UNIVERSITY OF EDUCATION, WINNEBA

USING COMPUTER-BASED INSTRUCTIONAL SIMULATIONS TO IMPROVE STUDENTS' PERFORMANCE IN THE CONCEPT OF CELL DIVISION

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DECEMBER, 2015

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A dissertation in the Department of Science Education, Faculty of Science Education, submitted to the School of Graduate Studies, University of Education, Winneba in partial fulfilment of the requirements for award of the Master of Education (Science Education) degree.

DECEMBER, 2015

DECLARATION

STUDENT'S DECLARATION

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

SIGNATURE:……

DATE:…….

SUPERVISOR'S DECLARATION

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

SIGNATURE:……

DATE:……

ABSTRACT

Empirical investigations on students' conception of cell division in Biology indicated a major misunderstanding of some scientific concepts even after being thoroughly taught. Therefore the main aim of this study was to investigate the impact of computer-based instructional simulations in the teaching and learning of cell division. The target population was the form two Biology students of the Seventh Day Adventist Senior High School, Asokore, Koforidua. Two Home Economics classes were selected for this study. The two Home Economics one (2HEI) students constituted the experimental group and the two Home Economics two (2HE2) students constituted the control group. The groups were selected based on a mean score from a pre-test that was administered. The total number of students used for this study was fifty eight. The control group was made up of thirty students whiles the experimental group was made up of twenty eight students. The experimental group was the group with the lower mean score and was taught cell division using computer-based instructional simulations for three weeks and the control group was the group with the higher mean score and was taught the same topic but using the traditional method for the same period. After the three weeks a post-test consisting of ten multiple – choice and three short answers theory test items were given to both groups. Descriptive statistic, paired and unpaired t-test were used for the analysis. The results indicated that the experimental group performed better after the post-test as compared to the pre-test. As a result, there is a need for Biology teachers to integrate computer simulations module into the teaching and learning processes to enhance students understanding of difficult concepts.

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Finally am grateful to my parents, siblings and my beloved husband.

DEDICATION

This dissertation is dedicated to my lovely sons; Samuel Sakyi Busumbru and Nana Osei Sakyi Nyamenim.

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LIST OF ABBREVIATIONS

BECE	Basic Education Certificate Examination
CBIS	Computer Based Instructional Simulation
CRDD	Curriculum Research Development Division
	Examination
GES	Ghana Education Service
HE	Home Economics
JHS	Junior High School
MOE	Ministry of Education
SHS	Senior High School
TIA	Traditional Instructional Approach
WASSCE	West Africa Secondary School Certificate

CHAPTER ONE

INTRODUCTION

OVERVIEW

This chapter deals with the introductory section of the study. The background of the study, statement of the problem and the purpose of the study are discussed in this chapter. It also presents the objectives of the study, research questions, hypothesis, significance and delimitation of the study.

BACKGROUND TO THE STUDY

Teaching and learning of science place a lot of challenges on teachers and it is a great worry to stakeholders in education; government, parents and schools. Many countries are currently experiencing a gradual drop in student participation and performance in science subjects. (Beauchamp & Parkinson, 2008.)

Poor performance of students in science subjects has brought about a debate on teachers' teaching methods and the students' mode of learning. Whereas most people see this performance as resulting from lack of important teaching competencies others see the lack of student motivation as a major contributing factor (Yunus & Ali, 2009). Another school of thought has it that the problem is caused by the two factors stated above (Koehler & Mishra, 2009).

This calls for an approach that treats teaching as integration between what teachers know and how they apply their knowledge in unique circumstances or contexts within their classrooms. Luis, Illera and Escofet (2009) support the ideas of Koehler and Mishra and propose the adoption of a learner-centered approach. An effective learner-centered approach requires the use of information and communication technology

(ICT) which engages students in a flexible learning situation bringing about dynamism in terms of location, time, materials, content and teaching approaches. In spite of the development that ICT integration in education has brought about in developed countries by way of enhancing teaching and learning of science, little has been done to integrate it in education in developing countries (Hare, 2007: Moonen, 2008: Tilya, 2008).

One of such ICT programs in education is computer-based instructional simulations. According to Akpan, (2001) and Coleman, (1998) computer simulations can be used as extremely effective tools to help students understand difficult concepts, cell division being one. Apart from this, other important but difficult topics in Biology studied by students and have been identified by some researchers, include Photosynthesis, Mitosis, Meiosis, Cellular Respiration, Protein synthesis and Mendelian genetics (Finley, Stewart & Yarroch, 1982). A number of researches have been conducted on the use of ICT in the teaching of science in Ghana. However, little is known about the impact of the integration of computer-based instructional simulations on the teaching and learning of cell division and its effect on students' performance in schools.

A study to investigate the impact of the integration of this module into the teaching and learning processes on the performance of students in cell division is therefore of much interest to the researcher.

STATEMENT OF THE PROBLEM

The use of ICT software programmes has generated many changes in the society and these changes have in turn made many institutions change their ways of handling their programmes. Even individuals have been and are strongly being influenced positively

through the application of ICT in their daily activities. However, its impact on education will be strongly felt positively if teachers integrate such new technologies as computer-based instructional simulations into the day to day teaching and learning situations in the classrooms.

Through the researchers own observations, it has been realized that Biology students in Seventh Day Adventist Senior High School (S.D.A.S.H.S.) Asokore –Koforidua have been getting low marks in their class exercises, assignments and examinations. This poor performance of students can be associated to the fact that some biological concepts are too abstract and students' find it difficult in learning such concepts and therefore their approach to answer such concepts are incorrect. This can also lead to poor performance in West African Senior Secondary Certificate Examination, WASSCE.

The performance of Ghanaian students in the WASSCE in biology has been a worry for many stakeholders in education for some years now. In the year 2008 for instance, out of the 19816 candidates who sat for the WASSCE May/June Biology examination in Ghana, 13265 (67.3%) either had a weak pass or failed. In other words, had grade C5 to F9. In 2009 out of the 24662 candidates who sat for the May/June WASSCE, 17604 (71.25%) either had weak pass or failed. The trend continued in 2012, 29232 candidates sat for the same examination and 19651 (67.4%) had either weak pass or failed. The abstract nature of most biological concept is a major contributing factor to the poor performance of Biology. This poor performance has created the perception among most Senior High Students (S.H.S.) that Biology and even Science in general is difficult and is preserved for the "gifted" children or children with high intelligent quotient.

For some years now, Ghanaian S.H.S. Biology teachers have been using the traditional method in teaching and this has proven ineffective as it reflects in the performance of students at the end of their period spent in school. The statement of the problem therefore is, will the use of computer-based instructional simulation have any influence on students understanding of some biological concepts? Research have found that computer-assisted instruction material in the teaching and learning processes helped students to understand concepts better. (Cepni, Tas & Kose, 2006)

According to researchers the usefulness of computer-based instructional simulations as a tool for classroom instruction cannot be underestimated. Sahin (2006), asserted that computer simulations are good supplementary tools for classroom instruction and also in laboratories, as they give the students the opportunity to observe real world experiences and interact with it. This, when integrated into the teaching and learning process will enhance the understanding of learners. A study to investigate the use of computer-based instructional simulations in the teaching of cell division and its effect on student's performance in S.D.A. S.H.S. is therefore desirable the researcher.

PURPOSE OF THE STUDY

The purpose of the study was to determine the impact of the use of computer-based instructional simulations when teaching cell division and its effect on students' performance and understanding of second year S.H.S students.

