UNIVERSITY OF EDUCATION, WINNEBA

USING COMPUTER ASSISTED INSTRUCTIONS TO IMPROVE THE TEACHING AND LEARNING OF CELL DIVISION AT ST. JOHN BOSCO'S COLLEGE OF EDUCATION

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

AUGUST, 2016

DECLARATION

CANDIDATE'S DECLARATION

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

NAME OF CANDIDATE……………………………………………

SIGNATURE: ……………..

DATE: ……………………………………………………………

SUPERVISOR'S DECLARATION

I hereby declare that, the preparation and presentation of this work were supervised in accordance with the guidelines for supervision of Project Work laid down by the University of Education, Winneba.

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

SUPERVISOR'S SIGNATURE: …………………………………………

DATE: ……………………………………………………………………

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DEDICATION

This work is dedicated to my lovely late parents, Mr. and Mrs. Adayira and my children Webase Pascal Adiali, Wekia Pascaline Adiali and Weniamo Pachomius Adiali.

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ABSTRACT

The purpose of this study was to use computer assisted instructions to improve the performance of second year science students of St. John Bosco's College of Education, Navrongo, in the teaching and learning of cell division. The research design used for this study is action research design. The main research instrument used for the study is test (objective and essay type test) The researcher employed random sampling to sample fifty (50) students out of a population of one hundred and twenty(120). The data gathered was analysed both quantitatively and qualitatively. The study revealed that computer assisted instruction is one of the most efficient way of teaching students. Frequency distribution tables and descriptive statistics were used to analyze the results. The results from the pre-test indicated that students really have difficulty in describing the process of cell division. However, in the post-test results, there was a great improvement since 90% of the students were able to answer the questions correctly. Based on the results and findings revealed from the study, the research recommends the following: The different kinds of computer assisted instructions can be utilized in order to assess the attribution of a particular software type in the teaching of science. Appropriate media should be integrated into the curriculum to complement the traditional method, since it results in higher learning outcomes in terms of achievement scores and result.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter is an introduction to the study. It also includes statement of the problem, purpose of the study, research questions, significance of the study, delimitation, limitations and organization of chapters.

1.1. Background to the Study

Students' lack of understanding of science concepts, especially biological concepts they learn in Senior High School has been the subject of most studies by science education researchers (Anderson & Renstrom, 1983). The general consensus of these studies has been that, students have misconceptions about biological concepts. A few studies have attempted to provide a list of topics which may be difficult for students at certain levels.

The constructivist theory of learning mainly emphasized new knowledge built on existing knowledge (Ausubel, 1968; & Duit 1994). According to this theory, learners make connections between what they already know and the material they are learning. After making conceptual linkages between new concepts and those they already possess, knowledge is constructed in learners' minds through the process of assimilation and accommodation. Because of the impact prior knowledge has on learning, teachers and researchers should have a good knowledge of learners' existing conceptions. Learners' alternative conceptions are very tenacious and well embedded in their knowledge structures (Duit, 2000) After making conceptual linkages between new concepts and those they already possess, knowledge is constructed in learners' minds through the process of assimilation and accommodation, Because of the impact prior knowledge has on learning, teachers and researchers should have a good knowledge of learners' existing conceptions. Learners' alternative conceptions are very tenacious and well embedded in their knowledge structures (Duit, 2000)

Students have become only recipients of science knowledge and therefore they are not given opportunities to study science in a way that encourages them to start becoming more autonomous learners. Memorizing facts and information is not the most important skill in today's world. Facts are constantly changing and thanks to our digital age, we are overwhelmed with information. The traditional learning approach used to teach science does not provide students the skills needed for this new age of information and does not exercise the ability to examine and make sense of this avalanche of data.

The Chief Examiner for Science at the Institute of Education at the University of Cape Coast (2013) in his report of the Diploma in Basic Education Examinations in Science had this to say "Most of the candidates who wrote the FDC 241B (Biology) Examinations in the year 2008 performed below average and lacked the background for the sciences since they could not answer most of the compulsory questions". The further commented that most candidates could not solve very simple mathematical problems and continued to spell very important scientific words wrongly. The Chief Examiner concluded that the sort of responses candidates produce gave indications that the teaching and learning of science in the Colleges of Education has lost certain fundamental attributes. A situation which actually reduces science to rote learning and which causes candidates to operate mainly at the memorization level at the expense of the other more advanced ways of learning such as comprehension, application, analysis, synthesis and evaluation. Even at the memorization level, many candidates were found wanting since they could not remember definitions, formulae, spellings and chemical equations. Also, he added that the candidates lacked the skill of observation; most of the students could not produce any good diagrams, be it those of experimental set-ups, structures, etc. They also did not conform to the laid down rules for making scientific drawing.

The traditional teacher-centered methodology used to teach science lessons does not help to develop students' autonomy awareness as expected and it does not help to promote interest and positive attitudes toward science in students, since they do not take an active role in their science learning by asking questions or by carrying out science hands-on activities that lead them to have real experiences that enhance classroom learning, improved understanding and enjoyment of science. Due to this fact, and taking into account that students who actively make observations, collect, analyze and synthesize information, and draw conclusions are more likely to increase their autonomy awareness and develop the critical skills that they will need later on, learner centered methods should be used in teaching the cell division concept in order to help students to increase their autonomy awareness within a more student-centered environment.

1.2 Statement of the Problem

It is believed that the use of teaching and learning resources in teaching helps to make the teaching and learning process simple However, research has revealed that in most colleges of education, these resources are not available or are not being used. This goes a long way to affect teaching and learning making it less interesting and ineffective Many educational assessment scholars have argued that for lessons to effective, its introduction and conceptual basis have to be captivating and in addition, appropriate teaching and learning resources have to be employed. To these authors, the absence of teaching and learning resources make lessons more abstract and difficult for the right search image to be transferred to teacher trainees who would later transfer the same search image to other learners of relatively younger developmental ages.

According to the Chief Examiner's Report (2013), majority of teacher trainees are unable to manipulate scientific equipment, solve problems in science, and apply scientific concepts in their day-to-day activities. The report further revealed that teacher trainees find it extremely difficult to explain scientific concepts. The examiner opined that the ability of teacher trainees to form scientific concepts depends on their own background in science and the conditions under which they are being taught. The resultant effect is the gap created in learning where some concepts in science were hitherto not well understood while under training so same difficulty is also being exhibited on the field of work.

The process of cell division is in fact very complicated which needs effective teaching to facilitate understanding. Volumes of literature exist on the use of teaching and learning resources in facilitating students′ learning. However, studies on the use of animated teaching materials in teaching the process of cell division are relatively few Also, existing studies lack cultural validity since the few studies undertaken were mostly done in developed countries making them culturally biased. This research is therefore envisioned to bridge this gap by assessing the use of computer-assisted instructions in facilitating understanding on the process of cell division among level 200 Science students of St. John Bosco's College of Education, Navrongo.

1.3 The Purpose of the Study

The ultimate purpose of this study was to use computer assisted instructions to improve the performance of second year students of St. John Bosco's College of Education, Navrongo.

1.4 Objectives of the study

The study is guided by the following objectives

1. explore the concept of cell division.
2. examine teacher trainees' knowledge on the process of cell division.
3. determine the effect of computer-assisted instruction on science teacher trainees' ability to describe the process of cell division.
4. Assess the development of instructional methods in Biology

1.5 Research Questions

In line with the objectives put forward, the study sought to answer the following questions:

1. What is the meaning of cell division?
2. What is the process of cell division?
3. What is the effect of computer-assisted instructions in the teaching and learning of cell
4. 4. What instructional methods division can be used to teach cell division?

1.6 Research Hypotheses

The following hypotheses were designed to guide and direct the study:

Hhypothesis H_0: There is no significant difference in scores between the mean pre-test scores and the mean post-test scores of students.

Hypothesis H_1: There is significant difference in scores between the mean pre-test scores and mean post-test scores of students.

1.7 Significance of the Study

Improvements of teaching methods, strategies and techniques have been the concern of many Science teachers and educators since time immemorial. These desires have motivated science teachers to carry out research work in various aspects of the subject that interest them. This study would, in effect, serve as a guide to teaching and learning of cell division

The findings of the study when implemented would help Science teachers not only to be able to teach well but also identify the usefulness of using computer-assisted instructions as teaching and learning materials in teaching the concept of cell division. The teachers would have less difficulty in teaching whilst the students would develop greater interest and be more courageous in solving and explaining problems in cell division in general.

The results of this study would also serve as a guide for teachers to vary their approach and methodology to teaching which will enable students understand the concept of cell division and other topics where the concept is applicable to minimize misconception. It would also serve as resource material for all stakeholders and others who would like to research further into this area of national interest.

The study would be of significance to educational policy makers because it will provide valuable information that will direct policy, planning and implementation in science educational studies.

Finally, this study would add up to the academic pool of knowledge on the teaching and learning of the process of division of cells in Science and its related topical areas.

1.8 Delimitation

The study is delimited to level two hundred (200) science students and not all students in the school. Teaching and learning resources are vast and diversely used in the teaching and learning process. This study focused on the use of computer-assisted instruction in the teaching of the process of cell division.

1.9 Limitation

Research of this nature will not have ended without any restraints or drawbacks to its successful completion. However, a few of such limitations that impede the smooth running are enumerated below.

Firstly, the study would have been more representative if all the levels in the college were covered. The study only covered level 200 science teacher trainees because of logistical constraints and time convenience. There were also different unplanned programmes that distorted the organized time set for the intervention. As a result of this, the researcher whacked time which delayed the stipulated period for feedback on the intervention programme organized.

1.10 Organization of the chapters

This study is written in five chapters. The first chapter is the introduction which consists of the background, statement of the problem, purpose of the study, delimitation, limitations and organization of the study. Chapter two addresses the related literature to the study such as the concept of cell division, methods of teaching science, the use of computer assisted instruction in teaching science and the effects of using computer assisted instruction in teaching the process of cell division.

