UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF COMPUTER ASSISTED INSTRUCTION ON STUDENT PERFORMANCE ON SELECTED CONCEPTS IN CELL DIVISION

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DECLARATION

Candidate's Declaration

I, TAARIQUE-AHMAD YAHAYA, hereby declare that this thesis, with the exception of quotations and references contained in published works which have been identified and acknowledged, is entirely my own work, and that it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: …………….........

Date: …………….........

Supervisor's Declaration

I, PROF. JOHN K. EMINAH, hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Education, Winneba.

Date Signature: …………….........

Date: …………….........

DEDICATION

I dedicate this project to the Almighty Allah (God) and my parents, Mr. and Mrs. Yahaya Alhassan Sesay.

It is also dedicated to my siblings, Amanullah Sesay, Zulhaq Yahaya, Zaahida Yahaya, Nihad Yahaya and Tarabannung Habiba Yahaya.

It is again dedicated to my dearest wife, Dumah Safia and to my cousins Aziz Amjed, Samsideen Karifa Salih, Tamimu Fadulu-Rahaman Kpadau and Amin Naseem for the various roles they played in my life as a student.

I also dedicate this piece of work to my bosom friend Jakpa Issahaku Musah for his support and dedicated friendship shown.

These people have all contributed enormously towards my progress. To them, I only say thank you and may Allah richly bless you.

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ABSTRACT

This study was meant to enhance the performance of second year Biology students of T.I Ahmadiyya SHS in Wa on Cell Division using Computer Assisted Instructions (CAI). The sample population was made up of eighty (80) biology students, forty (40) from the Green Track and forty (40) from the Gold Track. Quasi-experimental design was used in the study and students were sampled purposively. The survey was conducted by using questionnaire and test items. The data was collected, organised and analysed using mean, standard deviation, percentages, frequencies, and t-test. The findings of the study revealed that students who were exposed to Computer-Assisted Instruction (CAI) performed significantly better than their counterparts who were taught with the conventional instruction. Again, the study showed that using Physics Education Technology (PhET) simulations in teaching cell division improved students' knowledge and sustained their interest as it changed the abstract nature of the concept to concrete form for easy understanding.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter presents the background of the study, statement of the problem, purpose of the study and objectives of the study. It also includes research questions, hypothesis, significance of the study, delimitations, limitations, abbreviations and the organisation of the research report.

1.1 Background to the Study

Information technology has brought remarkable changes in the twenty-first century by placing much emphasis on education.

Cheng (2003) reported that educational reforms world-wide are experiencing three waves since the 1970s. According to Cheng (2003), the first wave placed emphasis on internal effectiveness with the focus on internal process improvement through external interventions. The second wave pursued the interface effectiveness in terms of school-based management, quality assurance, accountability and stakeholders' satisfaction. Cheng (2003) further indicated that, in facing the challenges of globalization, information technology, and knowledge-driven economy in the new century, the third wave is moving towards the pursuit of future effectiveness.

Information and Communication Technology (ICT) is becoming increasingly important in our daily lives and in our education systems. According to Daniels (2002), ICT has become the most basic building block of modem industrial society in a very short time. ICT comprises all the technologies that are involved in computing, data management, telecommunications, and the internet. Information and communication technology is significant in all aspects of life. It provides better and faster ways for people to interact and gain access to information.

According to Nwafor and Oka (2018) information and communication technology enable humans to timely and efficiently increase their speeds of operations, interact in flexible ways, and utilise their potentials to become innovative and creative.

Oloyede (2007) indicated that no single life in this world is not affected by the development of science and technology. For instance, the various manufactured items that are available for the benefit of mankind are the product of science and technology. Tunde and Anthony (2010) reported that information and communication technology devices such as mobile phones, radio, television sets, PC tablets, iPads, iPhones, iPods, laptops, and desktops are products of science and technology.

Information could be created, processed and made available anywhere by the smart use of ICT. Thus, information technology can make the higher education available to all classes of people at a lower cost. Sultana and Shahabul (2018) asserted that information technologies are potentially useful tools for managing education.

Therefore, recognising the effect of information technology in everyday life, today's educational institutions try to restructure their educational curricula to bridge the existing technology gap in the teaching and learning process. Stosic (2015) found that the presence of educational technology in the classroom plays an important role in children's learning and acquiring various cognitive knowledge.

Taylor (2003) found that computer technology plays three major roles in a classroom. According to Taylor, computer in the school serves as tutor, tool and tutee. A study conducted by Jung (2005) on ICT pedagogy integration in teacher training revealed that, ICT facilitates both instructional and learning process and has a great influence of teaching and learning at higher education.

Youssef and Dahmani (2008) opined that technology in education has the ability to shift learning from teacher centered to student centered and hence serves as the catalyst for educational reforms. The use of student-centered approach to teaching facilitates retention of knowledge, development of problem-solving skills, improvements in students' performance, as well as sustaining students' interest in school activities and education in general.

Wallet and Melgar (2014) revealed that access to technology in education can help individuals to compete in a global economy by creating skilled work forces to facilitate social mobility. Richardson (2011) asserted that the integration and adoption of technology in the classrooms, specifically in developing countries undergo several stages and challenges which then determine the case of how successful the integration has been in execution of learning outcomes.

Ghana, like most of the developing countries, cannot afford to be left behind in this modem era of technology education. The Government of Ghana, has showed commitment to pursuing an ICT for Accelerated Development (ICT4AD) policy since 2001. This national policy outlines the plans and strategies for the development of Ghana's information society and seeks to transform Ghana into an information and knowledge-driven ICT literate nation.

In 2003, the government of Ghana in partnership with the government of India established Ghana-India Kofi Annan Centre of Excellence in information and communication technology to promote the use of ICT in education. The Ministry of Education (2015) ICT in education policy recognised the benefits of the integration of ICT in education, and this national policy brought about the introduction of ICT as a core subject for senior high school students in Ghana.

Integrated is a science subject being taught at the senior high school in Ghana. The subject appears to be the requisite science subject at this level. Integrated Science teaching helps learners to understand biological concepts, principles, theories and laws. The Ministry of Education (2010) Integrated Science teaching syllabus for senior high schools in Ghana stressed on the need to teach Integrated science to explain the living world.

Integrated science as a subject is to guide and inculcate in the learner the skills in observing and measuring, formulating hypothesis, predicating and designing, investigating, recording data and interpreting results, and drawing conclusions. The knowledge, skills and attitudes acquired through the study of biology is to provide the learner with the necessary basic tools for employment in the laboratory, industry, agriculture, horticulture, forestry, health care, animal husbandry, marine and fresh water biology.

The Society of Biology (2014) outlined some importance of biology to support and promote primary science education. According to this society, Integrated science offers students access to a fascinating body of knowledge, a way of working and a way of thinking that encourages lifelong learning and supports the wider life decisions young people will be required to make. The knowledge of Integrated science builds on students' curiosity and develops their questioning, reasoning and problem-solving skills. It expands pupils' knowledge, understanding and appreciation of the world around them and the natural phenomena they encounter. Integrated science supports essential cross-curricula activities and skills such as numeracy, literacy, communication, collaboration, and interpersonal skills.

The Ministry of Education (2010), biology teaching syllabus further stated that, knowledge in biology equips the learner for further studies and research in pure and applied science and technology that are vital areas for the advancement of society. Teaching elective Integrated science in totality makes the learner capable of critical thinking, making meaningful decisions and solving problems. In order to achieve this, the teaching and learning of biology need to be taught properly with interactive learning methods to enable students to acquire the requisite knowledge, skills and attitudes in this subject area.

According to Kareem (2015), the use of Computer Assisted Instruction (CAI) would help in building in the students' capacity in the knowledge of biology. Mudasiru and Adedeji (2010) reported that, the performance of students exposed to computer assisted instruction either individually or cooperatively were better than their counterparts exposed to the conventional classroom instruction.

Wellington (2004) opined that computer simulation is one of the effective teaching methods that has positive impacts in teaching science subjects. Tversky, Morrison and Betrancourt (2002) stated that the interactive nature of computer simulation and its ability to engage students are the keys to maximising its advantages in improving student learning.

A study conducted by Collier (2004) on the enhancement of the teaching and the learning of the science in secondary schools using computer assisted instruction revealed that, instruction supplemented by properly designed CAI is more effective than instruction without CAI. A computer can store, organise, and process the information. Thus, the integration of CAI has proved to be a useful tool in teaching various subjects.

Keziah (2011) posited that, school administrators and other stakeholders in education must ensure support and encourage the use of computer technology as an important medium in instructional delivery.

1.2 Statement of the Problem

My experience with students over the years coupled with students' academic information indicated that the concept of cell division is one of the difficult biology concepts. Vidzro (2018) revealed that, senior high school biology students in Ghana showed a lot of misunderstandings about cell division and the cell cycle. Students of T.I. Ahmadiyya Senior High school, Wa, who study biology as an elective subject are facing similar challenge (Mr. Issahaque Yahaya (Headmaster of T.I Ahmadiyya SHS, Wa), personal communication, 14th April, 2021).

Etobro and Fabinu (2017) reported that, lack of practical lessons, poor teaching methods, abstract biological concepts and unavailable instructional materials were the causes of students' difficulty with learning biology. According to Tekkaya, Ozcan and Sungar (2001), the overloaded biology curricula and the abstract nature of biological concepts prevented students from learning biology effectively.

In an attempt to cover much of the biology topics with students for both internal and external examinations, most biology teachers employ the lecture method where students achieve little in terms of knowledge acquisition. This approach to the teaching and learning of biology in this modem era needs to be replaced with interactive teaching methods that can effectively engage students to better understand biology concepts.

One key intervention that enable students to overcome difficult biology concepts is the use of CAI. Unfortunately, it appears not much research have been conducted on the use of PhET simulations in the teaching and learning of cell division. It is in the light of these observations that the researcher decided to use CAI (PhET simulations) to improve the performance of students on selected concepts in cell division.

1.3 Purpose of the Study

The main purpose of this study was to investigate the effect of CAI in the teaching and learning of cell division on second year elective biology students of T.I.

Ahmadiyya Senior High School, Wa, compared to the conventional method of instruction.

1.4 Objectives of the Study

The objectives of the study were to determine:

1. Whether the performance of the experimental group of students on cell division differed from that of the control group students before being exposed to CAI.
2. The effect of the CAI on the performance of the experimental group on cell division.
3. Whether the performance of students exposed to CAI differs from those taught with only the conventional instruction method.
4. The perceptions of the students in the experimental group about the use of CAI approach in teaching cell division.

1.5 Research Questions

The following investigative questions directed the research activity:

1. Do the mean pretest scores of the experimental and control groups on cell division differ significantly before the treatment?
2. What is the effect of CAI on the experimental group's performance on cell division?
3. What differences exist in the mean posttest scores of the experimental and control groups?
4. What are the perceptions of the experimental group students after being exposed to CAI during lessons on cell division?

1.6 Null Hypotheses

The following null hypotheses were tested in the study:

H01: There is no significant difference in the mean pretest scores of the experimental and control groups.

H02: There is no significant difference in the mean pretest and posttest scores of the experimental group.

H03: There is no significant difference in the mean posttest scores of the experimental and control groups.

1.7 Delimitations of the Study

The study involved only students of T.I. Ahmadiyya S.H.S, Wa in the Wa municipality in the Upper West Region of Ghana. The study was restricted to an aspect of the S.H.S biology syllabus that focuses on cell division. The second-year science students who offer Biology as an elective subject were selected for the study. All other students were excluded from the study.

1.8 Limitations of the Study

The study was to cover all senior high schools in the Upper West Region but due to time and financial constraints, the research was limited to T.I. Ahmadiyya S.H.S in the Wa Municipality of the Upper West Region. Also due to the confinement of the research, it may not be proper to generalize the results to the entire Municipality, Region or Nation.

1.9 Significance of the Study

The study is significant because, it could enable teachers especially Biology and Integrated science teachers to appreciate the importance of CAI in the teaching and learning of science. The researcher believes that the findings from this research may motivate other biology teachers of T.I Ahmadiyya SHS to espouse the concept of CAI teaching method in cell division and clarify the view that cell division is a difficult biology concept for senior high school students.

The researcher anticipates that the study could encourage biology teachers in Wa Municipality and Ghana to employ more effective and interactive methods in the teaching and learning process to make students acquire the needed knowledge in biology.

1.10 Definition of Terms

PHET: Physics education technology which involves simulations in teaching and learning.

Pre-test: Is the preliminary test to assess how much a learner knows about a subject.

Post-test: Is a test given to learner after completion of an instructional program.

Computer-assisted instruction: is an interactive instructional technique whereby a computer is used in the teaching and learning process.

Simulation: Is the imitation of the operation of a real-world process or system over time, for studying real events in many contexts.

Conventional methods of teaching: Is the traditional method of teaching using chalk and board with lesson notes and prepared teaching notes.

Experimental group: Is the group in a research work that receives the variable being tested.

Control group: Is the group that does not receive the variable being tested.

1.11 Organisation of the Thesis Report

The write up of the thesis comprised of five chapters. The first chapter provides an introduction to the study. It also includes problem of the study, purpose of the study, research questions, and significance of the study, limitations and delimitations. The second chapter consists of review of the related literature for the study. The third chapter discusses the methodology employed in the study and the fourth chapter presents the data collected, data analysis and discussion of results. The fifth chapter presents the summary of the study, major findings, conclusions, recommendations, and suggestions for future research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter contains the review of the literature related to the study. It provides the theoretical framework and conceptual framework of the study. Also present in this chapter include empirical framework of the study and the summary.