OBJECTIVES

The objectives of this study were to determine:

1. the impact of using computer-based instructional simulations in teaching and learning of cell division in Biology;
2. the difference in performance between students exposed to computer-based instructional simulations to teaching and learning of cell division and their counterparts without this exposure.
3. the effect of using traditional instructional approach in the teaching and learning of biology

RESEARCH QUESTIONS

The study was guided by the following questions:

1. To what extent will students acquire biology concepts if CBIS is integrated in the teaching and learning of the subject biology?
2. What differences are there in the performance of students exposed to CBIS approach and their counterparts exposed to TIA to the teaching and learning of cell division?
3. Will there be any significant change in the performance of students exposed to TIA to the teaching and learning of biology?

HYPOTHESIS

1. There is no effect of the integration of computer-based instructional simulations on the teaching and learning process.
2. There will be no significant difference between control group performance and experimental group performance in the post achievement test.
3. There is no significant difference in performance of students exposed to TIA to the teaching and learning of biology.

SIGNIFICANCE OF THE STUDY

The study hopes to transform the teaching of Biology from the traditional method to a situation where computer-based instructional simulations will be incorporated into the teaching and learning of Biology. It also seeks to provide empirical evidence on the impact of integrating computer-based instructional simulation into teaching and learning of Biology and also to provide guidance for policy makers and stakeholders in education.

DELIMITION OF THE STUDY

The study was delimited to S.D.A.S.H.S. located in Koforidua Asokore and also to only S.H.S.2 Home Economics students who offer elective Biology as an elective subject. The study was delimited to an aspect of Biology focusing on cell division in the S.H.S. elective Biology syllabus.

LIMITATION OF THE STUDY

A broader survey of this research would have clarified to a large extent the effectiveness of the integration of computer-based instructional simulation in enhancing biology teaching since all environments are unique. Due to time and cost constraints the study was not extended to other institutions. The results of this research is therefore limited to only Home Economics students in the S.D.A S.H.S Asokore-Koforidua

ORGANISATION OF THE STUDY

This study is organized into five chapters. The chapter one touches on the overview of the study, the background of the study and the statement of the problem. The purpose of the study, objectives, research questions that guided the study and the hypothesis has also been outlined in the chapter one. The chapter one continues with the significance of the study and de-limitations. The chapter one ends with the organization of the study.

The chapter two also discusses relevant literature related to the study. The Chapter three dealt with the methodology employed in the study. The chapter four brought to light the results gathered and discussions of the findings. The chapter five which is the last chapter touches on the conclusion, summary, recommendations, limitations and suggested areas for further research.

CHAPTER TWO

LITERATURE REVIEW

OVERVIEW

The review of literature focused on work done by researchers in related fields. The topical issues reviewed in this literature include the theoretical framework of the study, the impact of ICT on the teaching and learning of science especially Biology, the concept of computer- simulation in the teaching of Biology and finally students' difficulty with some biological concepts and cell division.

THEORETICAL FRAMEWORK OF THE STUDY

The theoretical framework that the study was based on was Jean Piaget's theory of cognitive development and Lev Vygotsky's social constructivism theory.

According to Piaget (1954) the cognitive development of children toward formal thought could be facilitated through three cognitive process; Assimilation, accommodation and re-organization or equilibration.

According to Piaget (1954), when children assimilate, they perceive new objects and events according to their existing schemata (mental models or cognitive structures or internal representations of the world). The mental models of children formed by this prior knowledge and experience therefore control how they incorporate new experiences and new information into their minds. This may occur when the new experiences of children are aligned with their existing schemata or as a result of their failure to change a faulty understanding (Piaget, 1954).

Accommodation, however, results when children reframe or modify their existing schemata or mental representations of their internal world to fit the new experiences for learning to occur (Piaget 1954). Hence, as children exercise their mental structures in particular environmental situations, accommodation arises between the existing schemata and the more sophisticated mode of thought adopted by new experiences therefore has to be resolved via equilibrium process.

Equilibration maintains the balance between taking in new knowledge and always assimilating previously gained knowledge. Knowledge is therefore not a mirror of the world but is created or "constructed" from the individual's continuous revision and reorganization of cognitive structures in conjunction with experience (Piaget 1954). Piaget (1952) posited that the process of intellectual and cognitive development is similar to a biological act, which is adaptation to environmental demands. According to the cognitive paradigm, information in memory is represented by both images and verbal codes (Park & Hopkins, 1993). There is a referential connection that links verbal and non-verbal cues into a complete associative network to potentially allow such operations as imaging to words and naming to pictures. Therefore something is more likely to be remembered if only coded both verbally and visually because representatives of one form reinforces the other (Tennyson & Rash, 1988).

To Vygotsky (1978), every function of the child's cultural development appear twice; first on the social level and later on the individual level; first between people (inter-psychological) and then inside the child (intra-psychological). According to Vygotsky (1978), children are capable of performing at higher intellectual levels when asked to work in a collaborative situation than when asked to work individually. Vygotsky's (1978) Zone of Proximal Development (ZPD) emphasizes his belief that learning is

fundamentally a socially mediated activity. The zone is defined as the distance between a child's "actual developmental level as determined by independent problem solving" and the higher level of "Potential development as determined through problem solving' under adult guidance or in collaboration with more capable peers. He argued that instruction should be tied more closely to the level of potential development than the level of actual development. This means children are socially engaged in constructing their own knowledge. This is what has been termed "Social Constructivism "

Social constructivism not only acknowledges the uniqueness and complexity of the learner but also actually encourages, utilizes and rewards it as an integral part of the learning process (Wertsch, 1997).

Constructivism is a learning theory that states that students learn best by engaging in authentic learning tasks by asking questions and drawing on past experiences (Carlson, 2001). This means an effective learning experience can be considered as one that puts the student in control and encourages active participation, exploration, reflection and the individual construction of meaning. Galarneau (2005) opined that there is huge disconnection between knowing something in abstract and being able to make that knowledge actionable. Allmark (1995) proposed that the knowledge of practice is different from theory and cannot be reduced to it.

In order to promote students' learning it is necessary to create learning environment that directly expose the learner to the material being studied. For only by experiencing the world directly can the learner derive meaning from them (Tam, 2000). Simulation can provide students with an active learning experiences closely modeled on real situation that creates a bridge between the theory and practice (Gaba, 2004).

Simulation can be considered a variant of cognitive tools, that is they allow students' to test hypothesis and more generally "what-if " scenarios and enable learners to ground cognitive understanding of their action in a situation (Laurillard, 1993; Thomas & Milligan, 2004). Computer simulation integration in this respect is compatible with a constructivist's view of education. Newberry (1999) claims that the role of computer integration in teaching and learning enhances a wide range of school outcomes, including academic achievements, cognitive skills, motivation toward learning, self-esteem and social development. This indicates that computer simulation integration have a positive influence on students' achievements.

THE IMPACT OF ICT IN TEACHING AND LEARNING OF SCIENCE

The ability to work with information and communication technology (ICT) is recognized as one of the key competencies necessary for success in life and competition in the labour market (Levy & Murmane, 2001; Salganik 2001; Eurydice, 2002) which every citizen should possess. Concerning ICT, two important roles are assigned to schools. The first is to fulfill the expectations of society for demanding ICT skills and the second is to raise the quality of education in the schools with the support of ICT (Bell & Bell, 2003).

Information and communication technologies (ICTs) have become one of the fundamental building blocks of modern society. Technology influences the skills taught and enhances students learning. According to Wahyudi (2008), technology enables students to learn from feedback. The computer often provides fast and reliable feedback to students. Roschelle, Pea, Hoadley, Gordin and Means (2000) opined that

computer technology can help support learning and it is especially useful in developing the higher order skills of critical thinking, analysis and scientific enquiry.

