UNIVERSITY OF EDUCATION, WINNEBA

EFFECTS OF REALISTIC AND NON -REALIST SIMULATIONS ON STUDENTS ACHIEVEMENT ON THE TOPIC CELL DIVISION

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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 fulfillment of the requirements for the award of a MASTER OF EDUCATION degree in SCIENCE EDUCATION

DECEMBER, 2015

DECLARATION

STUDENT'S DECLARATION

I, Anastasia Abena Afrah, declare that, this dissertation with the exception of quotations and references contained in the published works which have all been identified and 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 hereby declare that preparation of the dissertation was supervised in accordance with the guidelines for supervision of thesis as laid down by the School of Graduate Studies, University of Education, Winneba.

Name of Supervisor.....

Signature…….....

Date…….....

ACKNOWLEDGEMENTS

My sincere thanks go to the Almighty God who gave me wisdom and strength to go about my studies and whose grace sustained me throughout my studies. It would not have been possible to complete this dissertation in a relatively short period of time without the support and help of a number of people whom I would like to recognize and thank.

First of all, to I would like to express my deepest appreciation and profound gratitude to my Supervisor, Dr. Mrs. Vida Eshun of the department of Science Education, for her constructive criticisms, invaluable advice, and expert guidance throughout the entire process of my dissertation. Without her help, this dissertation could not have been successfully completed, I say thank you very much.

I acknowledge the financial assistance and moral support from my sister, Dr. Mrs. Mataji Abotse –Arthur and my family members. My special thanks go to Messers Richard Owusu, Abdulai Alhassan, all of Adventist Senior high school Agona-Ashanti who helped me in gathering my data. I would like to thank Mrs. Sophia Sangmon, Mr. Seth Appiah-Ansah, Reverend Bismark Kwame Amposah, Assemblies of God Church Agona for their prayer support. Finally, I would like to thank Dr. Wonder Abotse, Madam Jennifer Ofori, Mr. Kennedy Dwomo, Sergeant Kofi Kodua-Owusu, Mr. Henry Brew-Daniels, Kofi Owusu-Adu, and Ben Nketiah who made wonderful contributions throughout the entire studies. I wish to express my appreciation to them all.

I cannot stop without showing my gratitude to all the lecturers who taught me during the course work, May God continue to shower his blessings upon you all. Amen!

DEDICATION

This dissertation is dedicated my daughter Benedicta Nana Adwoa Korama Blay-Achem and my mum and siblings.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

This research was primarily designed to help improve the academic performance of students in Adventist Senior High School in the Sekyere South District in the study of Cell Division in Biology. The target population comprised Senior High School Biology students. Using the quasi-experimental design 74 second year biology students were selected for the study, the researcher put students into two groups; experimental and control groups, each group comprised of 37 students. The researcher developed two interventions realistic and non-realistic simulation teaching approaches to teach the topic. Using the developmental research approach, both teaching strategy were pilot tested with 30 SHS biology students. This was followed by the sample size implementation and evaluation of the techniques intervention. A paired sample Tukey-test analysis was used to analyze the scores from the tests thus the pre and post-test of both the experimental and control group. In the experimental group the p-value gave 0.486 which showed that there was no significant difference between the means of the pre and post-test of the experimental group. The control group recorded a p-value of 0.000 meaning there was significant difference between the pre and post-test. The Tukey-Test: Two-Sample Assuming Unequal Variances was used to analyze the post-test of experimental group and post-test of control group which showed there were statistically significant difference among the two, where $p = 0.000$ ($\alpha = 0.05$). The study revealed that the selected students lacked conceptual understanding about the topic. Among other things it was suggested that biology teachers should be encourage to use realistic simulations approach in teaching and learning some abstract biological concept to minimax students understanding. Suggestions for further research into the problem of this study include the replication of the study in other schools in the country to provide a pool of data for possible full scale national attention.

CHAPTER ONE

INTRODUCTION

Overview

This chapter deals with the fundamental motivations and essence of the study as well as peculiar considerations that defined the scope of the study. It covers the background to the study, the statement of the problem, and the purpose of the study as well as the objectives of the study. The chapter also presents the research questions, hypotheses, significance of the study delimitations and limitations and definition of terms.

Background to the Study

For more than a decade science educators have hoped that the use of computer software programmes would help provide efficient and effective instruction (Weller, 1996). The use of computer simulations and educational technologies is not only driven by the desire of educators to improve instruction but also driven by policy makers such as Ghana Education Service (GES), Ghana National Association of Science Teachers (GAST) and all stakeholders who matter in Science and Technology education. These agencies have drawn policies, developed an agenda for the use of computer simulations and virtual labs technology at all levels of education in Ghana. They recommended that future research be based on the use of educational technologies such as simulations, in the teaching of science and focused on determining the best use of software packages in teaching more difficult topics in science and in biology (Hickey, Kindfield, Horwitz, & Christie, 1999; Anamuah - Mensah, 2004).