Chapter three is the methodology explaining the research design, population, sample and sampling procedure, research instrument, data collection procedure and data analysis plan. The results of the research are presented in the fourth chapter, and finally, the chapter five discusses results, findings, conclusions and recommendations for future practice and research.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Overview

This chapter reviews and summarizes the relevant results of some previous studies carried out in the area of study. The relevance of this is to give credence to the topic been researched into. It also aids in providing a framework for establishing the importance of the study as well as providing a benchmark for comparing the results of the study with other findings. The chapter is discussed under the following themes:

1. The Concept of Cell Division
2. Conventional Instructions verses Novel Instructions.
3. Computer Assisted Instruction as Viable Instruction Approach.
4. Development in Biology Instructional Approaches

2.2 The Concept of Cell Division

Growth and reproduction are characteristics of cells, indeed of all living organisms. All cells reproduce by dividing into two, with each parental cell giving rise to two daughter cells each time they divide. These newly formed daughter cells can themselves grow and divide; giving rise to a new cell population that is formed by the growth and division of a single parental cell and its progeny. In other words, such cycles of growth and division allow a single cell to form a structure consisting of millions of cells (Aldakheel & Al-Hussaini, 2002).

Cell division is a very important process in all living organisms. During the division of a cell, DNA replication and cell growth also take place. All these processes, i.e., cell division, DNA replication, and cell growth, have to take place in a coordinated way to ensure correct division and formation of progeny cells containing intact genomes. The sequence of events by which a cell duplicates its genome, synthesizes the other constituents of the cell and eventually divides into two daughter cells is termed cell cycle**.**

There are basically two types cell divisions. Thus; mitosis or mitotic and meiosis or meiotic cell division (Fu, Jiang, & Zhang 2011). Huh and Chen (2011) see mitosis as the process of cell division in which the daughter cells receive identical copies of DNA, which are also identical to that of the mother cell. On the other hand, meiosis is the process of cell division that results in the formation of cells containing half the amount of DNA contained in the parent cell, and having different copies of DNA from one another. According to Huh and Chen (2011), the cytoplasm and organelles are usually shared approximately equally between the daughter cells in mitosis. The purpose of meiosis is to produce haploid eggs and sperm (23 chromosomes in humans), so fertilization can produce a diploid zygote (fertilized egg with 46 chromosomes in humans).

Meiosis consists of two cell divisions. Meiosis I separates pairs of homologous chromosomes and Meiosis II separates sister chromatids 23 chromosomes in each egg or sperm. At the end of meiosis II, four (4) new daughter cells are formed.

2.3. Conventional Instructions Verses Novel Instructions

The expression 'traditional instructional approach' is also referred to as the conventional instructional approach (Geoff, 2006). The concept of traditional instruction tends to come to the mind of many adults who have experienced formal education especially, when they reflect on their own educational experiences. This concept has been described differently in parts by different writers. In one of the earlier comparative studies, the idea of the ‘passive-student’ was highlighted as one of the shortcomings of traditional instruction (Hake, 1998). Years later, traditional instruction had a nearly identical connotation with ‘lecture and questioning method’ (Sungur & Tekkaya, 2006).

Indeed, Knowles (1980) and Smith (1977) had earlier on asserted that traditional teaching methods was characterized by lectures, note taking and memorization. Traditionally, the teacher was at the centre of the learning process determining what the students learn and how they learn it (Haggerty, 2000). In fact, students were instructed by the teacher to study the textbook. The teacher provided information to the students, including concepts, facts, terms, and diagrams but it becomes the responsibility of the student to have these concepts in memory (Fiorini, 2003). According to Fiorini (2003), class periods were lecture based and involved note taking, usually through the use of a chalk board or white board. In this instructional style, it was expected that students answered questions generated by their teachers (Sungur &Tekkaya, 2006). Hattie (1992) added more defining attributes to this concept by stating that conventional/traditional method involves ‘teach-talk’. Hattie also itemized the following as some of the practices involved in the conventional method of teaching. These include students listen to a teacher explanation; students watch and listen to a teacher demonstration; students watch video; and students use paper and/or electronic resources that explain the topic in a self-contained way.

From fore mentioned descriptions of the conventional approaches to teaching, one will realize that the nature or quality of these instructions is dependent on the technological and economic status of the nation/institution as well as the professional qualification of the teachers (Carlson, 1989; Hase & Kenyon, 2000, Smith, 2002). For instance, in Ghana traditional teaching approach does not involve video show and electronic resources as claimed by Hattie (1992). In short, conventional teaching approach of a nation or institution refers to the predominately utilized teaching methods which are usually devoid of unconventional technologies.

However, as a result of differences in the level of technological advancements between nations, what is known to be conventional in one country may not be conventional in another. In reality, it is the default instructional approach which capitalizes on prevailing conditions in the educational setups to provide affordable and effective teaching aids to meet (at least in part) the needs of the society. Nonetheless, the insatiable nature of human needs and the need to envisage better future as society progresses demand that traditional instruction be constantly redesigned to reflect changes in the society (Okamoto & Shaw, 2005; Dutnall & Pillus, 2001).

Novel traditional instruction on the other hand, refers to any other instructional approach other than the traditional instructions (Tyson & Bucat, 1999; Hake, 1998; Hattie, 1992). It refers to any new instructional approach that serves as alternative to traditional instruction (Knowles, 1980). It may be psychological, technological, or methodological diverse from regular instructional approach. Of late however, technology plays a critical role in modeling new or novel instructions. Potency of unconventional instructions is usually test against the traditional instructional approach. The International Society for Technology in Education (ISTE, 2002) has identified some contrasts between traditional instructions and modern technology-based instructional environment. These are showed in Table 1.

Table 1: Differences between the Traditional Learning Environment and Technology-Based Instructional Environment

Traditional Learning Environment	New (Technology-based) Environment
1. Teacher-centered instruction	Student-centered instruction
2. Single-sensed stimulation	Multisensory stimulation
3. Single-path progression	Multi-path progression
4. Single medium	Multimedia
5. Isolated work	Collaborative work
6. Information delivery	Information exchange
7. Passive learning	Active/exploratory/inquiry based-learning
8. Factual, knowledge-based learning	Critical thinking and informed decision-making
9. Reactive response	Proactive/planned action
10. Isolated, artificial context	Authentic, real-world context

The effectiveness of traditional teaching, which is regarded as a distribution of information from an outward source to a learner, has frequently come under scrutiny (Biggs, 1996). Hill (1990) expressed similar sentiments when he commented that the standard classroom is indeed, one of the worst possible places in which learning should take place. According to ISTE (2002), traditional educational practice no longer provide prospective teachers with all the necessary skills for teaching students, who must be able to survive economically in today's workplace. These and many other reasons underscore the necessity and importance of integrating modern evidence-based instructions with time-tested professional practices to address lapses in the present classroom situation.

2.4. Computer-Assisted Instruction as Viable Instructional Approach

The expression 'Computer-Assisted Instruction' (CAI) is often seen by some authors as being synonymous with such expressions as Computer-Based Instructions (CBI), Computer-Aided Instructions (CAI), Computer-Managed Instructions (CMI) and Computer Enriched Instruction (CEI) (Hirschbuhl & Dwight, 1998). Other authorities also see CAI, CBI, CMI, and CEI forming the taxonomy of Computers' use in education (Niemiec & Walberg, 1987).

Computer-Based Education (CBE) and Computer-Based Instruction (CBI) are the broadest terms and can refer to virtually any kind of computer use in educational settings. Computer-assisted instruction (CAI) or Computer Aided Instruction (CAI) is a narrower term and most often refers to drill-and-practice, tutorial, or simulation activities (Hirschbuhl & Dwight, 1998). Computer-Managed Instruction (CMI) or Computer-managed instruction is an instructional strategy whereby the computer is used to provide learning objectives, learning resources, record keeping, progress tracking, and assessment of learner performance. Computer based tools and applications are used to assist the teacher or school administrator in the management of the learner and instructional process. CAI has been defined in diverse ways by different authorities. Hirschbuhl and Dwight (1998) defined it as an educational use of computers that usually entails using computer programmes which drill, tutor, simulates or teach problem-solving skills. Hall, Hughes, and Filbert (2000), also confirmed that CAI programmes use different types of instruction, including drill and practice, strategy instruction, and simulation to facilitate the teaching/learning process. Generally, the expression may connote any form of instructional approach where the computer is used to facilitate instructional delivery. It may involve specialized programmes such as those listed above, and other educational software, some of which may provide student-instruction interactive interface.

One unique characteristic of CAI is that it is Information and Communication Technology (ICT) driven (Hall, Hughes & Filbert, 2000). Its complexity and efficiency progress in rhythm to development in the ICT industry, and as ICT keeps on improving rapidly, CAI keeps on producing better results, making it an ever ready source of hope for instructional researchers. CAI uses diverse set of technological tools and resources to create, deliver, store, bring value addition and manage instruction (Kumar, Mittal, & Nandi, 2011). Apart from the computer, other ICT equipment serve as accessories and enhancements to the computer assisted instructional process. These may include LCD projector, modem, digital camera, loud speakers etc. Consequently, the use of such multimedia devices should create much more real effect in learners than most other pedagogical approaches.

The potentiality of CAI as a tool for enhancing learning can be conjectured from the psychological perspective. Steele (2008) defines perception as mental formation representing the essence of an item or process; a template for the creation of data blocks which represent a specific item or process, in the mind's memory. He equally sees it as a mental impression of something perceived by the senses, viewed as the basic component in the formation of concepts. Elliott, Kratochwill, Littlefield and Travers (2000) also defined perception as 'our ability to recognize the familiar and realize what we do not know'. From these definitions therefore, perception may be seen as an essential prerequisite that enhance concept formation. Since perception is based on sensing, any teaching approach that incorporates many stimulus modes should be able to stimulate many senses and as a result make more positive impact on the learning process and consequently on the concept formation and consolidation process. These last two, according to Steele (2008), are the intended outcome of every cognitive learning process. Therefore, the computer should undoubtedly, be a valuable asset to the instructor because of its ability to facilitate instructional delivery in multimodal fashion, thus enhancing perception and hence, conceptualization.

