $C_3$

## t-Test Analysis with Respect to Research Question Two

### t-Test: Two-Sample Assuming Unequal Variances

| | *EXPERIMENTAL GROUP 3* | *CONTROL GROUP* |
|---|---|---|
| *Mean* | *18.08108* | *15.86486* |
| *Variance* | *13.40991* | *11.12012* |
| *Observations* | *37* | *37* |
| *Hypothesized Mean Difference* | *0* | |
| *Df* | *71* | |
| *t Stat* | *2.721849* | |
| *P(T<=t) one-tail* | *0.00408* | |
| *t Critical one-tail* | *1.6666* | |
| *P(T<=t) two-tail* | *0.008161* | |
| *t Critical two-tail* | *1.993943* | |

# APPENDIX $C_4$

## t-Test Analysis with Respect to Research Question Two

### t-Test: Two-Sample Assuming Unequal Variances

| | ***EXPERIMENTAL GROUP 2*** | ***EXPERIMENTAL GROUP 3*** |
|---|---|---|
| *Mean* | *17.66667* | *18.08108* |
| *Variance* | *7.747126* | *13.40991* |
| *Observations* | *30* | *37* |
| *Hypothesized Mean Difference* | *0* | |
| *Df* | *65* | |
| *t Stat* | *-0.52602* | |
| *P(T<=t) one-tail* | *r 0.300331* | |
| *t Critical one-tail* | *1.668636* | |
| *P(T<=t) two-tail* | *0.600662* | |
| *t Critical two-tail* | *1.997138* | |

# APPENDIX $C_5$

## t-Test Analysis with Respect to Research Question Three

### t-Test: Two-Sample Assuming Unequal Variances

| | ***EXPERIMENTAL GROUP 3 (Individualised)*** | ***EXPERIMENTAL GROUP 1 (Cooperative)*** |
|---|---|---|
| *Mean* | *18.08108* | *21.875* |
| *Variance* | *13.40991* | *7.274194* |
| *Observations* | *37* | *32* |
| *Hypothesized Mean Difference* | *0* | |
| *Df* | *65* | *e* |
| *tStat* | *-4.94031* | |
| *P(T<=t) one-tail* | *2.88E-06* | |
| *t Critical one-tail* | *1.668636* | |
| *P(T<=t) two-tail* | *5.76E-06* | |
| *t Critical two-tail* | *1.997138* | |

# APPENDIX $C_6$

## t-Test Analysis with Respect to Research Question Three

### t-Test: Two-Sample Assuming Unequal Variances

| | ***EXPERIMENTA GROUP 2 (Individualised)*** | ***EXPERIMENTAL GROUP 1 ( Cooperative)*** |
|---|---|---|
| *Mean* | *17.66667* | *21.875* |
| *Variance* | *7.747126* | *7.274194* |
| *Observations* | *30* | *32* |
| *Hypothesized Mean* | | |
| *Difference* | *0* | |
| *Df* | *59* | |
| *t Stat* | *-6.03935* | |
| *P(T<=t) one-tail* | *5.56E-08* | |
| *t Critical one-tail* | *1.671093* | |
| *P(T<=t) two-tail* | *1.11E-07* | |
| *t Critical two-tail* | *2.000995* | |