According to Kablan (2004) cell division is an important topic in Biology which involves very complex concepts to be learned by students. Prior studies have indicated that most science students have poor grasp and misconception about the cell division concept and this could be attributed to traditional method of instruction employed by most Biology teachers in senior high schools in Ghana (Chattopadhay, 2012). Studies revealed that, most students fail to critically understand the cell division topic taught in the classroom. This lack of understanding translates to inability to achieve better and to apply this basic knowledge to their daily lives and other related topics like Genetics (Lewis & Wood Robinson, 2000).

Instructional methods influence achievement of students in education. While appropriate mode of instruction enhances learner achievement, inappropriate methods stifle knowledge retention and application Brown & Oke study (as cited in Brown, 1990). According to Brown (1990) ibid teaching is an interactive process through which knowledge and skills are shared with students, with the view to improve their understanding and ability to manipulate the social, political, economic and physical environment to enhance their survival. Ayot & Petal (1992) also noted that the main purpose of teaching is to bring about desirable learning in students. By this definition, students are to develop appropriate skills and knowledge that are necessary for improving human life and to solve problems. In most Ghanaian senior high schools‟ teachers initiate communication and influence students to think in a particular way as guided by the syllabus. However, whether the teacher leads the communication authoritatively throughout the instructional process or takes up facilitation role is a matter of choice. Research has revealed that, teachers in the Ghanaian secondary schools in this computer age often use methods of instruction that make their work

easier based on their beliefs, personal preference and norms of their disciplines (Watson, 2003).

Computer simulations (interactive media and non-interactive media) are software packages available for instruction. Realistic simulation is a 3-dimensional computer program that involves the act of imitating the behaviour of some situation or process by means of suitable analogues, especially for the purpose of study or personal training simulation whereas non-realistic simulation is 3-dimensional desktop virtual reality representing the real world by a computer program (Mayes & de Freitas, 2004). Studies have shown that, computer simulations enhance students‟ experience in the classroom by showing them the real concepts on the topic being treated. It does not only aid students visual learning but it makes learning more interactive so that students can make their own deductions making the instructional process become more fun as they are motivated by what they see. Lindgren & Schwartz (2009) also emphasized that visual- based teaching and learning process enhance students‟ understandings of learned concepts. Understandings of learned concepts enhance students‟ performance and achievement. An integration of computer simulation in teaching and learning process help students to clearly understand the characteristics of a phenomenon such as how the process of cell division occurs through visualization. The use of simulations in science has great impact on curriculum and instruction recognizes the need for its use in the teaching of most difficult topics and concepts.

Biology as a subject is known to have the highest number of student enrolment in recent years in senior high schools in Ghana. According to Ghana Education Service(GES) (2009) student enrolment in biology over the years has always surpassed the combined enrolment in other science subjects. These high enrolment

figures in biology indicate that biology is popular among the other sciences. However, this number does not match the students' achievement in the subject. Studies have shown that students either fail or get low grades in biology compared with physics and chemistry West Africa Examination Council (WAEC, 2013). Students‟ low performance has been attributed to instructional methods used by teachers, students‟ misconception and difficulty in understanding certain scientific concepts in biology. Topics such as Genetics, Cell Division, Photosynthesis, Respiration, Evolution and Protein synthesis are known to be difficult topics to be learned in Biology (Lazarowitz & Lieb, 2006; Saka, Cerrah, Akdeniz & Ayas, 2006). Cell division is one of the Biology topics which students learn in Form two in Ghanaian Senior High Schools. The main learning objective for Cell division as a topic is for students to understand the chromosome movement during mitosis and meiosis processes and how the products of these processes differ from the other. Therefore, mitosis and meiosis are two important concepts in cell division process.

Analysis of the West African Examination Certificate of Education, Biology papers from 2007 to 2012 shows that in Cell Division topic, subtopics such as Cell Cycle, Mitosis and Meiosis are not very popular though, sometimes questions regarding these topics are asked (WAEC, 2013). The question is why do students fail biology? Apparently, students still fail to understand Biology concepts and they have misconceptions about abstract concepts such as mitosis and meiosis and the ability to relate this to topics like genetics. Findings have shown that, learning problems in Cell Division faced by students have been attributed to several factors such as less conducive Biology learning environment, lack of effective teaching methods and learning approach that require memorization of abstract concepts by students, thereby

reducing students‟ engagement in the learning. Students just listen to the teacher‟s explanation, write down the important points and memorize concepts that they had learned (Kablan, 2004).