The integration of ICT in Biology lessons can raise not only the level of knowledge but students' attitudes towards Biology as well (Haunsel & Hill, 1989; Kubiatko & Halakova, 2009). Kelleher (2000) reviewed recent developments in the use of ICT in science classrooms. He wrote that ICT cannot replace normal classroom teaching. The review indicated that ICTs can be positive forces in science classrooms for a deeper understanding of the principles and concepts of science and can be used to provide new, authentic, interesting, motivating and successful educational activities. The new ICTs have other potential benefits as tools for enhancing science teaching and learning in schools (Skinner & Preece, 2003). These tools include those for data capture, multimedia, software for simulation, publishing and presentation tools, digital recording equipment, computer projection technology and computer controlled microscopes (Osborne & Hennessy, 2003).

The integration of computers and communication offers unprecedented opportunities to the educational system with its capacity to integrate and interact with each other over a wide geographic distance in a meaningful way to achieve the instructional objective.

Technology gives rapid and accurate feedback to students and this contributes towards positive motivation. The use of technology in Biology allows students to focus on strategies and interpretation rather than spend time on memorizing concepts. This helps students to get an in- depth understanding of concepts and principles being taught. ICT should therefore be used to support teaching and learning of science.

THE CONCEPT OF COMPUTER-BASED INSTRUCTIONAL SIMULATION AND ITS USE IN THE TEACHING OF BIOLOGY

The process by which a computer delivers some instructional materials to its users is simply termed computer-based instruction (CBI). In a broad sense CBI can be referred to as any type of computer used for educational purposes. The term can refer to either teaching-learning activities with a stand-alone computer or activities on the computer which have been designed to reinforce materials that have been taught by teachers.

CBI is designed mainly to teach its users (students) as an informative and interactive tool by keeping them engaged and making them active participants. CBI is an emerging way of using a computer in the teaching-learning process. It was considered the technological phenomenon to revolutionized education and training. Today the internet and computer technology are reported to have significantly altered the education landscape. The modern computer technology has made possible a new and rich learning environment - the simulation (Lee, 1999).

In an instructional simulation, students learn by actually performing activities to be learned in a context that is similar to the real world. Simulation also allows one to visualize invisible aspects of a system and test theoretical hypothesis by manipulation variables. According to Akpan and Andre (1999) computer simulation in science education is the use of computer to simulate dynamic systems of objects in a real or imagined world. There are different forms and types of computer simulation. According to Trundle and Bell (2010) computer simulation can include animations, visualization and interactive laboratory experiences.

Simulations are useful for simulating laboratories that are impractical, expensive, impossible or too dangerous (Strauss & Kinzie, 1994). Science simulations can be extremely effective tools used in helping students understand and experience practical application of scientific thinking (Coleman, 1998; Akpan, 2001; Akpan & Andre 2000). Research findings have shown the positive impact the use of computer simulation has on the teaching and learning process. Integration of computer simulation in teaching and learning process help students to clearly understand the characteristics of a phenomenon. Visual based teaching and learning processes enhance students' understanding of learnt concepts.

Instructional simulations are said to enable students to bridge the gap between reality and abstract knowledge by the discovery method, improve motivation and enhance learning through students' active interaction (De Jong, 1991). Integrating simulation however, seems to be most prevalently used for the acquisition of diagnostic skills, where students first learn the required factual information and principles and then use it in simulation to relate and apply that knowledge (Thomas & Hooper, 1991).

Once learning takes place assessment of that learning must occur, the performance of the student in terms of "show me, tell me, or do it" must be evaluated. If the appropriate performance is observed, then the desired learning has taken place (Gagne, Briggs & Wager 1992).

Computer-based instruction simulation uses symbols to represent the interactions of un-observable variables in naturally occurring phenomena like cell, mitosis and meiosis, protein synthesis, cellular respiration, photosynthesis and Newton's laws of motion.

STUDENTS DIFFICULTY WITH THE CONCEPT OF CELL DIVISION

Finley *et al.* (1982) have identified the following concepts as too difficult for students to understand and therefore memorize them; Mitosis, Meiosis, Respiration, Mendelian Genetics, Photosynthesis and Excretory system. According to Campbell and Reece (2002) the cell division process is a part of the cell cycle. Cells are formed when a parent cell divides to become two new cells. The cell division process includes two important processes such as mitosis and meiosis. Mitosis and meiosis are continuous processes. This cell division topic is one of the important topics in Biology and its complex concepts very difficult to understand.

Misconceptions about Biology's abstract concepts affect students' achievement. Mitosis and meiosis serve as the basis for understanding the molecular events of cell division which are difficult to observe with the naked eye. Understanding and construction of the knowledge about mitosis concepts at the molecular level depends on the ability of the students' visualization about the chromosomes' movement during mitosis and meiosis. Cell division is an important topic in Biology but the concepts: cell cycle, mitosis and meiosis are very complex to be learnt by the students (Smith, 1991; Oztap, Ozay & Oztap, 2003; Kablan, 2004; Knippels, Waarlo & Boersma, 2005; Baser, 2007: Muhamad, Badioze, Zaman and Ahmed, 2010;). Researchers and teachers continue to try to find ways of teaching cell division so as to minimize misconceptions. Diagrams and models, if used, will contribute to reducing these misconceptions and learning difficulties among students (Oztap el al, 2003). The complex and confusing nature of cell division and some other biological concepts may explain why most students have misconceptions about the subject which contribute to low academic achievements.

CHAPTER THREE

METHODOLOGY

OVERVIEW

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

RESEARCH DESIGN

The study employed the quasi-experimental design. The quasi-experimental design involves selecting groups upon which a variable is tested, without any random pre-selection processes (Shuttleworth, 2008). A quasi-experiment is constructed to analyse the effects of different educational programmes on two groups of children. According to them, these quasi-experimental research designs include, but are not limited to; the one-group post-test only design; the one group pre-test post-test design; the remove treatment design; the case control design; the non-equivalent control groups design; the interrupted time series design and the regression discontinuity design. According to Gribbons and Hermman (1997), the types of quasi -experiment frequently used include; time series design, pretest – posttest non-equivalent control group and post-test non-equivalent control group design.

Time series designs refer to the pre-testing and post-testing one group of subjects at different intervals. In pretest-posttest non-equivalent control group design, both a control group and an experimental group are compared. The groups are chosen and assigned out of convenience rather than through randomization (Heffner 2004). Post-test only non-equivalent control group design involves administering an outcome

measure to two groups or to a programme or treatment group and a comparison made (Gribbons & Hermman, 1997).

The study employed the post-test only non-equivalent control group design of the quasi -experiment research approach. The post-test only non-equivalent control group design was used because the study investigated the impact of two teaching approaches; computer-based instructional simulation approach and the traditional instructional approach on the experimental and control group which has not been equated by randomization (Cohen, Manion & Marrison, 2008).

In S.D.A.S.H.S Asokore –Koforidua, the two Home Economics classes (2HE1 & 2HE2) were used for the study because they are the only classes in the school who offer elective biology as one of their elective subjects. The study consisted of both an experimental group and a control group. Participants in the experimental group were taught cell division using computer-based instructional simulations whiles those in the control group were taught the same topic using the traditional instructional approach. The 2HE2 students constituted the control group and the 2HE1 students also constituted the experimental group. The Post-test Instrument was administered to the two groups after the implementation of the teaching methods and the results were collected.

POPULATION

The population of the study comprised all the Elective Biology students of S.D.A S.H, Asokore, Koforidua, New Juaben Municipality, Ghana. S.D.A. S.H.S. was chosen for this study because the researcher has been a teacher in this school for the past five (5) years and is familiar with the academic environment in the school. Biology students

were used because most biology topics are too abstract and needs simulation for students to see the real world in simulations environment.

