**UNIVERSITY OF EDUCATION, WINNEBA**

# IMPROVING STUDENTS' CONCEPTUAL KNOWLEDGE AND PERFORMANCES IN CELL DIVISION IN LIVING THINGS USING ICT INTEGRATION

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# DECLARATION

## Student's Declaration

I, **IRENE SARPAH**, hereby declare that this thesis, with the exception of quotations and references contained in published works that 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 hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

**Name: DR. CHARLES KWESI KOOMSON**

**Signature**: ……

**Date:** ……

## DEDICATION

To God and my family, especially my Dad Rtd. D.D.P. L.A. Amankwanor.

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## ACRONYMS

| | |
|---|---|
| AT | Activity Theory |
| CLTM | Conventional Lecture & textbooks method |
| EFL | English as a Foreign Language |
| ICT | Information Communication Technology |
| SHS | Senior High School |
| SCL | Student Centred Learning |
| UNESCO | United Nations Educational. Scientific and cultural organization |
| WSIS | World Summit on the Information Society |

## ABSTRACT

The purpose of this study was to use ICT to improve students' conceptual knowledge and understanding of cell division. An action research design was used for the study. The researcher employed random sampling to sample fifty (50) students out of a population of one hundred and twenty (120), 6 respondents were randomly selected for the qualitative aspect of the study. The data gathered was analysed both quantitatively and qualitatively. Pedagogical factors, such as interactive teaching methods and visual aids, significantly enhance student comprehension of cell division concepts. The use of demonstrations and animations in teaching science has been shown to improve learning outcomes. It was concluded that, effective biology education should prioritize pedagogical approaches that involve interactive teaching methods and multimedia resources to engage students and aid comprehension. Incorporating visual aids and demonstrations can help students better understand complex topics like cell division. To address the challenge of comprehending basic concepts in cell division, educational institutions should consider implementing innovative teaching methods, such as multimedia resources and hands-on laboratory activities, to facilitate a more intuitive and engaging learning experience. Additionally, personalized support, including tutoring or peer mentoring, should be readily available to students who express difficulty in grasping these concepts, ensuring that they receive the necessary assistance and resources to succeed in their cell biology coursework.

# 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 includes research questions, hypothesis, significance of the study, delimitation, limitation, abbreviations, and organisation of the research report.

### 1.1 Background of to the Study

Educators give special recognition to biology among the sciences because of its educational values, its close relation to man as a living organism, its peculiar field of experimentation and its interrelationships with the other sciences (Yeboah, 2014). The integration of Information and Communication Technology (ICT) into education has brought transformative changes to teaching and learning worldwide. One of the prominent challenges in education across the globe is enhancing students' conceptual understanding and academic performance in complex subjects, including biology. This study focuses on harnessing the power of ICT integration to improve students' conceptual knowledge and performance in the intricate topic of cell division in living organisms. Science is regarded as the bedrock of modern day's technology. Countries all over the world especially developing ones like Ghana are making lots of efforts to develop technologically and scientifically. This has become necessary because the world is turning scientific (Quarcoo-Nelson, Buabeng & Osafo, 2012). In all the history of education, science has held its leading position among all school subjects because it is considered as an indispensable tool in the development of the educated person.

Cell division is a fundamental biological process that underpins growth, development, and reproduction in all living organisms. It is, however, a conceptually challenging topic that often poses difficulties for students due to its abstract and intricate nature (Tibell & Rundgren, 2010). Regardless of location, students worldwide encounter similar conceptual hurdles when trying to grasp the mechanisms and intricacies of cell division. Traditional teaching methods have struggled to effectively convey these concepts globally, and this is where the potential of ICT integration comes into play.

Within the African context, educational challenges often intersect with resource limitations, making it even more critical to explore innovative teaching approaches. Across Africa, students grapple with the complexities of cell division in biology (Çalik & Ayas, 2005). However, many educational institutions in Africa face resource constraints, which can hinder the adoption of modern teaching methods like ICT integration. Therefore, investigating the efficacy of ICT in this context is particularly relevant.

Zooming in on Ghana, the challenges and opportunities in implementing ICT integration in education take on a unique dimension. Ghana, like many African nations, has made strides in improving its educational system but still faces infrastructure and resource limitations in many regions. The new education reform has placed emphasis on the teaching and learning of ICT. The further development of computers and the internet in the 1990s has introduced a virtually endless capacity for the acquisition of information and presentation of material and has proven to be one of the most influential tools for education. Online resources have provided easier access for students to material that had previously been difficult and time-consuming to obtain. Tools, such as slide shows created using Microsoft PowerPoint, and textbook CDROMs, are continually being

developed with the hope of creating more effective and interesting ways to convey information and enabling students to better understand classroom material.

The Ghanaian educational system emphasizes the importance of biology, including the topic of cell division, in its curriculum. However, there is a need to tailor approaches to fit the Ghanaian context, considering factors such as the availability of ICT resources, teacher training, and student access (McLoughlin & Lee, 2007).

### 1.2 Statement of the Problem

In contemporary education, the effective teaching and learning of complex scientific concepts, such as cell division in living organisms, present significant challenges. One specific concern revolves around the imperative to enhance students' conceptual knowledge and academic performance in this pivotal area of biology (Johnson, 2019). Cell division serves as a foundational concept in understanding the growth, development, and functioning of living organisms; however, many students grapple with comprehending the intricacies of this topic due to its abstract and dynamic nature (Brown, 2020).

In the biology lesson at Abetifi Presbyterian Senior High School, it was observed that 2021/ 2022 second year Senior High School (SHS) have difficulties conceptualizing the concept of cell division in living things. These difficulties have been attributed to the conventional lectures and textbooks methods (CLTM) often used by teachers at the Basic and SHS Levels in teaching this abstract concept to these young and novice students. This CLTM used by most of the teachers at the SHS have made it difficult for students to grasp the needed conceptual knowledge and practical skills embedded in the concept of cell division in living things.

This development had impacted negatively on the students' performance and interests in biology as a subject. If this poor performance among 2021/2022 second year SHS biology students is left untreated, then the country Ghana may soon lose great scientists of calibre like Professor Francis Kofi Allotey, Prof. Emeritus Ebenezer Laing, Prof. Elsie Effah Kafmann and many others in the near future.

Traditional teaching methods have been unable to fully address these challenges (Wilson, 2017). Textbooks, diagrams, and verbal explanations, which are often relied upon, may fall short in effectively conveying the dynamic and three-dimensional aspects of cell division (Roberts, 2016). Furthermore, the diverse learning styles among students are not always accommodated adequately, as traditional teaching methods may not cater to the needs of visual or kinesthetic learners (Jones, 2021).

The advent of Information and Communication Technology (ICT) presents a promising avenue to mitigate these issues (Anderson, 2019). ICT integration in education has the potential to revolutionize the teaching and learning of cell division (Brown, 2020). Through interactive simulations, animations, virtual labs, and educational apps, ICT can make the abstract concepts of mitosis and meiosis more tangible and comprehensible for students (Smith and Aderson, 2018). It also addresses the diverse learning styles by providing personalized learning experiences that cater to individual needs (Johnson, 2019).

This research aims to explore and implement effective strategies for integrating ICT tools and resources into the teaching of cell division in living things, with the primary objective of improving students' conceptual knowledge and academic performance in this critical area of biology (Roberts, 2016).

Addressing the problem of improving students' conceptual knowledge and performance in cell division through ICT integration holds immense significance (Jones, 2021). It not only contributes to the advancement of biology education but also equips students with the essential knowledge and skills required for careers in the life sciences (Anderson, 2019). Additionally, it has broader implications for the integration of technology in education as a whole (Brown, 2020).

This study strives to bridge the gap between traditional teaching methods and the potential benefits of ICT integration in biology education. By doing so, it seeks to empower students with a deeper understanding of cell division, ultimately nurturing a generation of scientifically literate individuals capable of making meaningful contributions to the fields of biology and beyond (Smith, 2018).

### 1.3 Purpose of the Study

The purpose of the study was to help improve the performance of second-year SHS students of Abetifi Presbyterian Senior High School in cell division in living things using the ICT integration.

### 1.4 Objectives of the Study

The objectives of this study are to: -

1) assess students' difficulties in understanding the concept of cell division in living things.
2) identify causes of students' difficulties in understanding the concept of cell division in living things.
3) evaluate the effects of ICT integration in classroom teaching on students' performance in the concept of cell division in living things.

4) examine SHS students' attitudes towards the use of ICT integration in learning the concept of cell division in living things.

### 1.5 Research Questions

The study was guided by the following research questions:

1. What are the students' difficulties in understanding the concept of cell division in living things?
2. What are the causes of students' difficulties in understanding the concept of cell division in living things?
3. Are there any differences in performance among the SHS students before and after exposure to the ICT integration in learning the concept of cell division in living things?
4. What are the SHS students' attitudes towards the use of ICT integration in learning the concept of cell division in living things?

### 1.6 Research Hypotheses

The research question three was be analyzed using the hypothesis below. The following hypotheses were designed to guide and direct the study:

$H_0$: There is no statistically significant difference in scores between the mean pre-test scores and the mean post-test scores of students before and after exposure to the ICT integration in learning the concept of cell division in living things.

### 1.7 Significance of the Study

The outcome of this study would help science educators and SHS teachers especially, Biology teachers at Abetifi Presbyterian SHS to embrace ICT integration into the teaching and learning of abstract biological concepts such as the cell division in living things.

The study would identify the SHS students' difficulties and challenges that impede their conceptual understanding of cell division in living things. This would enable biology teachers at the SHS level to adopt the innovative strategy such as classroom ICT integration to address students' difficulties in this concept.

Once more, the study would outline the causes of SHS students' difficulties in understanding cell division in living things. In this way, teachers will become more aware of the causes of students' difficulties so that innovative strategy could be used to solve such difficulties in biology classes.

The study would also highlight the attitudes of the pre-service science teachers' towards the use of ICT integration in the learning of abstract biological concepts such as the cell division in living things

Furthermore, the study would also bring to bear the effects of classroom ICT integration in improving students' performance in the concept of cell division in living things.

Finally, the study would serve as a source of reference for those who wish to carryout similar study into using ICT integration to improve students' performance in cell division and other abstract biological concepts.

**1.8 Delimitation of the Study**

The study was delimited to only Abetifi Senior High School. Within the Abetifi Senior High School, the study was further narrowed down to only the 2021-2022 second year students pursuing General Biology I course. Among the 2021-2022 second year, the study was delimited to only 50 students; made up of 30 males and 20 females used for the study. Again, the study was be further delimited to improving the performance of form two SHS students of Abetifi Presbyterian Senior High School in cell division in living things using the ICT integration.

## 1.9 Limitations of the Study

Some limitations anticipated to affect the validity and reliability of the results of study are that;

Firstly, the ICT integration into classroom teaching requires the efficient manipulation of some ICT tools such as; internet bundle and connectivity, laptop computers, desk-top computers, smartphones and projectors. These ICT tools are, however, very expensive in terms of cost and accessibility for both the teachers and students to afford.

Again, since the research subjects were humans, some students changed their behaviours and attitudes towards the researcher during the data collection. Thus, in an intact class of 100 students, the researcher ended up working with 50 students and this also affect the validation of the result.

Furthermore, absenteeism was another limitation. This is because most of the students often absented themselves from school especially, during the intervention stage and this again effected collection of data and subsequently, the study results.

Finally, the breakdown of my computer hard disc was another limitation. During the study, the hard disk of the computer I used for the lesson which also contained all the typed documents got crushed; making the retrieval of the typed document very difficult. Therefore, the whole work was retyped; and this was seen a major limitation.

## 1.10 Organization of the Study

This study was organized into five (5) chapters. Chapter one presents the background to the study, statement of the problem, purpose of the study, research questions, significance of the study, delimitation, limitations of the study and the organization of the study. Chapter two describes the review of related literature that underpins the study. Chapter Three discusses the methodology employed in the study and it includes research design,

population sample and sampling procedure, instruments, data collection procedure and data analysis methods. Chapter Four presents the analysis of the results and discussion of the findings of the study. Finally, Chapter Five being the last chapter covers the summary of the study, conclusions, recommendations and suggestions for further studies.

### 1.11 Operational Definition of Terms

**Computer Technology:** Refers to methods, systems, and devices which are used to better people's learning at home, school, work etc.

**ICT Integration**: Is the combination of various digital media types, such as text, images, sound, and video, into an integrated multisensory interactive application or presentation to convey a message or information to an audience.

**Traditional Learning:** Learning through pedagogies that focus on teacher directed instruction.

This may include lecture, discussion, group, and individual learning within the regular classroom environment.

**Interactive Learning:** Any educational strategy that encourages independent study through the use of computer technology and electronic media.

**Mobile Technology:** A variety of portable devices on which technology can be used. These could include mobile phones, laptops, tablets, etc.

**Smart Phone:** A cellular phone offering advanced capabilities, such as a PC-like operating system and Internet access.

**Student-Centered Learning (SCL):** Active and collaborative approaches to learning as opposed to teacher-centered approaches in which students passively gain knowledge from a lecture.

**Social media:** For the purpose of this study, social media is defined as any technology used to communicate beyond the classroom, including technology developed for social purposes and which have crossed over for uses in professional and academic uses (Bingham & Conner, 2010).

CDKs- cyclin-dependent kinases

# CHAPTER TWO

## REVIEW OF RELATED LITERATURE

### 2.0 Overview

This chapter discusses the literature relevant to the study. The major objective of the study was to explore the effect of ICT Instruction on Students' Achievement and Retention in Cell division. The purpose is to provide the basis for drawing generalization in the research study. The following topics will be discussed under this chapter:

1. theoretical framework
2. the concept of cell division
3. concept of ICT
4. ICT policy and educational trends in Ghana
5. accessibility to ICT resources in biology teaching
6. extent to which ICT resources are used in teaching biology.
7. teachers and pupils' attitudes towards ICT use
8. ICT as teaching and learning resources.
9. benefits of using ICT in the teaching and learning process
10. barriers that hinders' the use of ICT in the classroom teaching
11. factors determining the use of ICT to facilitate learning.
12. effects of gender on the use of ICT in teaching
13. empirical studies
14. chapter summary

### 2.1 Theoretical Framework of the Study

The theoretical basis of the study was built on notion of Meaningful Learning through Participatory Process. This idea holds that resources are used to involve students in the learning process, with teachers acting as facilitators (Ausubel, 1963). Meaningful

learning occurs when new information is connected to what is already known. This is substantive integration of new knowledge into cognitive structure through an interactive process that is non-arbitrary and non-verbatim. A deliberate attempt is made, with an emphasis on the integration of ICT, to link new knowledge with high order concepts into the students' cognitive structures during the teaching and learning process, which is the dependent variable in this study.

ICT Mind Engagement Model which emphasises the use of ICT in learning, establishes the cognitive framework, and links it to the information already existent there, is a supplement to Ausubel's idea of Meaningful Learning (Craig & William, 2004). David Ausubel, a cognitive learning theorist, emphasised that interactive learning is the best way for students to absorb material from different disciplines because it helps them better integrate what they have already learned with the new information that constructivism has offered.

The core concept of Ausubel's theory, a constructivist theory, is that students can have worthwhile learning experiences in an interactive classroom environment. According to Craig Will's Model, integrating ICT improves learning and transforms it into an active process that includes additional processes like analysis, evaluation, and judgement, emphasising the learners' capacity to construct and apply knowledge and skills acquired outside of the classroom setting.

An advocate of this theory, Ausubel, claims that students create their environments by fusing new knowledge with what they already know through cooperative learning with resources, teachers, and their surroundings. This is particularly beneficial when ICT is used to enhance and support interactive learning in the classroom by presenting a variety of learning activities. Ausubel emphasised the value of meaningful learning, which could

be accomplished by letting the students use ICT resources and connecting what they already knew to the new information in order to better understand and comprehend the concepts. Fundamentally, constructivism should let the pupils see and understand the subject matter (Kozma, 2003).

This study and the theory are well-aligned because ICT integration emphasises affective commitment to tie new knowledge to prior learning, make the organisation of new material explicit, and make the logical order of learning material explicit to the students.