Bullough (1988) asserts that pictures that are simple in detail but lacking in colour tend to make the recall of main ideas in a printed text book more effective. The computer on the other hand, do not only have the ability to project already stored pictures, but can even generate and/or modify pictures and movies to suit their intended use (Odoom, 2014). By extension therefore, computer projected photos have better ability to enhance recall and understanding than the ordinary colourless pictures. Bullough (1988), through his preferential studies, reiterates that students prefer verbal materials that are accompanied by pictures and colours. This statement also pre-supposes that since the computer has a better ability to blend the two, CAI will best cater for such preferences of students.

The fact that the computer is an audio-visual aid explains why its use should have added advantage over the traditional teaching approach. Carlton and Curl (2002), explained that audio-visual technology provides the teacher with a means for extending his students' horizon of experience. Carton and Curl (2002) also emphasized that audio-visual technology such as the computer provides the teacher with interest-compelling springboards which can launch students into a wide variety of learning activities. Hill (2010) also affirms this by stating that visuals have the advantages of being personal, that is, they are selected by the teacher, which leads to an automatic sympathy between teacher and materials, and consequently enthusiastic use of the material. Vicki (1996) asserted that traditionally, teachers used paper slides, movies and cassette players to enrich lessons, however, they may now employ a personal computer and hard disk storage to combine these different media sources in their teaching. By this Vicki implies that the above listed multimedia materials that were sources for enriching the teaching/learning process are all embodied in the modern computer, hence making it better asset in the teaching/learning environment. Bullough (1988) stated that some computer based programmes stress the development of cognitive strategies. Bullough cited software such as problem-solving and discovery programmes as examples of software that enhance cognitive development. This invariably implies that computer, by reason of the use of special software, have unique potential for enhancing cognitive development. The learning skills encouraged by computer animations appeared to be an effective way of assisting students to emphasize understanding rather than the acquisition of factual information (Norton & Crowley, 1995; O'Hagan, 1997; Sneddon, Settle, & Triggs, 2001). An effective teaching makes student more aware of their own knowledge and cognitive processes, as well as aware of how compatible these processes were with a given learning situation (Pastoll, 1992). Computer animations allow students not to be passive recipients of information as compared to the traditional modes of teaching in lectures (Norton & Crowley, 1995; Ramsden, 1996).

Indeed, empirical evidence on enhanced instructional delivery when CAI is employed abounds. In a review of empirical studies on CAI, Cotton (1997), among others concluded that the use of CAI as a supplement to conventional instruction produces higher achievement than the use of conventional instruction alone, and that computer-based education (CAI and other computer applications) produce higher achievement than conventional instruction alone. Cotton also stated that students learn instructional contents faster with CAI than with conventional instruction alone; they retain what they have learned better with CAI than with conventional instruction alone, and CAI activities appear to be at least as cost effective and sometimes more cost-effective than other instructional methods, such as teacher-directed instruction and tutoring. Karper, Robinson, and Casado-Kehoe, (2005) also confirmed this by stating that computer assisted instruction has been found to enhance students' performance than the conventional instructional method in counselor education.

Yusuf and Afolabi (2010) also stated that there is a plethora of established findings on the instructional value of computer, particularly in advanced countries. Yusuf and Afolabi conducted a study on the use of CAI to teach Biology in general. The findings of their study showed that the performance of students exposed to CAI either individually or cooperatively were better than their counterparts exposed to the conventional classroom instruction alone. However, no significant difference existed in the performance of male and female students exposed to CAI in either individual or cooperative settings. Watson (1993) also expressed similar idea when he stated in his impact report that some studies have found small positive correlation between ICT use in the classroom and students performance. From Hattie's (2008) table of effective sizes, the computer-assisted teaching has effect size of 0.37. Simulation and games only have effect size of 0.34 while visual representations and graphic organizers of various sorts have very high effect sizes among the lot on the table. Yet it is a common knowledge that visual representations and graphic organizers can best be presented by the use of the computer and its accessories. This implies also that the computer can even be used to improve the already high effective size of visual representation and graphic organizers.

From all the above evidences, CAI can be a source of hope to the Ghanaian biology teacher when it is used with the support of accessories such as LCD projector and audio system. That is, instructional modes may be in a form of text, pictures, diagrams, charts, audio and videos, all of which have the possibility of enforcing cognition and making learning pleasurable (Kulik *et al*.,1980; Lockard, Abrams & Many, 1997; Petrakis, 2000; Steffen, 1985).

2.5. Developments in Biology Instructional Approach

One of the essential science subjects is biology (Kareem, 2003). Indeed, biology occupies a unique position in the school curriculum. Biology is central to many science related courses such as medicine, pharmacy, agriculture, nursing, biochemistry and so on (Yusuf & Afolabi, 2010). It is obvious that no student intending to study these disciplines can do without biology. These factors, among others, have drawn attention of researchers and curriculum planners towards biology as a subject in the school curriculum (Kareem, 2003). In spite of the importance and popularity of biology among students, performance at senior high school level had been poor (Ahmed, 2008). The desire to know the causes of the poor performance in biology has been the focus of researchers for some time now. It has been observed that poor performance in the sciences is caused by the poor quality of science teachers, overcrowded classrooms, and lack of suitable and adequate science equipment, among others (Abdullahi, 1982; Bajah, 1979; Kareem, 2003). Students perform poorly in biology because the biology classes are usually too large and heterogeneous in terms of ability level. In addition, the laboratories are ill-equipped and the biology syllabus is over loaded (Ahmed, 2008; Ajayi, 1998).

Apart from the above mentioned causes for poor achievement of students in biology, it might be prudent reviewing the instructional approaches being used by biology instructors. Studies on instructional strategies for the sciences were belated compared to studies in other areas of the scientific enterprise. In the 1920s and 1930s, scattered studies of the relative values of various means of teaching science began to appear; some favoring information transfer and rote memorization as in the lecture/demonstration method, and some encouraging more student-centered, disputation-like methods that included group discussion and independent laboratory work (DeHaan, 2011). These were not specifically related to biology but rather to other sciences. Intuitively, scientists were interested in inquiry-based approach to teaching the sciences since that was consistent with the contextual development of natural science (DeHaan, 2011). Some of the first comparison quasi-experiments that could be found were designed to test whether in biology (Cooprider, 1922; Johnson, 1928) or other sciences (Downing,1931) independent student work in a laboratory setting was any more effective in improving test scores than instruction with the traditional lecture-demonstration method. These early investigations showed little benefit (DeHaan, 2011). Early biology education research investigations performed within the education community began to shed doubt on the efficacy of inquiry-based instruction.

A study by Barnard (1942) at the Colorado State College of Education, which appears to be the first controlled quasi-experiment to compare the effectiveness of the lecture-demonstration method and a problem-solving laboratory approach to teaching biology at the college level, again showed no appreciable differences on test scores. In a study twenty years later, Dearden (1962) compared demonstration and problem-based methods of teaching college biology, and again found no differences in measurements of learning. Later studies and periodic comprehensive reviews of the literature continued to show few advantages of inquiry-based teaching in biology and other sciences (DeHaan, 2011). Only toward the end of the 1980s and beyond has research begun to reveal fairly consistent (though small) advantages of inquiry-based instruction (Anderson, 2002).

Despite the early findings of the limitedness of the efficacy of the inquiry method, some educationists later had high opinion on it. On "best practices" for teaching science, specifically biology, Roberts (2001) recommends that students must be able to conduct investigations to discover the answer to a "problem" or question they may have about a biological concept. Students should learn about the concept of photosynthesis by asking questions like, "How does light intensity affect the rate of photosynthesis?" To him, it is not sufficient for students to memories the facts of photosynthesis; they need to design and conduct experiments to determine for themselves how light intensity affects photosynthesis. By being taught biological concepts in conjunction with the scientific method, students are able to think "scientifically." The rationale for investigative scientific inquiry is that "for someone to be able to solve problems and judge evidence in science requires them to have both a substantive evidence of science and procedural understanding" (Roberts, 2001). By teaching biology students procedural understanding, students will be able to make decisions about biological issues such as pollution, conservation, and health care (Bertsos, 2005). They will have learned the skills necessary to design, conduct, and analyze investigations, using controls and variables. By having this procedural understanding about biological issues, they are better equipped to critique information in advertising, news, and their own health concerns (Roberts, 2001).

To Robert (2001), the traditional "hands-on" laboratories employed in biology classrooms do not lend themselves to true "inquiry." Leonard, Speziale and Penick

(2001) also argue that inquiry promotes observing, asking and identifying questions and problems; identifying independent and dependent variables, formulating hypothesis, designing and conducting experiments, manipulating independent variables, collecting variables, organizing data, displaying data so that inferences can be made, inferring from data, generalizing, applying generalizations, communicating results, and formulating new hypotheses. If the above are really the objectives of scientific literacy, then it should be accepted that the paper and pencil tests could not immediately justify the efficacy of inquiry approach. This might be the reason why early researchers could not easily observe any significant positive effect of the inquiry approach.

During the early decades, as many were engaged in this unproductive laboratory experiences, supposing that they were using inquiry approach, faculties outside schools of education started using their college biology students as subjects to carry out radical “experiments” into instructional approaches. At Ohio State University, Sampson (1931), in collaboration with Tyler (1934), changed the instructional mode of the general botany course to a *problem discussion* method (Sampson, 1931) which is now recognized as *problem-based learning*. Unfortunately, no quantitative report on the outcome of this teaching approach was provided by these implementers. However, both men judged the success of their courses qualitatively through student questionnaires and interviews, and by what they noted as clear gains in the students’ ability to discuss problems intelligently (Sampson, 1931; Tyler, 1934).

Another conceptual and pedagogical framework which is now referred to as critical or scientific thinking (Downing, 1928) which originated early in the twentieth century and biology education researchers invested much of their effort in it. Downing (1928) published a list of the elements of scientific thinking based on his own analysis of the published works of great scientists. The concepts were put on a more scientific basis in developmental psychology with the work of Piaget and his colleagues (Inhelder & Piaget, 1958; Bruner, 1961). Inquiry based instructional strategies that foster these abilities have notably been identified as techniques to help students conceptualize rather than just memories; group discussion, usually in a laboratory setting; problem solving and problem-based learning; prior knowledge and alternate conceptions; and computer-assisted instruction (Bloom, Krathwohl & Masia, 1956;; Inhelder & Piaget, 1958; Bruner, 1961).