SAMPLE AND SAMPLING TECHNIQUES

The sample for this study was made up of two intact classes in S.D.A. S.H.S Asokore, Koforidua. These intact classes were 2HE1 and 2HE2. The 2HE1 class was made up of twenty eight students and 2HE2 class was also made up of thirty students, all these students offer Biology as an elective subject. These classes were selected based on purposive sampling. Second year S.H.S students were used for the study because cell division which forms part of the Elective Biology syllabus was yet to be taught in the second year S.H.S classes. Participants in the study have similar educational background since they all passed the BECE at the J.H.S. level. Also, they all passed the internal examinations in Integrated Science and Elective Biology in their first year in S.D.A. S.H.S., Asokore, Koforidua. The experimental group and control group were selected based on the pre-test instrument which was used in the study. The pre-test instrument, was administered to all the participants in the selected classes, in their respective classrooms at the same time. The mean scores were used to assign participants into the two groups. The class with the higher mean score, 2HE2 was selected as the control group and its students were taught cell division using the traditional method and the 2HE1 students with the lower mean score were taught using the computer-based instructional simulation and also served as the experimental group.

This was done to investigate, whether the class with lower mean score will perform better using the computer-based instructional simulation than the class with the higher mean score which had been taught with the traditional method

RESEARCH INSTRUMENT

The data collecting instrument were two test instruments of comparable standard. Quantitative data was collected from all participants, based on the two test instruments, pre-test and post-test. The pre-test was administered to students first to investigate their level of difficulty in understanding cell division. After the implementation of the intervention which lasted for three weeks, another test was given to all the students (post-test) to evaluate students' achievements. The test consisted of two sections; section A was made up of 10 objective questions, each question worth 1mark given a sub total of 10marks and Section B consisted of 3 short answers questions which also worth a total of 15marks. The sum total was 25 marks for each test.

VALIDITY OF THE INSTRUMENT

Validity determines whether the research truly measures what it was intended to measure or how truthful the research results are (Joppe, 2000). To check for validity of the instrument, thirteen questions each for the pre-test and post-test were given to two Elective Biology teachers with considerable experience in teaching, for their comments and suggestions, after which the questions were sent to the researcher's supervisor in the Biology Education Department of the University of Education, Winneba to evaluate the questions for content and construct as well as face validity. After the feedback was received the necessary changes to the questions were made. The improved questions were piloted in Oyoko Methodist Senior High School to ensure that the instrument was clearly understood by respondents.

RELIABILITY OF THE INSTRUMENT

Reliability refers to the consistency or dependability of the measurement or the extent to which an instrument measures the same way each time it is used under the same condition with the same subjects (William, 2006). To ensure that the research instrument produce scores that are stable and consistent and the test items are devoid of any ambiguities (Creswell, 2008), the pre-test and post-test were piloted using 35 S.H.S. 2 Elective Biology students from Oyoko Methodist S.H.S in Oyoko, Koforidua in the Eastern region of Ghana. Data from the pilot test were analyzed statistically to determine the reliability of the test instrument, using the Spearman Brown prophecy formula since all items were dichotomously scored. The analysis yielded a reliability of 0.58 and 0.65 for the pre-test and post-test respectively. According to Ary, Lucy and Asghar (2002), if the measurement results are to be used for making a decision about a group for research purpose, or if an erroneous initial decision can be easily corrected, then scores with modest reliability coefficient in the range of 0.50 to 0.60 may be acceptable. The above reliability coefficient for the pre-test and post-test therefore signified, that both test are considerably reliable.

DATA COLLECTION PROCEDURE

The treatment phase of the study lasted for three weeks in the third term academic year. The experimental group was taught section four unit four of the SHS elective Biology Syllabus which deals with cell division using the computer- based instructional simulations retrieved from www.cellsalive.com and https://www.youtube.com.watch. The control group was taught the same section and unit of the SHS elective Biology Syllabus using the traditional instructional approach which involves lecture, demonstration, illustration and discussion. After the

administration of the intervention process a post-test was administered to all participants in both group' this was done to assess the effectiveness of the incorporation of computer-based instructional simulation in teaching and learning processes on the performance of students in the cell division. Some of the stages of mitosis and meiosis captured from the experimental group lessons are indicated in figures 1-14. Below are the screen captured shots of some of the stages.

Fig. 1: Prophase of Mitosis

Fig. 2: Metaphase of Mitosis

Fig. 3: Late Metaphase of Mitosis

Fig. 4: Anaphase of Mitosis

Fig. 5: Telophase of Mitosis

Fig. 6: Cytokinesis (Resting Stage of the Cell)

Fig. 7: Early Prophase of Meiosis I

Fig. 8: Late Prophase of Meiosis I

Fig. 9: Metaphase of Meiosis I

Fig. 10: Anaphase of Meiosis I

Fig. 11: Telophase of Meiosis I

Fig. 12: Metaphase II of Meiosis

Fig. 13: Anaphase II of Meiosis

Fig. 14: Telophase II of Meiosis

DATA ANALYSIS PROCEDURE

The study collected only quantitative data and the quantitative method of data analysis was used. The data obtained from the experimental group and the control group on both test were analyzed statistically using paired t-test and unpaired t-test analysis. However some of the data were exported to Microsoft excel to plot bar graphs, pie chart and percentage scores were also calculated. This was done to answer the research questions and either reject or fail to reject the null hypothesis formulated for the study.

CHAPTER FOUR

RESULTS AND DISCUSSION OF FINDINGS

OVERVIEW

This chapter is devoted to the presentation of results of the study which was followed by discussions with relevant literature. The results and discussion were presented in order of the research questions and the null hypothesis generated from participants in the experimental and control group on the pre-test and post-test instrument. The quantitative data were organized and presented using descriptive statistics including frequency tables. The presentation has two main parts, part one deals with analysis of the data whiles part two focuses on the discussions of the findings.

Analysis with Respect to Research Question One

- **RQ 1**. To what extent will students acquire biology concepts if CBIS is integrated in the teaching and learning of the subject biology?

The differences between experimental group pre-test and post-test are presented in table 1 and discuss below.

Table 1. Frequency distribution of test scores of students in the experimental group

Marks Scored	Pre-test	Post-test
0-5	19	0
6-11	9	5
12-17	0	12
18-23	0	11
24-29	0	0

Frequency distribution of the experimental group pre-test and post-test was computed (table 1). Out of the 28 students who took the pre-test 68% students' scored marks in the range of 0-5, 32% students also scored marks in the range of 6-11, no student scored marks in the other ranges. However in the post test, performance of students did improve, as no student scored marks in the range of 0-5, 18% students scored marks in the range of 6-11, 43% students scored marks in the range of 12-17, 39% student scored marks in the range of 18-23, no students scored marks in the range of 24-29. The results showed that the performance in students pre-test compared to the post-test increased greatly.

As an intervention, the experimental group was taught cell division using CBIS, the mean score after the implementation of the intervention was improved (Table 2), it is obvious from the table that mean achievement scores on students post-test (15.75) is higher than the mean achievement scores on student pre-test (4.67), the graph below shows the mean increase in the post-test achievements of the experimental group (Figure 15), hence CBIS is more effective in teaching cell division.