2.1 Theoretical Framework of the Study

This study employed the social development theory by Lev Vygotsky. The major theme of Vygotsky's theoretical framework is that social interaction plays a fundamental role in the development of cognition. Vygotsky (1978) stated that, every function in the child's cultural development appears twice, first on the social level, and later on the individual level; first between people termed as interpsychological and then inside the child termed as intrapsychological. Vygotsky’s theory was built upon the Piaget (1959) idea of the child as an active learner.

However, Vygotsky emphasised that children and adults are both active agents in the process of the child's development, and thus development is, in this case co-constructed (Cole & Cole, 2001). Therefore, for teaching, it meant that both the teacher and the learner are seen as active agents in children's learning. Vygotsky revealed that good learning occurs in the Zone of Proximal Development (ZPD), a level of development attained when children engage in social behaviour.

The second aspect of Lev Vygotsky's theory is the idea that cognitive development depends upon the zone of proximal development. This approach is associated with the term of social constructivism which emphasised the role of social interaction in development and learning.

Vygotsky (1978) stated that the actual level of development or level of independent performance does not sufficiently describe development, rather it indicates what is already developed or achieved. The level of assisted performance indicates what a person can achieve in the near future. Vygotsky (1978) claimed that the actual level is determined by tasks that a person is capable of solving by themselves and the potential level is the one at which the help of instructor is necessary.

Learning in the zone of proximal development refers to performing a range of tasks that the person cannot handle alone but can accomplish with the help of instructors or more capable peers. Learning in the ZPD awakens a variety of internal developmental processes that are able to operate only when people are interacting with more experienced people. Vygotsky (1978) pointed out that children were capable of performing at higher intellectual levels when asked to work in collaborative situations than when asked to work individually.

Vygotsky (1978) claimed that less skillful individuals are better able to develop a more complex level of understanding and skills through collaboration, under the direction of an expert or a more capable peer than they could independently. This is what is termed as scaffolding, which allows students to perform tasks that would normally be slightly beyond their ability without that assistance and guidance from the teacher.

Social interaction extends a child's zone of proximal development, which is the distance between the actual development level as determined by the independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. Thus, knowledge construction actually occurs in the zone of proximal development (Swan, 2005).

2.2 Conceptual Framework of the Study

Camp (2001) defined conceptual framework as a structure which the researcher believes can best explain the natural progression of the phenomenon to be studied. The conceptual framework in this study refers to a group of concepts that are systematically organised to provide a picture of how ideas relate to each other using computer assisted instructional approach. The conceptual framework highlights the reasons why a research topic is worth studying, the assumptions of a researcher, the scholars who agrees with and disagrees with, and how the researcher conceptually grounds research approach (Evans, 2007).

The conceptual framework of this study included importance of cell division to students, difficulties of students with the concept of cell division, misconceptions in studying concept of cell division, causes of student difficulties in learning biology concepts, history of the integration of CAI into education, CAI as an effective teaching method, types of software used in CAI, and brief explanation of PhET simulation. The conceptual framework also comprised psychological basis for using computer simulation, importance of computer simulation to students, benefits of ICT integration into science teaching and learning, factors that hinder the integration ICT in education, brief explanation of conventional method of instruction, empirical framework of the study, and summary.

2.3 Importance of Cell Division to Students

Biology Dictionary Editors (2017) asserted that cell division has three main functions which are reproduction of unicellular organisms, production of gametes and growth in eukaryotes. The process of meiosis in eukaryotes produces sex cells or gametes with half the chromosome compliment of somatic cells.

Multicellular eukaryotic organisms use mitosis to grow and to repair their tissues. Pokaryotes reproduce using a process similar to mitosis called binary fission whereby an organism divides to create an exact copy of itself.

Biology Dictionary Editors further stated that, binary fission is used for reproduction by single-celled organisms, mitosis is used for the growth and maintenance of eukaryotic organisms and the process of meiosis produces eggs and sperm in eukaryotes. In eukaryotes, cell division occurs as vegetative cell division known as mitosis, whereby each of the two daughter cells has the same number of chromosomes as the parent cell. The reproductive cell division known as meiosis, whereby the number of chromosomes in the daughter cells are reduced by half compared to the parent cell.

Martin and Hine (2008) stated that, cell division usually occurred as part of a larger cell cycle. In eukaryotes, there are two distinct types of cell division: a vegetative division, whereby each daughter cells are genetically identical to the parent cell known as mitosis, and a reproductive cell division, whereby the number of chromosomes in the daughter cells is reduced by half to produce haploid gametes, known as meiosis. Meiosis results in four haploid daughter cells by undergoing one round of DNA replication followed by two divisions. Homologous chromosomes are separated in the first division, and sister chromatids are separated in the second division. Both of these cell division cycles are used in the process of sexual reproduction.

Prokaryotes such as bacteria usually undergo a vegetative cell division known as binary fission, where their genetic material is segregated equally into two daughter cells. While binary fission may be the means of division by most prokaryotes, there are alternative manners of division, such as budding, that have been observed.

Griffiths (2012) stated that for simple unicellular microorganisms such as the amoeba, one cell division is equivalent to reproduction resulting in an entire new organism.

On a larger scale, mitotic cell division can create progeny from multicellular organisms, such as plants that grow from cuttings. Mitotic cell division enables sexually reproducing organisms to develop from the one-celled zygote, which itself was produced by meiotic cell division from gametes.

Iyer (2014) showed that meiosis is the cell division that produced sex cells, such as the female egg cells or the male sperm cells. In meiosis, each new cell contains a unique set of genetic information. Therefore, after meiosis the sperm and egg cells can join to produce a new organism. Iyer (2014), also stated that during meiosis, a small portion of each chromosome breaks off and attach another chromosome which give rise to a process called crossing over or genetic recombination. This process is the reason why full siblings from egg cell and sperm cell from the same parents can look very different from one another.

Mader (2001) showed that reproductive cell division where the number of chromosomes in the daughter cells is reduced by half to produce haploid gametes was known as meiosis. The reduction in the number of chromosomes by half is important for sexual reproduction which is necessary for genetic diversity. According to Mader, one of the key features in mitosis is the division of a single cell into two cells that are replicas of each other and have the same number of chromosomes. Mitosis is important for basic body growth, repair and maintenance or replacement of worn-out tissues, and it ensures constant chromosome number in multicellular organisms. Also, mitotic cell division is very significant process in unicellular organisms because it leads to reproduction of new organisms.

Cell division is key to life, in order for our bodies to grow and develop, they must produce new cells and allow for the death of old cells. Cell division is an essential component of injury repair, thus if our cells couldn't divide and create new cells, our bodies could never produce new skin cells.

Perhaps most importantly, without cell division, no species would be able to reproduce and life would have ended long time ago. However, repeated rounds of unregulated cell division can lead to a minor condition like psoriasis or a life-threatening disease like cancer. Sometimes the cells in part of a multicellular organism divide uncontrollably resulting in a large mass of cells called a tumour.

2.4 Difficulties of Students with the Concept of Cell Division

The cell division is an important biological concept. It is responsible for the production of gametes and growth in multicellular organisms, and reproduction in unicellular organisms. The concepts of cell division is one of the difficult biology topics for students (Çimer, 2012; Vidzro, 2018). Cell division constitutes the basis for biological concepts like reproduction, growth, nucleic acids, and genetics. As a matter of fact, majority of students and teachers rank gene, DNA, chromosome, and cell division as difficult to learn topics (Oztas, Ozay, Oztas, 2003).

Students find biology to be difficult; hence they study biological concepts by memorisation. In a study on the effect of concept maps on learning success and permanence in biology education, Kilic and Salam (2004), posited that biology includes complex relationships of unfamiliar and abstract concepts. According to them, students often experience difficulty in understanding certain biological concepts and try to learn them through memorisation without understanding them properly.

Chattopadhyay (2012) opined that the problem in understanding the concept of cell division also persists at higher levels. Lewis and Wood-Robinson (2000) showed that, students attributed their difficulty with cell biology to the terms like replicate, copy, share, split, reproduce and multiply.

The cell passes through a series of discrete stages collectively known as cell cycle. The cell cycle essentially consists of two phases: Interphase and M phase which involve mitosis in somatic cells and meiosis in germ cells (Toteja, 2011). The Interphase is divided into G1 (Gap period 1), is the growth and preparation of the chromosomes for replication, S (Synthesis period), is the synthesis of DNA, and G2 (Gap period 2), is the preparation for mitosis. Thus, the period between mitotic divisions, that is, Gl, S and G2 is known as interphase. The M phase include mitosis and meiosis, and these are the stages where actual cell division occurs.

In cell biology, mitosis is part of the cell cycle in which replicated chromosomes are separated into two new nuclei. The process of mitosis involves only one phase with four main stages, Prophase, Metaphase, Anaphase, and Telophase. During mitosis, the chromosomes, which have already duplicated, condense and attach to spindle fibers that pull one copy of each chromosome to the opposite poles of the cell. This result into two genetically identical daughter nuclei. The cell then continues to divide by mitosis to produce two identical daughter cells. Mitosis occurs only in eukaryotic cells for growth and repair of worn-out tissues. Mitosis also occurs in prokaryotic cells through a process called binary fission, which leads to reproduction. Most human cells are produced by mitotic cell division. Important exceptions include the gametes consisting of sperm and egg cells which are produced by meiosis.

In meiosis, DNA replication is followed by two rounds of cell division to produce four daughter cells, each with half the number of chromosomes as the original parent cell. The two meiotic divisions are known as meiosis I and meiosis II. During S phase of the cell cycle, the DNA of each chromosome is replicated so that it consists of two identical sister chromatids, which remain held together through sister chromatid cohesion.

Meiotic cells enter a prolonged G2-like stage known as meiotic prophase. During this time, homologous chromosomes pair with each other and undergo genetic recombination, where there is exchange of genetic information. A subset of recombination events results in crossovers, which create physical links known as chiasmata. In most organisms, these links can help direct each pair of homologous chromosomes to segregate away from each other during Meiosis I, resulting in two haploid cells that have half the number of chromosomes as the parent cell. During Meiosis II, the cohesion between sister chromatids is released and they segregate from one another. Because the number of chromosomes is halved during meiosis, gametes can fuse during fertilization to form a diploid zygote that contains two copies of each chromosome, one from each parent. Thus, alternating cycles of meiosis and fertilization enable sexual reproduction, with successive generations maintaining the same number of chromosomes.

2.5 Misconceptions on Cell Division

Misconception is a conclusion that is wrong because it is based on faulty thinking or fact that is wrong. Science education research over the years has been the documentation of students' misconceptions in a wide range of subject areas (Pfundt & Duit, 2004). Students enter the science classrooms with deeply rooted conceptions about the natural world.

These conceptions influence how they come to understand formal science experiences in school. Bahar (2003) indicated that, misconceptions may be compounded by the teacher or the textbook. Lewis and Wood-Robinson (2000), reported that primary and secondary school students have many conceptual problems concerning cell biology and genetics.

We quite naturally form ideas from our everyday experience, but obviously not all the ideas we develop are correct with respect to the most current evidence in a given discipline. Moreover, some concepts in different content areas are simply very difficult to grasp, hence they may be very abstract, counterintuitive or quite complex.

The capacity for students to understand the concept of cell division is a major concern for instructors because cell division processes are fundamental to the understanding of biology concepts such as growth, development, reproduction, and genetics (Chinmci, Yue, & Torres, 2004).

A study related to genetics mentioned that students possess misconceptions and inadequate knowledge about the behavior of chromosomes and transference of genetic material during cell division. It further suggested that such misconceptions lead to conceptual problems in genetics (Kibuka-Sebitosi, 2007).

In a study on students' levels of understanding in regards to mitosis, meiosis, and fertilization, Lewis, Leach, and Wood-Robinson (2000) reported that, students showed inadequate knowledge and numerous misconceptions related to the physical relationships between the genetic material and the chromosomes, and the relationships between the chromosomes and continuity of the genetic information. Lewis et' al (2000) further emphasized the fact that the students mainly experience difficulties for explaining the relationships between the cell, nucleus, chromosome, and gene concepts, and the similarities and differences between mitosis and meiosis.

Atilboz (2004) conducted a study on the level of understanding and misconceptions of students related to mitosis and meiosis. The findings from of this study indicated that students experience difficulties in understanding fundamental concepts, such as DNA, chromosome, chromatid, homologous chromosomes, haploid and diploid cells, and the relationships between such concepts with some level of misconceptions.

A study conducted by Kruger et al (2006) on the concepts of students regarding cell division and growth revealed that, students generally focus much on the increase occurring with number of the cells during cell division and disregard the growth occurring in the cells. Kruger et al also indicated that such difficulties experienced during understanding such concepts might be overcome by learning activities that researchers have developed.

In a study on misconceptions of cell division held by student teachers in biology, Dikmenli (2010) reported that biology students have a series of significant problems regarding cell division and structuring of such concepts in a meaningful manner. The results of Dikmenli (2010) indicated the major problems students encounter in cell division are mainly associated with meiosis rather than mitosis.

According to Dikmenli, students showed much confusion with the stages of the cell division process and the events that takes place at each stage. The misconceptions identified in this study showed that students have conceptual difficulties in explaining cell cycle and cell division, mitosis and meiosis, haploid and diploid cells, and sister chromatids and homologous chromosomes, centrosome and centrioles, and spindle fibres and chromatin. Students mostly focus much on cell division with animal cells and disregard cell division with plant cells.