The differences between memorizing information and learning for understanding were made explicit when cognitive psychologist, Bloom and his colleagues at the University of Chicago published Bloom's Taxonomy of cognitive skill levels (Bloom, Krathwohl, & Masia, 1956). After George (1968) found that instruction in critical thinking offered advantages to high school biology students, Allen and his colleagues at West Virginia University began to use lecture time to teach critical thinking skills to introductory college biology students, employing video and discussion during class to enable students to apply concepts as they learned them. With these quasi-experiments, they were among the first to show significant improvements in pre / post-tests of students' critical thinking skills (Moll & Allen, 1982). To help students struggling with biological concepts, Novak (1970; 1977) and Arnaudin, Mintzes, Dunn and Shafer (1984) at Cornell University also introduced concept mapping to redirect students from rote learning to learning with understanding.

An important pedagogical shift from whole-class lecture or individual instruction to various forms of group discussion and cooperative learning began in the early 1970s (DeHaan, 2011). As years go by, different group sizes were experimented with where guided activities became the norm. The movement towards these small groups learning (SGL) was driven largely by earlier research among social psychologists showing the beneficial effects of cooperative learning and student discussion as contrasted with competitive or individual instruction (Deutsch, 1949; Hammond & Goldman, 1961). SGL was first presented as an explicit instructional strategy when Lyman (1981) introduced think-pair-share. Evidence for the benefits of cooperative learning was presented in 1981, when Johnson, Maruyama, Johnson and Nelson (1981) in the Department of Psychology at the University of Minnesota published a meta-analysis of 122 experimental studies, only one of which was carried out in a college biology classroom. The strong conclusion from this analysis was that student cooperation is superior to competition or to individualistic instruction in promoting achievement in learning.

Although it is often claimed that problem solving and problem-based learning (PBL) originated in medical education in the 1970s as an alternative to information-dense lectures given to large classes (Barrows, 1980). DeHaan, (2011) argued that the "problem approach" to teaching college biology was tested much earlier (Burnett, 1938), and quasi experiments with college students in a laboratory setting were initiated in a biology classroom at Colorado State University (Barnard, 1942) and Michigan State College (Mason, 1952) and in Zoology (Frings & Hichar, 1958) at Pennsylvania State University. None of these papers report meaningful improvements in student learning.

Hancock (1940), a college biology teacher in Montana, was the first to document a long list of common misconceptions held by his students, years before Driver and Easley (1978) concluded that such alternative conceptions interfere with learning. Well-known naive conceptions such as that plants obtain nutrients from the soil to increase biomass (Wandersee, 1983), and many prior concepts related to genetic transfer and evolution by natural selection have proven to be difficult for students of all ages to overcome (Brumby, 1979; 1981; Krajcik, Simmons, & Lunetta, 1988). At the University of Wisconsin, Madison, studies beginning in the 1980s contributed to investigations of alternative conceptions of meiosis (Collins, 1989; Collins & Stewart, 1987; Stewart, 1988). Their findings were used in the development of a computer-based model of instruction, the MENDEL tutoring system (Streibel, Stewart, Koedinger, Collins, & Jungck, 1987), and the development of the Genetics Construction Kit (Jungck & Calley, 1985; Collins & Stewart, 1987; Peterson & Jungck, 1988) that were explicitly designed to help students convert their alternative conceptions into canonical knowledge (DeHaan, 2011). Indeed alternative conceptions are really a problem in the biology classroom and it is therefore, imperative for teachers to be aware of these, and introduce mechanisms for conceptual change to enhance better understanding of the concepts being taught.

Biology education research investigations with CAI which began in the early 1980s were initially aimed at determining if computer-based instruction could assist certain groups of disadvantaged students because of the increasing number of user-friendly software and growing data-bases in existence (Bangert-Downs, Kulik, & Kulik, 1985; Roblyer, Castine, & King, 1988). Jungck at Beloit College was a pioneer in this area, with BIOQUEST (Jungck & Calley, 1985; Peterson & Jungck, 1988), a one-year introductory biology course centered around 12 strategic simulation programs. Here also, research works have shown that CAI has better influence on learning than traditional instruction.

One important issue worth noting is that in all the development of biology education research certain theoretical frameworks played a guiding role for this group of researchers. The first and foremost of these is Constructivism. Much of the effort in biology education research over the past century has been devoted to testing the tenets of constructivism (Cakir, 2008). Dewey set the tone and provided the term just before the turn of the century (Dewey, 1997/1998). Piaget's Theory of Cognitive Development, (Piaget, 1972; 1978), Ausubel's Theory of Meaningful Verbal Learning (Ausubel, 1963; Slavin 1988), and Vygotsky's Social Development Theory (Vygotsky, 1978) each modified Dewey's framework in ways that changed the focus of the biology education community from how instructors teach to how students learn (Raths, Wasserman, Jonas, and Rothstein,1966; Bodner, 1986; Glasersfeld, 1989). Schwab (1962) extended constructivist ideas to develop a "didactic theory' of knowledge that emphasized creation of learning experiences through active participation of the student, discussion, and multiple conceptions of subject matter. Schwab's theoretical framework served as the basis, during the 30-year period that began in the 1960s, for many instructional strategies for teaching science as inquiry (Rutherford, 1964).

Conceptual change theory became the next watchword for biology educationists (Fox, 1985). From Piaget's work in 1929 on children and Kuhn's ideas in 1970 about paradigm change grew conceptual change theory as well as the expanding body of research on alternative conceptions as discussed above (Carey, 2000).

Theoretical frameworks such as the theory of social interdependence, and the two theories of intelligence by Feuerstein (1979) and Gardner (1983) turn to be the latest set of theories under active experimentation; and this particular study is considering issues in the perspectives of the later. It must however, be mentioned that the theory of social interdependence led to experiments on the benefits of group interaction in the 1940s by social psychologist Deutsch (1949), who eventually theorized that when people with common goals work with each other in cooperative fashion, results are better than if they compete or work alone. This theory was fundamental to the rise of the various forms of cooperative learning and SGL, such as peer instruction and think-pair-share.

Despite insurgence of all these successive biology teaching methods over the years, it appears that most of them only flourished at the experimental level (Khan & Iqbal, 2011). Predominantly however, most biology teachers use the conventional passive approach which involves situations where a material is delivered to students using a lecture-based format (Khan & Iqbal, 2011). In contrast, a more modern view of learning is constructivism, where students are expected to be active in the learning process by participating in discussion and/or collaborative activities (Fosnot, 2012). Overall, the results of recent studies concerning the effectiveness of teaching methods favour the constructivists' active learning methods. Teaching-learning process is considered appropriate only if it addresses all the objectives of science education which are spread over knowledge domain, affective domain and psychomotor domain (Khan & Iqbal, 2011). Biology is a natural science which provides many opportunities and activities for the students. From research in developmental psychology came reminders that students learn best through experience (Dewey, 1916; 1938). The teaching of biology, like other science subjects, should therefore, focus on the development of scientific concepts, attitudes and skills (Khan & Iqbal, 2011).

In contrast to the positive findings on active student-centered methods, a study by Barnes and Blevins (2003) suggests that active, discussion-based methods are inferior to the traditional lecture-based method. What do the learners also say concerning these issues? In terms of students' preferences for teaching methods, a study by Qualters (2001) suggests that students do not favour active learning methods because of the in-class time taken by the activities, fear of not covering all of the material in the course, and anxiety about changing from traditional classroom expectations to the active structure. Similarly, a study by Casado (2000) which examined the perceptions across six teaching methods: lecture/discussion, lab work, in-class exercises, guest speakers, applied projects, and oral presentations. Students most preferred the lecture/discussion method. Lab work, oral presentation, and applied projects were also fairly regarded.

Biology as a subject is peculiar and much more carefulness is associated with its content delivery and assessment (Hunt, Haidet, Coverdale & Richards 2003). Perhaps this carefulness is necessitated by the fact that it is a life science (Khan & Iqbal, 2011). Scientists are therefore, not willing that error in their practices should endanger human life. This perhaps, is the reason for the conservatism practiced by biology tutors over the years. However, as Tanner and Allen (2004) articulated, the dominance of lectures and direct instruction, especially at the high school and undergraduate level, in an attempt to transmit the large body of accrued scientific knowledge efficiently, has created a relative monoculture of teaching styles in these settings. Although a variety of strategies have been developed to broaden access for students through more varied instructional strategies (Allen & Tanner, 2003; Tanner, Chatman, & Allen, 2003), these approaches are not widely used for a variety of reasons. This is not to say that lectures (or traditional instruction) have no place in the pedagogical toolbox of a science instructor, but rather that this tool tends to be overused (Powell, 2003). As such, teaching strategies used in science classrooms have created a situation that Tanner and Allen (2004) refer to as "instructional selection", in which by our very choice of pedagogy, teachers are constructing environments in which only a subset of learners can succeed.

Understanding the variety of learning styles that students bring to a science classroom will not only help some students learn more science, but also help more students learn any science (Tanner & Allen, 2004).

One of the oldest characterization of learning styles has been to define a learner's preferred mode of learning in terms of the sensory modality by which they prefer to take in new information. VAK is an acronym that stands for three major sensory modes of learning: visual, aural, and kinesthetic, depending on the neural system with which a learner prefers to receive information. More recently, this sensory framework has been expanded to VARK to include reading/writing as an additional type of mixed-sensory learning modality. Developed in 1987 by Neil Fleming, the VARK Inventory is a tool for assessing where an individual's preferences for learning lie within his/her sensory domains (Tanner & Allen, 2004).