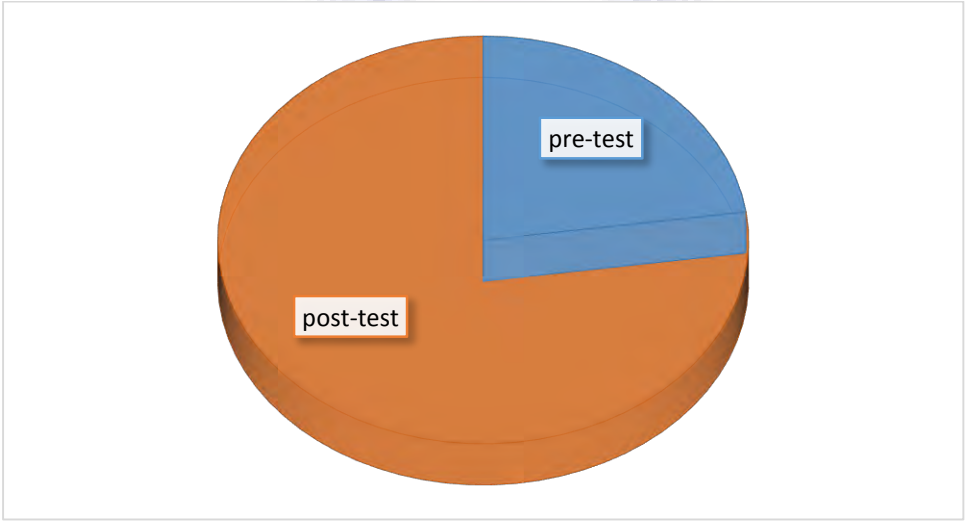

Figure 15. Experimental Group Pre-test and Post-test Means Compared

Testing of Hypothesis with respect to Research Question One.

To determine whether there is a statistically significant difference between students pre-test and post-test, research question 1 was formulated into a null hypothesis and tested.

It was hypothesized that:

Hypothesis 1: There is no significant difference in performance of the experimental group after the implementation of the intervention.

Table 2 indicates the significant difference of experimental group pre-test and post-test.

Table 2: Determination of Significant Difference between experimental group pre-test and post-test

Gp.Compared	Test	Mean	SD	t-value	p-value
Expt. Group	Pre-test	4.67	2.33	14.07	2.98E-14*
Expt. Group	Post-test	15.75	4.16		

* =significant at 0.05; $p < 0.05$

Paired t-test analysis showed that the difference in performance between students' pre-test and post-test was highly statistically significant, t (28) = 14.037, p= 2.98 (Table 2) since the tabulated p-value is less than 0.05 ($p<0.05$). This significant difference in performance was attributed to the integration of computer based instructional simulation in the teaching and learning process, It was therefore concluded that the integration of CBIS in teaching and learning processes had an effect on students understanding in the teaching and learning of cell division, the first null hypothesis was thus rejected.

Analysis with respect to research question two

- **RQ2**. What differences are there in the performance of students exposed to CBIS approach and their counterparts exposed to TIA to the teaching and learning of cell division?

The data collected were statistically calculated using unpaired t-test as shown in table 3

Table 3. T-test analysis of experimental and control groups pre-test

Groups compared	Test	Mean	SD	t-value	p-value
Experimental group	Pre-test	4.68	2.33	1.81	0.08[a]
Control group	Pre-test	5.77	1.69		

a = not significant at 0.05: p>0.05

Descriptive statistics such as mean and standard division was computed and used to determine the differences in performance between control group and the experimental group. The pre-test mean score on the experimental group was 4.679 and that of the control was 5.767. The control group had a higher mean score in their pre-test than the experimental group. Statistically there was no significant difference between the control group and the experimental group performance in the pre-test since the p-value of 0.08 was greater than 0.05. This indicates that the two groups of students used in the research initially were at the same level. However, in the post-test performance of the experimental group was different as compared to that of the pre-test performance.

The mean scores of both experimental group and control group post-test and results from the unpaired t-test analysis are shown in table.4.

Table 4. Determination of significant difference between experimental group and control group post-test

Groups compared	Test	Mean	SD	t-value	p-value
Experimental group	Post-test	15.75	4.16	9.84	2.79E-11*
Control group	Post- test	7.43	1.69		

* =significant at 0.05; $p < 0.05$

In the post-test, the mean score of the control group exposed to traditional instructional approach to teaching and learning of cell division was 7.43 (SD=1.695) and that of the experimental group who were taught cell division with computer based instructional simulations had a mean score of 15.75 (SD=4.159). There was a significant difference in performance of the two groups after the post-test since the p value 2.79E-11 was less than 0.05. The results showed that CBIS has been able to improve the understanding of even the weaker students. Hence CBIS method was more effective for teaching cell division in comparison to the TIA.

Test of Hypothesis with respect to research question two.

To determine whether the difference in performance between the experimental group and control group was statistically significant, research questions 2 was formulated into a null hypothesis and tested.

Hypothesis 2. There is no significant difference in performance of students exposed to CBIS and their counterparts exposed to TIA to the teaching and learning of cell division.

Unpaired t-test analysis showed that the difference in performance between the experimental group and the control group was statistically significant.

There was a significant difference in performance between the students exposed to computer-based instructional simulations and those exposed to the traditional instructional approach to teaching and learning of cell division. The students exposed to the computer-based instructional simulations had a better understanding of the concept of cell division than their counterparts exposed to the traditional instructional approach to teaching and learning (Table.4). It could be said that there was a significant difference in performance between students exposed to the computer-based instructional simulations and their counterparts exposed to the traditional instructional approach to the teaching and learning of cell division since the p-value is less than 0.05 (Table 4). The post-test scores of the control group and experimental group are captured in Fig.16

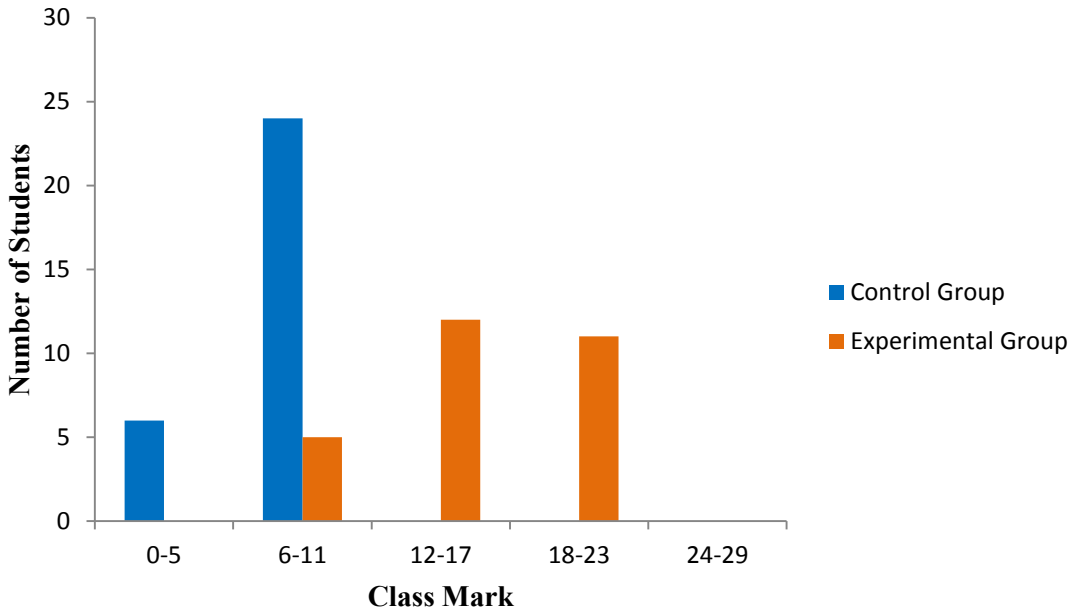

Figure 16: Experimental Group and Control Group Post-test Achievement Scores

Results from the graph (Fig.16) are an evident that, the students exposed to CBIS had a better conceptual understanding of cell division than their counterparts without the same exposure. Hence students acquire biology concepts better if CBIS is integrated into the teaching and learning of some abstract topic in the biology classroom. From all indications it is true that there is statistically significant difference in performance between students exposed CBIS and their counterparts exposed to TIA, therefore the second null hypothesis was also rejected.