The investigation's supporting theories are these two hypotheses. The first pertinent supporting theory for this study is the Activity Theory (AT) (Engeström, 1987) which takes a socio-cultural perspective. It backs up the idea that educators must place their lessons in the broader context of the learning environment. By using Activity Theory as the framework for this study, the interface between the teacher, learning, and idea development is shown in the learning as an activity in and of itself. Teachers can use activity theory (AT), a broad framework, to incorporate diverse learning activities into their lessons in order to foster each student's unique progress (Mingaine, 2013). The range of learning activities that play different roles in a learner's growth depending on the goal of the content itself cannot be brought about by ICT integration without the instructor acting as the major provider of these various activities. All purposeful learning activities are conceptualised according to Engeström's paradigm as the interaction of the elements of subject, object, tools, community, rules, and labour division. The following inquiries are addressed in this study using these elements of the activity theory model: (teaching experience, teaching approach, the place of learning in daily life, the necessity of knowledge and skills related to learning). The goal (or objective) of teaching and learning is to be accomplished (knowledge and skills acquisition, problem solving). ICT is not one

of the elements working in concert with the others to generate an effective learning process that fosters conceptual understanding and creativity in students (Engeström, 1987). The proponent of the idea is in favour of ICT integration in light of its elements. When teachers actively employ digital tools in the classroom to promote active engagement from students, it is said that they are at the stage of expansion. He concludes by defining Refinement as a stage in which technology is considered as a process and a useful tool to help pupils overcome problems in real life. All of the theories are relevant to this study because they shed light on the benefits and support the need for ICT integration in secondary school biology teaching and learning.

### 2.2 The Concept of Cell Division

Cell division in human cells is intricately regulated to guarantee precise duplication of genetic material and proper distribution of cellular components to daughter cells (Alberts at al., 2014). The process involves various key mechanisms such as cyclin-dependent kinases (CDKs) and cyclins, which orchestrate the orderly progression through different phases of the cell cycle. CDKs, a family of protein kinases, are activated at specific points in the cell cycle and play a crucial role in phosphorylating selected proteins to induce downstream processes. On the other hand, cyclins, which periodically activate CDKs, are essential for different phases of the cell cycle, with specific cyclins required at distinct stages like G1, S, G2, and M phases (Lodish et al., 2000). Moreover, cell cycle checkpoints act as surveillance mechanisms that monitor the order, integrity, and fidelity of major events during cell division. These checkpoints ensure that cells grow to the appropriate size, replicate and maintain the integrity of chromosomes, and accurately segregate genetic material during mitosis (Cooper et al., 2019). Dysfunctions in these checkpoint pathways can have significant implications on cell fate, including tumor suppression. The cell cycle checkpoints have evolved to control alternative cell fates and

maintain genome stability, with mechanisms that have been heavily informed by studies in simple organisms like yeasts and further developed in higher organisms.

### *2.2.1 Cell cycle*

The cell cycle in human cells is a series of events that a cell undergoes as it grows and divides. It consists of two major phases: interphase and the mitotic phase. Interphase is further divided into three stages: G1 (gap 1), S (synthesis), and G2 (gap 2). During interphase, the cell grows, replicates its DNA, and prepares for division. The mitotic phase consists of mitosis (nuclear division) and cytokinesis (cytoplasmic division) (Pines, 2001). Mitosis is the process by which the replicated DNA is separated into identical nuclei, while cytokinesis divides the cytoplasmic contents to form two daughter cells. The cell cycle is tightly regulated by internal control checkpoints, which ensure that all conditions are met for the cell to proceed through the different stages. There are three major checkpoints: one near the end of G1, a second at the G2-M transition, and the third during metaphase. These checkpoints monitor the preparedness of the cell to advance through the various stages of the cell cycle.

According to Nigg (2001) during interphase, the cell undergoes normal growth processes while also preparing for cell division. The first stage of interphase, G1, is the phase during which the cell accumulates the building blocks of chromosomal DNA and the associated proteins, as well as energy reserves to complete the task of replicating each chromosome in the nucleus (O'Connell et al., 2007). The S phase is the second stage of interphase, during which DNA replication occurs, resulting in the formation of two identical copies of each chromosome, known as sister chromatids. The G2 phase is the third stage of interphase, during which the cell undergoes the final preparations for mitosis. Mitosis is the process by which the replicated DNA is separated into identical nuclei. It consists of five stages: prophase, prometaphase, metaphase, anaphase, and telophase (Ganem et al.,

2007). During prophase, the chromosomes condense and the mitotic spindle begins to form.

### *2.2.2 Regulation of cell cycle*

The cell cycle is tightly regulated by cyclin-dependent kinases (CDKs) and cyclins, which promote progression through cell cycle phases. Key checkpoints (G1/S, G2/M, and metaphase-anaphase) ensure accurate cell division by monitoring DNA integrity and cell size. Furthermore, the checkpoints in the cell cycle play a critical role in monitoring DNA damage (Rieder et al., 1998). If DNA damage is detected, these checkpoints can halt the cell cycle progression, allowing time for repair mechanisms to fix the damage before proceeding with cell division. This is crucial for maintaining genomic stability and preventing the transmission of damaged DNA to daughter cells, which could otherwise lead to mutations or other cellular abnormalities (Cheeseman et al.,2008).

### *2.2.3 Mitosis: Phases and molecular events*

Mitosis comprises distinct phases: prophase, metaphase, anaphase, and telophase. During prophase, chromatin condenses into chromosomes. In metaphase, chromosomes align along the metaphase plate (Sullivan et al., 1986). Anaphase involves separation of sister chromatids, and telophase concludes with nuclear envelope reformation.

***Prophase:***

During prophase, the chromatin (a complex of DNA and proteins) condenses into visible chromosomes (Cheeseman et al.,2008). This condensation helps organize and protect the DNA during cell division. The nucleolus, which is responsible for producing ribosomes, also disappears during this phase. The mitotic spindle begins to form. The spindle is made up of microtubules and plays a critical role in moving and segregating the chromosomes

later in mitosis (Cheeseman et al.,2008). The centrosomes, organizing centers for microtubules, move to opposite ends (poles) of the cell and start to form spindle fibers.

***Metaphase:***

In metaphase, the condensed chromosomes align along the metaphase plate, which is an imaginary plane equidistant between the two poles of the cell. This alignment ensures that each daughter cell will receive the correct number and type of chromosomes (Rieder et al., 1992). The spindle fibers, attached to the centromeres of the chromosomes, exert tension and ensure that the chromosomes are properly aligned and oriented.

***Anaphase:***

According to (Stearns, 2001), Anaphase is characterized by the separation of sister chromatids. The connections (cohesins) holding the sister chromatids together at the centromere are cleaved by an enzyme called separase. As the connections are broken, the spindle fibers attached to the chromatids shorten, pulling the separated chromatids toward opposite poles of the cell. This movement ensures that each daughter cell will receive an identical set of chromosomes (Cooper et al., 2019).

***Telophase:***

Telophase marks the final stage of nuclear division. During this phase, the separated chromosomes arrive at opposite poles of the cell. Nuclear envelopes start to form around the sets of chromosomes, enclosing them in two distinct nuclei. The chromosomes begin to decondense back into chromatin. Simultaneously, cytokinesis, the division of the cytoplasm, usually begins during late anaphase or telophase (Cooper et al., 2019). In animal cells, a cleavage furrow forms, pinching the cell into two daughter cells. In plant cells, a new cell wall called the cell plate forms between the two nuclei (Cooper et al., 2019).

### *2.2.4 Regulation of mitosis and cytokinesis*

Mitotic progression is regulated by mitotic kinases such as Aurora kinases and spindle assembly checkpoint (SAC) proteins. SAC monitors kinetochore-microtubule attachments to ensure accurate chromosome segregation (Hinchcliffe et al., 1999). Cytokinesis completes cell division by physically dividing the cytoplasm. Contractile ring formation, regulated by Rho GTPases and the central spindling complex, drives cleavage furrow ingression and daughter cell separation (DeLuca, 2012).

### *Meiosis*

Meiosis is a fundamental process in sexual reproduction, ensuring genetic diversity in offspring. It involves two successive divisions (Meiosis I and Meiosis II), each comprising prophase, metaphase, anaphase, and telophase stages.

During prophase I, homologous chromosomes pair up and undergo genetic recombination through crossing over, increasing genetic variation

Metaphase I sees homologous chromosome pairs aligning at the metaphase plate, while anaphase I involves their separation and migration to opposite poles

Telophase I concludes with the formation of two haploid daughter cells. Meiosis II, similar to mitosis, separates sister chromatids, resulting in the formation of four haploid daughter cells, each genetically distinct.

### *Meiosis II*

**Prophase II:** If nuclear envelopes were formed, they fragment, and spindle fibers reappear.

**Metaphase II:** Chromosomes align at the metaphase plate, this time as single chromatids, with spindle fibers attached to each chromatid

**Anaphase II:** Centromeres divide, and sister chromatids are pulled to opposite poles of the cell by spindle fibers.

**Telophase II:** Chromosomes arrive at the poles of the cell, nuclear envelopes re-form, and the cell undergoes cytokinesis, resulting in four haploid daughter cells, each with a unique combination of chromosomes.

### *2.2.5 Cell division and disease*

According to Stearns (2001), Dysregulation of cell division can lead to diseases such as cancer. Abnormalities in cell cycle checkpoints or mitotic spindle apparatus can result in genomic instability and uncontrolled cell proliferation. G1/S Checkpoint: This checkpoint ensures that conditions are favorable for DNA synthesis (S phase) before cell division (Cooper et al., 2019). Dysregulation here can lead to the proliferation of cells with damaged DNA, increasing the risk of mutations being passed on to daughter cells (Cheeseman et al.,2008). G2/M check point, this checkpoint confirms the completion of DNA replication and checks for DNA damage before allowing entry into mitosis (M phase). (Hinchcliffe et al., 1999). Failure of this checkpoint can result in cells entering mitosis with unresolved DNA damage, leading to chromosomal abnormalities (Cooper et al., 2019). Mitotic Checkpoint (Spindle Assembly Checkpoint): This checkpoint monitors the proper attachment of chromosomes to the mitotic spindle. Incorrect attachment can result in unequal distribution of chromosomes during cell division (aneuploidy), a common feature of cancer cells (Cheeseman et al., 2008).

## 2.3 Concept of ICT

Information Communication and Technology (ICT) is a broad category of technological tools and resources that are frequently used in education to communicate, generate, distribute, save, and manage information (Brurton, 2003). They include computers, the

Internet, radio and television transmission, mobile (telephony), digital cameras, and software (such as E-mail discussion forums). The phrase "information and communication technologies" (ICT) has a lengthy historical history.

According to Pelgrum and Law (2003), the term "computer" was superseded with "IT" near the end of the 1980s (information technology). This indicated a shift in emphasis from computer technology to information storage and retrieval capabilities facilitated by computers. Following this, the term "ICT" was first used in 1992, when the general public first had access to email. ICT is a mode-specific term that emphasises the importance of unified communication and the integration of telecommunication (telephone lines and wireless signals), computer, as well as necessary enterprise. According to Wikipedia, ICT is frequently used as an extended synonym for information technology (IT), but it is a mode-specific term. ICT, as it is now known, is a group of technical resources and technologies that, when utilised properly, have the ability to significantly improve student learning (Wang, 2001). ICT was once thought to be the existence of a computer that could simplify mathematical and scientific activities. Instead of employing computers as the exclusive delivery mechanism in Kenya, complex technological fusions are used.

ICT is a term that educational technologists use and talk about a lot these days. Unless specifically defined, the word can also refer to the development of computer-based hardware and software packages that are mass-produced but nevertheless provide individualised use and learning, such as a careful blending of different mass media like text, audio, and video. ICT essentially combines many learning echelons into a teaching instrument that supports a variety of curricula presentations. ICT, or information and communication technology, is the fascinating union of computer hardware and software that enables you to combine video, animation, audio, graphics, and test resources to create powerful presentations on a reasonably priced desktop computer (Fenrich, 1997).

Text, images, sounds, animation, and video are all present in ICT, and some or all of them are grouped into a single, coherent programme (Phillips, 1997). ICT nowadays is a skilfully crafted synthesis of text, visual art, sound, animation, and video components. It becomes interactive ICT when you provide the end user, or the person viewing an ICT project, influence over "what," "when," and "how" the elements are delivered and presented. ICT is therefore described as the synthesis of several media elements (audio, video, graphics, text, animation, etc.) into a cohesive whole that offers the end user greater advantages than any one of the media parts could do on its own.

In addition to being an effective presentation tool, ICT has special benefits for the educational sector. ICT gives teachers the ability to provide students a virtual experience with their subject. The secret to delivering this experience is having graphic, video, and audio elements all present at once rather than sequentially. The popularity of the current generation of video games on the market serves as the best example of the attractiveness of ICT learning. These are ICT programmes that seamlessly combine text, audio, video, and animated visuals. Through ICT, the learning process may be made more collaborative between teachers and students, more goal-oriented, interactive, and flexible in time and location. It can also be personalised to each individual's learning preferences and unaffected by distance. Technology makes learning enjoyable and friendly, free from the worry of shortcomings or failure. It is possible to say that the use of ICT in the classroom has had a significant impact on teaching and learning methods (Slack, 1999). When using ICT, which one teacher called as "using the ICT "hook," students are perceived to be more motivated. Slack (1999) reports that teachers have said that ICT allows pupils to work at a varied speed and that some packages can be customised to meet the needs of individual students. When ICT is employed, teachers have said that they believe children are learning collaboratively. Instead of playing a prominent role, the instructor takes on

the roles of facilitator, problem-solver, and guide. ICT in the Process of Teaching and Learning ICT as a concept first emerged in the early 1990s. Computer media is a component of ICT.

### 2.4 ICT Policy and Educational Trends in Ghana

ICT approaches must now be included in the curricula of Ghana's pre-tertiary institutions due to policies like the Ghana ICT for Accelerated Development Policy (ICT4AD), among others. ICT has the power to affect every facet of educational activities.

In order to promote creativity, professional growth, information management, and better teaching and learning strategies, schools must support the effective use of ICT. Around the world, ICT is being used more and more frequently for teaching and learning, but in Ghana, official support for initiatives to encourage ICT use in education has just recently begun to develop. To guide the process of integrating ICT into education, other economic sectors, and teaching and learning, the Ghanaian government developed a variety of ICT policies:

The first national ICT strategy in the nation was the Ghana ICT for Accelerated Development Policy (ICT4AD), which was established in June 2003. The National Pre-Tertiary Education and ICT in Education. The main objective of this strategy is to promote an improved educational system supported by the deployment and use of ICT, ensuring the provision of educational services at pre-tertiary and tertiary institutions to improve access (National Pre-Tertiary Education Curriculum Framework, 2018). Every Ghanaian educational institution should be encouraged to have Internet access, and all pre-tertiary institutions should be equipped with computers (schools, colleges, and universities). The country's second ICT policy was the ICT in Education Policy, which was established in November 2008.

The main goal of this strategy is to provide university graduates from Ghana with a platform where they may confidently employ ICT skills to develop knowledge and original projects that improve technology (Ministry of Education ICT in Education Policy, 2008). ICT was introduced as a teaching subject and a foundation for its integration into the teaching and learning process at all levels of the educational system was given. These were the methods employed to do this (Ministry of Education ICT in Education Policy, 2008). Additionally, they included providing basic ICT skills training for Ghanaian teachers and ensuring ICT skills training for all teachers. Teacher training colleges were also outfitted and retooled to produce creative and inventive instructors.

The overarching objective of this strategy is to give graduates from Ghanaian institutions a platform where they can self-confidently use ICT skills to create meaning, knowledge, and start new technological discoveries (Ministry of Education ICT in Education Policy, 2008).

A platform for ICT integration into the teaching and learning process at all levels of the educational system was provided, and ICT was introduced as a teaching subject. These strategies were used to achieve this. They included outfitting and retooling teacher training colleges to train creative and innovative teachers (Ministry of Education ICT in Education Policy, 2008). The government's next initiative was the 2015 ICT in Education Policy. Three pillars-ICT as a tool for learning and working, ICT integration into teaching and learning, and ICT as a potential career path for students support this approach. An essential strategy for maintaining ICT integration and piquing students' attention is the inclusion of ICT at all levels of the Ghanaian educational system. The government has taken a number of steps to put these policies into practise, such as mandating ICT education at all educational levels, providing teachers with laptops, equipping 926

elementary, senior high, and a few tertiary institutions with computers and uninterruptible power supplies, and more.