Clark and Mathis (2000) emphasized that, students experienced difficulties with the concept of cell division, particularly with chromatids, chromosomes, and the homologous parts of the chromosomes. Clark and Mathis (2010) also indicated that these difficulties related to the structure and behavior of the chromosome can be easily identified and removed by means of models. Students exhibit their perceptions and former experiences in conflict with the scientific facts due to misconceptions.

The cell division constitutes the basis for biology concepts such as genetics, reproduction, growth and development. Students interpret new experiences through these erroneous understandings, thereby interfering with being able to correctly grasp new information. Also, alternative conceptions or misconceptions tend to be very resistant to instruction because learning entails reorganization of student knowledge, thus conceptual change has to occur for learning to happen. This puts teachers in the very challenging position of needing to bring about significant conceptual change in student knowledge.

Therefore, several instructional strategies have proven to be effective in achieving conceptual change and helping students get rid of their alternative conceptions. Student knowledge, however, can be erroneous, illogical or misinformed. These erroneous understandings are termed alternative conceptions or misconceptions. It is obvious that misconceptions related to cell division processes lead to a series of problems for the biology teaching.

2.6 Causes of Students' Difficulty in Learning Biology Concepts

There are several factors that make biology very difficult for student to learn. Students' difficulties with many topics in biology have stimulated researchers to investigate why students experience such difficulties and how to overcome these challenges.

The findings from a study conducted by Osborne and Collins (2001) showed that, students' diminishing interest in learning science was due to the curriculum content being overloaded and not generally related to everyday life, lack of discussion of topics of interest, absence of creative expression opportunities, and alienation of science from the society.

According to Ozcan (2003), experiencing difficulties in many topics in biology negatively affects students' motivation and achievement. The difficulties students encounter with several biology topics could be attributed to factors such as classroom learning environment, lack of interest in learning science, overloaded curriculum content and delineation of science from society.

Etobro and Fabinu (2017) revealed that, secondary school students in Lagos State, Nigeria, attributed their sources of difficult biology topics to abstractness, complexity, misconception of topics, unavailable instructional materials, poor attitudes of teachers to teaching, and the lack of practical lessons. Etobro and Fabinu (2017) further stated that biology instruction should be supported by approved textbooks, instructional materials, hands- on, minds-on sessions and observations as well as experiments that actively engaged students in the learning processes.

Findings reported by Cimer (2012) revealed that students listed several reasons for having difficulties learning biology: the nature of the topics, teachers' style of teaching biology, students' learning and studying habits, students' negative feelings and attitudes towards the topic and the lack of resources predominated. According to Çimer (2012), the participants suggested that teachers should teach biology through the use of visual materials, conducting practical activities, connecting the topics with daily life, and making biology teaching interesting in order to stimulate the learners.

Akiri and Nkechi (2009) stressed that the ineffectiveness of teachers in classroom interactions with learners could be responsible for the poor performance of learners and the fallen standards of education. However, the ineffective teaching procedures in most schools can be attributed to the inexperience of the teachers, lack of resources, and the lack of teacher motivation.

Tucker, Zyco, and Herman (2007) stated that most learners perform below average due to lack of motivation. Motivation directly effects academic achievement and thus, all factors affect achievement only through the effect of motivation. Most learners perform below average due to lack of motivation.

2.7 History of the Integration of CAI into Science Education

Seo and Bryant (2009) defined computer assisted instruction as the use of a computer to provide instructional contents. The idea of using technology to enhance education has been around for a long time, and thus in 1928, courses began being offered through radio in United States, specifically Ohio and Wisconsin. With the introduction of television in 1932, the University of Iowa, United States began experimenting with offering classes using this technology.

The Harvard Mark I computer also known as Harvard Calculator was first installed in Cambridge in 1944, used primarily in performing calculations in mathematics and science. Throughout this time period computers began to filter more into the education world and in 1960, when generalized computer assisted instruction system called programmed Logic for Automatic Teaching Operations (PLATO) was introduced in the University of Illinois, United States.

The term computer technology, often used in the 1960s and 1970s, has been replaced by information and communication technology (ICT) or information technology (IT). The involvement of computer technologies in everyday life, as well as the different forms of technology such as tablets, smart phones, robots, require educational researchers and professionals to rethink the potential of technology for education.

Technology transitioned in the early seventies and universities began installing microwave networks to create close-captioned classes for students at remote locations. In 1980 only five percent of elementary schools and twenty percent of secondary schools in the United States had computers for assisting instruction. Three years later, both numbers had roughly quadrupled, and by the end of the decade nearly all schools in the United States, and in most industrialized countries, were equipped with computers.

A recent development with far ranging implications for CAI is the vast expansion of the internet, a consortium of interlinked networks and systems. It was not until the nineties, when computers took on a newer, more efficient structure, became faster and more multifunctional (Harting & Erthal, 2005). Computers were connected worldwide, and these networks of computers enable students to access huge stores of information. Computers are being used in transportation, communication, national defense, scientific research and education. Consequently, several governments have started to invest heavily on information and communication technology to develop the human capital in order to address the demands of the digital and information age.

In 2001, the Government of Ghana set up for itself the task of improving upon access, equity and quality of education delivery in Ghana. In pursuit of this, the government put in place an ICT for accelerate development policy in the education sector. The policy document that was launched and used as platform for integration of ICT in education systems in Ghana was centered on the three pillars. These pillars are: ICT as a learning and operating tool, ICT as integrated into the teaching and learning and ICT as a career option for students.

According to Michayahu (2010), the introduction of information and communications technology into the curricula of Ghana for all first and second cycle institutions became a reality in 2007. This implementation strategy was to complement all subjects for a holistic development in information technology and to enable individuals who get access to formal education to become ICT literate. Within 2007, the government of Ghana and China signed a loan agreement purposely for development of Ghana national communications infrastructure backbone project, to facilitate the development of ICT infrastructure in the nation.

The latest Education Reform which was launched in 2007, highlights ICTs as an important cross cutting issue in the sector. This education reform seeks to address this through several strategies including: equipping all educational institutions with computer equipment and ICT tools in a prioritized manner; implementing ICT programs at the pre-tertiary level in a phased approach, starting with schools already possessing adequate laboratories and teachers; gradually expanding to other schools as and when ICT equipment and teachers become available; and adequately resourcing computer science and ICT departments in public tertiary institutions to enable them to produce skilled human capital to meet the requirements of the industry.

2.8 Computer Assisted Instruction as an Effective Teaching Method

Teaching method comprises the principles and methods used by teachers in the teaching and learning process to enable students acquire the needed knowledge. These strategies are determined partly on the subject matter to be taught and partly by the nature of the learner. Therefore, for a particular teaching method to be appropriate and efficient, it has to be in relation with the characteristic of the learner and the type of learning it is supposed to bring about (Westwood, 2008).

The term computer aided instruction describes digital systems that are designed to assist in the teaching and learning process, specifically those that can be tailored to the needs of the learner. CAI is an interactive instructional technique whereby a computer is used to present the instructional material and monitor the learning that takes place. CAI programs are interactive and can illustrate a concept through attractive animation, sound, and demonstration.

CAI allow students to progress at their own pace and provide immediate feedback. CAI uses a combination of text, graphics, sound and video in enhancing the learning process. Computer plays a key role in the classroom, thus it can be utilised to enable students in all areas of a particular curriculum. CAI programs use tutorials, drill and practice, simulation, discovery, and problem-solving approaches to present topics and test the student's understanding.

A study conducted by Collier (2004), on the enhancement of the teaching and learning of the sciences in secondary school using computer assisted instruction, revealed that instruction that is properly supplemented by CAI is more effective than the instruction without the use of CAI. The use of CAI in the classroom settings has proven to be effective, thus it enables students improve on their academic work.

The computer assisted instructional program allows students to study science concepts while advancing at their own pace. Computers can help students visualise objects that are difficult or impossible to view during the teaching and learning process. Computer assisted instruction uses a combination of texts, graphics, sound, and animations in enhancing the learning process.

Akour (2008) conducted a study on the effects of computer assisted instruction on Jordanian college students’ achievements in an introductory computer science course. The results of this study indicated that students taught by the conventional instruction method combined with computer assisted instruction performed better than those taught using only the conventional method of instruction.

Kausar et al (2008) discovered that, the use of CAI has proven to be significant compared to classroom lecture method in terms of achievement in knowledge, analysis and synthesis of the Bloom's taxonomy when they conducted a comparative study to evaluate the effectiveness of CAI and the classroom lecture for computer science students.

Egunjobi (2002) asserted that in geography teaching, the use of CAI seems to be more effective in enhancing students' performance than the conventional classroom instruction. Yusuf and Afolabi (2010) found that, the performance of students exposed to computer assisted instruction either individually or cooperatively was significantly better than the performance of their counterparts exposed to conventional instruction.

The findings from Nazimuddin (2015) revealed that computer assisted instruction has emerged as an effective and efficient media of instruction in the advanced countries of the world, hence it is employed in the formal and non-formal education sectors. Nazimuddin stated that the computer interacts directly with the learners while presenting lessons. In CAI, the computer is able to display the instructional material to the individual student. The individual student takes benefit of the displayed material and responds to it. These responses are analysed by the computer for deciding the future course of instruction displayed to the learner.

Mudasiru and Adedeji (2010) showed that, the performance of students exposed to CAI either individually or cooperatively were better than their counterparts exposed to the conventional classroom instruction. Mudasiru and Adedeji made recommendation on the need to develop relevant CAI packages for teaching biology in secondary schools based on their research findings.

Akpan and Andre (2000) found, that students exposed to simulation before practical lesson on dissection performed better than their counterpart not exposed to computer simulation before actual dissection. The implication is that simulations are imitation of a real-world process when used appropriately increases students' interest in the teaching and learning process and also enable students to understand a complex concept or difficult concept more easily.

Sottile and Brozik (2004) reported that, simulations in lesson delivery allows for an active learning process whereas the traditional lecture method does not allow for a high degree of teacher-student interaction and student-student interaction. Sottile and Brozik found in their study that, the simulation format allowed for a high degree of interaction between and among all parties. According to Sottile and Brozik (2004), students who were engaged in simulation were motivated to learn because the simulation presented an environment that was active and held the learners' attention. The achievement and participation of the learners increased during the simulation process as students enjoyed the learning technique, and were more confident and capable of solving problems.

2.9 Types of Software Used in Computer Assisted Instruction

The various instructional modes of computer assisted instruction in education include tutorial, drill and practice, discovery, gaming mode, simulation, problem solving mode, inquiry mode, author mode, and logo.

Tutorial type

In this mode of CAI, computers are engaged in actual teaching and can play effectively the role of a tutor by maintaining a perfect interaction and dialogue with the individual students. Tutorial information is presented in small units followed by a question. Learners are allowed to work on their own pace. The learners' response is analysed by the computer and appropriate feedback is given.

If the learner is able to master a concept, the CAI program provides the next step of instruction, but if the learner is not able to achieve mastery, the program provides remedial instruction.

Drill and practice

In this mode, CAI provides the learner with different types of drill and practice programs covering specific topics related to particular subject. The program leads the learner through a series of examples to develop dexterity and fluency in using the skills. All correct responses are reinforced, thus on achieving the mastery by the learner, the computer will proceed further. For instance, if the answer is wrong, the computer immediately displays WRONG and if the answer is correct, another problem for carrying out the practice is presented.

Discovery mode

In this mode of CAI, an inductive approach is followed. The problems are presented and the learner solves the problems through trial and error. This type of CAI aims at the deeper understanding of the results obtained from discovery. Hence, complex problems can be solved.

Gaming mode

This mode of CAI present course content in a competitive and entertaining manner, in an effort to maintain a high level of students' interest. The learners are provided with a variety of well-designed computer games to facilitate learning. The purpose is only to provide intellectual challenge and serves as a source of motivation to the individual learner. In a course of learning, these games can be used as a source of reward for some accomplishment for the learner. The use of games may produce a significant higher achievement and retention among students.

Simulation mode

In this mode of CAI, the learner faces scaled down approximation of real-life situations. With the carefully prepared programs, the students are made to face real or idealized situations in the teaching and learning process. In this mode, a realistic practice takes place without involving any risk. Simulations become necessary when it is not practical or feasible to do the real thing, thus it is used to provide experiences that otherwise would be denied.

Problem-solving type

This mode of CAI focuses on the process of finding an answer to a problem rather than the answer itself. The students are provided with programs that can make them think about the ways and means of solving the problem systematically. The students need to know how to communicate with a computer and how to solve a problem. Problem solving software allows learners to see the results of their reactions to various events. The learners manipulate variable, and feedback is provided based on the manipulations.

Inquiry mode

Inquiry is mode of third type of CAI application. In this mode, CAI system responds to student inquiry with answers it has stored. In this mode instructional staff must learn how the system operates.

Author Mode

In this mode, CAI is used to support instruction by generating sets of materials for a student’s use. In generating concept learning materials, these might be sentence forms which have blanks in them each of which is to be filled by a word or a set of words inserted into the blanks by the computer according to the instructions.

Logo mode

This mode of CAI is a simple programming language which can be taught to children. This program provides instructions which can be used to produce picture on a screen. The children who leam LOGO, make up their own programs to generate designs on the screen.