Analysis with Respect to Research Question Three

- Will there be any significant change in the performance of students exposed to TIA to the teaching and learning of biology?

Table 5 follows up with the presentation of the frequency distribution of the control group pre-test and post-test and the results are discussed below.

Table 5. Frequency distribution of test scores of students in the control group.

Marks scored	Pre-test	Post-test
0-5	16	6
6-11	14	24
12-17	0	0
18-23	0	0
24-29	0	0

Frequency and percentage distributions of the control group pre-test and post-test were used together with the mean score. From the frequency table 53% students scored marks in the range of 0-5, 47% students scored marks in the range of 6-11, no student scored marks in the other ranges. However in the post-test there was a slight improvement in performance, 20% students scored marks in the range of 0-5, 80% students scored marks in the range of 6-11, no students scored marks in the other ranges, although the performance was not encouraging after three weeks of continuous teaching and learning but there was a slight change as compare to the pre-test achievement.

Testing of Hypothesis with respect to Research Question Three

To determine whether there is a statistically significant difference between control group pre-test and post-test, research question 3 was formulated into a null hypothesis and tested.

It was hypothesized that:

Hypothesis 3. There will be no significant change in performance between control group pre-test and post-test achievements.

The data collected were calculated statistically using the paired t-test as shown in table 6.

Table 6: Determination of Significant Difference between control group pre-test and post-test

Group	Test	Mean	SD	t-value	p-value
Control group	Pre-test	5.77	2.24	3.39	0.001*
Control group	Post-test	7.43	1.69		

To determine whether the difference in performance was statistically significant a paired t-test analysis was conducted. From table five there is a slight increase in the mean score, looking at the graph in figure three the change in performance was not outstanding as compared to their counterparts in the experimental group, however paired t-test analysis showed that the difference in performance between the student pre-test and post-test was statistically significant since the p-value was 0.001 (Table 5). This shows that traditional instructional approach has some positive effect on students understanding, but cannot be compared with computer-based instructional simulations method to teaching and learning. Statistically there is a significant difference between control group pre-test and post-test achievements, therefore the third null hypothesis was thus rejected. The outcome of the differences in control group pre-test and post-test is shown in fig 17.

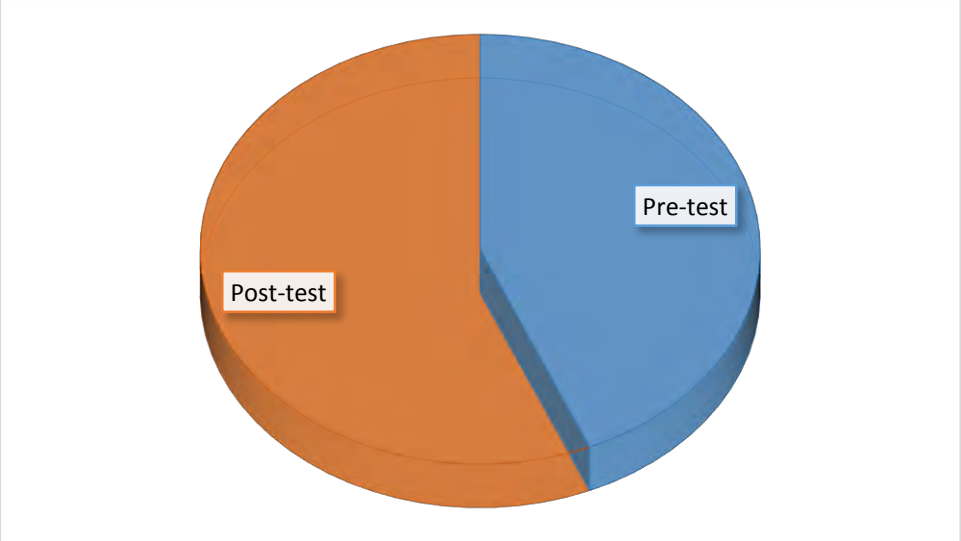

Figure 17. Control group means compared

DISCUSSION OF FINDINGS

The study set out to find the impact of computer-based instructional simulations module on the performance of S.H.S 2 students in cell division. Findings with respect to research question one were positive in that the performance in the post-test of the S.H.S 2 students exposed to the CBIS module in the teaching and learning processes did improve tremendously compared to their pre-test achievements. The frequency distribution of students post test and pre-test in the experimental group has been provided in table 1.

These findings reaffirm the previous studies of Kiboss et al. (2006), who investigated the effect of a computer based instructional simulations (CBIS) programs on students understanding of cell theory in school biology and observed that the CBIS module, positively affected the development of students understanding and perception of cell division lessons in school biology. Similarly Osborne and Hennessy (2001), reported that ICT enhances the effectiveness of information presentation and also stimulates students' interest.

The understanding of the experimental group after the intervention indicated that the intervention strategy was very effective hence such classic performance. This confirms the argument of Miller (2001), Kozma (1994) and McArthur and Stasz (1990) that the use of technology in classrooms increases knowledge and expands the understanding of learners.

Again Cohen and Riel (1989) concluded that technology can increase performance of learners and broaden the knowledge base of learners if they are well directed by someone knowledgeable in it. This study is consistent with the findings of Hoadley, Gordin, Means, Pea and Roschelle (2000). According to them the use of technology in teaching and learning biology is effective in that computer technology can help support learning and it is useful in developing the higher order skills of critical thinking analysis and scientific enquiry. To them ICT integration in teaching and learning of biology builds confidence and it is a great tool for helping slow learners to improve upon their performance. The findings indicated that CBIS was an important tool used in improving student understanding of abstract topics and the results of the findings proved positively.

Findings with respect to research question two. The objective was to determine if there is a significant difference in the performance of experimental and control group, findings from the unpaired t-test analysis showed that for both groups there was no significant difference in the pre-test achievements p value was 0.08 (Table 3). This showed that at the beginning of the research all the groups were at the same level.

However the performance in the post-test increased tremendously for the experimental group, this improvement in the experimental group was attributed to their exposure to the integration of the computer-based instructional simulations in the

cell division processes. The improvement could be seen in their ability to answer question correctly and therefore scored a higher mean mark.

It could be said that the CBIS to a great extent reduced the level of abstraction. The use of CBIS facilitates the organization of conceptual structure of students to aid in a better understanding of the concept. This proved that there was an effective gain in student's conceptual understanding and consequently in their performance over the intervention period. The performance of students in the experimental group improved positively. The results is in congruent with Azar and Sengiilef (2011), Riffell and Merrill (2005) and Tambade and Wagh (2011) who also indicated in their studies that the use of computer assisted instructions had an advantage over traditional instruction.

To these researchers computer assisted instructions help students to concentrate on the physical meaning of abstract concepts, hence obtaining an in-depth understanding of the theory.

The findings reaffirm the previous studies of Akour (2006) and Akpan and Andre (2000), conducted in biology which indicate that the achievement scores of students exposed to CBIS were higher than those students exposed to traditional conventional or regular method for instructions.

These researchers Kiboss and Ogunniyi (2003), and Okoro and Etukudo (2001) also confirmed that computer-based instructional simulations has been an effective tool in enhancing students performance than the traditional or conventional classroom instruction in subjects other than biology. Thus physics and in chemistry as well. Gagne (1985) asserted that increased amounts of practice can be a first order factor in affecting the amount of material retained.