### 2.5 Accessibility to ICT Resources in Biology Teaching and Learning

The ease with which ICT resources can be obtained and used during the teaching and learning process is referred to as "accessibility." The ICT integration process is successful when the resources are straightforward for teachers and students to access. Dragana and Zuochen (2012) claim that educational institutions do not offer ICT resources. This suggests that ICT resources are not available to instructors and pupils. The paucity of ICT resources, the high implementation costs, and the absence of a distinct digital curriculum, according to Langat (2015), are barriers to the deployment and use of ICT in the teaching and learning process. ICT resources are few, according to Mingaine (2013), but instructors are also compelled to use these tools because they lack formal training to develop, study, and use their ICT abilities.

The fundamental objectives of education, according to MOEST (2005) are said to be improved national and international access to ICT resources, as well as their quality and equity in service provision at all levels. The policy emphasises its commitment to ensure that all students' learning requirements are satisfied by making appropriate ICT learning resources available and encouraging effective and efficient ICT use at all levels of school.

### 2.6 Extent to which ICT Resources are used in Teaching Biology

Information and communication technology (ICT) is an established part of all of our lives, and very essential to education (Eamon 2008). The discussion surrounding ICT in education focuses on how it might affect teaching and learning as well as the policies that must be put in place to ensure that ICT's promise to improve students' educational., experiences is fully fulfilled.

The use of various ICT tools, such as computers, DVDs/simulations, the internet, video, and projectors, in the teaching and learning process is referred to as information communication technology, or ICT. It entails accessing information as well as the tools and services used in the teaching and learning process, as well as transferring, storing, retrieving, and exchanging views, opinions, and ideas (UNESCO, 2006). The usage of ICT tools, including websites, simulations, the internet, word processing, projectors, and computers, including laptops and desktops, was highlighted in this study.

Additional research has shown that in order to raise the level of successful ICT integration in the teaching and learning process, ICT use is incorporated into national policies and legislation in the majority of countries. Since 2003, when schools in Canada began using desktop or laptop computers for instructional purposes, such as lesson planning, execution, or evaluation, there is a high level of ICT integration (Dragana & Zuochen, 2012).

The World Summit on the Information Society (WSIS) conducted a study at the International Institute of Educational Planning with the goal of improving teachers' ICT proficiency and facilitating the use of ICT in the achievement of the developmental goals of the member countries, according to UNESCO report on developing and using indicators of ICT use in Education.

The main goal of the Plan is to make sure that everyone has the knowledge and skills required to fully benefit from ICT in a variety of fields, regardless of individual educational gaps. Ireland has made significant expenditures in ICT infrastructure in schools and in training for teachers and other professionals since the 1990s because they know that young people need to have their lives transformed by ICT and that they need opportunities to develop ICT skills from a young age (Eamon, 2008). Yet, Wagner and

Kozma (2003) assert that Africa uses ICT less frequently than industrialised nations like Canada.

They also suggest that even the most impoverished African nations should have computers in their pre-service teacher training facilities. New technologies should be introduced to educators and students during the learning process. Eamon (2008) contends that schools should adhere to simplified rules for integrating ICT into instruction. According to Kozma (2005), ICT should incorporate fundamental changes to improve education delivery and access in order to improve instructional effectiveness. Students who gain ICT knowledge and skills are better equipped for jobs where ICT is the primary focus of instruction. This improves students' learning through ICT integration in teaching and learning which influences students' achievement positively in Biology.

The Kenya Ministry of Education policy in Sessional Paper No. 1 2005 encourages the use of ICTs and related emerging technologies to improve lifestyle, support free basic education, improve health by combating diseases, increase agricultural sector by ensuring food security and integrate technology in advancement and development of research for social and economic development (MOEST, 2005).

On the policy on ICT integration in education, the Ministry of Education Science & Technology (MOEST, 2005) has set up a center called The National ICT Innovation and Integration Centre (NI3C). The center is charged with the role of gathering, documenting and facilitating the dissemination of information on the use of ICT in education, being the benchmark in making important decisions of ICT issues. The extent to which the implementation of ICT integration has been achieved is yet to be established. NI3C also conducts sessions and workshops to stakeholders in education on ICT integration, testing new pedagogical concepts and methodologies in relation to ICT integration, researching

on emerging technologies that can be integrated in education and arranging for teachers' professional development on ICT integration. The main aim of NI3C is to be an avenue for promoting and facilitating the dissemination of information on new technology in instructional process (MOEST, 2005). The Mission of the Centre is to gather all the information relevant to the integration of ICT in all aspects of education. The strategic plan of the MOEST (2005) holds that ICT can help realize the above stated mission substantially. The Kenyan government Ministry of Education in 2010 identified five secondary schools in each constituency across the country and supplied them with some basic ICT resources to promote ICT use in instructional process. There are also established centers of excellence in various schools as a way of promoting ICT use in classroom instruction especially in this techno savvy era (MOEST, 2005). This is a good plan which would go a long way to ensure the integration of technology in the instructional process in order to boost performance in all areas.

### 2.7 Teachers and Pupils' Attitude towards ICT Use

The attitude and use of ICTs by teachers and students in the teaching and learning process are significantly influenced by the ICT skills and knowledge of teachers and students. ICT abilities can affect how teachers and students conduct when using it in class activities. Also, the selection and use of ICTs that can be employed in the teaching and learning process can be influenced by teachers' and students' knowledge of ICT. In the study by Husain (2010), it was found that teachers believed that using ICT abilities for creating and presenting information was a crucial technical ability that teachers needed to achieve to improve the educational system.

However, the study by Zhang (2013) found that although teachers had some expertise about using the Internet for teaching and learning, they were not very good at doing so.

The study also indicated that teachers had very little expertise of IT and network technology.

Nonetheless, Sánchez et al (2012), study discovered that teachers had a favourable attitude about using digital technologies. Also, their survey showed that teachers were prepared to keep using digital tools in the classroom. Moreover, Sánchez et al. (2012) came to the conclusion that the majority of the teachers were prepared to keep learning computer tools for their usage in the classroom. According to Sánchez et al. (2012), teachers believed that computer tools were useful for retaining students' attention, enhancing interventions with students who needed assistance, and enhancing both teacher and student motivation and academic performance. Researchers Mehra and Newa (2009), Husain (2010), and Ndibalema (2014) found that teachers had a favourable attitude about using ICT.

The studies went on to state that ICT has to be prioritised more in teacher education curricula so that future educators can handle the system's many obstacles, particularly the new roles that instructors would play in ICT-based teaching-learning systems. Hew and Brush's study from 2007 indicated that teachers had unfavourable attitudes towards ICT. Although not negative, a second study by Sarangi (2003) revealed that teacher educators have a poor positive attitude towards ICT. According to Ang'ondi (2013), the Kenyan government launched the Economic Stimulus Programme (ESP) -ICT project, which had the dual goals of strengthening teachers' ICT integration skills and providing 1050 schools with ICT infrastructure.

It was anticipated that present and upcoming inventions will provide the crucial ICT infrastructure, know-how, and mindset required to promote ICT integration in teaching and learning in schools. According to research by Ang'ondi (2013), instructors were

likewise excited about integrating ICTs into the classroom, but there were still a number of obstacles keeping them from making full use of the technology. The teachers appeared to identify obstacles to a seamless ICT integration as insufficient infrastructure, a lack of knowledge and expertise about ICT integration, their own attitudes and views, and curriculum. Students are enthusiastic to embrace the use of ICTs in the teaching and learning of complex concepts (Yang & Kwok,2017).

According to Zhang's (2013) research on Internet Use in English as a Foreign Language (EFL) Teaching and Learning in Northwest China, both teachers and students had a favourable attitude about using the Internet for English teaching and learning. Furthermore, Zhang (2013) came to the conclusion that younger students who are part of the internet generation should support online English learning. Tezci (2011) found that the majority of future instructors only associated basic ICT technologies with educational use. Although the school's IT resources were inadequate and out of repair, teachers believed that ICT integration was successful.

Also, a study by Chien, Wu, and Hsu (2014) revealed that students in schools have high expectations for the use of ICT in the classroom. This is so that the new generation of students, who could be referred to as the "digital native phenomena" to ICTs, can grow up around technology. Also, their research showed that pupils had larger expectations for ICT integration in the classroom the younger they are. The research by Chien, Wu, and Hsu (2014) further demonstrated how much personal factors, such as self-perceptions, influence ICT integration.

Likewise, Chien, Wu, and Hsu's (2014) research revealed that both teachers and students were on board with using ICTs both within and outside of the classroom. Eventually, Chien, Wu, and Hsu (2014) came to the conclusion that teachers' attitudes, competency,

and lack of confidence were the main factors preventing ICT integration in the classroom. According to studies, Nigerian educators have a favourable attitude towards computer education. Yoloye (1990), for instance, discovered that educators at the University of Ibadan had favourable attitudes towards computers and actually want to receive computer training. Similar to this, the majority of teachers in Nigeria have favourable views on computer education (Yusuf & Afolabi, 2010).

### 2.8 ICT as a Teaching and Learning Resource

According to UNESCO's ICT policy, Technology can support more democratic and open planning and management of education. Communications technology can increase equity, ensure inclusion, and provide access to education. When resources are limited, using technologies to strategically employ 23 open-source content can provide a workaround for the manufacturing of textbooks' bottleneck. To demonstrate consistency between implementation and content, Loveless (2011) refers to more current studies on the use of technologies to enhance "excellent pedagogical design" (teaching strategies, learning environment, assessment and feedback, underlying learning theories).

According to the author, educators' use of technology is based on their vision and ideas about "why they think their practise important and how they may best build experiences and settings for pupils" in response to the queries "Why?" "What?" and "How." Additionally, social media applications like Facebook, Twitter, Wikipedia, YouTube, WhatsApp, Telegram, Instagram, and Snapchat are preinstalled on mobile devices. These applications are a part of the so-called Social Web 2.0, which is best characterised by the ideas of social interaction, content sharing, and collective intelligence (Alabdulkareem, 2015).

Teachers can utilise this platform to provide material like homework and assignments and to instantly respond to students' queries and misconceptions about the subject being covered. To prevent the social media platform from being used for non-academic purposes, teachers must at all costs control how it is utilised by developing tight guidelines. Thoughts on how to adapt these kinds of technologies and creative media techniques to encourage students to "become the authorities on issues through study, storytelling, and creation" have been raised among educators.

For instance, students and teachers in Singapore and New Zealand are using WhatsApp as a platform to promote intercultural understanding and long-term teacher collaboration in order to meet students' demands for 21st-century learning. Similar to this, teachers and students use social media sites like Twitter in a variety of ways, such as to find new information, spark discussion, interest, and collaboration, connect with local and international issues, explore, exchange, and publish thoughts, ideas, and perspectives, communicate information, and join professional learning networks (Shannon et al., 2011).

Increased opportunities for students to "work more continuously across home and school settings, activities to be initiated outside of the school, practise on exercises to be undertaken when or where desired" are indicated by the growing accessibility of mobile technologies (in the form of smart phones, iPads, iTunes, and smart watches) (Passey, 2010). According to a study by Mulima (2013), ICTs can improve the delivery of religious education instruction and student learning. Additional studies have demonstrated that teachers' use of computers, visual resources like charts, posters, and models (computer simulated), were helpful for making the lessons appealing and engaging for students (Mistler-Jackson & Songer, 2000; Paul & Fernandez, 2000).

According to Aguilar et al. (2012), the evolution of ICT has made it possible for ICT tools to be turned into instructional tools that may further enhance students' educational experiences and revolutionise how information is gathered, handled, and analysed. By claiming that giving information in such diverse modalities (audio, visual, images, models, and charts) gives words a more tangible meaning and directly demonstrates linkages and relationships among ideas, Imer (2007) concretized this theory.

Furthermore, Imer (2007) argued that teaching through many modalities gives students access to useful channels of communication, powerful verbal messages, and memorable pictures. This has the potential to improve student achievement by boosting motivation and attitude.

### *2.8.1 Significance of ICT in education*

According to UNESCO's ICT policy, Technology can support more democratic and open planning and management of education. Communications technology can increase equity, ensure inclusion, and provide access to education. When resources are limited, technology can be used wisely to employ open-source content to get around the bottleneck of textbook creation, dissemination, and updating (UNESCO, 1995). ICT offers students a learner-centered environment, chances to make decisions and hone their critical thinking abilities, chances to gain new knowledge, opportunities to analyse, synthesise, and evaluate data and learning resource (Chai, Koh, & Tsai, 2010).

ICT also enables pupils to solve issues while learning through exploration and inquiry. These three qualities autonomy, aptitude, and creativity improve learning (Fu, 2013). ICTs have the potential to boost motivation and autonomy in learning and teaching, as well as the retention of information and skills (William, 2004). Students' attention and motivation are increased when ICT is used to directly communicate with them about

realities and experiences that would normally be communicated through text at their own pace.

William (2004) adds that it has been seen that students experience increased autonomy and self-direction when working in pairs on computers or other ICTs, and teachers become less directive as a result. As a result, learners often have independent learning experiences, which in turn helps them develop self-confidence in the learning process.

Studies by Saverinus and Williams (2008) demonstrate the growing significance of ICTs in education. Their research demonstrates that the use of ICTs in education has an increasing number of beneficial consequences, including enhanced student retention rates, increased motivation among teachers and students, and autonomy in learning. Increased motivation can also improve students' and teachers' attitudes towards learning. ICTs can be used as a medium for teaching and learning to foster more creative thinking in the context of integrated education, according to a study by Maimum et al. (2011) on the integration of ICTs in the teaching of Islamic religious subjects.

Therefore, it is crucial for educators to develop new information technology quickly and to the proper extent in order to match the capabilities of both teachers and students in the classroom. This is because new information technology has the potential to foster more creative thinking in the context of integrated education. Adwa College in Ethiopia should critically focus on integrating ICT in each course to make courses engaging and simple for their students to learn, according to Mewcha and Ayele's (2015) proposal. They go on to say that if ICT usage is incorporated into the courses that teachers teach, their productivity is realised. According to their research, the Adwa College should offer ICT resources, including hardware and software

ICTs were thought to improve teaching and learning in Religious Education (R.E.), encourage involvement, change in classroom atmosphere, creativity, and motivation, as well as make it easier for students to absorb and retain information (Mulima, 2013). Moreover, Zhang (2013) suggested that when students' knowledge paradigms broaden, ICT enables them to become more self-assured, inventive, and creative. ICTs can improve students' communication, knowledge, and ability to possess all four learning abilities by facilitating the acquisition of the essential data, according to Zhang's (2013) further argument.

Using the tools that ICTs may offer during the teaching and learning process, ICTs can also assist students in being able to coherently articulate their thoughts and ideas. Gee (2011) has found that ICT encourages students' creativity and enhances the calibre of both teaching and learning.

### *2.8.2 Advantages / strengths of ICT usage in biology lessons*

Due to its interactivity, flexibility, and integration of many media that can promote learning, take into account individual differences among learners, and boost their motivation, ICT is particularly beneficial and profitable in education.

The main benefit of digital media above other media is the availability of interactivity. It speaks of the exchange of information and responses. With the help of interactivity, students can modify the presentation's parameters, see their findings, and react to multiple-choice questions. They can also control the speed of applications and the amount of repetition to meet their individual needs. The use of educational ICT encourages teaching practises that go beyond the teacher's traditional position of information provider to include that of a guide, supporter, and facilitator, much like the use of

textbooks does. ICT offers a variety of media, which are frequently put together in useful ways.

This presents an opportunity to express ideas using the computer in several forms, such as: Pictures, including scanned photos, drawings, maps, and presentations; sounds, such as speech, noise, and music recordings; video with intricate processes and "talking heads"; simulations and animation; conversations between students (social networks, online discussions, blogs, etc.). Presentations supplemented by eye-catching graphics or animations frequently have better visual appeal than texts that are only text and can promote the appearance of emotions to support the information delivered.