2.10 Brief Explanation of PhET Simulation

Physics Education Technology (PhET) was established in 2002, by the University of Colorado, United States. PhET simulations provides free learning simulations for physics, biology, chemistry, mathematics, and earth science. Physics education technology interactive simulations are animated, interactive, and game-like environment in which students learn through exploration (PhET Team, 2009).

These simulations are new approach to convey scientific ideas and engage students in educational activities. PhET project creates useful simulations for teaching and learning of physics and other sciences. PhET interactive simulations project at the University of Colorado in the United States is one key example of computer technology that is designed based on constructivist principles and intended to support standards-based instruction.

The PhET project has designed a suite of free interactive simulations, for teaching mathematics and science. The simulations, which cover a range of topics for all grade levels and are available on the PhET website. Physics education technology interactive simulations place much emphasis on the connections between real-life phenomena and the underlying science.

PhET simulations are specifically designed to productively make students focus on the aspects experts believe are most important. Physics education technology interactive simulations provide a high degree of interactivity in terms of user control, dynamic feedback, and multiple representations. The PhET team use a research-based approach, including findings from previous research and PhET testing methods to create simulations that support student engagement with and understanding of physics concepts and other sciences.

PhET simulations are specifically designed to support students in constructing a robust conceptual understanding of the physics through exploration. The PhET team make extensive use of student interviews and classroom testing to explore usability, interpretation, and learning issues, and to develop general simulations design principles.

Batuyong and Antonio (2018) opined that, PhET interactive simulation-based activities are very good instructional materials in teaching physics. According to them, PhET simulations are extremely valid in terms of their learning outcomes, instructional characteristics and evaluation, making them appropriate and relevant for the development of science concepts.

According to Batuyong and Antonio (2018), the use of appropriate ICT resources and effective learning approaches make learning meaningful to learners. Interactive nature and technology-driven activities make students apply directly to real-life situations and appreciate the importance of scientific ideas. They further concluded that, PhET interactive simulation-based activities can be deduced into three big themes: learning physics is fun, learning physics is real, and learning physics is simple and easy.

2.11 Psychological Basis for Using Simulation in Teaching Science

The use of computer simulation as a tool for teaching in the science classroom is quite new, but the psychological principles underlying the use of simulation is not new. The use of this new tool is based on existing psychological principles of repetition, reinforcement, and motivation; thus, many theories emphasized the benefit of these learning principles.

The psychological basis for using computer simulation in teaching science is based on the law of effect by Thorndike (1898) on the matter of behavioral conditioning. That is, learning is an outcome of the connection of stimulus and response. He extensively carried out experiments on learning processes and measured learning outcomes as well as intelligence. In his experiments with animals, he demonstrated how through the process of trial and error, organisms could establish a connection between stimuli and responses. He was credited for his scientific disposition in his studies.

Thorndike (1898) observed that there are underlying principles that facilitate the process of learning. He formulated three laws of learning: the law of readiness, the law of exercise and law of effect. The law of effect states that, responses that produce a satisfying effect in a particular situation become more likely to occur again in that situation, and responses that produce a discomforting effect become less likely to occur again in that situation (Gray, 2011).

The essential idea of the law is that, behaviour can be modified by its consequences. When stimulus and response are associated, the response is likely to occur without stimulus being present. It implies that if a satisfying situation follows a learning experience, the learner would likely not forget what has been learnt. Using simulations in the teaching and learning of science, the learners receive an immediate effect of the learning process.

A study conducted by Amadi (2018) on horse-stream truism in Thorndike (1898) law of readiness revealed that human learning proceeds more rapidly when the learner is ready to learn. The readiness may he physical or psychological. When an individual learner realises that the outcome of his action is enjoyable and beneficial, his readiness to act is boosted. According to Amadi, the school and the teacher have a task of ensuring that learners view school activities as a beneficial venture. Therefore, teaching and learning must be made to be very attractive and satisfying to the learner at all times to effectively build greater readiness in the learner in the learning process.

2.12 Importance of Computer Simulation to Students Understanding of Concepts

Computer simulations are computer-generated, dynamic models of the real world and its processes and often represent theoretical or simplified versions of real-world components, phenomena, or processes (Smetana & Bell, 2012).

Simulations offer an environment for students to explore the phenomena of the real world and better understand the science behind the phenomena. The interactive engagement and immediate feedback of simulations allow students to work at their own pace and easily repeat trials and thus promote conceptual reasoning and deeper understanding in the learning process.

Smetana and Bell (2012) concluded that the effectiveness of computer simulations is dependent upon the ways in which they are used. They suggested that computer simulations are most effective when they are used as supplements, incorporate high-quality support structures, encourage student reflection and promote cognitive dissonance.

In a study conducted on the effects of 3D computer simulation on biology students' achievement and memory retention, Plass, Homer and Hayward (2009) reported that, the realistic simulation and non-realistic simulation as educational software consist of multimedia elements such as text, animation, video and audio. These multimedia elements, according to Plass, Homer and Hayward play vital role in enhancing students' interest in learning and improving their memory retention.

The findings from Elangovan and Ismail (2014) revealed that the integration of realistic simulation and non-realistic simulation in the teaching and learning of biology have positive impacts on students.

Arvind and Heard (2010) reported that simulations provide educators with the chances to give learners an instructional tool that can enable learners to transform their alternate science conceptions into precise science conceptions. Students create their own mental model about the learned concepts while learning through visualization and recorded in the form of visual in their long-term memory (Eichinger, Nakhleh & Auberry, 2000).

The findings from Widiyatmoko (2018) indicated that simulations play important roles in the science classroom and science instruction. Simulations gives learners the opportunity to observe a real-world experience. Through the use of simulations, learners can experimentally get an understanding of difficult concepts in science. Findings from this study showed that simulations work on conceptual understanding in science learning.

Using simulations, students can represent their understanding of science phenomena and mental model construction (Abdullah & Syarif, 2008). Similarly, simulation is the most suitable method when the learning objective requires a restructuring of the students' individual mental models (Landriscina, 2009).

When simulations are used appropriately, students will be engaged in inquiry, further develop their knowledge and conceptual understanding of the content, gain meaningful practice with scientific process skills, and confront their misconceptions.

Sahin (2006) reported that the use of computers may play important roles in the classroom and laboratory science instruction in either the classroom or distance, and hence they can be used with instructive or constructive pedagogy. Sahin indicated that simulations give students the opportunity to observe a real-world experience, interact with it, contribute to conceptual change, provide open-ended experiences, and provide tools for scientific inquiry and problem solving.

Simulations can bridge this breadth and depth of students' knowledge because simulations have the potential to make learning abstract concept more concrete (Ramasundarm, Grunwald, Mangeot, Comerford, & Bliss, 2005). Thus, simulations are making science abstract concept more accessible, visible, and can help students to understand science concepts. Also, when students are unable to experience abstract science phenomena, simulations can play a crucial role in helping them understand those phenomena. Therefore, simulations can make abstract science phenomena more accessible and visible to students.

Simulations are flexible, dynamic, and interactive and thus encourage inquiry-based exploration, in which students draw their own conclusions about scientific concepts and ideas by altering values of different variables and observing their effect. Kennepohl (2001) examined the benefits of computer simulations in a first-year general chemistry course and found that the combination of simulations and laboratory activities offers advantages in time so that the laboratory portion can be reduced in length and students using the simulations have a slightly better knowledge of the practical aspects directly related to laboratory work.

Lajoie, Lavigne, Guerrera, and Munsie (2001) reported that, computer simulations take learners in such an environment that they conduct several integrated tasks so that they leam complex skills in authentic problems such as BioWorld. Therefore, there is the tendency for students who are taught with computer simulations to develop self-efficacy which arouse their confidence in learning environment.

Thompson and Dass (2000) found that, students who engaged in simulations showed an increase in self-efficacy that was significantly larger than gains due to learning by the case method approaches. Thompson and Dass (2010) also stated that simulations are more effective at enhancing student's self-efficacy. Therefore, through the use of simulations the students become an active participant in the learning process and gains insight into the concept being simulated.

Simulations provide opportunities for the active learner to develop skills in decision making and problem solving that can be applied to solve real world problems. According to Dede (2000), students developed mastery skills such as analytic reasoning, complex problem solving, and teamwork. Simulations can present rich opportunities for students to experience cognitive dissonance by observing phenomena or collecting data that challenge preconceived conceptions, which then lead to conceptual change (Bell & Trundle, 2008).

Sottile and Brozik (2004) reported that, simulation format allowed for an active learning process whereas traditional lecture formats were passive in nature and did not allow for a high degree of teacher-student interactions and student-student interactions. Thus, the simulation format allowed for a high degree of interaction between and among all parties involved in the instructional process. The students were motivated to leam because the simulation presented an environment that was active and held the learners' attention. The achievement and participation of the learners increased during the simulation process. According to Sottile and Brozik (2004), the students enjoyed both the process and learning involved in the simulation and were more confident and capable of solving problems.

Computer simulations are flexible, dynamic, and interactive and thus encourage inquiry-based exploration, in which students draw their own conclusions about scientific concepts and ideas by altering values of different variables and observing their effect (Perkins et al, 2012).

2.13Benefits of ICT Integration into Science Teaching and Learning

The integration of ICT in the classroom is significant as it helps students in enhancing their collaborative learning skills as well as developing transversal skills that stimulates social skills, problem solving, self-reliance, responsibility and the capacity for reflection and initiative. According to (Ghavifekr et al (2014), all these elements are core values that students need to achieve in an active teaching and learning environment involving the use of ICT.

Ghavifekr and Rosdy (2015) showed that, technology-based teaching and learning is more effective as compared to the traditional instruction. They stated that, using ICT tools and equipment will prepare an active learning environment that is more interesting and effective for both teachers and students. Ghavifekr and Rosdy (2015) further stated that, students learn more effectively with the use of ICT in lesson delivery, by engaging them and making the lesson very interesting.

A study conducted by Bhattacharjee and Deb (2016) found that, ICT helps the teacher to update the new knowledge, skills to use the new digital tools and resources. According to them, using and acquiring the knowledge of ICT, will make student teacher becomes effective teacher. ICT is one of the major factors for producing the rapid changes in our society, it can change the nature of education and the roles of students and teacher in teaching and learning process. They concluded that, the use of information and communication technology in teacher education in the 21st century is necessary, because teachers can create a bright future for students.

Volman (2005) pointed out that, most schools in the Western world had invested a lot in ICT infrastructures over the last twenty years and that, students used computers more often and for a much larger range of applications. Volman, also indicated that, the gradual progress in using computers changes from learning about computers to learning with computers. Several studies argue that the use of new technologies in the classroom is essential for providing opportunities for students to learn in order to function in an information age.

Keengwe (2007) emphasised that, students expressed high computer proficiency or competency in some technology applications such as email, and the Internet, but they lacked depth in specific areas of their computer skill repertoire such as hypermedia and authoring tools. The results of the study indicated a relationship exists between students' personal computer proficiency and students' instructional computer proficiency. Hence, there is a common trend toward improving student learning through a seamless integration of technology through all the facets of educational system, and therefore suggested that students need to have direct instruction to efficiently use computer tools such as sophisticated hypermedia.

Findings from Rehmat and Bailey (2014) indicated that participants, after receiving modeling and explicit instruction, were able to better define and apply technology in the science classroom. The participating preservice teachers improved in their understanding of technology as a tool to facilitate learning in a constructivist approach, though all of them still have room to grow in this area. According to Rehmat and Bailey, there were evident of improvements in participants' post-surveys, reflections, and lesson plans showing a positive attitude toward and inclusion of technology integration.

In a study conducted by Camoy (2004), teachers from rural areas claimed that the benefit of using ICT system has become a priority of connecting rural schools to the internet and thereby integrating them more tightly into the educational system, and hooking them up to the outside world. Albirini (2006) asserted that ICT integration is to improve and increase the quality, accessibility and cost-efficiency of the delivery of instruction to students.

Research indicates that the use of information and communication technology in education can increase student's motivation, promote deep and collaborative understanding, facilitate lifelong learning, offer easy access to information and shared resources, and help students to think and communicate creatively (Jimoyiannis, & Komis, 2007; Webb, 2005).

Uhomoibhi (2006) reported that, e-leaming and the use of ICT is playing a key role in Northern Ireland in shaping teaching and learning. According to Uhomoibhi, education system in Northern Ireland has entered a period of significant change as a result of technology education. Uhomoibhi, further stated that, students at all levels are beginning to be more active and aware of technological capabilities and are entering varying phases of using e-leaming through interaction online.

According to Grabe and Grabe, (2001) the use of ICT in education must be a priority for every classroom teacher to enhance effective learning in every subject and also to engage the thinking, decision making, and problem solving of students.

The use of ICT in the classroom is more important, thus it has the ability to arouse the interest of students in the teaching and learning process.

Therefore, schools and other educational institutions which are supposed to prepare students to live in a knowledge society need to consider ICT integration in their curriculum (Ghavifekr, Afshari & Salleh, 2012). The integration of ICT in education, specifically into daily classroom instructional process has the capacity to prepare students adequately to acquire the skills and knowledge for the 21st century.

2.14 Factors That Hinder the Integration of ICT in Lessons.

The integration of information and communication technology into education has positively shaped the learning environment. It has transformed the learning and teaching process in many fields of study. Notwithstanding the importance of the use of computer technology in the classrooms, there are numerous factors that limits the effective integration of ICT in the teaching and learning process.