Reflection on variation allows students to develop relationship between changes in variables in theoretical system allowing mental models to develop, which enhance retention and can also be called upon for further leaning (Gagne et al. 1992), simulation allows the students to reflect.

Davidovitc, Parush and Shitub (2006), discussed the advantage of simulation-based teaching he said it allow students to make inputs, acquire experience and consider results, "we acquire true knowledge through the use of our five sense followed by reflection (Dunn, 2005). Simulation allows students to utilize these senses in the teaching and learning processes.

However the results of this study contradict that of Owusu, Monney & Appiah and Wilmot (2010) who could not find any significant difference between students exposed to CBIS and those exposed to traditional method. From their discussion, it could be realized that the CBIS has a less positive effect on student performance. However based on the evidence and strength of the findings of this study a strong case can be made in favor of incorporating CBIS in Biology teaching and learning in the SHS curriculum in Ghana.

Finally, with respect to research question three, the study set out to find the effect of TIA on the performance of the control group in cell division. Findings with respect to research question three were positive in that, the performance of the control group pre-test did improve in the post-test achievements (Table 5). Statistically the change in performance was significant. This was evident that traditional instructional approach has some positive effect on students understanding. Comparing the means of the students' pre-test (5.77) and post-test (7.43) although the performance improved a bit, it was not the best. This indicated that the students taught with TIA to some extent

could not understand certain concepts better, hence getting low scores in their post-test

The findings supports the research of Selinger (2004) who claimed that ICT can improve the quality of education because multimedia content helps to illustrate and explain difficult concepts in way that were previously inaccessible through traditional teaching resources and methodology. In this case one can say that the TIA could not helped the students to understand the difficult concepts in cell division hence getting low marks.

Akour (2006) also emphasized that students taught using traditional instruction combined with the use of CBIS performed significantly better than students taught using the traditional instruction in a college setting. In view of this it could be said that if the students in the control group were taught using the CBIS and TIA performance would have been better.

In conclusion, observations made whiles implementing the CBIS it was realized that the school lacked the equipment necessary for integration of the CBIS into the teaching and learning situation but because of the study the researcher sought assistant elsewhere for the success of the study. Also student in the experimental group were excited in their lessons, interest was sustained, they also learn the concept at ease as compared to their counterparts in the control group, students' perception and attitude towards Biology changed. Cooper and Brna (2000) reported that pleasure and variety kept students engaged and motivated, this was really true in the simulations class. The use of CBIS as a teaching method appeared highly appreciated by the students in the experimental group, this helped to increase their understanding and enhanced their learning as they performed very well in the post test.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

OVERVIEW

This chapter of the study presents summary of the findings, conclusion and recommendation and suggested area beneficial for further research.

SUMMARY OF FINDINGS

The major summary of key findings has been presented according to the research questions and has been reviewed using an appropriate tool.

1. Difference in experimental group pre-test and post-test. The experimental group was the group with the lower mean score. After the intervention strategy the performance was more than double compared to the previous performance. Achievement scores in the students pre-test and post-test showed a remarkable difference. It was evident that students performed better in the post-test in comparison to their pre-test.

   There was a highly statistically significant difference in performance after the students were exposed to the computer-based Instructional simulations.

   This indicates that the intervention strategy have a positive effect on students understanding of the concept of cell division.

2. Differences in performance between experimental group and control group.

   The findings from the discussed hypothesis (2) suggest that prior to the administration of the intervention strategy, the experimental group was the sample with the lower mean score in the pre-test achievement score, but from the analysed results in table 3 and 4 the experimental group though had a

lower mean sore in the pre-test, they were able to perform significantly better than their counterparts in the control group. This indicates that students exposed to computer based instructional simulation had a better conceptual understanding of the cell theory than their counterparts without the same exposure.

3. Difference in control group pre-test and post-test prior to the intervention strategy the control group had the higher mean score in the pre-test achievement scores. After the implementation of the traditional instruction approach there was a slight increase in performance which was not encouraging. Results in table six attest to the fact that there difference in performance was not remarkable. This indicates that although traditional instructional approach has a positive effect it cannot be compared with the computer based instructional simulations on the teaching and learning processes.

CONCLUSIONS

The findings of the study tend to suggest that when Computer-based instructional simulations are efficiently used as a teaching strategy, it can enhance and improve students' performance and understanding of some biological concepts.

The results revealed that the 2HE1 students exposed to computer based instructional simulations to the teaching and learning of cell division performed significantly better than their counterparts exposed to the traditional instruction approach.

The results has also shown that students exposed to the computer based instructional simulations acquired biology concepts to a greater extent than their counterparts without same exposure.

Although both methods had some positive effect on student's performance, out of these two, the computer based instructional simulations method to teaching and learning processes was found more suitable and effective with respect to the marks achieved by the students in cell division test.

RECOMMENDATIONS

Based on the major findings of this study, the following recommendations are posited;

1. Biology teachers in the school should use innovative and more effective learner-centered instructional strategy thus, computer –based instructional simulations to promote meaningful learning of difficult biological concepts. Appropriate simulations should therefore be developed for use in the Ghanaian school system.
2. The head of the institution should organize in-service training in professional development courses related to the integration of CBIS in teaching and learning process for biology teachers.
3. The head of the institution should acquire equipment and facilities necessary for the integration of CBIS in the teaching processes.
4. The Ministry of Education, GES and other stakeholders involved in education should organize periodic workshop and in-serving training for science teachers as well as biology teachers to unveil the effectiveness simulations in enhancing performance of students so that the performance in the sciences at the end of WASSCE could be improve.

SUGGESTIONS FOR FURTHER STUDIES

The following areas must be considered for further study:

1. It is suggested that the study should be replicated to include SHS 1 and SHS 3 biology students in SEDASS, Asokore.

2. Similar study should be conducted in other regions in Ghana and results compared with my research.
3. The study must be replicated to include other difficult biology concepts such as protein synthesis, cellular respiration, genetics, chromosome theory of heredity and hormonal control of human reproduction; this would provide a basis for a wider generalization of the conclusions drawn from the findings of the study.
4. Similar studies should be conducted in a much larger sample size at different levels of science education to provide a sound basis for the integration of computer based instructional simulations in Science Education in Ghanaian Schools.

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APPENDICES

APPENDIX A

PRE-TEST QUESTIONS

Duration: 40 Minutes

Pretest data collecting instrument – student's knowledge of cell division test

Class/Form of participant; ……....

School of participant; ……...

General Instructions; This test contains thirteen (13) questions grouped into two sect ions namely section A and B, section A consist of ten objectives test and section B co nsist of three essay questions. Please answer ALL questions.

SECTION A

1. Which one of the following stages is not present during mitosis?
   A. metaphase
   B. telophase
   C. interphase
   D. prophase
2. In which of the following structures does meiosis occur?
   A. the root tip of a plant
   B. the skin of a human
   C. the ovaries of a locust
   D. the zygote of a rabbit
3. In a single cell organism mitosis is use for.....
   A. development
   B. repair
   C. growth
   D. reproduction
4. The diploid (2n) number of chromosomes for humans is……..
   A. 24
   B. 23
   C. 44
   D. 46

5. Crossing over result in……
   A. new species
   B. new genetic combination
   C. cancerous growth
   D. gametes
6. Which one of the following is mitosis not used for?
   A. repair in multicellular organism
   B. asexual reproduction in unicellular organisms
   C. production of gametes
   D. development of baby in mother's womb
7. Which one of the following does not occur in meiosis?
   A. two daughter cells at completion
   B. four daughter cells at completion
   C. two nuclear divisions
   D. formation of bivalent
8. During which stage of mitosis do spindle fibers pull the chromosomes to oppo site poles?
   A. anaphase
   B. metaphase
   C. telophase
   D. interphase
9. What is the last phase of meiosis?
   A. prophase II
   B. telophase II
   C. anaphse II
   D. metaphase II

10. During which stage of meiosis are the replicated chromosomes arranged along the equator?
    A. prophase II
    B. metaphase II
    C. prophase I
    D. metaphase I

SECTION B

1. Describe the activities of the cell during interphase.
2. Give four differences between the two types of cell division that occur in the mammalian Body.
3. Give two importance each of the types of cell division in mammals.