ICT may cater to a variety of different learning styles; some pupils learn better by reading, others by hearing, some by watching, etc. Also, the use of ICT enables a variety of working styles; students can choose how to investigate the contents and how to use interactive and collaborative tools on their own. Also, students can modify their own learning procedures in accordance with their interests and talents.

They can work on projects that interest them and go over information as many times as they like without feeling embarrassed about their learning progress. So, the usage of ICT can be customised to the various interests, social and cultural backgrounds, learning preferences and rates, etc., of the pupils. Active, self-directed learning can be encouraged by individual learning. Moreover, group work can be facilitated by ICT applications. Students in small groups can work with ICT apps together to share knowledge and sharpen their communication skills.

For pupils with exceptional needs, the interactive possibilities of ICT result in considerable flexibility: Synthetic speech can help dyslexic students become accustomed to the content of digital texts. By using ICT, autistic kids display improved phonological awareness and word reading (Andresen and van den Brink, 2013).

Due to the computer's adaptability to individual needs, which includes the ability to repeat, hear loud, and other features, students with severe physical and speech impairments benefit from studying with ICT, Andresen & van den Brink, (2013). Students who are deaf find it easier to study when the material is presented visually (Andresen & van den Brink, 2013). Students' ability to access information can be significantly improved by the computer. Information can be accessed at any time via delivery platforms like the World Wide Web. Also, it is rather simple to update web-based instructional resources, i.e., to modify design, content, training techniques, etc.

### *2.8.3 Disadvantages / limitations of ICT usage in education*

**Learning that is self-regulated**: Some students are unable to handle the independence offered by ICT that uses hypertext.

**Distraction**: Due to competing messages, unclear presentations of the material can lead to distraction. ICT with a non-linear structure allows the user to click on the links provided, which may divert attention from the subject being learnt. ICT apps' vast amounts of information may divert our focus when we are studying. When multiple media are offered at once, the learner can only focus on a few of them while ignoring the rest. This could lead to neglecting crucial facts. Humans are unable to utilise all accessible channels at once, which can limit our ability to fully utilise ICT. minimal interaction Even though learner-ICT application interaction is growing, it is still viewed as limited in comparison to elaborate human-human interaction.

**No selected feedback**: Most computer-assisted learning programmes offer very little input. In general, computers can only supplement one-on-one instruction, not replace it. Frequently, the feedback given is just a correct or wrong answer; it doesn't help with learning tactics or additional material explanations. ICT apps are unable to recognise a learner's specific needs or issues; hence they are unable to provide personalised assistance. Simulations frequently fall short: It might be crucial for students to get real-world experience. For instance, it's important to go outside and see insects in their native habitats if you're studying insects in biology.

**Absence of skills on the part of students and teachers**: Pupils, especially those of a mature age, may not be ICT literate. Moreover, teachers might not have certain personal qualities necessary for using ICT to educate effectively. Making audio, video, and graphical content can be more difficult than writing regular texts.

**Time-consuming**: Making use of ICT can take some time. ICT production in particular takes a long time.

**Access**: Not all pupils have the right kind of access to the Internet and appropriate devices. This can restrict the range of instruction.

**Social in/exclusion**: Not all members of a society can be involved in the use of ICT technology due to lack of access to the Internet or lack of hardware to make full use of the educational material on the web.

**Equipment issues**: Hardware and software need to be set up such that using them is as easy and direct as possible. Issue with bandwidth: Low bandwidth results in sluggish sound, visual, and video performance, interrupting streaming, and long download waits, which can make learning more difficult.

**ICT can go anywhere**: Paper-based notes can be read anywhere, including the bus, the beach, and other public places, but web-based or ICT materials need particular apparatus. The text on computer displays may not be as simple to read as the content on paper since they are not the same as paper. The best way to see a document with extensive amounts of information that must be read from top to bottom is definitely on paper. It could still be preferable to read books and journal papers on paper. When looking for information, end users frequently favour technology; nevertheless, when reading, they frequently prefer printouts.

### 2.9 Benefits of Using ICT in the Teaching Process

ICT is important, and teachers use it for a variety of reasons, according to numerous studies that range from case studies to survey research. ICT can have a variety of effects on the teaching and learning processes. ICT has a considerable potential to improve student accomplishment and teacher learning, according to Bransford et al., (2000) analysis of many research that examined the literature on ICT and learning. Technology can be a key component in assisting face-to-face teaching and learning in the classroom (Wong et al., 2006).

The use of computers, according to many researchers and theorists, can aid children in learning, lessen the amount of direct instruction given to them, and allow teachers the chance to assist those kids who have specific requirements. The usage of new technologies, according to Gillespie (2006), can help students learn knowledge, interact with resources like images and videos, and promote communication and teamwork.

According to Osborne and Hennessy (2003), modern technology may also increase students' motivation, clarity of thought, and capacity for data comprehension. According to BECTA (2003), the efficacy of incorporating new technology into education varies

depending on the curriculum, region, and class being used. Here are a few benefits that have been mentioned for utilising ICT to support education.

### *2.9.1 Individualized interactivity*

The emphasis in earlier educational methods was on the passive, one-way transmission of knowledge from professors to pupils. World Bank (2004) asserts that the use of technologies that change how needs, preferences, and requests are presented can improve the learning process. Current trends towards a constructivist approach to teacher-student interaction support this claim. The majority of ICT tools are interactive, which makes them perfect for a creative learning approach that emphasises experimentation and creative thinking skills.

### *2.9.2 Delivery of educational resources*

ICT can be utilised to quickly and affordably deliver current resources utilising one or more media to a large number of educators and students. Resources can simply be updated without imposing significant additional expenditures for dissemination to teachers and students. The vast resource pool found on the World Wide Web is an added bonus. According to Tinio (2002), ICT has the capacity to transcend location and time, enabling asynchronous learning. Online resources are available seven days a week, twenty-four hours a day. ICT has enabled instructions to be received simultaneously by multiple geographically dispersed learners to be able to access resource persons, learning resources, mentors and professionals from all over the world.

### *2.9.3 Access to global knowledge base/internet*

According to a 2004 World Bank assessment, the capacity to share knowledge and experiences with an expanding worldwide networked community may be the ICT's most obvious benefit to education. Students can actively look out their international

counterparts to collaborate on research projects on a range of subjects, such as environmental or health challenges. Students and the larger community have access to both international and regional cultural resources thanks to the same technology.

### *2.9.4 Facilitating interaction with resources*

Bullock (2004) asserts that ICT offers educators a wide range of very intriguing prospects for developing resources that enable highly interactive learning. This may result in the development of engaging and stimulating interactions between students and instructional resources. According to Plomp et al. (2007), ICT can be utilised to deliver challenging, authentic content that will interest students in the learning process. Examples of ICT include videos, television, and multimedia computer software that combines text, sound, and vibrant moving visuals. Moreover, networked PCs with internet access might boost student motivation since they integrate the diversity of media and interactivity of other devices.

## 2.10 Barriers that Hinders the Use of ICT in the Classroom Teaching

It might be challenging to successfully incorporate ICT into education because it is a complicated process. Schoepp (2015) defines a barrier as any situation that makes it challenging to advance or accomplish a goal. A number of things prevent the integration of ICT into classroom learning. Some of the causes are related to the school (internal), while others are related to the community (external) and the teacher's personal situation. These elements are classified as both manipulative and non-manipulative by researchers. Non-manipulative characteristics include things like age, teaching experience, and computer proficiency. The availability of IT infrastructures, government legislation, and the availability of outside support are all manipulative elements, as are attitudes, phobias, interests, computer skill levels, etc.

### *2.10.1 Teachers' attitude towards the use of ICT and teachers' ICT knowledge and skills*

Ajzen (1988) defines attitude as a tendency to react favourably or adversely to something, someone, or an event. ICT integration into the classroom depends a lot on the support and attitudes of the teachers. Teachers' attitudes and views about technology are among the factors that affect the successful integration of ICT into instruction (Hew & Brush, (2007), Keengwa, & Onchwari, (2008) the adoption of technology by teachers and the extent to which they use it in the classroom are both influenced by attitudes about ICT.

Numerous theorists such as van Braak, (2001), Vannata & Fordham, (2004) have argued that teachers' attitudes on using technology in the classroom have a significant influence. According to Venkatesh et al., (2003) attitude is one of the most crucial notions in decision-making since it has a significant role in social judgements and behaviours. One of the most important elements that helps or hinders the integration of ICT into classroom education is the mindset of the teachers.

Positive attitudes towards using ICT in teaching are commonly acknowledged as a required condition for effective ICT usage in teaching, contrary to the findings of Rhoda and Gerald (2000), who concluded that negative views are a barrier to integrating ICT in teaching. According to Myers and Halpin (2002), teachers' attitudes towards using ICT in the classroom are a key indicator of its adoption in the future. In addition, a Bullock (2004) study discovered that teachers' attitudes constitute a significant enabling or disabling element in the adoption of ICT-based teaching approaches.

In a similar vein, a study conducted by Kersaint et al., (2003) discovered that teachers who have a favourable attitude towards ICT-based teaching are more likely to feel at ease utilising it and to regularly take advantage of it in their instruction. Fundamentally,

Woodrow (1992) argues that the development of a favourable teacher attitude towards information and communication technology is necessary for any successful deployment of an ICT-based teaching and learning approach.

### *2.10.2 Teacher competence and confidence*

The ability to manage a broad range of varied technologies for a variety of objectives is referred to as ICT competency. ICT-assisted teaching is the most appropriate ability for a teacher to have, however many lack it (Prestride, 2012). This could be as a result of it scarcely being covered in their training programme. According to Prestride (2012), a secondary school teacher must be proficient in data processing, word processing, the internet, spreadsheets, PowerPoint presentations, and e-mail. These ICT tools are crucial for teachers since they help with lesson planning, test analysis and design, knowledge acquisition, and class presentation, among other things. (Bordbar, 2005) asserts that teachers' computer proficiency is a significant predictor of integrating ICT in the classroom. The majority of teachers who expressed a negative or indifferent attitude towards the integration of ICT into teaching and learning processes lacked the information and skills necessary to make "informed decisions," according to Al-Oteawi (2002). According to a study by Peralta and Costa (2007), teachers who have more computer experience are more confident in their abilities to use them efficiently.

In conclusion, Jones, (2004) stated that a direct correlation exists between teachers' competency and confidence. In relation to the perceived competency of their students, teachers' judgements of their capacity to use computers in the classroom are correlated with their confidence. The degree of confidence teachers has utilised the technology is a key factor in determining their levels of involvement. According to Dawes (2006), instructors who are uneasy or unsure about using computers in the classroom will make every effort to avoid them. Most of the study suggests that this is a significant obstacle to

teachers' use of ICT in the classroom BECTA, (2003). Several research has investigated the causes of teachers' lack of trust in ICT.

Beggs (2000) claimed that instructors' "fear of failing" was a factor in their lack of confidence. On the other hand, Balanskat et al., (2006) found that teachers lack the confidence to use ICT in the classroom because they lack the ICT skills to do so. Using ICT in front of a class of students who might already know more than they do causes anxiety in many teachers who don't consider themselves to be ICT experts. On the other hand, teachers who confidently integrate technology into the classroom are aware of its benefits. Another barrier that is directly related to teacher confidence is the ability of teachers to integrate Technology into educational practise BECTA, (2003).

According to Australian research by Newhouse (2002), many teachers lacked the knowledge and abilities necessary to use computers and were unenthusiastic about the modifications and incorporation of supplemental learning that would result from integrating computers into their teaching practises. According to recent studies, the severity of this obstacle varies from nation to nation. According to studies, one of the greatest obstacles to teachers' acceptance and implementation of ICT in poor nations is their lack of technological proficiency (Pelgrum,2001). For instance, the biggest impediment in Syria has been identified as instructors' lack of technological proficiency Albirini, (2006).

### *2.10.3 Limited access to ICT facilities*

The inclusion of ICT in education requires that schools have access to ICT infrastructure and resources. The primary hurdle preventing teachers from using ICT in teaching has been found as inaccessibility or unavailability of ICT, a school level barrier. Lack of access to hardware and software, as well as subpar hardware and improper software, are

just a few examples of the several reasons that contribute to resource shortage. ICT resources including hardware, software, and other resources are largely dependent on accessibility and availability for effective adoption and integration into teaching in schools. It goes without saying that teachers won't use ICT resources if they can't access them.

As a result, having access to computers, modern software, and hardware is essential for successful technology adoption and integration. According to a number of studies, a significant barrier to instructors implementing new technology in the classroom is a lack of access to resources, including at home Bingimlas (2009). According to a study by Yildrim (2007), having access to technical resources is one of the best methods for instructors to use ICT in the classroom pedagogically. Not only is it necessary to have access to hardware and software, but it's also crucial to employ the right programmes and tools to enhance teaching and learning (Tondeur et al., 2008).

ICT resources are not always inaccessible because the school does not have the necessary hardware, software, or other ICT resources. It could be the result of a number of things, including a lack of personal access for teachers, inadequate resource organisation, low-quality technology, improper software, or defective software. Teachers' access to infrastructure, resource shortages and insufficiency, and ICT use during class are considered factors in determining the extent of access to ICT at a school.

### *2.10.4 Teaching experience*

Although some studies claimed that instructors' teaching experience had no bearing on how they used computer technology in the classroom (Buabeng-Andoh, 2012), the majority of studies revealed that teachers' teaching experience had a bearing on the effective use of ICT in classrooms (Wong et al., 2008). In her study, Gorder (2008) found

that the freedom to 18 tailor education to teacher-perceived student requirements and technological comfort levels were connected to effective computer use. Furthermore, it was asserted by Beak et al. (2008) that more seasoned teachers are less prepared to include ICT into their instruction.

Similar findings were found in the United States, where teachers with less experience in the classroom were more likely than those with more experience to use computers into their instruction (Gorder, 2008). This gap may be caused by the fact that new instructors have more that teaching experience does not erase computer phobias experience using technology.

### *2.10.5 Inadequate ICT infrastructure*

West African nations struggle with inadequate technological infrastructure, including outdated hardware and software, slow internet speeds, sparse bandwidth, intermittent electricity, and geographical and demographic issues like high population densities and extreme poverty, as well as a lack of teachers participating in curriculum development and evaluation and a teachers' brain drain to the west (Behrane, 2012).

Few teachers, though they varied by nation, cited infrastructure issues including a lack of computers in good working order, unstable electricity, or limited internet connectivity, according to Hennessy et al. (2010). Professional Growth The successful incorporation of computers into classroom instruction is greatly dependent on teachers' professional development.

According to Ertmer et al., (2003), while new instructors wanted to use technology and had sufficient technical skills, they lacked expertise about how to incorporate it into their lessons. It is obvious that allowing teacher candidates to utilise ICT in their programmes while they are in school is essential if they want to use the technology to enhance their

teaching activities. When given the opportunity to use the technology in practise, learn, share, and collaborate with peers, teachers are more inclined to incorporate it into their lessons.

Teachers' awareness and foresight are improved by training programmes that include instructional approaches and strategies to address beliefs, skills, and knowledge. The literature most commonly mentions a lack of efficient training as a hindrance. There is a requirement to give training in order to obtain high levels of teacher competency in ICT, and maybe not unexpectedly, a substantial body of literature suggests that good training is essential if teachers are to implement ICT effectively in their teaching (Kirkwood et al., 2000).

According to a recent study conducted in Turkey, the lack of in-service science teacher training programmes is the major obstacle to the adoption of modern Technologies in science. Zden (2007) and Toprakci (2006) came to the conclusion that a barrier to ICT adoption in Turkish schools is the lack of teacher training.

### *2.10.6 Lack of technical support*

Teachers cannot be expected to overcome the obstacles stopping them from utilising ICT without both competent technical support in the classroom and whole-school resources (Lewis,2003). According to Pelgrum (2001), one of the biggest obstacles to ICT use in education, in the eyes of primary and secondary teachers, was a lack of technical support. It was discovered that technical issues were a significant hurdle for teachers.