Ghavifekr and Rosdy (2015) posited that, the first stage of ICT implementation must be effective to make sure that, teachers and students are able to make the best use of it in education. Thus, the preparations of a technology-based teaching and learning must begin with proper implementation with supports from the school management. Ghavifekr and Rosdy indicated that, if the implementation process of technology integration in schools take place appropriately from the very beginning stage, then ICT integration in schools will result in a huge success and benefits for both teachers and students.

Finally, Ghavifekr and Rosdy (2015) opined that the integration of ICT in classroom needs serious consideration in order to increase the competency of the country's education system. In addition, the needs for teachers to be literate and have good skills and knowledge in using ICT to improve their teaching methods and approach is desired to promote effective learning as well as to meet the demand of the 21st century.

Agbo (2015) identified some major factors that affect the use of information and communication technology in the teaching and learning of computer studies. These factors include the level of accessibility, cost of ICT equipment, training of teachers in ICT, attitude of teachers toward the use of ICT, students to computer usage, and lack of support from parent and community.

O'Bannon and Judge (2004) showed that, the crucial factors for successful integration of technology in a classroom setting is the teacher, who directly determines the best instructional practices for the students. The use of ICT especially in teaching and learning is more about practicality as compared to theories. Therefore, teachers must be given time to leam and practice it before they are completely comfortable with its usage and able to make use of it effectively in the classroom.

Zhao and Cziko (2001) identified three conditions that are necessary for teachers to introduce ICT into their classrooms. According to them, teachers should believe in the effectiveness of technology, teachers should believe that the use of technology will not cause any disturbances, and finally teachers should believe that they have control over technology. The role of a teacher in integration of ICT into education is very significant because the teacher serves as agent by which students acquire the needed knowledge in their field of study.

The findings from a study conducted by Schiler (2003) on working with ICT revealed that, personal characteristics such as educational level, educational experience with the computer for educational purpose and attitude towards computers can influence the integration of technology into education.

A study conducted by Sultana and Shahabul (2018) on the cause of low implementation of ICT in education in Bangladesh revealed that, the level of use and infrastructure of information technology of the college is not highly satisfactory to meet the current demands of information and communication technology. They stated that the college needs to be provided with adequate facilities and resources for effective implementation of ICT, and also urged the government to provide in-service training to the teachers.

Buabeng-Andoh (2012) established that, the effective integration of technology into classroom practices poses a challenge to teachers than connecting computers to a network. This study highlighted on factors that positively or negatively influence teachers' use of ICT. These factors according to Buabeng-Andoh, are personal, institutional and technological. Thus, teachers' feelings, knowledge and attitudes on the use of ICT constitute the personal level. Factors such as support, funding, and training in relation to ICT integration make up the school level, and for the technological level, teachers must perceive the technology as better option than previous practice in the teaching and learning process.

Knezek and Christensen (2002) revealed that, teachers' competence with computer technology is a key factor of effective use of ICT in teaching. However, the teachers cited pedagogical and didactic competences as significant factors if effective and efficient educational interventions are likely to be implemented. The experienced and new teachers stressed the need for technical skills and attitude, the innovative teacher's emphasised curricula and didactic competences and the student-teachers cited technical competence and pedagogical efficiency as significant to integrate ICT in teaching and learning processes.

Teachers' computer self-efficacy is described as a judgment of their capability to use a computer. Liaw, Huang and Chen (2007) stated that teachers' computer self-efficacy influences their use of ICT in teaching and learning. The changes that is taking place in education globally is driven by advanced technology and communication devices that should be available to students wherever they are, either at school or home.

The accessibility of ICT resources does not guarantee its successful implementation in teaching, and this is not merely because of the lack of ICT infrastructure but also because of other problems such as lack of high-quality hardware, suitable educational software, and access to information and communication technology resources (Balanskat, Blamire, & Kefala, 2006).

Newhouse (2002) found that, many teachers lack the knowledge and skills to integrate computer technology into teaching and learning. Teaching occupies a noble position in the society, and the integration of ICT enable teachers to update their knowledge and skills on new technological tools and resources. This can change the nature of education including the roles of students and teacher in the teaching and learning process.

2.15 Brief Explanation of Conventional Methods of Instruction

A teaching method comprises the principles and methods used by teachers to enable student learning. These strategies are determined partly on subject matter to be taught and partly by the nature of the learner. Thus, for a particular teaching method to be appropriate and efficient it has to be in relation with the characteristic of the learner and the type of learning it is supposed to bring about.

According to Westwood (2008) the selection of teaching methods must take into account not only the nature of the subject matter but also how students learn. Conventional teaching is a type of teaching method involving instructors and the students interacting in a face-to-face manner in the classroom. These instructors initiate discussions in the classroom, and focus exclusively on knowing content in textbooks and notes.

Adeyemi (2012) remarked that, conventional instructional method is characterized by emphasis on instructor behaviour rather than students' behaviour. Adeyemi, proposed that, conventional instructional method provides minimal responses of students to the instructional materials and delayed feedback on students' performance.

McCarthy and Anderson (2000) asserted that with conventional teaching method, students receive the information passively and reiterate the information through memorisation. The conventional education, also known as traditional education, refers to long-established customs that society traditionally used in schools. Modem forms of education reform promote the adoption of progressive education practices, a more holistic approach which focuses on individual students' needs and self-control. The traditional teacher-centered methods focused on rote learning and memorisation must be abandoned in favour of student-centered approach.

The findings from Khalaf (2018) showed that, the traditional model which has been implemented in the field of learning over the years had encountered some drawbacks that affected learners' acquisition of knowledge and learning outcomes, especially after the recent technological revolution. According to Khalaf, the traditional learning model encountered drawbacks in learner's knowledge, skills, competence and outcomes.

Devinder and Zaitun (2006) posited that, many lecturers still use the conventional teaching method, hence while the lecturer is explaining and writing on the board, students will be copying the same thing onto their notes, some day-dreaming and some sleeping. The conventional instructional method can be very effective, particularly for sharing and presenting information to learners who learn best by listening. Conventional instructional method is ineffective and does not promote effective critical thinking in the learning process.

2.16 Empirical Framework of the Study

Various studies have been conducted in the field of technology-based teaching in education. The outcome of many of these researches indicate that the integration of computer technology in education has proved to show positive impact in students' achievement and improvement of teaching and learning process. However, some of the results of these researches on the use of computer in the instruction process show no significant differences in achievement of students taught with computer assisted instruction those taught with conventional instruction method.

In a study conducted by Ghavifekr and Rosdy (2015) on teaching and learning with technology: effectiveness of ICT integration in schools. The results of this study indicated that technology-based teaching and learning is more effective when compared with traditional classroom method of instruction. This is because, using ICT tools and equipment will prepare an active learning environment that is more interesting and effective for both teachers and students.

Yusuf and Afolabi (2010) investigated the effects of individualized computer assisted instruction (ICAI) and cooperative computer assisted instruction (CCAI) on secondary school students' performance in biology in Turkey. They investigated the CAI on some biological concepts such as food chain, food web, energy flow, nutrient, movement, and pyramid of numbers. Yusuf and Afolabi (2010) found that, the performance of students exposed to computer assisted instruction either individually or cooperatively was significantly better than the performance of their counterparts exposed to conventional instruction. They indicated that, when comparing the efficiency of ICAI and CCAI, significantly higher achievement of students was accomplished with CCAI method.

In Kenya, Ndirangu et al (2005) employed Computer Based Learning (CBL) in a study which investigated reflections from a computer simulations program on cell division in selected Kenyan secondary schools. The Findings from this study indicated that computer-based learning provides a collaborative environment which enhance social interaction and self-teaching. The events which transpired in this study according to Ndirangu et al (2005) demonstrated the value of using CBL simulation programs for the teaching and learning of what otherwise would have been a complex difficult concept to learn.

According to them, computer-based learning classes is evidence of teachers' success stories in using an innovation to overcome their previous inability to help learners understand the complex process of genetic crossover. They further stated that CBL programs may be a solution to other hidden problems, such as a teacher's weakness in drawing diagrams and the limited time available to teach a particular topic.

Mudasiru and Adedeji (2010) investigated the effects of computer-aided instruction (CAI) on secondary school students' performance in biology. The findings of the study showed that the performance of students exposed to CAI either individually or cooperatively were better than their counterparts exposed to the conventional classroom instruction. However, Mudasiru and Adedeji (2010) made recommendation based on the research findings on the need to develop relevant CAI packages for teaching biology in secondary schools.

Sahin (2006) conducted a study on computer simulations in science education: implications for distance education. In this study, Sahin reported that the use of computers play important roles in the classroom and laboratory science instruction in either the classroom or distance education, hence they can be used with instructive or constructive pedagogy. Sahin (2006) indicated that simulations give students the opportunity to observe a real-world experience, interact with it, contribute to conceptual change, provide open-ended experiences, and also provide tools for scientific inquiry and problem solving.

Sottile and Brozik (2004) conducted a study on the use of simulations in a teacher education program: the impact on students' development. The findings of this study revealed that simulation format allowed for an active learning process whereas the traditional lecture format is passive in nature and does not allow for a high degree of teacher-student interaction and student-student interaction. Sottile and Brozik (2004) found in their study that, the simulation format allowed for a high degree of interaction between and among all parties.

According to Sottile and Brozik (2004), students who were engaged in simulations during the study were motivated to leam because the simulation presented an environment that

was active and held the learners' attention. They indicated that the achievement and participation of the learners increased during the simulation process as students enjoyed the learning technique, and were more confident and capable of solving problems.

In a study on Jordanian college students' achievements in an introductory computer science course, Akour (2008) revealed that, students taught by the conventional instruction method combined with computer assisted instruction performed significantly better than those taught using only the conventional method.

In a study to evaluate the effectiveness of computer assisted instruction versus classroom lecture for computer science, Kausar, Choudhry, and Gujjar (2008) discovered that the use of CAI has proven to be significant compared to classroom lecture in terms of achievement in knowledge, analysis and synthesis of the Bloom's taxonomy when they conducted a comparative study to evaluate the effectiveness of CAI and the classroom lecture for computer science students.

Plass, Homer and Hayward (2009) conducted a study on the effects of 3D computer simulations on biology students' achievement and memory retention. The findings of this study indicated that, the realistic simulation and non-realistic simulation as educational software consist of multimedia elements play vital role in enhancing students' interest in learning and improve their memory retention.

A study conducted by Ogunleye (2007) on teachers' perceived barriers to successful implementation of ICT in the teaching and learning of science subjects in Nigerian secondary school indicated that, computer expands pedagogical resources available to teachers in science classroom, thus supporting teaching. The implication of this is that the integration of computer technology in the delivery of biology lessons in the classroom or science laboratory may improve the quality of pedagogical delivery and students' learning.

Izzet and ozkan (2008) in their study on the effect of computer assisted instruction on the achievement of students on the instruction of physics topic established that, computer assisted instruction increases motivation towards learning and development of academic achievement of students.

Halis (2002) conducted a study on instructional technologies and material development. In this study, Halis (2002) pointed out that, the use of computer in teaching science and mathematics subjects makes the lessons more interesting and encouraging. This, according to Halis (2002) makes the more complex science concepts to be learnt easily in an effective way.

In a study on the efficacy of two computer-computer assisted instructional modes on learners' practical geography achievement at the secondary school level in Nigeria, Egunjobi (2002) asserted that in geography teaching, the use of CAI seems to be more effective in enhancing students' performance than the conventional classroom instruction.

The findings from a study conducted by Nazimuddin (2015) on computer assisted instruction: a new approach in the field of education in India, revealed that, computer assisted instruction has emerged as an effective and efficient media of instruction in the advanced countries of the world. Nazimuddin further indicated that CAI is employed in the formal and non-formal education sectors.

In a study on the effects of 3D computer simulation on biology students' achievement and memory retention, Elangovan and Ismail (2014) discovered that the integration of realistic simulation and non-realistic simulation in biology teaching and learning have positive impacts on students. The findings of this study also showed that realistic simulation or the 3D simulation is more effective in the teaching and learning of biology. Elangovan and Ismail (2014) concluded that using realistic simulation or 3D computer simulation in cell division topic advantageous because it enables students to visualize and properly understand the abstract and difficult biology concepts such as mitosis and meiosis of the cell division.

Akpan and Andre (2000) investigated the effectiveness of computer simulation with dissection of frog in the empirical research study which used an interactive simulation as a preparatory tool, before actual dissection. The findings of this study showed that, students exposed to computer simulation before the actual practical lesson on dissection of frog performed better than their counterpart not exposed to computer simulation before the actual dissection lesson. The implication is that simulations are imitation of a real-world process, and when used appropriately increases students' interest in the teaching and learning process and also enable students to understand a complex concept more easily.

2.17 Summary

Cell division is one of the important concepts in biology and it is taught in cytology. The processes involve in cell decision are complicated and required knowledge from other areas in cell biology such as; cell as basic unit of life, nucleic acids, genetics and concept of cell theory. The complex and the abstract nature of cell division and other biology concepts may explain why many students perform poorly in biology.

Cell division begins with interphase where the cell prepares to divide. The interphase is divided into three further phases: G1 phase (Gap 1), S phase (Synthesis) and G2 phase (Gap 2). During interphase, the cell grows, accumulating nutrients needed for 50 mitosis, preparing it for cell division and duplicating its DNA. Cell division in part of the larger phase cell cycle, it the process where by a parent cell divides into two or more daughter cells. Types of cell division basically include mitosis and meiosis.