Cell division process is a complex concept that is difficult to understand if taught with traditional teaching methods (Buckley, 2000). Computer simulation is one of the effective teaching methods that facilitate students‟ learning in Science (Wellington, 2004). The teaching of cell division using computer simulations involves visualization which enables students to observe the whole process of cell division while listening to teacher‟s explanation. This approach enables the students to clearly understand the mechanism of the cell division process and to recall the required information in answering questions. Kiboss, Wekesa & Ndirangu (2004) explained that a realistic simulation enhances students‟ understandings about learned Biology concepts and achievement. Research findings showed a positive impact on the use of computer simulation in the teaching and learning process.

Effective teaching and learning process should enable all learning goals and objectives to be achieved. Simulation teaching and learning approach is based on constructivist learning which supports students with different learning styles such as visual, auditory and kinesthetic (Jimoyiannis, 2009). The use of various multimedia materials in the teaching and learning process make the learning process more interactive, attracts students to pay more attention and creates a deep curiosity towards the subject that they are learning. Furthermore, computer simulations help students to understand concepts clearly through visualization. Better understanding leads to good academic performance and high achievement among students. Students‟ achievement in science and technology subjects including Biology determines the

extent of effectiveness of the instructional approach used by teachers (Kiboss, 2002). Therefore, teachers should consider students‟ needs in the learning process by selecting effective teaching aids and materials based on students‟ ability and level of understanding so as to reduce students‟ misconceptions and improve their achievement.

In Ghana the use of computer simulations to teach science was introduced about four years ago to enhance student understanding and improve the performance of students at all levels of education and also to create science, technology and innovation culture in the existing educational curriculum Science Technology and Innovation Policy (STIP, 2009). However, the story is different as most science teachers in the senior high schools are very reluctant to use or do not use these software programs at all resulting in the poor performance of students in science subjects in general and biology in particular (WAEC, 2010). This therefore, calls for studies to find out the effects of interactive and non-interactive simulations on senior high school students‟ achievement in Ghana.

Statement of the Problem

Teaching methods are the complement of content, just as instruction is the complement of curriculum. In Ghana, most biology teachers claim that Cell Division topic is one of the most difficult topics in Biology. The causes of this observation were not farfetched. Biology, according to Sert, Dicken & Darcin (2008), is a more interrelated science field with respect to the concepts it covers compared to other sciences. This implies that biology has elements of other pure science subsumed in it. Kiboss (2002) emphasized that students‟ learning problem in Cell Division topic is

caused by science teacher‟s expository instructional method which is more focused on teacher-centered learning strategies.

It has been emphasized by various researchers of science curriculum at various levels of education that; “scientific concept taught in abstract forces student to resort to rote-learning without understanding” (Fielder,1993). Biological concepts such as cell division, digestion circulation of blood, flowering plants etc. are such clear examples. This has led to the poor performance of students in biology at the Senior High School level an indicated by the chief examiner‟s report, West Africa Examination Council (WAEC, 2013).

This assertion by the biology chief examiner about the students‟ performance is also shared by colleague biology teachers and examiners. Analysis and discussions of the students‟ low performance revealed that major contributing factor is the use of the inappropriate methods of teaching biology by teachers and inadequate classroom facilities. Most biology teachers have adapted to the conventional or lecture method of teaching. This method in addition to charts and improvised teaching and learning materials are unable to properly explain abstract concepts such as cell division, DNA replication excretion enable students.

To overcome some of the difficulties teachers and students faced under this method, as suggested by Meyer & Powers (1994); Sariya, North & Duca, (2005) is to use is to select effective instructional method such as realistic simulations to captivate, sustain and enhances students interest. Also, adopt reasonable and adjustable pace that balances content coverage and student understanding and achievements.

The use of simulations in teaching cell division provides a picture of reality of cell division. It is seen in action, that is happening; accompanied by explanations of the various stages, engaging students‟ attention through to the end of the lesson. These qualities of the use of simulations prompted the researcher to investigate the effects of realistic and non-realistic simulations on the achievements of Senior High School students in cell division.

Objectives of the Study

The study was conducted based on the following objectives:

1. To compare the achievement in the pre-test and post-test of the group of students who will learn Cell Division topic using realistic simulation.
2. To compare the achievement in the pre-test and post-test of students who will learn Cell Division topic using non-realistic simulation.
3. To compare the effectiveness of realistic simulation with non-realistic simulation on students‟ post-test after they had learned the Cell Division topic.