These technical obstacles included things like waiting for websites to load, having trouble connecting to the Internet, printers that wouldn't print, broken computers, and having to use outdated computers for teachers. Technological difficulties prevented the lesson from being taught smoothly or the activities in the classroom from flowing naturally (Sicilia,

2005). With the aid of ICT assistance in schools, instructors may use ICT in the classroom without having to waste time troubleshooting software and hardware issues.

According to BECTA (2003), there is a definite connection between two technical barriers: teachers are more inclined to avoid using technology altogether the more frequently actual breakdowns occur (perhaps as a result of a lack of preventative technical maintenance). According to the report, teachers who attempted to complete a task on a computer but were unsuccessful owing to technical issues would then refrain from using the computer for a number of days. This therefore emphasises the need of having sufficient technical help in classrooms.

In general, several studies have identified a variety of the following or related factors as pervasive barriers: a dearth of computers, a lack of high-quality software, a lack of time, technical issues, teachers' attitudes towards computers, a lack of funding, a lack of teacher confidence, resistance to change, a lack of administrative support, a dearth of computer skills, a poor fit with the curriculum, a dearth of incentives, scheduling issues, and a dearth of training opportunities,

## 2.11 Factors Determining the Use of ICT to Facilitate Teaching in Secondary Schools

The following procedures must be taken into account if ICT adoption and use in secondary school classrooms are to be ensured. The degree to which teachers embrace ICT-based teaching and learning depends heavily on their willingness to do so. Teachers ultimately decide how to use and implement ICT-based teaching in the classroom (Bullock, 2004).

### *2.11.1 Attitude towards ICT*

In their study, Drent and Meelissen (2007) found that the teacher's innovative use of ICT is directly influenced by their ICT mindset. Good attitudes frequently enable less tech-savvy teachers to pick up the abilities required for using technology-based activities in the classroom. Harrison and Rainer (1992) discovered that individuals with negative views towards ICT had lower levels of proficiency with the technology and were, as a result, less inclined to embrace and adapt to it than those with favourable attitudes.

They came to the conclusion that improving people's computer skills requires them to change their unfavourable attitudes. The use of ICT by teachers has a significant impact on their positive attitudes about technology (Keengwe & Onchwari, 2008). Hence, teachers must have a favourable attitude about using technology if they hope to do so successfully in their classes. When teachers are sufficiently at ease with technology and educated about its use, this attitude develops.

### *2.11.2 Competence in ICT use*

According to Van et al., (2004) ICT competence is the capacity to handle a variety of ICT applications for many purposes. The competency of the teacher, according to Bordbar (2010) is one of the key predictors of ICT integration into teaching and plays a significant role in its successful implementation. Pelgrum (2001) asserts that teachers' expertise and knowledge play a key role in the success of educational innovations. He also discovered that the second biggest barrier to using ICT in education was instructors' lack of knowledge and expertise.

According to Knezek and Christensen's (2000) hypothesis, teachers who have more experience and understanding utilising ICT will use it more frequently to support instruction in the classroom. Moreover, Berner (2003) came to the conclusion that

teachers should build their competence in accordance with the educational objectives they wish to achieve with the aid of ICT.

### *2.11.3 Computer self-efficacy*

The self-efficacy of teachers has been studied, and it has been found to have a bigger impact on how they use ICT. A belief in one's own capacity to carry out a task or action required to accomplish a goal or task is known as self-efficacy. Self-efficacy, in its truest sense, refers to a person's belief in his or her capacity to carry out the tasks for which they strive. The degree to which a teacher believes success is under his or her control and the chance that the teacher will be successful in using ICT for educational purposes are both indicators of how confident they are (Peralta & Costa, 2007).

A teacher's computer self-efficacy is a determination of how effectively they can utilise a computer. The usage of ICT in teaching and learning by instructors is influenced by their computer self-efficacy, according to Liaw, Huang, and Chen (2007). Similar to this, Yuen and Ma (2008) found that the ease of computer usage and perceived instructor efficacy were key factors in Hong Kong teachers' use of ICT. Jones (2004) asserts that teachers who lack confidence are hesitant to employ computers in the classroom.

It has been suggested that "fear of failure" and "lack of ICT understanding" are some of the causes of teachers' lack of confidence in adopting and integrating ICT into their teaching (Balanskat et al., 2006a). Similar to this, according to 21% of the teachers polled in a survey by BECTA (2003), instructors' lack of confidence affects how they use computers in the classroom. According to BECTA (2003), many teachers who do not think they are adept at utilising CT feel nervous about employing it in front of a class of students who may know more than they do.

### *2.11.4 Teacher' working experience*

According to Gorder (2008), the actual use of technology and the teacher's experience were highly associated. Moreover, according to Baek, Jung, and Kim (2008), experienced 24 teachers are less prepared to use ICT into their teaching. Similar findings were found in the United States, where the National Centre for Education Statistics found that teachers with less experience in the classroom were more likely than those with more experience to use computers into their instruction.

### *2.11.5 Professional development*

The successful incorporation of computers into classroom instruction is greatly dependent on teachers' professional development. Studies have shown that ICT-related training programmes improve teachers' computer use skills, regardless of their experience level (Bauer & Kenton, 2005; Franklin, 2007; Wozney et al., 2006). They also influence teachers' attitudes towards computers (Hew & Brush, 2007; Keengwe & Onchwari, 2008), help teachers reorganise the task of technology, and show teachers how new technology tools are important in student learning (Plair, 2008). According to Lawless and Pellegrino (2007), when training programmes put a strong emphasis on subject content, values, and the technology, instructors are more likely to adopt and integrate ICT into their lessons.

Teachers are better equipped to use technology to support students' learning and achievement along with an increase in technological knowledge, confidence, and attitudes. Students' performance can be significantly improved by teachers who use technology and new teaching methods they have learnt via professional development (Lawless & Pellegrino, 2007).

### *2.11.6 Accessibility access to ICT*

The availability of resources and infrastructure in schools is a requirement for integrating ICT in education (Plomp et al., 2009). ICT resources including hardware, software, and other resources are primarily dependent on accessibility and availability for effective adoption and integration into teaching in schools. According to a study by Yildrim (2007), having access to technical resources is one of the best methods for instructors to use ICT in the classroom pedagogically.

### *2.11.7 Availability of technical support*

According to BECTA (2003), a school's lack of technical support increases the likelihood that routine maintenance will not be performed, increasing the danger of technical failures. According to Jones (2004), when a computer breaks down, there are disruptions. If there is a lack of technical support, it is possible that the normal maintenance on the computer won't be done, which prevents teachers from utilising computers in the classroom. Due to the lack of technical help in the event of a technical issue, teachers will be discouraged from utilising computers out of concern for equipment failure.

## 2.12 Effect of Gender on the Use of ICT in Teaching and Learning

A number of research have been conducted to determine how gender affects the usage of ICT in teaching and learning. Lawless and Pellegrino (2007) asserts that teachers' self-evaluations of their knowledge, perceptions, and usage of ICT in teaching and learning are significantly influenced by their gender. As a result, gender inequalities in ICT use in the classroom are unavoidable. The type of ICT tool or software, a teacher's personal preference, and a teacher's initiative to learn how to use ICT in teaching and learning, according to Luu (2011), are what account for gender variations in the use of ICT in teaching and learning.

According to an Australian study, full-time female teachers were less confident in utilising ICT for teaching and learning in 2005 than were male instructors (Jamieson-Proctor, Burnett, Finger & Watson, 2006). Similar to this, Ghavifekr, Kunjappan, Ramasamy, and Anthony (2016) demonstrate that male teachers use ICT tools in the classroom at a higher rate than female teachers. In contrast, female teachers utilise ICT to teach more in Ghanaian primary schools than the male teachers. Additionally, Yuan and Lee's (2012) research in Taiwan found no difference in gender perspectives among school teachers about the use of ICT in mathematics instruction and learning.

The reviews on this topic stated above show how differently men and women use ICT in various contexts. In opposition to this, this study looked into how gender differs in the usage of ICT in the classroom. The ability of teachers to use ICT tools to teach varies by gender and is influenced by factors such as lack of internet connectivity, electricity or power issues, insufficient ICT tool availability, and teachers' technical ICT knowledge (Natia & Al-hassan, 2015).

According to Yunus (2007), there are a number of elements that influence how women and men use ICT. One of the reasons is that many teachers do not use ICT tools in teaching and learning because they are unfamiliar with them. Male and female instructors in Namibia are encouraged and required to properly select and use the available ICT tools in accordance with the aim of teaching and learning, notwithstanding the disparities that come with gender in the use of ICT.

### 2.13 Empirical Studies

The development of inquiry-based instruction in both elementary and secondary schools is emphasised by the scientific education community. Reform-driven publications in scientific education stress the value of inquiry as a teaching strategy and a framework for

learning (Nathia & Al-hassan, 2015). Inquiry-based scientific education entails getting students involved in the same kinds of procedures that scientists employ. Asking questions, formulating hypotheses, planning investigations, analysing data, drawing conclusions, redesigning studies, and creating and modifying theories are some of these activities (Kubasko, Tretter & Andre, 2007).

Stuckey-Mickell and Stuckey-Danner (2007) found out how students felt about the virtual biology labs that were utilised in two online beginning biology courses. An online survey asking students about their opinions of the CDROM-based Virtual Biology laboratories and face-to-face (F2F) laboratories, they undertook during the courses included Likert type and open-ended questions. The results showed that although the majority of students (86.9%) thought the F2F laboratories were more effective than the virtual laboratories on a number of different criteria, many of them (60.8% on one criterion) thought the virtual laboratories were also beneficial.

The authors explore how the design of the learning experience, the usage of virtual laboratories, and/or the use of synchronous collaboration technologies may have an impact on student-identified concerns with interaction and feedback. The authors also offer ideas for further study on the application of virtual biology laboratories in an online environment. In their discussion of how teachers use computer-based technologies to enhance science learning, Hennessy, Deaney, and Ruthven (2006) proposed that technology helps the progressive application and construction of knowledge. Both developing computer-based learning technologies and curriculum-related science activities are impacted by such applications. By enhancing human potential, technology aids students in connecting theories and phenomena.

According to Chi-Yan and Treagust (2004), technology is being used more frequently by biology teachers to support their instruction. Over the past 20 years, numerous computer technologies have been employed in colleges and universities to improve student learning in various biological disciplines.

New learning opportunities have been made possible by computer technology and educational software, which can alter the atmosphere of conventional science classrooms. This does not necessarily imply that traditional education is unsuccessful as a means of teaching. Traditional approaches, however, occasionally fall short of capturing the knowledge and passions of students who have grown up in the digital era. Technology can improve educational settings and expand opportunities for real-world practise (Zumbach, Schmitt, Reimann & Starkloff, 2006). Computer technologies facilitate the creation and application of instructional strategies that support a wide range of crucial science competencies (Maor & Fraser, 1996).

According to Angadi and Ganihar (2015), technology and multimedia help students build their knowledge by enabling them to make connections between their past knowledge and new concepts. This claim is supported by research that argues constructivist approaches and technological integration should be a natural element of science education. Researchers have looked into computerised magnifying devices and video-based virtual environments in an effort to advance group learning activities and viewing comfort in the setting of science education.

Susanne (2002) investigated cancer cell biology and discovered that an interactive, constructivist instructional module examining the use of multimedia can enhance science learning. The use of multimedia in bioscience education has the potential to create novel learning environments and pedagogy applications that will increase student interest,

engage them in the research process, help them become more adept at critical thinking and problem-solving, and help them gain a conceptual understanding of biological concepts.

The impacts of audio, animation, and spatial aptitude in a multimedia computer programme for high school biology have been studied (Klein & Koroghlanian, 2004). The study looked at the impact of practise and post-test performance, attitude, and time on instructional style (text vs. audio), illustration mode (static illustration vs. animation), and spatial ability (low vs. high). The findings showed a substantial relationship between spatial ability and practise success and attitude. On the practise items, participants with high spatial abilities outperformed those with low spatial abilities. Individuals with low spatial ability reacted to attitude questions on mental effort, interest, and amount of focus more favourably than participants with good spatial ability.

Participants who received animation stayed on the programme for noticeably longer than those who received static illustrations, according to the results. According to Paris (2004), e-Learning can enhance academic performance. Also, particularly for timid and underachieving children, a straightforward multimedia presentation helped the pupils understand a subject better without the aid of a teacher.

Aremu and Sangodoyin (2010) looked into the academic achievement of biology and computer animation students in senior secondary schools in Nigeria. This study investigated the effects of computer animation on the biology academic performance of Nigerian senior secondary school students.

It is advised that secondary school students in Nigeria be taught biology using computer animation because it proved successful in raising student achievement. According to Ali and Elfessi (2004), technology has a limited impact on teaching and learning because it

primarily serves as a delivery method for instruction rather than a major factor in determining learning. It can only assist with learning in the classroom. Hence, both the beneficial and detrimental impacts of multimedia are supported by empirical data. The most important thing is to analyse these results and determine the particular causes and circumstances for which multimedia is effective and for which it is not. Although it appears that multimedia is speeding up learning, this is not a general truth. The primary situations in which multimedia is useful are covered in the next section. Teachers of today are worried about how to use technology to improve and enrich their students' learning.

According to Cline (2007), the purpose of technology in the classroom is not to replace conventional methods of instruction, but rather to enhance instruction in critical thinking, creative communication, and analytical problem solving. Students can learn "from" computers, where technology is essentially used as tutors and helps to increase students' basic skills and knowledge, or they can learn "with" computers, where technology is used as a tool that can be applied to a variety of learning goals and can help develop higher order thinking, creativity, and research skills.

## 2.14 Chapter Summary

The media that a teacher chooses does not affect whether learning will take place, claims (Fenrich,2005). The learner only hears the teacher's message through the media. The message must be heard and understood by the pupil for learning to take place. The media has no influence over this. The quantity of learning that can take place, however, can vary depending on the medium one uses. If educators use instructional strategies that benefit from the media's advantages, this can have a good impact on student learning.

Comprehensive multimedia packages don't always need to include each and every type of media. Learning from materials created using several media is typically more effective than learning from materials created using only one medium. This is partially because various brain regions process information in various ways. For instance, certain areas of the brain process text while others handle visual information. Information is learned and retained more readily when multimedia programmes engage more brain areas. You can and should utilise more than one medium to teach the skill in various circumstances. Decide which media will best support your chosen educational technique. Audio is frequently present in video content. Using too many different media at once can hinder learning.

Making media mix decisions should be based on the content being taught, the method of teaching it, the method of testing it, and the characteristics of the target audience that have already been identified. For different categories of learning outcomes, different media might be required. For the attitude component, for instance, video might be appropriate, but it might not be able to give the essential corrective feedback for the intellectual skills component. Do not choose media only to impress or out of convenience.

The use of ICT and multimedia in the classroom has the potential to drastically alter current teaching and learning practises. In order to bring each student closer to the centre of the learning processes, the organisation of the school may embrace reflexive, pragmatic, and experiential approaches. Utilizing multimedia frequently results in more flexible timetables and student-centered work. The teacher's position frequently shifts from one of authority or knowledge provider to one of conductor or facilitator of the learning process. Students require a vast array of acceptable personalised tactics that will

allow them to be active and critical learners because they must find their own unique access to the rapidly changing environment.

One of the most crucial skills in lifelong learning will be the capacity to share information cooperatively with others in a society where the majority of goods are the result of teamwork. This requires having the right tactics and understanding their justifications and methods of application.

# CHAPTER THREE

# METHODOLOGY

## 3.0 Overview

This chapter provides detailed description of the methodology employed in the study which includes the research design, population, sample and sampling techniques, reliability and validity of the study, data collection and analysis.

## 3.1 Research Design

The research design guides the researcher in planning and implementing the study to achieve the intended goal. The design used for the study was action research. This is because the study sought to solve specific problem by improving students' conceptual knowledge and performance in cell division in living things using the ICT integration. According to Creswell (2012), an action research design has an advantage by allowing teachers to address specific and unique problems that are closest to them in their local settings and also bring changes in their classroom. Again, the design was used because it can be adjusted to meet varied conditions and situations which help in getting accurate and reliable results. Also, this design allows for gathering quantifiable data that could be used for statistical inference on target audience through data analysis.