Although all learners can use all of these sensory modes in learning, one mode is often dominant and preferred (Fleming, 1987). Visual learners learn through seeing and prefer to learn through drawings, pictures, and other image-rich teaching tools. Auditory learners learn preferentially through hearing and are adapted at listening to lectures and exploring materials through discussions and might need to talk through ideas. Reading/writing learners learn preferentially through interaction with textual materials, whereas kinesthetic learners learn through touching and prefer learning experiences that emphasise doing, physical involvement, and manipulation of objects. In fact, as one progresses through schooling, pedagogy often emphasizes kinesthetic learning with young children through the use of models and manipulative, moves on to more visual learning as language develops in the elementary school years, and culminates in primarily aural learning in the form of lectures, accompanied by increased reading and writing, in the high school and college years (Tanner & Allen, 2004). An exception is often the college laboratory setting, which continues to offer opportunities for mature learners to use manipulations in building science knowledge (Hunt, Haidet, Coverdale & Richards, 2003

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter provides detailed description of the methodology that was employed in the study. This includes the research design, population, sample and sampling procedures, research instrument, data collection procedure (pre-intervention, intervention, post-intervention) and the method of data analysis procedure adopted.

3. 1 Research Design

The research design used for this study is action research design. Action research is a reflective process that allows for inquiry and discussions (Cannae, 2004). It is collaborative in nature and involves the application of scientific methods to solve classroom problems (Cannae, 2004). According to Watts (1985), action research is a process that participants go through by examining their own educational practices and carefully using the best techniques to improve practice.

It is a participatory and democratic process concerned with developing practical knowledge in the pursuit of worthwhile human purposes, grounded in a participatory worldview which is believed to have emerged at this historical moment (Bill, 1986). It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities.

Action research according to Cannae (2004) involves the application of scientific methods to solve classroom problems. It uses pre-test and post-test data from the teaching of two instructional units to identify student-teacher controlled factors which promote or inhibit students' academic achievement (Bill, 1986).

Action research is attractive to educational researchers because it seeks to identify peculiar problem in the educational field especially in the classroom and suggest possible rectification to the problem by offering suitable intervention and recommendations for use by other educators. Donato (2003), citing Mills (2000), defines action research as any systematic inquiry conducted by teacher researchers to gather information about ways that their schools operates; how they teach and how well their students learn. O'Brien (1998) posits that action research is learning by doing. Thus, a group of people identify a problem, do something to resolve it, see how successful their efforts were, and if not satisfied, try again. This design was chosen in order to find possible solution to the problem identified and that teacher trainees will be able to construct their learning on the process of cell division, more especially their understanding and latent teaching of the concept of cell division in Ghanaian schools.

3.2 Population

A research population is a well-defined collection of individuals or objects which have similar characteristics. All individuals or objects within a certain population usually have a common, binding characteristic or trait. In this regard, the population and the sample were carefully selected.

The research focus is on using computer assisted programme to teach cell division in colleges of education. There are two Colleges of Education in the Upper East Region of Ghana. These are Gbewaa College of Education in Pusiga within the Bawku Municipality and St. John Bosco's College of Education in Navrongo within the Kassena

– Nankana Municipality. However, for the convenience of this study, St. John Bosco's College of Education was chosen because the researcher is a resident tutor of the college. The target population consisted level 200 science students totaling 120.

3.3 Sampling Technique

Sampling is done usually because it is impossible to test every single individual in the population. It is also done to save time, money and effort while conducting the research. The researcher would wish to test all the individuals to obtain reliable, valid and accurate results. However, testing all the individuals is impossible; thus, the researcher has sampled level 200 science students for the study.

The stratified sampling technique was used to select students' sample. The researcher combed through all the students' science exercise book and grouped pupils into two strata based on their ability and inability to respond to questions on cell divisions. With the help of the random sampling technique, the strata were further screened using "YES" and "NO" on paper to select 50 students for the sample of the study. All those who picked "YES" were selected for the study while those who picked "NO" were excluded in the study. Stratified sampling, according to Awanta and Asiedu-Addo (2008), is the process of selecting a sample in such a way that identified subgroups in the population are represented in the sample the same proportion that they exist in the population.

3.4 Profile of the Upper East Region

It will be prudent that the background of Upper East Region be looked at to fully understand the basis of this research. So far as this study focuses on the use of computer-assisted instruction in facilitating understanding of the process of cell division in St. John Bosco's College of Education in the Kasana Nankana District, it is essential that the educational background of the region be brought to bare. The Upper East Region occupies a total land area of 9,826 square kilometers, which is 4.1% of Ghana's total land area (Ghana Statistical Service, 2005). The Kasena Nankana District is one of the two (2) districts of the Upper East Region of northern Ghana. The district is popularly known for its tourist areas and interesting cultural festivals. The region has two colleges of education. These are Gbewaa College of Education in Pusiga within the Bawku Municipality and St. John Bosco's College of Education in Navrongo within the Kassena – Nankana Municipality.

3.5 Research Instrument

The instrument used for the collection of data was tests (objective and essay type). The tests were used in two folds; pre-test and post-test. The researcher selected tests as the research instrument because they are easy to administer and there is less time needed to administer the test rather than the other complicated assessments that require more personal time with students (Harpster, 2001). There are explicit directions, so administering these tests are far easier. It is easy to use test to identify problems and instigate change or reform (Stigler & Hiebert, 1999).

3.6 Validity of the Instrument

Validity is the most important consideration in developing and evaluation of measuring instruments (Ary *et a*l, 2002). It is used to determine if an instrument measures what it is intended to measure. Therefore to ensure the validity of the test, draft copies were given to two research assistants at the graduate school of the University of Cape Coast who read through and made significant corrections to ensure face validity. After this modification, the test items were again sent to my supervisor for further review.

3.7 Data Collection Procedure

All the fifty (50) teacher trainees sampled for the study responded to the pre-test administered to determine their previous knowledge on the process of cell division. The pre-test was conducted on 7th September, 2015. The intervention programme begun in the 3rd week of September, specifically on 15th September, 2015. After one (1) week of intensive lessons and activities on the use of computer assisted instructions in teaching the process of cell division (intervention programme). The students were again tested (Post-test). This test included but not limited to the set of questions that constituted the pre-test. The additional questions were aimed at determining the amount of knowledge the students have gained from the intervention activities. The pre-test and the post-test were marked and graded. The test items are shown in the appendices A and B respectively.

3.7.1 Pre-Intervention Stage (Pre-test)

The researcher found out students had difficulties describing the process of cell division. This was evident after a formative assessment was conducted and subsequently graded. It was realized from pre-test that majority (80%) of the students performed poorly. During the marking, the researcher identified that students performed poorly, not because they have not come in contact with the term before but simply because they did not understand the concept and this reflected greatly in their responses. Refer to appendix 'A' for the test items.

3.7.2 Intervention Stage

The test scores from the pre-test revealed the need for an intervention programme. Students were taken through the concept as well as the process of cell division using Computer Assisted Instructions as the medium of instruction. The total sample was exposed to a 20-minute documentary of the process of cell division. They watched and listened to the documentary, the researcher intermittently came in to clarify some of the stages and types of cell division. There are two types of cell division: Mitosis and Meiosis.

Mitosis is a part of the cell cycle in which chromosomes in a cell nucleus are separated into two identical sets of chromosomes, and each set ends up in its own nucleus (Figure 1). In general, mitosis (division of the nucleus) is often accompanied or followed by cytokinesis, which divides the cytoplasm, organelles and cell membrane into two new cells containing roughly equal shares of their cellular components. Mitosis and cytokinesis together define the mitotic (M) phase of an animal cell cycle, that is, the division of the mother cell into two daughter cells, genetically identical to each other and to their parent cell.

The process of mitosis is divided into stages corresponding to the completion of one set of activities and the start of the next. These stages are prophase, prometaphase,

metaphase, anaphase, and telophase. During mitosis, the chromosomes, which have already duplicated, condense and attach to spindle fibers that pull one copy of each chromosome to opposite sides of the cell. The result is two genetically identical daughter nuclei. The rest of the cell may then continue to divide by cytokinesis to produce two daughter cells. Kalatova, Jesenska, Hlinka and Dudas (2015) opine that producing three or more daughter cells instead of normal two is a mitotic error called tripolar mitosis or multipolar mitosis (direct cell triplication / multiplication). According to these authors, such errors during mitosis can induce apoptosis (programmed cell death) or cause mutations. Various rare types of cancer can arise from such mutations (Kalatova, Jesenska, Hlinka & Dudas, 2015).

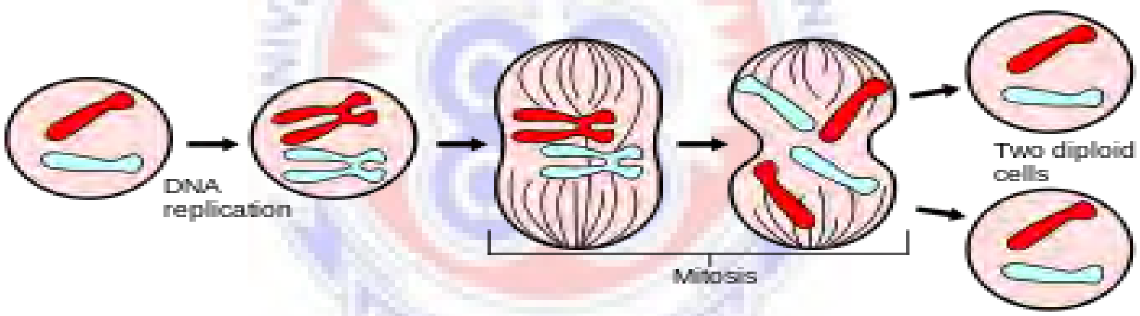

Figure 1: Stages of Mitosis

Mitosis occurs only in eukaryotic cells and the process varies in different organisms. For example, animals undergo an ‘open mitosis’, where the nuclear envelope breaks down before the chromosomes separate, while fungi undergo a ‘closed mitosis’, where chromosomes divide within an intact cell nucleus. Furthermore, most animal cells undergo a shape change, known as mitotic cell rounding, to adopt a near spherical morphology at the start of mitosis.