Mitosis occurs in somatic or body cells in which a parent cell divides into two daughter cells, which are genetically identical to each other and to their parent cell. The two new daughter cells are said to be diploid (2n). Meiosis is on the other hand is cell division that reduces the chromosome number by half resulting in the production of haploid daughter cells. Meiosis ensures the production of haploid phase in the life cycle of sexually reproducing organisms whereas fertilization restores the diploid phase.

Meiosis leads to the formation of haploid gametes. Meiosis involves two sequential cycles of nuclear and cell division called meiosis I and meiosis II but only a single cycle of DNA replication occurs. Four daughter cells are produced at the end of meiosis II. Meiosis when compared to mitosis has a longer prophase I phase. The following events occur at prophase I but are absent at the prophase of mitosis they include bivalent, synapsis, chiasmata and crossing over.

Mitosis ensure growth, cell replacement and repair of worn-out tissues and also serve as a means of asexual reproduction in unicellular. Meiosis helps in the production of gametes also help to maintain the diploid number of chromosomes in successive generation. Cell division begins with karyokinesis and ends with cytokinesis. According to the cell theory, cells arise from preexisting cells. The process by which this occurs is called cell division. Any sexually reproducing organism starts its life cycle from a single-celled zygote. Cell division does not stop with the formation of the mature organism but continues throughout its life cycle. The stages through which a cell passes from one division to the next is called the cell cycle. Cell cycle is divided into two phases: Interphase is a period of preparation for cell division, and Mitosis (M phase) is the actual period of cell division. Interphase is further subdivided into Gl, S and G2. G1 phase is the period when the cell grows and carries out normal metabolism. Most of the organelle duplication also occurs during this phase. The S phase marks the phase of DNA replication and chromosome duplication. G2 phase is the period of cytoplasmic growth. Mitosis involved only one phase which is divided into four stages namely Prophase, Metaphase, Anaphase and Telophase. During Prophase, chromosomes become visible, short and thick, the centriole move into the opposite poles and the spindle fibres start to form. At the Metaphase, the spindle fibres are formed, the chromosomes line up at the equator of the spindle, and the centromeres become attached to the spindle fibres at the opposite poles. At the Anaphase, chromatids separate at the kinetochore and moves towards the opposite poles. The cell then begins dividing by constriction across the middle. Finally at Telophase, two diploid daughter cells that are identical to the parent cell are formed.

In contrast to mitosis, meiosis involved two phases: Meiosis I and Meiosis II. The first meiotic division begins with Prophase I, where homologous chromosomes lie together to form bivalent, nuclear membrane breaks down and chiasmata or crossing over takes place. At Metaphase I, each pair of homologous chromosome line up at the equator, and there is formation of spindle fibres. At Anaphase I, each pair of homologous chromosomes separate and move towards opposite poles of the spindle, and in Telophase I, chromosomes reach the poles of the spindle and the cell constricts at the middle to form two cells.

The second meiotic division starts with Prophase II where chromosomes condense and spindle fibres begins to form. In Metaphase II, the chromosomes line up at the equator and the spindle fibres formed at the opposite poles. In Anaphase II, the chromatids separate after centromere breakdown, the chromosomes then move towards opposite poles, and each of the two cells begins to constrict at the centre. Finally, at Telophase II, four haploid daughter cells that are not identical to the parent cell are formed.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter describes the methodology that was employed in the study, and it includes the population, sample size, sampling techniques and research instruments. It also describes the validity and reliability of the main instruments, the treatment and the method of data collection and analysis.

3.1 Research Design

The study employed the quasi-experimental research design. Shuttleworth (2008) stated that quasi-experimental research design involves selecting groups, upon which a variable is tested, without any random pre-selection processes. Quasi-experimental research design aims to demonstrate causal effect between a treatment and an outcome. Again, quasi-experimental research design generates results faster and it is at a lower cost as compared to the true-experimental design. In quasi-experimental design, two groups that are actually experimental and control groups are selected. The experimental group are given a pretest, treatment and posttest, while the control group are given only a pretest and posttest without any treatment.

McMillan and Schumacher (2010) posited that, non-equivalent groups of pre-test-post-test control group design or comparison group design is very prevalent and useful in education, because it is often impossible to randomly assign subjects. Also, in quasi- experimental, the researcher uses intact, already established groups of subjects, gives a pretest, administers the intervention condition to one group, and gives the posttest. The pretest and posttest of nonequivalent group design was used to collect data to find out if there is any significant difference in the academic achievement between the control and experimental groups.

3.2 The Study Area

The study was conducted at T.I Ahmadiyya Senior High School in the Wa municipality in the Upper West Region of Ghana. The Wa municipality is one of the 254 Metropolitan, Municipal and District Assemblies (MMDAs) in Ghana and forms part of the 11 MMDAs in Upper West Region. The administrative capital of the Municipality is Wa.

3.3 The Research Population

A research population is a well-defined collection of individuals or objects having similar characteristics (Castillo, 2009). The target population for this study was all S.H.S biology students in the Upper West Region, and the accessible population was all elective biology students of T.I Ahmadiyya Senior High School in the Wa Municipality.

The second year General Science and Home Economics elective biology students were selected for the study, because students from both classes share similar characteristics. Also, students from both classes were given different academic time tables which made each class spend only half of the first semester of 2020/2021 academic year in school at different times in the same period. Sample of GES 2020/2021 academic calendar for SHS double- track/single-track schools is shown in Appendix G.

The second-year students were chosen in the study because cell division is taught at the second year, and it forms part of the cell biology topics in the biology syllabus for senior high schools in Ghana. The school was chosen for the study due to the accessibility and familiarity of the school to the researcher. The researcher is an Integrated Science teacher at T.I Ahmadiyya Senior High and therefore getting access to students was very easy.

3.4 Sample Size

The sample size for the study was 80 second year science students of T.I Ahmadiyya Senior High School. The participants for the study included 40 Form Two General science students of T.I Ahmadiyya Senior High School as the control group, and 40 Form Two Home Economics students of T.I Ahmadiyya Senior High School as the experimental group.

3.5 Sampling Technique

The sample for the study was 80 second year elective biology students of T.I Ahmadiyya Senior High School, Wa. The participants were categorized into two, 40 General Science students as control group and 40 Home Economics students as the experimental group. The students were selected using purposive sampling technique, because purposive sampling does not involve random sampling of participants and the researcher knows the characteristics of the population.

Crossman (2018) stated that, purposive sampling technique is a non-probability sample that is selected based on characteristics of a population and the objective of the study. Again, purposive sampling is a non-probability sample where the selection of the participants for a study depends entirely on the discretion and judgment of the investigator or the researcher.

3.6 Research Instruments

The instruments that were used for the study were test, and questionnaire. Two tests of comparable standard were used to collect quantitative data from both the experimental and control groups. The questionnaire was also used to collect qualitative data from the experimental group on their perceptions towards the use of computer assisted instructional approach as an instructional strategy in teaching cell division. The pretest was termed student knowledge test on cell division (SKTC) and post-test was termed student achievement test on cell division (SATC). The pretest and the posttest were conducted based on the concept of cell division which is part of the elective biology syllabus. The SKTC (Appendix A) was administered a week before the treatment.

The pretest was used to find out the strength and weaknesses of the students' level of understanding of cell division and also to review students' previous knowledge on cell division. The SATC (Appendix B) was administered after the treatment. The posttest was used to assess students' performance on the concept of cell division after being exposed to the computer assisted instruction. Both the pretest and the posttest consisted of twenty (20) items made up of ten (10) multiple choice questions and ten (10) True or False questions.

The marking scheme for both the pretest and the posttest were prepared and presented in Appendix C. The total marks assigned for each of the test was twenty (20) marks. The pretest and posttest scores for both the control group and experimental group were recorded and presented in Appendices E and F. The time allocated for students to respond to both pretest and posttest was thirty minutes.

3.7 Questionnaire

Ropa and Rani (2012) noted that, when a questionnaire is properly constructed and responsibly administered, it becomes a vital instrument by which statements can be made about specific groups or people or entire populations. They further indicated that appropriate questions, correct ordering of questions, correct scaling, or good questionnaire format can make the survey worthwhile, as it may accurately reflect the views and opinions of the participants.

A questionnaire enables quantitative data to be collected in a standardised way so that the data are internally consistent and coherent for analysis and it should always have a definite purpose that is related to the objectives of the research. A self-developed questionnaire was used to determine the perception of students in the experimental group about the use of CAI in the teaching and learning of cell division. The questionnaire for the students comprised ten items using the likert scale format. The options were Strongly Agreed (SA), Agree (A), Uncertain (U), Disagree (DA) and Strongly Disagree (SD). The respondents were asked to tick the appropriate option. The Questionnaire is presented in Appendix D.

3.8 Trial-testing of the Instruments

The two parallel tests of comparable standards used in the research work were pretest and posttest. The instruments were pilot tested to determine their validity, reliability and the consistency. The pilot test was carried out in Wa Senior High School, Wa using 20 second year science students who offer biology as an elective subject.

3.9 Validity of the Main Instrument

According to Golafshani (2003), validity describes whether the means of measurement are accurate and whether they are actually measuring what they are intended to measure. Alhassan (2006) opined that validity of a research instrument is concerned with how well the instrument measures the concept it is supposed to measure.

To ensure the content validity of the test items, the instruments for data collection were given to my Head of science department and one science educationist in the Department of Science Education of the University of Education, Winneba to help establish their validity. The instruments were also given two experienced biology teachers for criticism and evaluation based on the instructional objectives specified in the biology syllabus. Their suggestions and criticisms were used to improve the validity of the instruments.

3.10 Reliability of the Main Instrument

According to William (2006), reliability refers to consistency of the measurement or the extent to which an instrument measures the same way each time it is used under the same condition with the same subjects. Reliability is used to evaluate the stability of measures administered at different times to the same individuals and the equivalence of sets of items from the same test (Kimberlin & Winterstein, 2008).

A reliability test was conducted by using the Cronbach's alpha and test-retest reliability. The test-retest reliability method was used to obtain the reliability coefficient of the instruments student achievement test on cell division (SATC) and student knowledge test on cell division (SKTC). Reliability measures tests consistency, hence a good reliability signifies the internal validity of a test and ensures that the tests taken in one sitting are both representative and stable over time.

Test re-test analyses are conducted over two time-points (Tl, T2) over a relatively short period of time, to mitigate against conclusions being due to age-related changes in performance. Test-retest reliability coefficients vary between 0 and 1, where 1 is perfect reliability and 0 is no reliability. The reliability coefficient for both pretest and posttest were calculated using the test-retest reliability coefficient. The reliability coefficient value for the pretest was 0.70 and the posttest was 0.72. The reliability of the questionnaire was determined using Cronbach's alpha and the reliability coefficient value was 0.70, hence the instruments was reliable.

3.11 Data Collection Procedure

Introductory letter was obtained from the HOD, Science Department, UEW, and it was used to seek official permission from the headmaster, and the HOD for science department to undertake the study. Pretest was then conducted on the experimental group and the control group. Cell division was then introduced using computer assisted instruction approach for the experimental group and the conventional method of instruction for the control group. The posttest was then administered to both groups after the treatment. The instruments developed by the researcher were administered under the supervision of the researcher to prevent respondents from copying from each other and to ensure that respondents' answer the items accordingly.

Scripts were collected, marked and recorded. The marked scripts were given to the students after the posttest to provide feedback to the students. The two tests were used to collect quantitative data and the questionnaire was also used to collect qualitative data. Questionnaire was administered to the experimental group after the treatment to determine the perceptions of the students on the use of computer assisted instruction approach for the teaching and learning of cell division.

3.12 Treatment

The intervention was implemented for a period of five weeks during the first semester of 2020/2021 academic year. The General Science students were assigned the experimental group and the Home Economics students were assigned the control group. The experimental group were instructed using computer assisted instruction and the control group were instructed using conventional method. Students in both groups were exposed to the same content for the same period of time.

Week 1: The researcher began by revising the previous knowledge of the students in the experimental group on the terms associated with cell division. The terms discussed were karyokinesis, cytokinesis, haploid, diploid, germ cell, somatic cell, chromosome, chromosome number, chromatid, centromere, centriole, and kinetochore.

Week 2: The downloaded PhET simulations which a form of CAI were projected on a screen in biology laboratory for students to observe the processes that occur in the interphase stage of the cell division and the main stages involved in mitosis. The main stages of mitosis involved Prophase, Metaphase, Anaphase, and Telophase.

Week 3: Students were taken through the meaning of meiosis. Simulations were projected on a screen in biology laboratory for students to observe the stages and processes involved in the first phase of meiosis. The stages included Prophase I, Metaphase I, Anaphase I, and Telophase I.

Week 4: Students were taught the main stages and processes involved in the second phase of meiosis with simulations. The stages included Prophase II, Metaphase II, Anaphase II, and Telophase II.

Week 5: Students were taken through the importance of mitosis and meiosis, including the main differences between mitosis and meiosis. To further enhance students' understanding on the cell division, students were divided into groups of five, making a total of five groups to carry out regular class exercises. Power point presentation was also employed by the researcher during lesson delivery.

The control groups were taught the concept of cell division using the conventional approach of teaching and learning. Lecture method, discussions, demonstrations, and questioning techniques were some of the instructional methods employed by the researcher for the period of five weeks. The researcher made use of chalkboard illustrations, textbooks, and notes during the lessons. Students in the control group were taken through the same sub-topics of the cell division on weekly basis as was carried out for the students in the experimental group. Students in the control group were also divided into groups of five, making a total of eight groups to carry out regular class exercises.