## 3.2 Population

Since the purpose of this study was to find out the impact of ICT integration in teaching cell division on senior high schools. According to Rahi (2017), population of a study refers to all the people or objects that possess some characteristics that the researcher seeks to understand. Again, Harwell (2011) also conceptualised a research population as a group of individuals or objects capable of providing the whole or part of the answers

that satisfy the research questions of the study. The estimated population of the study is 1000 students at the Abetifi Presebyterian School.

### *3.2.1 Target population*

The target population for this study was all the SHS Form 2 students in the school.

### *3.2.2 Accessible population*

The accessible population was form two elective biology students at Abetifi Presbyterian SHS. The SHS Form 2 students were chosen because they had done ICT as a course of study and were therefore trusted to be familiar with the use of computers. Another reason was the fact that Form 2 SHS students have also covered quite a lot as far as the SHS biology syllabus was concerned.

## 3.3 Sample Size

The sample size for this study was made up of one of the two SHS 2 elective biology classes made of fifty (50) students

## 3.4 Sample and Sampling Procedure

Polit and Beck (2017) explained a sample as a group of people or objects from a targeted population for a study. The study adopted the census sampling technique to sample respondents for the study.

The intact SHS 2 classes were made up of students who offered Biology as an elective subject. Second year SHS students were used in the study because cell division is taught during the year second of the SHS science programme as it forms part of the SHS 2 Elective Biology syllabus.

The total sample size was 50 elective biology students of form two classes. The 50 students were made up of 30 males, whereas 20 of them were females. The ages of the

respondents ranged between 16 and 19 years; with an average age of 17 years. A purposive sampling technique of the non-probability sampling procedure was used to select the students. An intact class was used since almost all the students in that class had difficulties of understanding the concept of cell division. Also, the research further used the simple random sampling technique to sample 6 respondents for the qualitative aspect of the study.

### 3.5 Research Instruments

The study used both quantitative and qualitative data-gathering instruments namely interview (interview schedule), tests and questionnaire. The interview schedule constituted the qualitative data gathering instrument whereas tests and questionnaires also constituted the quantitative parts of the instrument.

In addition, written documents such as diary notes were made to augment the information that was obtained from the main instruments. The combination of these approaches ensure the triangulation of the data collected (Rahi, 2017). Triangulation, according to (Rahi, 2017) is a powerful way of demonstrating concurrent and participants' validity, particularly in qualitative research and can enhance the credibility, transferability, dependability and conformability aspects of a piece of resource. These three (3) instruments used for this study have been described extensively below:

#### *3.5.1 Questionnaire*

The questionnaire seeks to gather information on students' knowledge about the topic of cell division understudy. The questions were be general idea as to whether students understand the concept of cell division or not. A semi-structured questionnaires were given to respondents to find out a greater chance of expressing their views, ideas, opinions and suggestions on the concept of cell division and ICT integration. Quantitative and

qualitative data was collected through the questionnaires developed by the researcher and modified by experienced teachers after undergoing Pilot study. It was based on research questions 1 & 2. The questionnaires were administered by the researcher and comprised of five question items each on the research question. Student questionnaires had three sections, B and C. Section A dwelt on personal information; section B was based on research question one while section C was on research question two. Sample of the question items could be found in Appendix A.

### *3.5.2 Tests (Pre- test and Post –test)*

A teacher made test was designed to identify students' strengths and weaknesses in explaining the concept and stages of cell division under the following headings; The post-test will be used as an assessment and evaluation test to measure student's level of understanding of the concept of cell division after the intervention. Student's performance in the pre-intervention test compared to that of the post-intervention test.

Each test (pre-test & post-test) had two (2) sections namely Section A and B. The Section A had 5 objectives (multiple choice questions) whereas Section B also had five (5) questions containing or provided with 15 fill-in spaces to be completed. The respondents were to answer these question items for 20 marks for each paper.

A paired sample t-test was used to find out whether or not there was a statistically significant difference between the mean scores of the pre and the post test at the statistically significant level of alpha 0.05, after using the intervention. And it was based on research question three. Sample of the pre-test could be found in Appendix B whereas that of the post-test could also be found in Appendix C respectively.

### *3.5.3 Interview*

Bode and Henry (1983) state that interviewing is an appropriate instrument for any study as it helps the interviewer to cover all the dimensions of the investigations through probing of the respondents. Therefore, the researcher used a semi - structured interview to find out information pertaining to the use of ICT in the schools in terms of availability, usage and challenges in usage.

According to Harrell and Bradley (2009), a semi-structured interview schedule allowed the researcher to interact with the respondents (pre-service science teachers), to talk to them, to listen to them and gain access to their real-life experiences.

The interview as an instrument that the researcher used was based on research question two. Researcher formulated five (5) question items based on the SHS students' attitudes towards the use of ICT integration in learning the concept of cell division in living things.

## 3.6 Reliability and Validity

### *3.6.1 Validity of instruments*

A valid instrument accurately measures what it is supposed to measure (Bennars & Otiende, 1994). According to Mugenda and Mugenda (2003), an instrument that yields valid data will necessarily yield valid information. The validity of the instrument was determined by using long serving teachers in the district to judge how well the measuring instruments met standards through content. The instruments appearance, showing genuine features was checked to ensure originality. Comparison of the outcome of the prevailing conditions with the predicted outcome was made and correction made.

Experienced teachers in the county ascertained construct validity during construction of instrument by presenting it for review during piloting. The researcher also ensured that the scores from instruments accurately predicted a criterion measure by making

amendments. The researcher ensured both face and content validity of the instrument. The face validity was done by colleague biology teachers to ensure the correct grammar and eliminate any ambiguity.

The content validity was done by submitting the instruments to my supervisor to critique based on the study objectives.

### *3.6.2 Reliability of instruments*

Reliability can be defined as the degree of consistency between the measures of the same kind. Kothari (2005) defines reliable instrument as that instrument that provides consistent results. The researcher ensured that responses from respondents are consistent across variables through testing and retesting the questionnaires. Students of the same class level and streams were used to ensure that the individuals do not vary their responses if the instruments were to be administered a second time. Test-retest reliability was used to establish the reliability of the test items. Test-retest reliability is a critical psychometric property often emphasized in research and instrument development for its role in ensuring measurement consistency over time. This stability is essential in longitudinal studies, clinical assessments, and educational testing. As noted by Nunnally and Bernstein (1994), this reliability measure "provides evidence of the instrument's ability to yield consistent scores when the construct being measured has not changed." Furthermore, its application in various fields is demonstrated by studies such as (Buabeng-Andoh, 2012), who employed test-retest reliability to validate a psychological questionnaire, showing that repeated administrations yielded highly correlated results ($r = 0.89$), supporting the instrument's consistency and suitability for assessing individuals' emotional well-being over time. Such findings highlight the indispensable role of test-retest reliability in ensuring that measurement instruments maintain their integrity and that results can be interpreted with confidence in both research and practical applications.

The questionnaire items was also piloted in a different school in the municipality who were also teaching the same concept. Rectifications were made to ensure that errors made during administration or scoring of instruments is eliminated. The questionnaire items were also be given to experts in the Department of Biology Education to look at the content validity.

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.

After the data from the pilot study was analysed, a Cronbach alpha value of 0.72 was gotten. In general, the Cronbach alpha value was 0.72. Therefore, based on the study of Griethuijesen et al., (2014) the instruments are valid, as he indicated that a Cronbach alpha coefficient of 0.6 is acceptable and valid.

### 3.7 Data Collection Technique

The data was collected using questionnaires, tests and Interview schedule. The researcher visited the class for introduction under study before the start of research to familiarize with respondents and request for their cooperation made.

For effective data collection, permission was sought from the authorities of the School, Head of Science Education Department and the colleague biology tutors in the Department. In addition, the consent of the 50 students used for the study was also sought. Upon series of engagements and meetings with the authorities, date and time were agreed upon to carry out the study. In all, twelve (12) weeks were used for the study. Out of the twelve (12) weeks, one (1) week for pre-intervention activities; six (6) weeks were used for the online study; three (3) were used for the face-to-face interaction in the classroom; whereas the last two (2) weeks were for the post-test and the end-of semester

examination for the respondents. Data collection was done in three (3) stages namely pre-intervention, intervention and post-intervention stages.

To conduct this study, permission was sought from the management of Abetifi Presby SHS. The purpose of the study and other activities of the study were discussed with the headmaster. The researcher teaching in the same school and class introduce the proceeds of the research to students. The students on the other hand were to respond to questionnaires and test items. They were guided to respond to questionnaires and a teacher from the science department was asked to help invigilate the pre-test and post-test

The pre-test was also used to engage the students to know the types of preconceptions that students brought to the classrooms as to why they could not perform without the intervention. After the pre-test, the students were taught for four weeks on the phases of cell division. In the first two weeks, the students were taught interface and the phases of mitosis, the remaining weeks were divided into two for the phases of meiosis. The students were introduced to the guiding principles in the phases of mitosis and meiosis using the blackboard and chalk method, whilst students listen. No visual representation aids were used. The teacher simply drew 2-dimensional structures, used the guiding steps and procedure of how the chromosomes separate.

Then visual representation aids, using ICT integration videos on cell division on the same guideline steps and procedure of how the chromosomes separate was employed to teach.

At the end of the teaching period, a post-test was administered to them to measure their performance. The answer sheets were collected after 30 minutes and were scored after which the marks were recorded. The purpose of the post-test was to evaluate the achievements of the students.

## 3.8 Intervention Design

### *3.8.1 Pre–intervention stage*

At the pre-intervention stage, the researcher decided to teach the topic 'cell division' using the traditional methods. The researcher used lecture-cum-illustration method where the teacher was placed at the centre of the instructional process making oral presentation of information to students with chalkboard illustrations. After the lesson, the researcher conducted a pre-test to ascertain the level of students' understanding of the concept of cell division. The result of the pre-test is shown in Appendix C.

The students were taken through the same procedure of teaching but in addition, a visual representation aids, using ICT integration videos on cell division was employed. The researcher to use computer technology to teach the topic" cell division to students. In order to use set computer technology to teach the topic, materials such as a computer set/laptop, a projector, interactive whiteboard screen, a video tutorial, and a simulation of the mechanism under study were needed. The researcher with the assistance of a teacher in the department organized all the necessary teaching and learning materials and Computer Based Learning (CBL) tools needed for the intervention including those that were not readily available in the school.

The students were also involved in the organization of resources, arrangement and setting-out of the classroom so as to arouse their interest and attract their attention to the lesson. The test-screening process was conducted immediately after setting up the materials prior to the lesson period. This early preparation is necessary when using computer technology and other ICT integration resources to help avoid anxiety, tension and embarrassment. The seating arrangement of the class was properly made in such a way that all students can get access to the projected interactive whiteboard screen.

### *3.8.2 Intervention stage*

The researcher introduced the lesson taking into account what the students already know and sustained their interest by showing them a systematically designed Microsoft PowerPoint presentation of various phases of cell division. The researcher then presented a 3-dimensional video showing the phenomena of cell division. The video was shown severally with the researcher pausing at some point to explain some stages to students and also ask and take questions in both phases of mitosis and meiosis.

### *3.8.3 Post intervention stage*

After the implementation of intervention which sought to use computer technology to teach the topic "cell division, a post-test was conducted to assess the student's understanding of the lesson using computer technology as a medium of instruction. Students were made to answer almost the same sets of questions at the pre-test. The marks obtained from the post-test were computed to represent the effectiveness of the intervention. The result of the post-test is shown in Appendix D.

## 3.9 Data Analysis

Descriptive and inferential statistics were used to analyse the data Responses on students' attitudes and questionnaires administered towards the use of ICT integration in learning the concept of cell division in living things were analysed using the Statistical Package for Social Sceintific Research (SPSS v27). A paired sample t-test was employed to find out the differences in performance among the SHS students before and after exposure to the ICT integration in learning the concept of cell division in living things using data collected from the pre and the post tests. The paired sample t-test was used to find out whether or not there was a statistically significant difference between the mean scores of the pre and the post test at the statistically significant level of 0.05, after the intervention. Also, the interview data was gathered and analysed thematically.

### 3.10 Ethical Considerations

There were laid down principles and guidelines for conducting studies in an ethically appropriate manner which required researchers to obtain approval from the ethics committee or equivalent and the participants (Halai, 2006). According to Kusi (2012), ethical concerns in educational research were related to the way researchers behaved or carried out their practices and the effects they had on the research subjects. Similarly, to this, Cohen, Manion, and Morrison (2012) recommended two things to look out for when it came to ethical considerations: first, the methodology used to gather information on the research subject (matters such as informed consent, confidentiality, and persons involved). There was an open acknowledgement of those whose research affected our current study as well as the contributions of all those who were involved in the research. The ethical issues the researchers considered were access, confidentiality, maintaining the anonymity of respondents, and data security.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.0 Overview

This chapter focuses on the presentation of results of the study which was followed by discussions with relevant literature. The results and discussion were presented in order of the research questions and the null hypothesis generated from participants in the experimental and control group on the pre-test and post-test instrument. The quantitative data were organized and presented using descriptive statistics including frequency tables.

## 4.1 Demographic Characteristics of Respondents

This section provides information on the demographic characteristics of student respondents. A summary of the data is presented in Table 4.1.

**Table 1: Demographic Characteristics of Respondents**

| | Parameter | Frequency | (%) |
|---|---|---|---|
| **Age of respondent** | 16-18 years | 38 | 76.6% |
| | 19-21 years | 12 | 24% |
| | **Total** | **50** | **100** |
| **Gender** | Male | 33 | 66 |
| | Female | 17 | 34 |
| | **Total** | **50** | **100** |

Source (field data, 2023)

Data from Table 1 indicates that majority (76.6%) of respondents were between the ages of 16 to 18 years whiles 24% were between 19-21. also, males made the majority of respondents (representing 66% of total respondent) whiles females accounted for 34% of the respondents. The results indicates that the science programme is dominated by males as opposed to their female counterparts. This situation may be attributed to the

stereotyping associated with science education which indicates that the learning of science is the preserve of boys whiles females are more inclined towards the Arts. This indicate that women perceive Engineering and Computer Science fields as an uninteresting area dominated by male enthusiasts who are highly studious intellectuals.

### 4.1 Research Question One

**What are the students' difficulties in understanding the concept of cell division in living things?**

This question sought to gather information related to students' difficulties in understanding the concept of cell division in living things. The data collected and analyzed in relation to the primary sources for the acquisition of undergarments are presented in Table 2

**Table 2: Difficulties in Understanding the Concept of Cell Division**

| Statement | SD (%) | D (%) | N (%) | A (%) | SA (%) | $\bar{x}$ (std) |
|---|---|---|---|---|---|---|
| I find it challenging to grasp the basic concepts of cell division. | 0 (0.0) | 0 (0.0) | 1 (2.0) | 15 (30.0) | 34 (68.0) | 4.66 (0.52) |
| Understanding the different stages of cell division (e.g., mitosis and meiosis) is difficult for me. | 0 (0.0) | 2 (4.0) | 0 (0.0) | 27 (54.0) | 21 (42.0) | 4.34 (0.69) |
| I struggle to comprehend how DNA replication is connected to cell division. | 0 (0.0) | 0 (0.0) | 0 (0.0) | 18 (36.0) | 32 (64.0) | 4.64 (0.48) |
| Visualizing the cellular processes involved in cell division is a challenge for me. | 0 (0.0) | 5 (10.0) | 1 (2.0) | 23 (46.0) | 21 (42.0) | 4.20 (0.90) |
| I have difficulty understanding the significance of cell division in the growth and repair of organisms. | 0 (0.0) | 8 (16.0) | 0 (0.0) | 24 (48.0) | 18 (36.0) | 4.04 (1.01) |
| The terminology and scientific jargon related to cell division confuse me. | 0 (0.0) | 3 (6.0) | 2 (4.0) | 21 (42.0) | 24 (48.0) | 4.34 (0.77) |
| I feel confident in my ability to explain cell division to others. | 13 (26.0) | 16 (32.0) | 0 (0.0) | 12 (24.0) | 9 (18.0) | 2.76 (1.52) |
| I often require extra help or resources to understand cell division. | 0 (0.0) | 2 (4.0) | 2 (4.0) | 25 (50.0) | 21 (42.0) | 4.30 (0.74) |
| Cell division is a topic that I find interesting. | 0 (0.0) | 27 (54.0) | 1 (2.0) | 11 (22.0) | 11 (22.0) | 3.12 (1.28) |
| I believe that improving my understanding of cell division is important for my education. | 9 (18.0) | 8 (16.0) | 0 (0.0) | 18 (36.0) | 15 (30.0) | 3.12 (1.51) |

**Key: SD=Strongly Disagree; D=Disagree; N=Neutral; A= Agree; SA= Strongly Agree**

The provided Table 2 presents a comprehensive overview of respondents' attitudes and perceptions regarding the topic of cell division. Each statement in the table is associated with a percentage breakdown of responses, representing the levels of agreement or disagreement among participants. Additionally, mean scores and standard deviations are provided to quantify the central tendencies and variations in the responses.