On the other hand, meiosis is a specialized type of cell division that reduces the chromosome number by half. This process occurs in all sexually reproducing singlecelled and multicellular eukaryotes, including animals, plants, and fungi. Errors in meiosis resulting in aneuploidy are the leading known cause of miscarriage and the most frequent genetic cause of developmental disabilities (Kalatova, Jesenska, Hlinka, & Dudas, 2015).

In meiosis, DNA replication is followed by two rounds of cell division to produce four potential daughter cells, each with half the number of chromosomes as the original parent cell (Figure 2). The two meiotic divisions are known as *Meiosis I* and *Meiosis II*. Before meiosis begins, during *S*-phase of the cell cycle, the DNA of each chromosome is replicated so that it consists of two identical sister chromatids, which remain held together through sister chromatid cohesion. This S-phase is referred to as ‘premeiotic S-phase’ or ‘meiotic S-phase’. Immediately following DNA replication, meiotic cells enter a prolonged G2-like stage known as meiotic prophase. During this time, homologous chromosomes pair with each other and undergo genetic recombination, a programmed process in which DNA is cut and then repaired, which allows them to exchange some of their genetic information. A subset of recombination events results in crossovers, which create physical links known as chiasmata between the homologous chromosomes. In most organisms, these links are essential to direct each pair of homologous chromosomes to segregate away from each other during *Meiosis I*, resulting in two haploid cells that have half the number of chromosomes as the parent cell. During *Meiosis II*, the cohesion between sister chromatids is released and they segregate from one another, as during mitosis. In some cases, all four of the meiotic products form gametes such as sperm, spores, or pollen. In female animals, three of the four meiotic products are typically eliminated by extrusion into polar bodies, and only one cell develops to produce an ovum.

For the reason that the number of chromosomes is halved during meiosis, gametes can fuse (fertilization) to form a diploid zygote that contains two copies of each chromosome, one from each parent. Thus, alternating cycles of meiosis and fertilization enable sexual reproduction, with successive generations maintaining the same number of chromosomes. For example, diploid human cells contain 23 pairs of chromosomes (46 total), half of maternal origin and half of paternal origin. Meiosis produces haploid gametes (ova or sperm) that contain one set of 23 chromosomes. When two gametes (an egg and a sperm) fuse, the resulting zygote is once again diploid, with the mother and father each contributing 23 chromosomes each. This same pattern, but not the same number of chromosomes, occurs in all organisms that utilize meiosis.

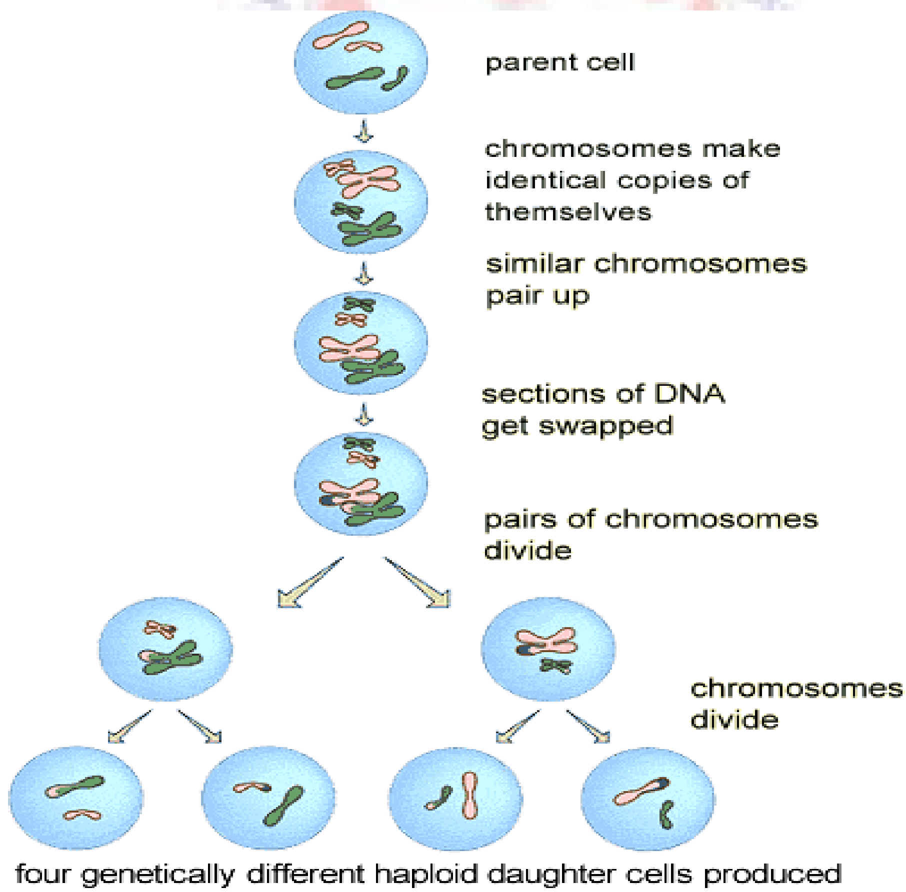

Fig.2 stages of meiosis

3.7.3 Post- Intervention Stage (Post-Test)

According to Taale and Ngman (2003), post-intervention stage provides a researcher the opportunity to evaluate the intervention programme carried out in an action research. After the intervention procedure had been carried out, the researcher again conducted model tests to evaluate the intervention activity. The set of questions given out during their pre-intervention stage was re-administered. refer to appendix 'B' for the test items

3.8 Data Analysis

The data collected was first numbered serially, edited, coded and analysed. Frequency, mean and percentages were used to analyse the data. A computer software known as Statistical Product and Service Solution (SPSS) version 19 was used to analyse the data.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

In this chapter, the results of the research have been presented and interpreted. The aim of this study was to answer the following questions;

1. What is the meaning of cell division?
2. What is the use of computer-assisted instructions in teaching of the process of cell division?
3. What is the effect of computer-assisted instructions in the teaching of the process of cell division?
4. What f instructional methods can be used to teach cell division?

The data collected was analysed quantitatively and qualitatively. The results from the pre-test and post-test raw scores were analysed using both the descriptive and inferential statistics employed on the Statistical Package of Social Sciences (SPSS). The results are presented in two forms. The first aspect contains the quantitative analysis of the performance of the students in both the pre-test and the post-test. The descriptive statistics used was to analyse the data projected the sample size, minimum and maximum scores, the mean scores and standard deviation for both the pre-test and post-test. The data was further analyzed using inferential statistics to project the p-values and t-values from the paired sample T-test.

4.2 Data Presentation and Analysis

This section presents and discusses the various research questions and hypothesis. It has been categorized into four sections; A, B and C based on the research questions and hypotheses.

4.1.1 Section A:

Research Question 1: What is the concept of cell division?

This aspect presents respondents responses on their level of knowledge on the concept of cell division. In answering this research question, a pre-test and a post-test evaluation were conducted. The results of the test have been summarised in Tables 2, 3, 4 and 5.

Table 2: Frequency distribution of the raw scores of the pre-test

Scores	Frequency	Percentage (%)
1 – 5	12	24.0
6 – 10	10	20.0
11 – 15	11	22.0
16 – 20	8	16
21 – 25	4	8
26 – 30	4	8
31 – 35	1	2
36 – 40	0	0
Total	50	100

Table 2 depicts the raw scores of respondents who participated in the pre-test. Out of 50 students, 12 students representing 24% scored between 1 and 5 inclusive. Ten students scored between 6 and 10 while eleven students scored between 11 and 15 inclusive. Eight students scored between 16 and 20 exclusive with four students each scoring between 21 and 25, and 26 and 30 respectively. Only one student scored between 31 and 35 with none of them scoring marks ranging from 36 to 40. It is obvious from the marks that out of the 50 students who took the test, 41 students representing 82 per cent obtained marks less than half of the total marks and only 9 students representing about 18 per cent scored half or more of the total marks. This is very clear that level 200 science students of St. John Bosco's College of Education have difficulties in describing the process of cell division. This abysmal performance also reinforces the calls for thorough diagnosis to identify the root causes of the problem and also to suggest best solutions to the problem.

An intervention was therefore designed and implemented after identifying the causes. After the implementation, another test was conducted to check the effectiveness of the intervention. Table three shows the results of the post-test.

Table 3: Frequency distribution of the raw scores of the post-test

Score	Frequency	Percentage (%)
1 – 5	0	0
6 – 10	0	0
11 – 15	1	2
16 – 20	5	10
21 – 25	5	10
26 – 30	6	12
31 – 35	11	22
36 – 40	22	44
Total	50	100

From the post-test results in Table 3, it can be deduced that no student contained marks between 1 and 5, and 6 and 10 inclusive respectively. One (1) student representing 2% got marks from 11 to 15 and five students each scoring marks between 16 and 20, and 21 and 25 inclusive respectively. Majority of the respondents (22 students) representing 44%, scored 36 to 40. Again, 6 (12%) and 11 (22%) students scored between 26 and 30, and 31 and 35 inclusive respectively. It was realized from the post-test results that, 44 students representing 88%, who took the test obtained half or more of the total marks of 20. These improvements in students' performance indicate the effect of the computer-assisted instruction as resource in teaching and learning of the process of cell division.

However, 6 students, representing 12%, scored marks less than half of the total marks which indicate that some students still have little problems in describing the process of cell division.

Thus, after the intervention, the evidence gathered from the post-test scores suggests that incorporating the intervention tool (computer-assisted instruction) into the teaching of the process of cell division improved the achievement scores (88% of students scored above the average mark). Hence, the use of computer-assisted instruction has a positive effect on students' achievement scores of describing the process of cell division. This excellent performance of the students clearly shows that the problem which was identified has been duly solved to a greater extent.