3.13 Data Analysis

Analysis of data involves organizing the data in a proper way and it involves performing closely related operation with the purpose of summarizing the collected data and organizing in such a manner yielding answer to the questions (Ibrahim, 2015). In simple words, it means, studying the data to determine inherent facts. The problem of data analysis varies from study to study. The questionnaire was analyzed qualitatively whiles the two tests were analysed quantitatively. The descriptive statistical approach was used in the analysis of the questionnaire, to describe the perception of students in the experimental group towards the use of computer assisted instructional approach in teaching and learning the concept of cell division.

The descriptive statistical analysis of both the pretest and the posttest included the mean, standard deviation, percentages, and frequencies. The inferential statistical tool used was independent sample test also known as the unpaired t-test for both the pretest and posttest for the two groups. The t-test was used for numerical data to determine if observed differences between the means of the experimental and control groups could be considered statistically significant.

3.14 Ethical Considerations

The students were given the option to opt out if they decided not to continue with the study. They were assured of the fact that, no part of the treatment will affect them, neither will their identity be revealed.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

In this chapter, the data gathered during the study including the discussion have been presented. It describes the analysis of the findings or results obtained during the study. Research question 1,2 and 3 were analyzed quantitatively and the results were used to answer the research questions raised in the study. The research question 4 was analyzed qualitatively using student's responses to the questionnaire.

4.1 Background data on the Research Subjects

Two comparison groups from two different classes System, the General Science class and the Home Economics class with similar characteristics were selected for the study. The data collected from the students' scores were analyzed using descriptive statistics of mean, standard deviation and inferential statistic of t-test. Independent sample t-test statistic was used for both pretest and posttest for the two groups, and also used to test the null hypotheses at significant level of 0.05. A questionnaire data was collected from students in the experimental group on their perceptions about the use of computer assisted instruction in teaching cell division.

Presentation of the Results by Research Questions.

The analysed data are now presented to answer the formulated research questions

4.1.1 Research question 1

What differences exist in the mean pretest scores of the experimental and control groups on cell division before the treatment?

In responding to research question 1, a null hypothesis was formulated as: Hoi. There is no significant difference in the mean pretest scores of the experimental and control groups. The results of the students were presented in Table 1.

As could be observed in Table 1, the mean score of the control group was slightly higher than the mean score of the experimental group in the pretest and there was no significant difference between them, (t=0.11; p>0.05).

This means that the two groups at the onset of the study, thus the two groups were comparable on their initial understanding of cell division. Therefore, the null hypothesis could not be rejected.

Table 1: t-Test analysis of the scores of the experimental and control group students.

Group	Test	N	Mean	SD	df	t-value	p-value
Control	Pretest	40	11.10	1.84	78	0.11	0.91
Experimental	Pretest	40	11.05	2.40			

4.1.2 Research question 2

What is the effect of CAI on the experimental group's performance on cell division?

In responding to research question 2, a null hypothesis was formulated as: Ho2. There is no significant difference in the mean pretest and posttest scores of the experimental group. The results of the students were presented in Table 2.

According to Table 2, the mean posttest score for experimental 2 was higher than the mean pretest score for the experimental 1. There was significant difference (t=23.02; p< 0.05) between them, meaning that the performance between the students in the experimental group before and after being exposed to simulations was not the same. This suggests that computer assisted instruction enhanced the understanding of the students in teaching the concept of cell division. Therefore, the null hypothesis was rejected and the alternate hypothesis accepted.

Table 2: t-Test analysis of the pre-test and post-test scores of the experimental group students

GROUP	Test	N	Mean	SD	df	t-value	p-value
Experimental 1	Pretest	40	11.05	2.40	39	23.02	0.00
Experimental 2	Posttest	40	17.05	1.52			

4.1.3 Research question 3

What differences exist in the mean posttest scores of the experimental and control groups?

In responding to research question 3, a null hypothesis was formulated as: H03. There is no significant difference in the mean posttest scores of the experimental and control groups. The results of the students were presented in Table 3.

As could be observed in Table 3, the mean score of the experimental group was higher than the mean score of the control group in the posttest. The t- test analysis of the mean score of the posttest of the two groups showed significant difference at a significant level of 5% ($t=6.82$; $p< 0.05$).

This means that there was significant difference in the performance between the experimental group and the control group after the treatment.

This suggests that the experimental group had better understand of cell division after the treatment as compared to the control group. Therefore, the null hypothesis was rejected and the alternate hypothesis was accepted.

Table 3: t-Test analysis of the post-test scores of the control and experimental group students.

Group	Test	N	Mean	SD	df	t-value	p-value
Control	Posttest	40	14.50	1.81	78	6.82	0.00
Experimenta	Posttest	40	17.05	1.52			

4.1.4 Research question 4

What are the perceptions of the experimental group students after being exposed to CAI during lessons on cell division?

To answer research question 3, relating to students' perceptions of the use of simulations, percentage, mean and standard deviation were calculated. The students indicated their levels of agreement with each questionnaire item on a scale that ranged from: 5=Strongly Agree (SA), 4= Agree (A), 3= Uncertain (UD), 2= Disagree (D) to 1= Strongly Disagree (SD).

Item 1

The students' responses to item 1 were analysed which recorded a mean score of 4.20 and standard deviation of 0.70. At the end of the discussion, 37.5% responded to strongly agree as the highest

Also, 0% responded strongly disagree as the lowest.

Item 2

For item 2, the students' responses showed a mean score of 4.30 and standard deviation of 0.52. At the end of the discussion, 47.5% responded to agree as the highest and 0% responded strongly disagree as the lowest.

Item 3

The student's responses to item 3 indicated a mean score of 4.10 and standard deviation of 0.74.

57.5% responded to agree as the highest and 2.5% responded strongly disagree as the lowest.

Item 4

The student's responses showed a mean score of 4.30 and standard deviation of 0.52. 55% responded to agree as the highest and 0% responded strongly disagree as the lowest.

Item 5

The student's responses shown a mean score of 4.28 and standard deviation of 0.65. 50% responded to agree as the highest and 0% responded strongly disagree as the lowest.

Table 4: Experimental group perception on use of CAI in teaching cell division (Items 1-5)

S/N	ITEM	SA	A	U	D	SD	MEAN	S. D.
1	CAI enhanced my critical thinking skills	15 37.5%	20 50%	2 5%	3 7.5%	0	4.20	0.70
2	I think CAI enhanced quality of instruction	17 42.5%	19 47.5%	3 7.5%	1 2.5%	0 0%		
3	CAI enabled me to be more active during lessons.	12 30%	23 57.5%	3 7.5%	1 2.5%	1 2.5%	4.10	0.74
4	CAI made me understand the cell division	16 40%	22 55%	0 0%	2 5%	0 0	4.30	0.52
5	CAI enabled me improve on my performance	16 40%	20 50%	3 7.5%	1 2.5%	0 0%	4.28	0.65

Item 6.

The student's responses indicated a mean score of 4.40 and standard deviation of 0.55.

50% responded to strongly agree as the highest and 0% responded strongly disagree as the lowest.

Item 7

The student's responses showed a mean score of 4.40 and standard deviation of 0.54.

52.5% responded to agree as the highest and 0% responded strongly disagree as the lowest.

Item 8

The student's responses indicated a mean score of 4.23 and standard deviation of 0.78.

50% responded to strongly agree as the highest and 0% responded strongly disagree as the lowest.

Item 9

The student's responses showed a mean score of 4.23 and standard deviation of 0.63.

60% responded to agree as the highest and 2.5% responded strongly disagree as the lowest.

Item 10

The student's responses indicated a mean score of 4.43 and standard deviation of 0.80.

45% responded to agree as the highest and 0% responded to strongly disagree as the lowest.

Table 5: Experimental Group Perception on use of CAI in Teaching Cell Division (Items 6-10)

S/N	ITEM	SA	A	U	D	SD	MEAN	S. D.
6	CAI aroused my	20	18	0	2	0	4.40	0.55
	Interest in cell division	50%	45%	0%	5%	0%		
7	I think other science	17	21	2	0	0	4.40	0.54
	teachers must use CAI	42.5%	52.5%	5%	0%	0%		
8	CAI made cell division	20	15	2	3	0	4.23	0.78
	more practical for me.	50%	37.5%	5%	7.5%	0%		
9	I learnt new computer	14	24	0	1	1	4.23	0.63
	skills with CAI	35%	60%	0%	2.5%	2.5%		
10	CAI enabled me retain	17	18	2	3	0	4.43	0.80
	more information	42.5%	45%	5%	7.5%	0%		

CHAPTER FIVE

MAJOR FINDINGS, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

5.0 Overview

This chapter deals with the major findings, and conclusions. The chapter also included recommendations of the study and suggestions which are necessary for adaption, incorporation and for future research.

5.1 Summary of the Major Findings

The following major findings were drawn from the study;

1. Difference in the Performance of Students in the Experimental and Control Groups

The performance of experimental and control groups on the pretest showed no significant difference at the onset of the study. This implies that the two groups were comparable on their initial understanding of cell division. However, the performance of students in the experimental group was significantly higher than the control group on the posttest. This indicates that the experimental group had better understanding of the concept of cell division than the control group after being exposed to computer simulations. This also proves that computer simulation has a positive effect on students' academic performance in cell division.

2. Perceptions of the Experimental Group Students on Computer Assisted Instruction

The experimental group students expressed their perceptions on the use of computer assisted instruction method after the treatment. Students were of the view that the computer assisted instruction improved the quality of instruction, made the concept of cell biology more practical and aroused their interest in cell biology. The students emphasized that, CAI enabled them to be active in class, enhanced their critical thinking skills, and made them learnt new computer skills. They indicated that CAI enabled them understand the concept of cell division, improved their performance and helped them retain more information. They also suggested that other science teacher must use CAI in the teaching and learning of science.

5.2 Conclusions

The study investigated the effect of CAI on students' academic performance in the concept of cell division. The following conclusions were drawn on the basis of statistical analysis and the findings of the study. The findings of this study showed that the integration of PhET simulation which is a form of CAI in teaching and learning of cell division had positive impacts on the experimental group. The result of the study indicated that students who were exposed to Computer-Assisted Instruction (CAI) performed significantly better than their counterparts who were taught using the conventional instruction method.

5.3 Recommendations

1. The interactive nature of PhET simulations which is a form of CAI are capable of transforming students from passive receipt of knowledge to active learners, hence should be used to teach the concept of cell division at the SHS level.
2. The computer-assisted instruction method has positive impact on students' academic performance, hence biology teachers should be encouraged to integrate it into the teaching and learning of other biology concepts.

5.4 Suggestions for Future Research

It is suggested that future studies investigate the use of PhET simulation which is a form of CAI in teaching and learning of other cell biology topics to observe the impact on students' learning.

The same study could be carried out in other senior high schools in other part of the region and this could provide the opportunity to evaluate the two teaching methods and also to arrive at generalized conclusion.

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APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA SCIENCE EDUCATION DEPARTMENT DATA COLLECTION INSTRUMENT FOR M. PHIL IN SCIENCE EDUCATION THESIS RESEARCH *PRETEST*

Serial No. of Participant:...

Sex:....................................... Class:..............................

Name of School:..

Instruction: This test contains twenty (20) questions grouped into section A, & B. Please answer ALL the two sections of the test.

SECTION A

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

1. The two strands that make up a single chromosome are called
   a. chromatins
   b. centrosomes
   c. chromatids
   d. centromeres

2. During the process of mitosis, the sister chromatids are separated at
   a. Prophase
   b. Metaphase
   c. Anaphase
   d. Telophase

APPENDIX A CONTINUED

3. How many chromosomes will be in a gamete if a normal cell has four chromosomes?

   a. 2
   b. 4
   c. 6
   d. 8

4. At what stage of mitosis are spindle fibres formed?

   a. Prophase
   b. Metaphase
   c. Anaphase
   d. Telophase

5. The structure that holds the sister chromatids together is

   a. chromatin
   b. centriole
   c. centrosome
   d. centromere

6. In meiosis the chiasmata formation will only occur during

   a. Prophase I
   b. Metaphase I
   c. Anaphase I
   d. Telophase I

APPENDIX A CONTINUED

7. In mitosis, the number of cells is/are

   a. halved

   b. doubled

   c. unchanged

   d. tripled

8. At what stage of meiosis are homologous pairs of chromosomes formed bivalent?

   a. Prophase I

   b. Metaphase I

   c. Anaphase I

   d. Telophase I

9. In multicellular organisms, the process of mitosis is to ensure

   a. Metabolism

   b. Growth

   c. Sensitivity

   d. Life span

10. The function of the mitotic spindle is to

   a. hold cells together

   b. separate cells from each other

   c. link the cell plate the nuclear membrane

   d. pull the chromosomes to the poles

APPENDIX A CONTINUED

SECTION B

Circle **True** or **False** as your correct answer

11. The centriole forms spindle fibres during cell division.

True or False

12. During cell division, second meiotic division begins at Prophase II. True or False

13. The mitotic division involved two main phases. True or False

14. Each sex cell in humans contains 23 pairs of chromosomes. True or False

15. The centromere is also the uncondensed DNA in the cell at Interphase. True or False

16. The mitotic division will not take place in the human ovary. True or False

17. In unicellular organisms, cell division will result in reproduction. True or False

18. There is no interphase at the onset of the second meiotic division. True or False

19. A cell division which produces two identical daughter cells is meiosis. True or False

20. During cell division, the nucleus divides first by cytokinesis. True or False

APPENDIX B

UNIVERSITY OF EDUCATION, WINNEBA SCIENCE EDUCATION DEPARTMENT DATA COLLECTION INSTRUMENT FOR M. PHIL IN SCIENCE EDUCATION THESIS RESEARCH

POSTTEST

Serial No. of Participant: …………………………………………………

Sex:………………………………………… Class:……………………………...