The first set of statements addresses the difficulty in comprehending fundamental concepts related to cell division. A striking 68% of respondents strongly agree that they find it challenging to grasp these basic concepts, resulting in a relatively high mean score of 4.66. This indicates a prevalent struggle among the surveyed group. Furthermore, a considerable percentage of respondents (30%) strongly agree that understanding the different stages of cell division is difficult, contributing to a mean score of 4.34. These high percentages demonstrate a significant consensus regarding the complexities of cell division, as reflected in the low standard deviations (0.52 and 0.69, respectively), indicating a narrow spread of responses.

The next group of statements revolves around the connection between DNA replication and cell division, as well as the visualization of cellular processes involved in cell division. 64% of respondents strongly agree that they struggle to comprehend how DNA replication relates to cell division, yielding a mean score of 4.64. Similarly, 42%of participants strongly agree that visualizing these cellular processes is a challenge. These percentages underscore the substantial difficulties many face in understanding these facets of cell division. The standard deviations for both statements remain relatively low, signifying a high level of agreement among respondents.

Statements regarding the significance of cell division and the impact of scientific terminology reveal some diversity in responses. A substantial 48% strongly agree that they have difficulty understanding the significance of cell division, with a mean score of 4.04. Regarding scientific jargon, 48% also strongly agree that it confuses them, with a mean score of 4.34. In both cases, the standard deviations are moderately higher, indicating more variability in responses and suggesting that participants' experiences may differ significantly.

Turning to the statement about feeling confident in explaining cell division to others, a notable 32% of respondents disagree, highlighting a lack of confidence. However, the wide standard deviation of 1.52 suggests a significant spread of responses, implying that while many respondents lack confidence, some feel more assured in their explanatory abilities. The need for extra help or resources to understand cell division is highlighted by 50% of participants strongly agreeing with this statement. The mean score of 4.30 reflects the prevalence of this sentiment, while the standard deviation of 0.74 suggests some variance in the extent to which individuals rely on additional support.

Lastly, respondents' interest in cell division and their belief in its importance for education yielded more mixed responses. Approximately 54% agree that cell division is an interesting topic, while 30% strongly agree that improving their understanding of it is crucial for their education. However, both statements exhibit relatively high standard deviations (1.28 and 1.51, respectively), indicating that respondents' interests and beliefs about the educational significance of cell division vary considerably.

This analysis reveals that cell division is generally perceived as a challenging topic by a significant portion of respondents, with notable struggles in grasping fundamental concepts, visualizing processes, and understanding the relationship between DNA

replication and cell division. While there is consensus on these challenges, perceptions regarding the significance of cell division, confidence in explaining it, and the level of interest in the topic are more diverse. These findings underscore the importance of tailored educational approaches to address the specific needs of students who find cell division difficult and highlight opportunities for further research and instructional improvement in this area.

The survey results indicate that a significant percentage of respondents find cell division to be a challenging topic, particularly when it comes to grasping basic concepts, understanding different stages, and connecting it with DNA replication. These findings align with the well-established notion that cell biology, including topics like cell division, is often considered challenging by students.

Research in biology education has consistently shown that cell biology can be conceptually difficult for students due to its abstract nature and the need to visualize microscopic processes (Smith & Tanner, 2010). Concepts related to DNA replication and cell division are known to be especially complex (American Association for the Advancement of Science, 2011). A significant portion of respondents expressed confusion about the scientific jargon related to cell division. This highlights a common issue in biology education where students may struggle with the specialized terminology used in the field. Studies have found that students often have difficulty with scientific language and terminology, which can act as a barrier to understanding complex biological concepts (Marbach-Ad et al., 2010).

Respondents' lack of confidence in explaining cell division to others is consistent with the idea that students may feel uncertain about their ability to teach complex biological concepts. However, the wide standard deviation suggests that some individuals are more

confident, which could be related to differences in prior knowledge or teaching experience. Research indicates that students' confidence in their ability to explain scientific concepts can influence their learning and engagement (Seymour et al., 2000).

The results further show a mixed response regarding interest in cell division and the perceived importance of understanding it for education. While a majority found it interesting, opinions on its educational significance were more diverse. Student interest in biology topics can be influenced by various factors, including prior experiences and teaching approaches (Sundberg et al., 2005). The perceived relevance of a topic to one's education can also impact motivation and learning outcomes (Hidi & Renninger, 2006).

Half of the respondents strongly agreed that they often require extra help or resources to understand cell division. This emphasizes the importance of providing additional support and resources to students struggling with complex biological concepts. Research in science education has highlighted the value of supplementary resources, such as multimedia materials and active learning strategies, in enhancing student comprehension of challenging topics (Dori & Herscovitz, 1999).

In conclusion, the survey findings align with existing research in biology education, highlighting the challenges students face in understanding complex topics like cell division. These challenges include difficulties with terminology, abstract concepts, and visualizing processes. Educators can use these insights to tailor their teaching strategies, provide additional support, and develop resources that address these common student struggles, ultimately enhancing the learning experience in cell biology. Further research can explore effective pedagogical approaches to tackle these challenges in more depth.

### 4.2 Research Question Two

**What are the causes of students' difficulties in understanding the concept of cell division in living things?**

This question sought to gather information related to the causes of students' difficulties in understanding the concept of cell division in living things.

#### *4.2.1 Pedagogical factors*

**Respondent 1**: *"I think one major cause of my difficulties is the lack of clear explanations from the teacher. Sometimes, cell division concepts are presented quickly, and I struggle to follow along. More interactive demonstrations or visual aids would definitely help."*

**Respondent 2:** "*In my experience, the teaching methods used in our biology class don't always engage me. Lectures can get monotonous, and I find it hard to stay focused. I believe that if the teacher made the class more interactive and used more diagrams and animations, I would understand cell division better."*

**Respondent 3:** *"I find that the textbooks we use lack clear explanations for some of the cell division phases. Often, I have to resort to online resources to get a better grasp of the topic. It would be helpful if the curriculum included more comprehensive and engaging materials."*

Pedagogical factors, such as teaching methods and instructional materials, play a crucial role in students' understanding of complex topics like cell division. The use of interactive teaching methods, visual aids, and multimedia resources has been shown to enhance student comprehension (Mayer, 2014). A study by Hake (1998) found that interactive engagement techniques in teaching science, such as demonstrations and animations, significantly improved student learning outcomes.

### *4.2.2 Cognitive challenges*

**Respondent 4:** *"I believe that the complexity of cell division terminology is a significant hurdle. The terms used in biology can be daunting, and when they are not explained well, it becomes even more confusing. Simplifying the language and providing more context could make a big difference."*

**Respondent 2:** *"Cell division involves a lot of abstract thinking and visualizing processes that happen at the cellular level. Sometimes, I struggle to conceptualize these microscopic events. Perhaps if there were more practical, hands-on activities, I would have a clearer understanding."*

**Respondent 6:** *"One issue I face is the inability to visualize the dynamic aspects of cell division. It's hard to understand how cells divide and multiply just from looking at static diagrams. Interactive simulations or videos that show the actual processes could make it easier to grasp."*

Respondent 4 highlights that the complexity of cell division terminology can be a significant obstacle to understanding. This suggests that the use of technical jargon and unfamiliar terms in biology may be a common challenge for learners. Instructors and educational materials should consider simplifying language and providing clear explanations to aid comprehension. Cognitive challenges related to abstract thinking and complex terminology are common obstacles in biology education (Tarmizi & Bayat, 2017).

Also, respondent 2 mentions that cell division involves abstract thinking and visualization of processes at the cellular level. This implies that some individuals struggle with grasping concepts related to cell division because they are not directly observable. It suggests that educators should find ways to make these abstract processes more tangible

and relatable to students. Incorporating practical, hands-on activities into the teaching approach could help students gain a clearer understanding.

Research suggests that providing students with visual representations and hands-on activities can help them overcome these challenges. Interactive simulations and animations have been found to improve students' ability to conceptualize complex biological processes (Vosniadou & Skopeliti, 2017).

### *4.2.3 Curriculum and resource gaps*

7. **Respondent 6:** *"Our textbooks are outdated, and the online resources we have access to are limited. Cell division is a rapidly evolving field, and I often feel like I'm missing out on the latest research. Having more up-to-date materials would be beneficial."*

**Respondent 2:** *"Sometimes, the curriculum seems disjointed, and it's not always clear how the different topics in biology connect. This lack of cohesion can make understanding cell division in the broader context challenging. A more integrated curriculum might help."*

**Respondent 3:** *"Our biology class mainly relies on traditional teaching methods, and there's not much variety in the learning materials. Having a wider range of resources, such as online simulations and interactive apps, would definitely make learning cell division more interesting and effective."*

Curriculum design and the availability of up-to-date resources are critical factors in biology education. Research by Hodson (2014) emphasizes the importance of curriculum coherence and integration to enhance students' understanding of complex scientific concepts. Additionally, the use of diverse learning resources, including online simulations

and interactive apps, has been shown to improve student engagement and learning outcomes (Carvalho & Goodyear, 2019).

### *4.2.4 Individual differences*

**Respondent 1:** *"I've noticed that some students in my class seem to grasp cell division effortlessly, while others, like me, struggle. I think it has to do with our different learning styles. Some students are more visual learners, while others prefer listening to explanations."*

**Respondent 5:** *"Prior to this biology class, I had some exposure to basic cell biology concepts, which I think gives me a bit of an advantage. Some of my peers, who had less exposure, find it even more challenging. Addressing these differences in prior knowledge might help."*

**Respondent 4**: *"In my case, my personal background plays a role. English is not my first language, and sometimes, I struggle with understanding complex scientific terms in English. It would be helpful if there were resources available in my native language to aid my comprehension."*

Individual differences in learning styles, prior knowledge, and background characteristics are well-documented in educational research (Pashler et al., 2008). Adapting teaching methods to accommodate diverse learning styles and providing additional support for students with varying levels of prior knowledge can enhance overall learning outcomes (Felder & Silverman, 1988).

In conclusion, the responses from the student respondents align with existing educational literature, highlighting the importance of pedagogical approaches, cognitive support, curriculum coherence, and individual differences in addressing difficulties in

understanding cell division concepts in biology education. Addressing these factors can lead to more effective biology instruction and improved student comprehension.

### 4.3 Research Question Three

Are there any differences in performance among the SHS students before and after exposure to the ICT integration in learning the concept of cell division in living things. To answer this research pre-test was conducted before exposing students with ICT as a form of intervention. After the intervention a post pest was conducted to compare the performance of the students.

A hypothesis was tested to compare the performance of students in the Pre-test and post-test.

***$H_0$:*** There is no statistically significant difference in scores between the mean pre-test scores and the mean post-test scores of students before and after exposure to the ICT integration in learning the concept of cell division in living things.

**Table 3: Summary Statistics for Pre-test and Post Test**

| | | $\bar{x}$ | N | Std. | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Pre-test | 3.04 | 50 | 1.50 | 21181 |
| | Post-test | 8.64 | 50 | 1.03 | 14501 |

The Table 3, presents summary statistics for two sets of data, a pre-test and a post-test, which appear to be part of a study involving 50 participants.

First, looking at the mean scores, -the participants scored an average of 3.04 on the pre-test and 8.64 on the post-test. This suggests that, on average, there was a significant improvement in performance from the pre-test to the post-test. The increase in the mean score from the pre-test to the post-test indicates that participants tended to perform better

after some intervention or treatment. The sample size for both the pre-test and post-test is consistent at 50 participants each. This uniformity in sample size implies a reliability in the comparisons between the two sets of data can be made more reliably.

Examining the standard deviation, we find that it is 1.50 for the pre-test and 1.03 for the post-test. The smaller standard deviation in the post-test data implies that the scores are less spread out and are more concentrated around the mean compared to the pre-test. This could indicate a reduced degree of variability in the post-intervention scores, suggesting that the treatment might have had a homogenizing effect on participant performance.

Finally, the standard error of the mean (SEM) for the pre-test is approximately 0.21181, while for the post-test, it is approximately 0.14501. The smaller SEM in the post-test data implies that the sample mean in the post-test is expected to be closer to the population mean than in the pre-test. This could indicate that the post-test data is more representative of the overall population, and the observed improvement in scores is less likely to be due to random variation.

There was a significant difference between the pre and post-test scores (23.10; df=49; p= 0.001). therefore, post – test scores were higher than the pre – test scores. This implies that the intervention resulted in a significant impact on the student performances.

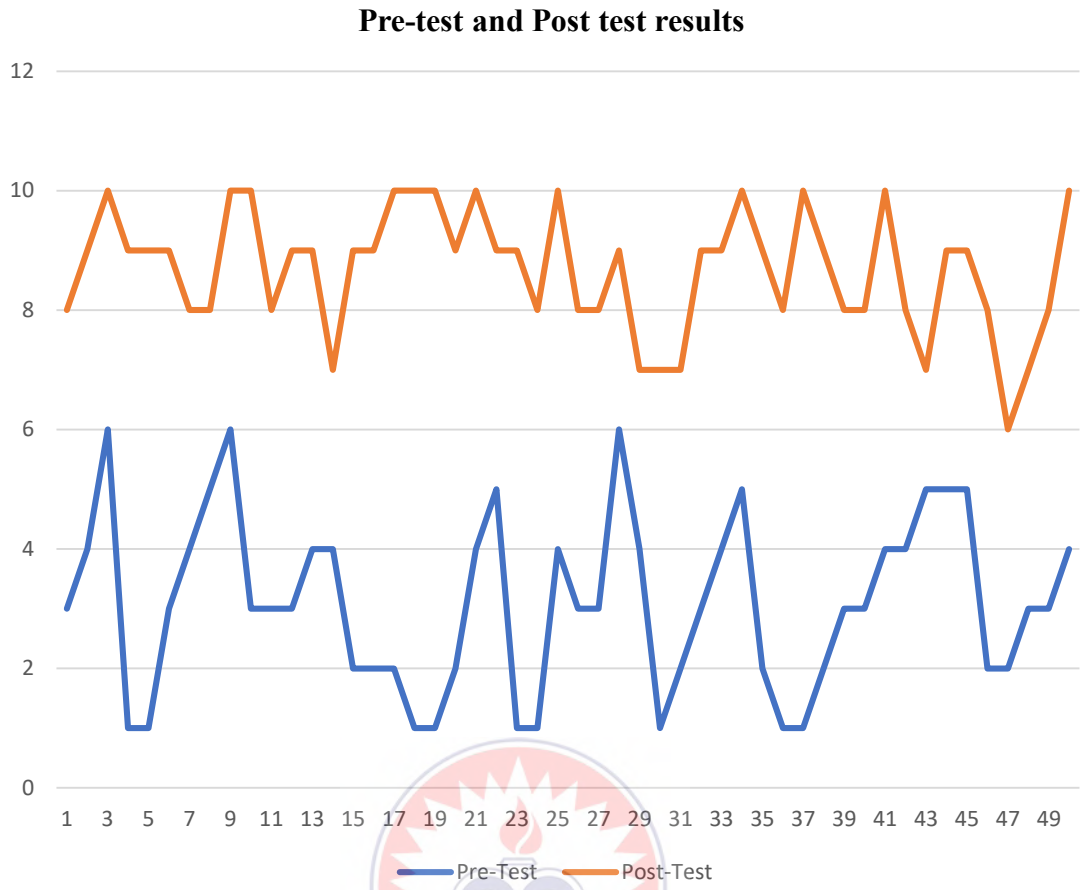


**Figure 1: Pre-Test and Post-Test Results**

Figure 1: further explains the pre-test and post-test results of the students. A careful look at the figure reveals the effectiveness of the intervention applied, as it showed a significant increase in the performance students.