Table 4: Distribution of Responses of Respondents on the Concept of Cell Division

Question	Correct		Incorrect	
	Freq.	%	Freq.	%
Centrioles are found only in plant cell	8	16	42	84
What types of cell division reduces the chromosomes number by one half?	18	36	32	64
Cells divide the following reasons except	14	28	36	72
The point of attachment of chromatids is known as	7	14	43	86
Cytokinesis is the division of	12	24	38	76
Total	59	24	191	76

Table 4 indicates that out of the 50 students sampled, majority of the respondents were not able to answer questions on "the point of attachment of chromatids is known as.., centrioles are found only in plant cell, cytokinesis is the division of … and cells divide for the following reason except …" with percentages 86, 84, 76 and 72 respectively. Followed closely were 32 (64%) respondents who incorrectly answered the question "what types of cell division reduces the chromosomes number by one half?", however, 18 (36%) were able to answer "What type of cell division reduces the chromosomes number by one half? On the average, 24 per cent of the questions asked during the pre-intervention stage on the concept of cell division were answered correctly while 76 per cent of the questions were answered incorrectly. This is very clear that level 200 science students have difficulties in describing the process of cell division. This results go to confirm the assertion of Sharma, Gupta and Kumbkarni (1961) that most teacher trainees might have possibly been exposed to the concept of cell division but could hardly describe the concept since they lack clear understanding.

4.1.2 Section B:

Research Question 2: What is the process of cell division?

This research question sought to find out teacher trainees knowledge on the process of cell division. Tables 5, 6, 7, 8 and 9 provide a summary of the results.

Table 5: Distribution of Respondents Responses on the Process of cell division

Question	Correct		Incorrect	
	Freq	%	Freq.	%
During what stage do the nuclear membrane and the nucleus remains intact?	21	42	29	48
At the end of anaphase I the becomes a…………cell	11	22	39	78
During metaphase I in meiosis, it is the……………that arrange themselves at the equator of the cell	11	22	39	78
In which stages of genetic materials (synapsis) occur?	13	26	37	74
Total	56	28	144	72

Table 5 captures students' level of knowledge on the process of cell division. Four questions were asked on this aspect to test students' level of knowledge on the process of cell division. The table indicates that averagely less than 50 per cent of the students in most cases were able to answer correctly because of dangling responses, thus could not attain the total marks allotted to each question. After critically analysing the presentation of answers by the students in terms of the overall performance in each question, the researcher also look at the answers given by some individual students on the various stages of the process of cell division. This is illustrated in Tables 6, 7, 8 and 9 below.

Table 6: Process 1. Prophase 1 stage of cell division;

Student	Response
1	In prophase I, chromosomes thicken and become visible, centrioles begin to move to opposite sides of the cell spindle fibres begin to form.
2	In prophase I, homologous chromosomes in the nucleus.
3	In prophase, the reproductive cell divides into two cells.
4	The cell divides into two daughter cells with the same number of chromosomes as the parent all.
5	At this stage dehydration of the cell takes place. Also the nuclear membrane and the nuclear remain intact.

However, several researchers (Stahl, & Luciani, 1972; Toth, Baka, Veeck, Jones, Muasher & Lanzendorf, 1994; Muñoz-Elías, Woodbury, & Black, 2003) explained that, the first stage in the process of mitosis (before prophase) begins, the chromosomes duplication to form two long, thin strands called chromatids. During prophase itself, the chromatids condense and thicken to form distinct bodies. Chromatids making up a single chromosome are joined at the middle in an area called the centromere. The membrane surrounding the nucleus disappears, and the spindle begins form. In prophase and the later stages of mitosis until separation of the individual chromatids during anaphase, each chromosome consists of two chromatids, and each chromatid contains a complete copy of the genetic information belonging to the chromosome. For example, human beings have 23 pairs of chromosomes in all somatic cells, or 46 chromosomes in total. At the end of prophase, each of these 46 chromosomes contains two identical chromatids.

It is clear from these explanations given that the students answers given lacks the necessary conditions that occur during the prophase 1 stage

Table 7: Anaphase stage of cell division;

Student	Response
1	In anaphase, chromosomes arrange themselves at the equator and spindle fibres begin to pull sister chromatids apart.
2	In anaphase, chromatids complete and move to opposite ends.
3	Here cytokinesis the division of the cytoplasm occurs.
4	During anaphase period, the cell chromosome divides into chromosomes.
5	At this stage, the sister chromatids start to move apart.

According to Gonzalez, Casal, and Ripoll (1988), fibers of spindle apparatus pull each pair of sister chromatids apart. One goes to one pole of the cell, the other goes to the other pole. Out of the five answers sampled, it was only student 5 whose answer is correct. However, there were other processes that were left out. As stated by Brown, Goetsch, and Hartwell (1993), the anaphase begins when the centromeres of each pair of sister chromatids separate, and the now-daughter chromosomes begin moving toward opposite poles of the cell due to the action of the spindle fibers. Depending on where the centromere is located along the chromosome, a characteristic shape appears during chromosome movement. The two shown above give V and J shapes. At the end of anaphase, a complete set of chromosomes has assembled at each pole of the cell.

Table 8: Metaphase Stage of Cell Division.

Student	Response
1	In metaphase, chromosomes arrange themselves at the equator of the nucleus.
2	Metaphase chromosomes line up themselves at the equator of the cell and spindle fibres are formed which later pull sisters chromatid to the ends.
3	Metaphase is the period which the cell chromosome becomes thickened and ready to split into spindle fibres.
4	At this, the chromosomes each pair of sister chromatids are joined together.
5	During metaphase, spindle fibres are completely formed and each pair of sister chromatids join together.

Looking at these answers, student 1 and 2 answers were correct. Even that, student 1 answers cannot be completely accepted because the student failed to explain what happens after the chromosomes arranged themselves at the equator of the nucleus as opined by (Sharma, Gupta & Kumbkarni, 1961).

Bajer (1957) explained that, the chromosomes are lined up along the cell's equator, also known as the equatorial plate, and are attached to the mitotic spindle apparatus via microtubules (to try and visualize the microtubules extending from the poles to the chromosomes on the equator, think of the Earth - it's as if rope was extending from the chilly north and south poles to the chromosomes basking in the sun at the equator).

Table 9: Telophase Stage of Cell Division.

Student	Response
1	At telophase sister chromatids are pulled apart and cell begins to divide
2	In telephase chromosomes begin to pair
3	The parent cell divides into 2 daughter independent cells”
4	Telephase here the cell divides completely
5	“Sister Chromatids reach their destination, cytokinesis begins.”

Looking at their answers, it was revealed that student 1 and 5 have their answers correct and student 3 came close to the answer.

The final phase of cell division, in which membranes form around the two groups of chromosomes, each at opposite ends of the cell, to produce the two nuclei of the daughter cells. The spindle disappears, and the cytoplasm usually divides (in the process called cytokinesis). In mitosis, telophase is preceded by anaphase. In meiosis, telophase occurs twice, once as part of the first meiotic division (when it is usually called telophase I) and once during the second meiotic division (when it is usually called telophase II). During telophase I, the members of pairs of homologous chromosomes which have separated during anaphase I (anaphase of the first meiotic division) regroup at the two ends of the cell (Ruchaud, Carmena, & Earnshaw, 2007).

Telophase occurs in which these separated chromosomes reach the opposite poles of the dividing cell and the nuclei of the daughter cells form around the two sets of chromosomes. As soon as the chromosomes stop moving and is kind of like prophase but only backwards. The chromosomes uncoil back into chromatin, the nuclear envelope reappears around the chromatin and the nucleolus reappears in the nucleus. Mitosis is done at this point but the cells still need to split apart, which is what cytokinesis does. A cleavage furrow pinches off the two cells from each other and produces two daughter cells. Then the cells get ready to do it all over again (Taylor, 1960).

This results show that most of the students were not able to answer the questions on the concept of cell division. On the processes involve in the prophase 1 stage, explanations given by the students lack the necessary conditions that occur during the prophase 1 stage. Looking at the answers, only two student's answers were correct. Even that, one of the students' answers cannot be completely accepted because the student failed to explain what happens after the chromosomes arranged themselves at the equator of the nucleus as opined by (Sharma, Gupta & Kumbkarni, 1961).

4.1.3 Section C:

Research Question 3: What is the effect of computer-assisted instructions in the teaching of the process of cell division?

This research question aimed at determining whether there is or no significant difference in the mean scores of teacher trainees before and after the use of the intervention tool (computer-assisted instruction) in describing the process of cell division. In answering this research question, a null and alternative hypotheses were tested. Tables 11 and 12 provide the summary of the results.

4.1.4 Testing of the Hypotheses

Null hypothesis H_0: There is no significant difference in scores between the mean pre-test scores and the mean post-test scores of students.

Alternative hypothesis H_a: There is significant difference in scores between the mean pre-test scores and mean post-test scores of students.

Table 10: Descriptive Statistics of Pre-Test and Post-Test Scores

Intervention	Frequency	Minimum score	Maximum score	Mean score	Std. Deviation
Pre-Test	50	2	32	20.18	7.975
Post-Test	50	15	38	40.16	7.869

Table 10 presents the statistics of the pre-test and post-test scores of respondents (students). From table 11, the mean of pre-test score was 20.18 and that of post-test score was 40.16. Thus, the mean score of 19.98 (which is difference between post-test mean score and pre-test mean score) shows a significant improvement in students' performance in describing the process of cell division after the intervention programme of computer-assisted instruction had been implemented.

A comparison of standard deviations of the pre-test score, 7.975 and post-test score, 7.869, revealed that the standard deviation of the post-test was less than that of the pre-test which indicates that the scores in the post-test were more spread around the mean mark which is 40.16 than it was in the pre-test scores. The minimum and maximum marks of pre-test scores and post-test scores are respectively 2, 32 and 15, 38. It is clear that both the minimum and the maximum marks of post-test scores are by far larger than that of the pre-test scores. This improvement is as a result of the motivation derived from the use of the CAI as an intervention tool which subsequently sustained the students' interest in describing cell division.