MARKING SCHEME

OBJECTIVE TEST

1. C
2. C
3. D
4. D
5. B
6. C
7. A
8. A
9. B
10. D

1 mark each (total 10marks)

SECTION B

QUESTION ONE

Although interphase is a resting stage, the cell is engaged in several activities t o prepare for division. The following are significant features of the interphase stage

- Chromosomes are not visible; they look like thread like structures.
- The genetic material (DNA) replicate and new organelles are formed.
- Centrioles replicate if present.
- The cells build up a large store of energy to carry the process of mitosis throug h.
- The nuclear membrane and nucleolus remain intact. (1mark for each point, tot al 5marks)

QUESTION TWO

Differences between Mitosis and Meiosis

Mitosis	Meiosis
Mitosis occurs in somatic (body) cell	Meiosis occurs in cells of sex organ s
Two new cells are formed	Four new cells are formed
Mitosis involves only one division	Meiosis involve two division
Absence of chiasmata and crossing over in pro phase	Chiasmata and crossing over are pre sent in prophase 1
New cells morphologically similar to original c ell	New cells differ in morphology fro m original cell.
Chromosomes number is kept constant as com pared to the original cell	Chromosomes number in new cells i s half as compared to the original ce ll.

Any four correct points **(½ mark for each point, total 4marks)**

QUESTION THREE

Importance of mitosis

1. Mitosis occurs to maintain chromosome number in all body cells.
2. It also maintains constant chromosome number of all individuals reproduced b y asexual means.
3. It occurs to bring about growth, cell replacement and repair of tissues.

Any two correct points, each point is **1 ½ marks (total 3marks).**

Importance of meiosis

1. Meiosis results in the formation of gametes (sex cells).
2. It prevents the duplication of the chromosome number during fertilization.
3. It creates genetic diversity in a population.

Any two correct points each point is **1 ½ mark (total 3marks).**

APPENDIX B

POST-TEST QUESTIONS

Duration: 40 minutes

Post-test data collection instrument – students' achievement in Cell Division Test

Class/Form of participant,……

School of participant,……

General instructions: This test consists of thirteen (13) questions grouped into two sections namely section A and B. Section A consists of ten objectives test and section B three essay questions. Answer ALL questions.

SECTION A

Circle the correct option

1. Meiosis results in……
   A. 2 haploid daughter cells
   B. 4 haploid daughter cells
   C. 2 diploid daughter cells
   D. 4 diploid daughter cells

2. During which phase of mitosis do chromosomes first become visible?
   A. Interphase
   B. late telophase
   C. late prophase
   D. late metaphase

3. A Spindle is formed during which stage of the cell division?
   A. G_2
   B. interphase
   C. prophase
   D. metaphase

4. A cell with a diploid number of 24 undergoes meiosis, how many chromosomes are in each daughter cell?
   A. 6
   B. 12
   C. 24
   D. 48

5. A cell with 10 chromosomes undergoes mitosis. How many daughter cells are created? ___ Each daughter cell has ___ chromosomes.
   A. 2,10
   B. 10,2
   C. 2,20
   D. 1,10

6. Cytokinesis begins in which phase?
   A. anaphase
   B. telophase
   C. metaphase
   D. prophase

7. Which phase occurs directly after metaphase?
   A. interhase
   B. prophase
   C. anaphase
   D. telophase

8. After which stage is nuclear division completed?
   A. prophase
   B. metaphase
   C. telophase
   D. interphase

9. The DNA replicate during which stage of the cell cycle?
   A. mitosis
   B. G_1
   C. G_2
   D. S

10. The region where sister chromatids is attached to each other is called the……..
   A. centromere
   B. spindle
   C. centriole
   D. aster

SECTION B

ANSWER ALL QUESTIONS

1. Briefly describe the significant things that occur at the four stages of mitosis. 10marks
2. Outline two differences between prophase 1 of meiosis and prophase of mitosis. 3marks
3. Give three importance of cell division. **2marks**

MARKING SCHEME

OBJECTIVE TEST

1. B	6. B
2. C	7.C
3. D	8.C
4. B	9.D
5. A	10.A

10marks

SECTION B

1. Mitosis is a type of cell division in which cellular material is divided between two daughter cells.

1 mark

The four stages of mitosis

Prophase

- Chromosomes at this stage looks likes thread like structures
- The chromosomes become shorter, fatter and visible as two separate strands called chromatids.
- Spindle fibres start forming
- Chromatids duplicate

2marks

Metaphase

- Spindle fibres form completely.
- Nuclear membrane breaks down.
- Chromatid pairs line up on equator of cell.

$1^1/_2$marks

Anaphase

- Centromeres split into two
- Chromatids are pulled towards opposite poles

2marks

Telophase

- Chromatids reach poles (its destination) and re-form into chromosomes
- Cell begins to constrict at equator
- The nuclear membrane and nucleolus re-form in each cell
- Spindle fiber disappear

2marks

After this stage the cycle of mitosis is completed and new one begin again

$1^1/2$ marks

2. Differences between

Prophase of mitosis	**Prophase 1 of meiosis**
1. No formation of homologous chromosomes	Homologous chromosomes appear in the nucleus
2. No pairing of homologous chromosomes	Homologous chromosomes pair up
3. There is no crossing over no chiasmata	Chromatids of chromosomes cross over each other, chiasmata is present

Any 2x1 = 2 marks

3. Importance of cell division

a. Cells divide so living things can grow
b. Cells divide to replace old, dead or damage cells
c. Cells divide to bring about asexual and sexual reproduction

3x1 = 3marks

APPENDIX C

t-TEST ANALYSES

t-Test Analysis with Respect to Research Question One

t-Test: Paired Two Sample for Means

	Control group	*Experimental group*
Mean	4.678571	15.75
Variance	5.411376	17.30556
Observations	28	28
Pearson Correlation	0.278434	
Hypothesized Mean Difference	0	
Df	27	
t Stat	14.0737	
P(T<=t) one-tail	2.98E-14	
t Critical one-tail	1.703288	
P(T<=t) two-tail	5.96E-14	
t Critical two-tail	2.051831	

t-Test Analysis with Respect to Research Question Two

t-Test: Two sample assuming unequal variances

	Control group	*Exp. group*
Mean	7.43333333	15.75
Variance	2.87471264	17.30556
Observations	30	28
Hypothesized Mean Difference	0	
Df	35	
t Stat	9.84321333	
P(T<=t) one-tail	6.3995E-12	
t Critical one-tail	1.68957246	
P(T<=t) two-tail	1.2799E-11	
t Critical two-tail	2.03010793	

_t_-Test Analysis with Respect to Research Question Three

_t_-Test: Paired Two Sample for Means

	Control group	*Exp. group*
Mean	5.766667	7.433333
Variance	5.012644	2.874713
Observations	30	30
Pearson Correlation	0.082058	
Hypothesized Mean Difference	0	
Df	29	
t Stat	3.38696	
P(T<=t) one-tail	0.001024	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.002049	
t Critical two-tail	2.04523	