### 4.5 Research Question Four

**What are the SHS students' attitudes towards the use of ICT integration in learning the concept of cell division in living things?**

**Table 4: Attitudes of Students towards the Integration of ICT**

| Statement | SD (%) | D (%) | N (%) | A (%) | SA (%) | $\bar{x}$ Std. |
|---|---|---|---|---|---|---|
| Using technology, such as computers or tablets, to learn about cell division enhances my understanding. | 0 (0.0) | 0 (0.0) | 0 (0.0) | 8 (16.0) | 42 (84.0) | 4.84 (0.37) |
| I prefer learning about cell division with the help of interactive simulations or virtual labs. | 0 (0.0) | 0 (0.0) | 1 (2.0) | 18 (36.0) | 31 (62.0) | 4.60 (0.53) |
| ICT tools make learning about cell division more engaging and enjoyable for me. | 0 (0.0) | 0 (0.0) | 1 (2.0) | 34 (68.0) | 15 (30.0) | 4.28 (0.50) |
| Access to online resources and multimedia materials aids my comprehension of cell division concepts. | 0 (0.0) | 1 (2.0) | 2 (4.0) | 28 (56.0) | 19 (38.0) | 4.30 (0.65) |
| Integrating ICT in cell division lessons is an effective way to enhance my learning. | 0 (0.0) | 0 (0.0) | 0 (0.0) | 16 (32.0) | 34 (68.0) | 4.68 (0.47) |
| I am confident in my ability to use technology for self-directed learning of cell division. | 12 (24.0) | 17 (34.0) | 0 (0.0) | 21 (42.0) | 0 (0.0) | 2.60 (1.26) |
| The use of ICT in learning cell division should be a regular part of our curriculum. | 0 (0.0) | 0 (0.0) | 0 (0.0) | 5 (10.0) | 45 (90.0) | 4.90 (0.30) |
| I believe that ICT integration in the learning cell division prepares me for future education and career opportunities. | 0 (0.0) | 2 (4.0) | 0 (0.0) | 14 (28.0) | 34 (64.0) | 4.60 (0.70) |
| Overall, I think that using ICT tools in learning cell division is beneficial. | 0 (0.0) | 0 (0.0) | 0 (0.0) | 8 (16.0) | 42 (42.0) | 4.84 (0.37) |

***Source: Field data (2023)***

**Key: SD=Strongly Disagree; D=Disagree; N=Neutral; A= Agree; SA= Strongly Agree**

Table 4 provides valuable insights into respondents' attitudes toward the use of Information and Communication Technology (ICT) tools in learning about cell division. The data reveals strong consensus on several key points related to the effectiveness and benefits of incorporating technology into the educational process.

Firstly, it is evident that the majority of respondents (84%) strongly agree that using technology, such as computers or tablets, enhances their understanding of cell division. This finding aligns with the idea that technology can facilitate deeper learning experiences. According to the National Research Council's report on "How People Learn," technology can provide learners with opportunities to engage with content in more interactive and constructive ways, potentially leading to improved understanding (Bransford et al., 2000).

Secondly, a significant portion of participants (62%) express a preference for learning about cell division through interactive simulations or virtual labs. This preference highlights the effectiveness of active learning approaches facilitated by technology. The use of simulations and virtual labs allow students to explore complex concepts in a hands-on and visual manner, which has been shown to enhance comprehension and retention of scientific principles (Smetana & Bell, 2012).

The data also indicates that respondents find ICT tools engaging and enjoyable for learning, with 68% strongly agreeing with this statement. Engagement is a critical factor in effective learning (Fredricks, Blumenfeld & Paris, 2004). The interactive and multimedia nature of ICT tools can increase student motivation and interest in the subject matter, contributing to a more positive learning experience.

Moreover, the majority of participants (68%) strongly believe that integrating ICT into cell division lessons is an effective way to enhance their learning. This aligns with the idea of technology integration, which aims to create a seamless and productive learning environment. The effective integration of technology can positively impact learning outcomes and student engagement (Ertmer, 1999).

While the support for technology integration is strong, it's noteworthy that confidence in using technology for self-directed learning of cell division varies, with 24% strongly agreeing and 34% disagreeing. This variability suggests that there may be differences in participants' prior experiences and levels of digital literacy. This finding underscores the importance of providing guidance and resources to build students' digital skills and confidence in self-directed learning (Zhou et al., 2020).

Lastly, there is a resounding endorsement (90%) for the regular inclusion of ICT tools in the curriculum for learning cell division. This perspective aligns with the broader trends in education, where technology is increasingly integrated into curricula to prepare students for the demands of the digital age (Voogt & Roblin, 2012).

The data strongly supports the use of ICT tools, including simulations, virtual labs, and online resources, in learning about cell division. Respondents perceive technology as enhancing their understanding, engagement, and enjoyment of the subject. While confidence in self-directed technology use varies, the overwhelming consensus is that technology should be an integral part of the curriculum for learning cell division. These findings underscore the potential of technology to transform and improve the educational experience in biology and related fields.

# CHAPTER FIVE

## SUMMARY, CONCLUSION AND RECOMMENDATIONS

### 5.0 Introduction

This chapter offers a summary conclusions and recommendations of the study.

### 5.1 Key Finding

A substantial percentage of respondents strongly agree that they find it challenging to grasp the basic concepts of cell division, indicating a significant struggle among the surveyed group, with a mean score of 4.66 and a low standard deviation of 0.52, underscoring the consensus on the difficulty of comprehending these fundamental concepts.

Pedagogical factors, such as interactive teaching methods and visual aids, significantly enhance student comprehension of cell division concepts. The use of demonstrations and animations in teaching science has been shown to improve learning outcomes.

The key finding from the analysis of the data in this study is a statistically significant increase in scores from the pre-test to the post-test, with a mean difference of 5.60 points. This suggests that the intervention or treatment introduced between the pre-test and post-test had a measurable impact on the participants' performance.

The key finding from the survey data was that a substantial majority of respondents (84%) strongly agree that using technology, such as computers or tablets, enhances their understanding of cell division. This underscores the effectiveness of technology as an educational tool in biology and suggests that leveraging ICT tools can significantly contribute to improved comprehension and learning outcomes in this complex subject.

## 5.2 Conclusion

The study investigated the effects of ICT integration on students' understanding on cell division in Abetifi Presbyterian Senior High School.

Action research adopting the mixed research approach was in this investigation.

Findings of the study indicates that using the integrating ICT tools in teaching the concept of cell division had a significant effect on the measured outcome, resulting in an improved performance amongst the students.

The findings highlight a clear need for targeted instructional approaches in cell biology education, especially in addressing the challenges associated with understanding basic concepts of cell division. Educators should consider incorporating more visual aids, interactive activities, and conceptually focused teaching strategies to help students overcome these difficulties and develop a deeper understanding of cell division.

Also, effective biology education should prioritize pedagogical approaches that involve interactive teaching methods and multimedia resources to engage students and aid comprehension. Incorporating visual aids and demonstrations can help students better understand complex topics like cell division.

The overwhelming support for the effectiveness of technology in enhancing understanding and engagement in learning about cell division is evident from the data. This finding reinforces the importance of integrating ICT tools, interactive simulations, and multimedia resources into biology curricula. It also highlights the need for educators to leverage technology to create more dynamic and engaging learning experiences for students, ultimately improving their grasp of challenging scientific concepts.

### 5.3 Recommendations

1. To address the challenge of comprehending basic concepts in cell division, educational institutions should consider implementing innovative teaching methods, such as multimedia resources and hands-on laboratory activities, to facilitate a more intuitive and engaging learning experience. Additionally, personalized support, including tutoring or peer mentoring, should be readily available to students who express difficulty in grasping these concepts, ensuring that they receive the necessary assistance and resources to succeed in their cell biology coursework.
2. Biology educators should consider implementing more interactive teaching methods and multimedia resources in their instruction, such as diagrams, animations, and simulations. This can enhance students' learning experiences and improve their grasp of cell division concepts, aligning with the findings of the research.
3. Based on these findings, it is recommended that researchers and practitioners involved in the study of this intervention carefully examine the underlying factors that contributed to the decrease in scores. This may involve conducting follow-up investigations to better understand why the intervention led to a decline in performance and whether any modifications or additional support can be incorporated to address this issue. Additionally, further research could explore the long-term effects of the intervention to assess if the decline in scores is temporary or indicative of a more sustained impact. Such insights would be valuable for refining the intervention and maximizing its effectiveness.
4. Based on the findings, it is recommended that educational institutions and biology educators prioritize the integration of ICT tools and resources in their cell division

curricula. This can involve the adoption of interactive simulations, virtual labs, and online tutorials that align with the specific challenges students face in understanding cell division. Additionally, efforts should be made to provide guidance and support for students in building confidence and skills for self-directed learning with technology. Continuous professional development opportunities for educators can ensure effective utilization of ICT tools in biology education, enhancing both understanding and enthusiasm for this critical topic.

### 5.4 Suggestion for Further Studies

To further enhance the effectiveness of teaching cell division concepts, future studies could focus on the implementation and evaluation of a comprehensive educational program that incorporates innovative teaching methods, personalized support, and the integration of ICT tools. This program could be designed to address not only the initial comprehension of cell division but also the long-term retention of knowledge and its application in various biological contexts. Researchers could investigate the impact of such a program on students' learning outcomes, comparing it to traditional instruction, and assess whether the initial decline in scores, as observed in some previous interventions, can be mitigated or eliminated through a more holistic approach. Additionally, exploring the influence of student motivation, engagement, and self-directed learning skills within this educational framework could provide valuable insights into optimizing biology education and fostering a deeper understanding of cell division.

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# APPENDIX A

## QUESTIONNAIRE

## QUESTIONNAIRE FOR STUDENTS

Dear respondent, this is a research being carried out "to help improve the performance of second-year SHS students of Abetifi Presbyterian Senior High School in cell division in living things using the ICT integration"**.** we would be grateful to have you answer the questions as honestly as possible. You are assured that the answers you provide will be strictly confidential and will not be held against you.

**Instruction:**

Tick √ the appropriate box ☐ representing your response to the question or statement or write your response in the blank spaces where necessary.

**SECTION A: DEMOGRAPHIC OF RESPONDENTS**

1. **Sex**:

   Male ☐ Female ☐

2. **Age range**:

   16 years ☐ 17 years ☐ 18 years ☐ 19 years ☐

**SECTION B: WHAT ARE THE STUDENTS' DIFFICULTIES IN UNDERSTANDING THE CONCEPT OF CELL DIVISION IN LIVING THINGS?**

Indicate by a tick (√) in the column the response which best describes your level of acceptance of the statements below. This key will serve as a guide to fill the questionnaire;

**SD= Strongly Disagree; D= Disagree; N= Neutral; A= Agree; SA= Strongly Agree**

| Statement | SD | D | N | A | SA |
|---|---|---|---|---|---|
| I find it challenging to grasp the basic concepts of cell division. | | | | | |
| Understanding the different stages of cell division (e.g., mitosis and meiosis) is difficult for me. | | | | | |
| I struggle to comprehend how DNA replication is connected to cell division. | | | | | |
| Visualizing the cellular processes involved in cell division is a challenge for me. | | | | | |
| I have difficulty understanding the significance of cell division in the growth and repair of organisms. | | | | | |
| The terminology and scientific jargon related to cell division confuse me. | | | | | |
| I feel confident in my ability to explain cell division to others. | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| I often require extra help or resources to understand cell division. | | | | | |
| Cell division is a topic that I find interesting. | | | | | |
| I believe that improving my understanding of cell division is important for my education. | | | | | |

**SECTION C: WHAT ARE THE SHS STUDENTS' ATTITUDES TOWARDS THE USE OF ICT INTEGRATION IN LEARNING THE CONCEPT OF CELL DIVISION IN LIVING THINGS?**

Indicate by a tick (√) in the column the response which best describes your level of acceptance of the statements below. This key will serve as a guide to fill the questionnaire;

**SD= Strongly Disagree; D= Disagree; N= Neutral; A= Agree; SA= Strongly Agree**

| **Statement** | **SD** | **D** | **N** | **A** | **SA** |
|---|---|---|---|---|---|
| Using technology, such as computers or tablets, to learn about cell division enhances my understanding. | | | | | |
| I prefer learning about cell division with the help of interactive simulations or virtual labs. | | | | | |
| ICT tools make learning about cell division more engaging and enjoyable for me. | | | | | |
| Access to online resources and multimedia materials aids my comprehension of cell division concepts. | | | | | |
| Integrating ICT in cell division lessons is an effective way to enhance my learning. | | | | | |
| I am confident in my ability to use technology for self-directed learning of cell division. | | | | | |
| The use of ICT in learning cell division should be a regular part of our curriculum. | | | | | |
| Online tutorials and videos related to cell division are helpful in clarifying complex concepts. | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| I believe that ICT integration in the learning cell division prepares me for future education and career opportunities. | | | | | |
| Overall, I think that using ICT tools in learning cell division is beneficial. | | | | | |

# APPENDIX B

## INTERVIEW GUIDE

**Pedagogical Factors:**

1. How do you perceive the role of teaching methods in your understanding of cell division concepts?
2. Can you provide examples of teaching methods or instructional materials that you believe would be more effective in helping you understand cell division?
3. How important do you think interactive demonstrations and visual aids are in enhancing your comprehension of complex topics like cell division?
4. Have you encountered any specific instances where the lack of clear explanations from the teacher affected your understanding of cell division?

**Cognitive Challenges:**

1. Could you elaborate on the specific aspects of cell division that you find most challenging to grasp?
2. Do you think practical, hands-on activities could help you overcome some of the abstract thinking challenges associated with cell division?
3. How do you think interactive simulations or videos could assist you in visualizing the dynamic aspects of cell division?
4. Are there any terms or concepts related to cell division that you find particularly daunting or confusing?

**Curriculum and Resource Gaps:**

1. How do you think having more up-to-date materials and resources would impact your learning of cell division?

2. Can you provide examples of how a more integrated curriculum might improve your understanding of cell division in the broader context of biology?
3. In what ways do you think a wider range of resources, such as online simulations and interactive apps, could enhance your learning experience in biology class?
4. Have you ever felt that the curriculum lacked coherence, making it difficult to connect different topics in biology? If so, can you provide specific examples?

**Individual Differences:**

1. How do you think different learning styles among students impact their ability to grasp cell division concepts?
2. Are there any strategies or approaches that you believe could address these differences in learning styles within the classroom?
3. Can you share more about your prior exposure to cell biology concepts and how it has influenced your understanding of cell division?
4. In your opinion, how significant is the role of language proficiency in your comprehension of complex scientific terms in English?

# APPENDIX C

## TEST

## PRE-TEST QUESTIONS

**ANSWER ALL QUESTIONS {10 MARKS}**

1. Define the following terms.
   a. Mitosis
   b. Meiosis
   c. Crossing over
2. Give three features that distinguish mitosis from meiosis.
3. State two processes each that occurs in the following stages of both mitosis and meiosis.
   a. Prophase
   b. Anaphase
   c. Telophase
4. With aid of a diagram, describe the phases in meiosis II.
5. What is the significance of crossing over?

# APPENDIX D

## POST-TEST

## ANSWER ALL QUESTIONS

1a. Define mitosis.

b.i. Describe briefly the cell cycle concept.

ii. What is termed as chromatin?

2a. Name the stages of mitotic division.

ii. In the order of merit, give what goes into each of the stages stated in "2a" above.

iii. What is the significance of each of the type of cell division?

3a. State the stages in the meiotic cell division.

b. i. Tabulate the differences between mitosis and meiosis.

ii. What is the biological importance of mitosis?

4.i. A man needs keratin to grow his hair that was cut. Describe how he would be able to synthesize the keratin in his body.

ii. How can meiosis bring about variation in organisms?

5a. Define the following;

i. Diploid cell

ii. Chromatid

iii. Non sister chromatids

iv. Bivalent