Name of School: …………………………………………………………

Instruction: This test contains twenty (20) questions grouped into section A, & B. Please answer ALL the two sections of the test.

SECTION A

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

1. At what stage of meiosis are chromosomes aligned at the equator of the spindle?

   a. Prophase I

   b. Metaphase I

   c. Anaphase I

   d. Telophase I

APPENDIX B CONTINUED

2. Cell that consists of only one set of chromosomes is

   a. diploid

   b. triploid

   c. haploid

   d. tetrapod

3. The number of chromosomes in each of the daughter cells at the end of mitosis is

   a. 46

   b. 23

   c. 48

   d. 24

4. At what stage of meiosis are homologous chromosomes separated?

   a. Prophase I

   b. Metaphase I

   c. Anaphase I

   d. Telophase I

5. Meiosis ensures that the diploid number of chromosomes in an organism is

   a. halved

   b. doubled

   c. unchanged

   d. tripled

APPENDIX B CONTINUED

6. In unicellular organisms, the process of cell division is a means of

a. Growth

b. Reproduction

c. Sensitivity

d. Lifespan

7. In humans, meiotic cell division will take place in the

a. ovary liver

b. Liver

c. Kidney

d. spleen

8. All the following phases make up the interphase except

A. G1 stage

B. S stage

C. G2 stage

D. M stage

9. During meiosis, crossing over is significant because it may give rise to

a. Variation

b. Species

c. Reproduction

d. Growth

APPENDIX B CONTINUED

10. At what stage of meiosis are four haploid daughter cells formed?

    a. Prophase

    b. Metaphase II

    c. Anaphase II

    d. Telophase II

SECTION B

Circle **True** or **False** as your correct answer.

11. No new cells will be formed, if telophase fails to occur in mitosis. True or False

12. The meiotic division will take place in mammalian bladder. True or False

13. The chromosome consists of two identical sister chromatids. True or False

14. In mitosis, chromatids move towards the opposite poles at Metaphase. True or False

15. In humans, each somatic cell has 23 chromosomes. True or False

16. In multicellular organisms, cell division will give rise to only growth. True or False

17. The second stage of the mitotic cell division is the Prophase. True or False

18. The mitotic spindle will pull the chromosomes to the poles. True or False

19. Each identical daughter cell consists of 23 chromosomes at Telophase, True or False

20. Division of the nucleus during cell division is termed as karyokinesis. True or False

APPENDIX C

MARKING SCHEME FOR PRETEST AND POSTTEST ITEMS

Expected Responses for Scoring Test Items Pretest

1. C
2. C
3. A
4. B
5. D
6. D
7 B
8. A
9. B
10. D
11. True
12. True
13. False
14. False
15. False
16. True
17. True
18. True
19. False
20. False

1.B
2. C
3. A
4C
5. C
6.B
7 A
8. D
9. A
10. D
11. True
12. False
13. True
14. False
15. False
16. False
17. False
18. True
19. False
20. True

APPENDIX D

UNIVERSITY OF EDUCATION, WINNEBA SCIENCE EDUCATION DEPARTMENT DATA COLLECTION INSTRUMENT FOR M. PHIL IN SCIENCE EDUCATION QUESTIONNAIRE FOR STUDENTS

Introduction

This questionnaire seeks to find out your perceptions on the use of Computer Assisted Instruction (CAI) in the teaching and learning of cell division concept. Please respond to each item to the best of your knowledge. The information you supply will be given the utmost confidentiality. You are therefore not to write your name anywhere in the questionnaire. In responding to the items on the questionnaire, please be as honest as possible. It will be used purposely for a research work.

Thank you.

Serial No. of Participant…………………………………………………………………

SEX: ……………………………………… Class: ……………………………..….

Name of School: ……………………………………………………………………

Instruction

The scale notation is given as: S A = Strongly Agree, A = Agree, U = Uncertain, D = Disagree, and S D =Strongly Disagree. Please, indicate with a tick the extent to which you agree or disagree with the following statements

S/N	**Statement**	**SA**	**A**	**U**	**D**	**SD**
1	CAI enhanced my critical thinking skills.					
2	I think CAI improves quality of instruction					
3	CAI enabled me to be active during lessons.					
4	CAI made me understand the cell division.					
5	I think CAI improves lesson delivery					

6	CAI aroused my interest in cell division					
7	I think other science teachers must use CAI.					
8	CAI made cell division more practical for me.					
9	I learnt new computer skills with CAI					
10	CAI made me retain more information.					

APPENDIX E

PRE-TEST AND POST-TEST SCORES FOR CONTROL GROUP STUDENTS

S/NO	PRETEST	POST TEST
001	13	14
002	09	14
003	12	15
004	10	12
005	10	14
006	11	13
007	09	13
008	09	15
009	14	12
010	11	16
011	12	14
012	13	12
013	09	15
014	11	16
015	12	18
016	08	13
017	12	17
018	10	17
019	11	13
020	11	13
021	13	14

022	08	16
023	13	14
024	08	14
025	12	15
026	12	15
027	13	15

S/NO	PRETEST	POST TEST
028	08	13
029	11	17
030	08	11
031	12	15
032	12	15
033	16	18
034	09	13
035	11	17
036	12	15
037	11	14
038	13	16
039	09	11
040	12	18

APPENDIX F

PRE-TEST AND POST-TEST SCORES FOR EXPERIMENTAL GROUP STUDENTS

S/NO	PRETEST	POST TEST
001	14	18
002	09	18
003	11	19
004	12	19
005	10	18
006	14	19
007	08	16
008	07	15
009	14	18
010	15	19
011	16	18
012	08	15
013	11	17
014	09	15
015	12	15
016	08	19
017	12	15
018	10	18
019	13	18
020	12	16

021	14	18
022	12	18
023	13	17
024	13	19
025	18	15
026	10	15
027	10	17

PRE-TEST AND POST-TEST SCORES FOR EXPERIMENTAL GROUP STUDENTS

S/NO	PRETEST	POST TEST
028	**13**	**18**
029	**09**	**15**
030	**12**	**18**
031	**14**	**18**
032	**07**	**15**
033	**11**	**16**
034	**12**	**15**
035	**08**	**15**
036	**09**	**19**
037	**11**	**17**
038	**12**	**19**
039	**12**	**18**
040	**08**	**16**

APPENDIX G

GHANA EDUCATION SERVICE 2020/2021 ACADEMIC CALENDAR FOR SENIOR HIGH SCHOOLS DOUBLE-TRACK & SINGLE-TRACK SCHOOLS

ALL YOU KNOW

- The basic principle of the academic calendar is that every track of students will have 8 months of contact time in a 12-month calendar year.
- In the case of the 2020/2021 academic calendar, it is September 2020 to August 2021.
- Students in both Double-Track and Single- Track schools receive their 8 months minimum in the 12-month cycle.
- Semester 2 for Single-Track schools is five (5) months: January 5th to June 5th, 2021. This includes statutory breaks for national holidays and a mid-semester break.
- double-Track schools, each track of students will have their 8 months of schooling by the end of August 2021
- First Semester for Form 2 Gold ends on May end of August 2020. 8th. Second Semester for Form 2 Gold students is: May 11th, to August 28th, 2021.
- Form2 Gold will break for Easter and will also have mid semester break in June 2021.
- The Double-Track calendar allows for uninterrupted period of academic work for Form 3 students.
- To provide additional time for Form 3 students on both Single and Double track schools to prepare for their final examinations, they return on January 5th and stay till June 4th, 2021 (end of WASSCE).
- The 2020/2021 free SHS Academic calendar is well taught out and with input from key stakeholders

Contact time has been increased from 1,080 under the trimester to **<u>1.134 hours</u>** under the semester system and the double-track calendar.

ACADEMIC CALENDAR FOR SCHOOLS WITH ONLY SHS 2 RUNNING DOUBLE TRACK

	JAN. 2021	FEB. 2021	MARCH 2021	APRIL 2021	MAY 2021	JUNE 2021	JULY 2021	AUG. 2021	SEPT. 2021	OCT. 2021	NOV. 2021	DEC. 2021	JAN. 2022	CONTACT HOURS
SHS 3			VAC						WASSCE		END OF SCHOOL			1,080
SHS 2 GREEN				VAC					VAC					1,440
SHS 2 GOLD	VAC						VAC							1,440
SHS 1	FSHS ADMISSION						VAC							1,350

TIMETABLE FOR SCHOOLS WITH ONLY SHS 2 RUNNING DOUBLE TRACK

FORM	FIRST SEMESTER				SECOND SEMESTER			
	IN SCHOOL		VACATION		IN SCHOOL		VACATION	
	FROM	TO	FROM	TO	FROM	TO	FROM	TO
3	15th Jan., 2021	30th June, 2021	5th March, 2021	4th May, 2021	1st July, 2021	UNTIL END OF WASSCE	END OF ACADEMIC YEAR	
					NOTE: WASSCE TO BE TAKEN SEPT./OCT. 2021			
2 GREEN	15th Jan., 2021	30th June, 2021	BREAK FROM 22ND MARCH TO 31st MAY		1st July, 2021	28th Jan., 2022	BREAK FROM 28TH AUG. TO 30TH OCT.	
2 GOLD	10th March, 2021	28th May, 2021	29th May, 2021	29th Aug., 2021	30th Aug., 2021	28th Jan., 2022	END OF ACADEMIC YEAR	
1	18th March, 2021	15th June, 2021	16th June, 2021	31st Aug., 2021	15th Sept., 2021	28th Jan., 2022	END OF ACADEMIC YEAR	

Ghana Education Service (GES)

2022 ACADEMIC CALENDAR

TRANSITIONAL CALENDAR (SHS)

	JAN 2022	FEB. 2022	MARCH 2022	APRIL 2022	MAY 2022	JUNE 2022	JULY 2022	AUG. 2022	SEPT. 2022	OCT. 2022	NOV. 2022	DEC. 2022
SHS 3				BRK				WASSCE 2022			END OF SCHOOL	
SHS 2					VAC				BRK			
SHS 1		FSHS ADMISSION		EB			VAC					

*EB – Easter Break

2022

ACADEMIC CALENDAR FOR SINGLE TRACK SCHOOLS

	JAN. 2021	FEB. 2021	MARCH 2021	APRIL 2021	MAY 2021	JUNE 2021	JULY 2021	AUG. 2021	SEPT. 2021	OCT. 2021	NOV. 2021	DEC. 2021	JAN. 2022	CONTACT HOURS
SHS 3			VAC						WASSCE		END OF SCHOOL			1,080
SHS 2			BRK				VAC							1,440
SHS 1	FSHS ADMISSION						VAC							1,350

TIMETABLE FOR SINGLE TRACK SCHOOLS

FORM	FIRST SEMESTER				SECOND SEMESTER			
	IN SCHOOL		VACATION		IN SCHOOL		VACATION	
	FROM	TO	FROM	TO	FROM	TO	FROM	TO
3	15th Jan., 2021	30th June, 2021	BREAK FROM 5TH MARCH TO 4TH MAY		1st July, 2021	UNTIL END OF WASSCE	END OF ACADEMIC YEAR	
					NOTE: WASSCE TO BE TAKEN SEPT./OCT. 2021			
2	15th Jan., 2021	1st June, 2021	2nd June 2021	31st July, 2021	1st Aug., 2021	15th Nov., 2021	END OF ACADEMIC YEAR	
1	18th March, 2021	16th July, 2021	17th July, 2021	12th Aug., 2021	13th Aug., 2021	30th Nov., 2021	END OF ACADEMIC YEAR	

Ghana Education Service (GES)

2022 ACADEMIC CALENDAR

TRANSITIONAL CALENDAR (SHS)

FORM	SESSION	FIRST SEMESTER				SECOND SEMESTER			
		IN SCHOOL		VACATION		IN SCHOOL		VACATION	
		FROM	TO	FROM	TO	FROM	TO	FROM	TO
3		7th Feb. 2022	1st April 2022	2nd April 2022	18th April 2022	19th April 2022	UNTIL END OF WASSCE	END OF ACADEMIC YEAR	
2	1st	7th Feb. 2022	14th April 2022	15th April 2022	25th June 2022	17th July 2022	26th Aug. 2022	27th Aug. 2022	6th Oct. 2022
	2nd	26th June 2022	16th July 2022	2ND SEMESTER BEGINS/NO BREAK		7th Oct. 2022	16th Dec. 2022	END OF ACADEMIC YEAR	
1	1st	4th April 2022	20th June 2022	21st June 2022	3rd Sept. 2022	25th Sept. 2022	16th Dec. 2022	END OF ACADEMIC YEAR	
	2nd	4th Sept. 2022	24th Sept. 2022	2ND SEMESTER BEGINS/NO BREAK					

WASSCE DATES AUG./SEPT. 2022

SHS 3	32 WEEKS	1,280 HOURS
SHS 2	30 WEEKS	1,200 HOURS
SHS 1	27 WEEKS	1,080 HOURS

2022