Table 11: Paired Sample Test for Pre-Test and Post-Test Scores

Variable	*N*	Mean	Standard Deviation	*t-value*	*df*	*p-value*
Pre-Test	50	-3.036	1.679	-2.557	9	0.000
Post-Test						

Table 11 depicts a paired-sample test for the pre-test and post-test scores of respondents (teacher trainees) in describing the process of cell division. From table 12, the paired-sample test produced a p-value of 0.000 which is less than the level of significance (0.05). Hence, the researcher reject the null hypothesis and accept the alternative hypothesis. Accordingly, it is concluded that there is a significant difference between the mean scores of students in the Pre-test (20.18) and the post-test (in describing the concept and process of cell division.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND SUGESTIONS FOR FURTHE STUDIES

5.0 Overview

This chapter summaries the research findings, conclusions and gives recommendations and suggestions for further studies.

5.1. Summary of findings

The ultimate purpose of this study is to use computer assisted instructions to help St. John Bosco's College of Education, Navrongo level 200 science students to describe the process of cell division. Specifically the study seeks to: explore the knowledge of students on the concept of cell division, find out about teacher trainees' knowledge on the process of cell division and determine whether there is any difference in students' performance in using computer assisted instructions to teach the concept and process of cell division.

The research design used for this study was the action research design. The data collected from the pre-test scores and post-test scores were first subjected to descriptive statistics using Statistical Package for Social Sciences (SPSS) and later presented in the form of percentages and frequency tables.

The process of intervention revealed that there is a significant difference in the mean achievement scores of students using CAI to their mean achievement scores when CAI was not used. The statistical difference showed that the intervention tool (computer-assisted instruction) used improved students' knowledge in problems involving cell division.

The findings have serious implications for science teaching and learning. The question about teachers' pedagogical and content knowledge requirements cannot be over-emphasised for effective classroom teaching and learning of science, specifically the teaching and learning of cell division. This is because effective lesson presentation requires expert execution of a set of decisions and actions in the pre-instructional, interactive and post instructional phases of teaching that depend on the knowledge base of the teacher. At the pre-instructional phase, decisions about what content to include in lesson presentation and organising the content in a logical and meaningful manner require extensive content knowledge base with a repertoire of pedagogical strategies. This is achieved by enabling the students to construct ideas and make meaning of on their own. The teachers' pedagogical content knowledge cannot exclude the issue of language and improved teaching resources since it is only through these resources that any form of teaching can be possible.

5.2 Conclusions

This study has shown a comprehensive breakdown of quantitative data, a general preview of the situation facing science students in colleges of education in Ghana. Furthermore, the figures and descriptive information have provided an overall synopsis on the use of computer assisted programme in helping level 200 science students of St. John Bosco's College of Education, Navrongo to understand and describe the process of cell division.

It is evident from the findings of the study that using computer-assisted instructions immensely improved students' achievement scores in describing the concept of cell division, more particularly, the process of cell division. Thus, the use of CAI in the study of concepts in Science improves on students' precision in description and scoring.

There was a common feeling of confidence among students using the CAI. It is therefore concluded that, the use of CAI as a teaching aid sustains and motivates students' interest in learning science.

5.3 Recommendations

Based on the results and findings revealed from the study, the researcher recommends the following:

1. There is a very genuine acceptance that the use of computer assisted programme helped St. John Bosco's College of Education, Navrongo level 200 science students to understand the process of cell division. In view of that, it is recommended to tutors at the colleges of education, specifiacaly those in the sciences to incorporate CAI in the pedagogical strategies if they expect their students to have improved performance.
2. This study was limited to the use of computer assisted programme to help only St. John Bosco's College of Education, Navrongo level 200 science students to describe the process of cell division, and it can be replicated with a larger sample size for more generalization to a bigger population.

5.4 Suggestions for Further Studies

A single research work cannot successfully exhaust the study of any research work. The following areas are also notable for further studies:

1. The use of computer-assisted instruction in describing the process of cell division: A comparative study of level 200 science students of two colleges of education in the Navrongo Municipality. This is aimed at widening the sample size to help achieve broader results for easy generalisations.
2. The use of computer-assisted instruction in describing the process of cell division in animals: A case study of level 200 students of St. John Bosco's College of Education.

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APPENDICES

Appendix A

Pre-test Questions

University of Education, Winneba

Department of Science Education

Student's Knowledge in Basic Biological Concept Test

Dear students,

This test is aimed at assessing your fundamental knowledge in biology. This is to enable your teacher adopt the most appropriate teaching technique to help you understand better concepts in biology in subsequent days. The results of this test will be treated confidentially.

Thank you.

SECTION A (MULTIPLE CHOICE TEST)

Instructions: Each question in this section is followed by four options lettered 'A' to 'D' choose the most appropriate option for your answer by circling the letter that corresponds to your chosen option with a pencil.

ANSWER ALL QUESTIONS IN THIS SECTION

1) When an animal cell is surrounded by only a cell membrane, plant cell is surrounded by a cell wall mall of ……………….. A. Chitin B. Cytoplasm C. Lipid D. Cellulose
2) All the following are enzymes except A. Lipase B. Maltase C. Lactose D. Protease
3) Plants obtain their food through…………. A. Absorption B. Photosynthesis C. Respiration D. Excretion
4) During what stage do the nuclear membrane and the nucleus intact? A. Anaphase B. Telophase C. Metaphase D. Interphase
5) The cell theory states that……. A. All organisms are composed of one or more cells B. Cells themselves are alive C. Cells come from other cells D. All of the above

6) The process by which chromosomes are equally divided and distributed to the daughter cells during cell division is called……………….A. Mitosis B. Cytokinesis C. Meiosis D. Binary fission
7) The phase of mitosis when the chromatin condenses is called……….. A. Anaphase B. Telophase C. Prophase D. Metaphase
8) What type of cell division reduces the chromosome number by one-half? A.46/23 B. Meiosis C. Mitosis D. Cytokinesis
9) Cell divide for the following reasons except A. Reproduction B. Repair of wound tissues C. Growth and development D. For cytokinesis to occur
10) During interphase the DNA exists as A. Chromatin B. Chromosome C. Histone D. Chromatid
11) Small membrane enclosed structures within cells that perform specific functions are called……….. A. Organs B. Tissues C. Microtubules D. Cytoplasm
12) Which of the following organelle is not surrounded by one or more membrane A. Ribosome B. Chloroplast C. Vacuole D. Micro body
13) Cytokinesis in plant cell is accomplished by………….. A.A contractile ring made of actins filament B. The formation of a cell plant C. Astral projection D. Neighboring cells that exert external force
14) During metaphase I in meiosis, it is the………...that arrange themselves at the equator of the cell A. Chromosomes B. Chromatids C.DNA D. Sister chromatids
15) The point of attachment of sister chromatids is known as………….. A. Replication B. Centro mere C. Crossing over D. Chiasmata
16) Haemoglobin is…………….. A. Complete sugar B. Protein C. Enzyme D. Blood cell
17) Which of the following trait is not influenced by the environment? A. Height B. Body weight Skin color D. Blood group
18) Night blindness is caused by deficiency of……………. A. Vitamin B B. Vitamin A C. Protein D. Vitamin C
19) The tendency of an organism to resemble its parents is……………….. A. Variation B. Genetics C. Genotype D. Heredity
20) Genes are produced by………….. A .Chromosomes B. Centioles C. Centro mere D. Nucleus

SECTION B

Instruction: Answer all question in this section

1) Mitosis is to somatic cells whereas meiosis is to……………………….
2) There are 46 chromosomes in a somatic cell. True/false
3) Both not tubers and rhizomes internodes. True/false
4) A…………is used to measure the amount of rainfall
5) Name the two type of digestion
6) Digestion of protein begins in the…………………….
7) The egg of the hen contains many cells. True/false
8) Carbohydrates are made up of small units called polysaccharides. True/false
9) Gaseous exchange takes place in the alveoli sacs. True/false
10) All food chain begin with a producer. True/false

APPENDIX B

Post-Text Questions

Dear students,

This test is aimed at assessing your knowledge and understanding on the topic '***cell division'***. All the sections of the test are equally important, and it is expected that you will pay attention to all of them so as to enable me to have a fair assessment of achievement in the topic. Results of this test will be treated confidentially.

Thank you.

SECTION A (MULTIPLE-CHOICE OBJECTIVE TEST)

Instructions: Each question in this section is followed by four options options lettered 'A' to 'D'. Choose the most appropriate option for your answers by circling around the letter that corresponds to your chosen option with a pencil.***If you decide to change your answer, erase the first one completely and re-circle your new choice***

1) During what stage do the nuclear membrane and the nucleus remain intact?

   A. Anaphase B. Telophase C.Metaphase D. Interphase

2) Centrioles are found only in plant cells. True/false

3) What type of cell division reduces the chromosome number by one-half?

   A. 46/23 B. Meiosis C. Mitosis D. Cyntokinesis

4) Cells divide for the following reasons except

   A. For reproduction C. Repair of worm out tissues

   B. Growth and development D. For cytokine sis to occur

5) At the end of anaphase I, the cell is a……………cell.

   A. Haploid B. Diploid

6) During interphase, the DNA exist as…………..

   A. Chromatin B. Chromosome C. Histone D. Chromatid

7) During metaphase I in meiosis, it is the…………that arrange themselves at the equator of the cell.

   A. Chromosomes B. Chromotids C. DNA D. Sister chromatids

8) The point of attachment of sister chromatids is known as……………..

   A. Replication B. Centro mere C. Crossing over D. Chiasmata

9) Cytokine sis is the division of the…………….

A. Cell membrane B. Nucleus C. DNA D. Chromosome

10) In which stage of meiotic cell division does exchange of genetic material (synapsis) occur?

A. Anaphase II B. Anaphase I C. Prophase I D. Interphase

SECTION B

Answer all questions in this section.

1) Describe what happens during the following stages of cell division.
   I. Prophase I
   II. Anaphase
   III. Metaphase
   IV. Telophase
2) a. Compare mitosis and meiosis in a tabular based on the factors below.

Factor	*Mitosis*	*Meiosis*
Type of cells in which they occur		
Chromosome (n) of cells formed		
Number cells formed		

b. give the significance each of mitosis and meiosis.

c. this mitotic cell below is in which stage?

3) Indicate the sequence in which the mitotic cell division below goes through.