Research Questions

The study aimed to answer the following research questions:

1. What is the difference in achievement between pre-test and post-test in Cell Division of Form 2 SHS students‟ taught using realistic simulation?
2. What is the difference in achievement between pre-test and post-test in Cell Division of Form 2 SHS students‟ taught using non-realistic simulation?
3. How different are the achievement scores between the group of Form 2 SHS students taught with realistic simulation and those taught with non-realistic simulation?

Research Hypotheses

The following null hypotheses were tested in the study:

- $H_0$1: There is no significant difference among the mean scores of the students‟ pre-test and post-test using realistic simulation to teach the topic cell division.
- $H_0$2: There is no significant difference among the mean scores students‟ pre-test and post-test using non-realistic simulation to teach the topic cell division.
- $H_0$3: There is no significant difference in achievement between students taught with realistic simulation and students taught with non-realistic simulation.

Significance of the Study

The importance of the research cannot be overlooked. The findings, recommendations and suggestions are important source of information to the teachers in the schools where the study was undertaken and other teachers who teach biology. It would also provide useful information to the Ministry of Education and other educational authorities to undertake interventions that would promote and integrate pedagogical techniques that would help students understand difficult concepts in biology. This study will also serve as a source of information for future researchers who will want to undertake similar line of action. In addition, the findings will augment the pool of data required by other educational researchers in their bid to design interventions to curb educational problems in the sciences in general and biology in particular.

Delimitations of the Study

The study focused on the views of chief examiners report, biology teachers with respect to the topic cell division in the selected senior high school. Due to financial constraints, the study covered only 74 students. Additionally, data were collected from students in senior high school 2 only. Students in senior high school 1 and 3

were excluded due to the fact that the topic „cell division" for the study is in the Ghanaian SHS 2 biology syllabus and students are to be taught when they are in second year.

Limitations

Research limitations are those elements over which the researcher has no control (Dusick, 2011). Dusick explained this point that in most instances, any assumption the researcher makes becomes a limitation. Since assumptions are inevitable in empirical studies, the study had some unavoidable limitations. Ideally all the Senior High Schools (SHS) in the Sekyere South District should be targeted in this study. However, this study targeted only school due to lack of funds, proximity and accessibility. This was done in order to cut down cost and for effective management of time to complete the study within the time limit, and also to enable the researcher to undertake thorough and adequate data collection. In researches of this type where direct contact with respondents is made, there is bound to be psychological and emotional imbalances which can make students artificial and would not reflect normal classroom situations. To get a true picture of how some difficult concept in biology are taught in the school, the researcher occasionally sat in the classroom during biology lesson to release tension from the students.

Operational Definition of Terms

In this section, definition of terms is provided including explanation where necessary. In so doing, cognizance is taken of the scope of the context of the research.

Educational simulation is a simulation of some type of reality (system or environment) but which also includes instructional elements that help a learner

explore, navigate or obtain more information about that system or environment that cannot generally be acquired from mere experimentation.

Realistic simulation: is a 3-Dimensional computer program that involves the act of imitating the behaviour of some situation or process by means of suitable analogues, especially for the purpose of study or personal training simulation.

Non-realistic simulation: is a 3-Dimensional desktop virtual reality representing the real world by a computer program.

Organisation of the Study

This research report is presented in five chapters. The first chapter deals with the background to the study, statement of the problem, purpose of the study, research questions, educational significance of the study, delimitation of the study, limitation of the study, definition of terms and organisation of the study.

The review of the relevant literature on the study forms chapter two. Chapter three deals with the methodology. This comprises the design of the study, population, sample and sampling techniques used, instrument and data collection procedure as well as the procedure for analyzing the data. Chapter four, dealt with the presentation of results and the discussion of the findings. Lastly, the conclusion which includes the summary of the study, the main findings and recommendations constitute the fifth chapter.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Overview

This section reviews relevant literature related to the study. It presents learning theories, theoretical frame work for the study. A review on aims of Biology education at the Senior High School in Ghana, use of computer simulations in Science teaching and learning especially in Biology, types of simulations, studies on use of computer simulations in Science and Biology education, use of simulations to reduce students‟ misconceptions of Biological concepts, teachers‟ and students‟ attitudes towards the teaching and learning of Cell Division.

Learning Theories

Learning is one of the most important activities in which humans engage. It is at the very core of the educational process, although most of what people learn occurs outside of school (Shuell, 2013). Most psychologists and philosophers over the years have sought to understand the nature of learning, how it occurs, and how one person can influence the learning of another person through teaching and similar endeavors.

Learning theories according to (Mayes & de Freitas, 2004) are conceptual framework describing how information is absorbed, processed, and retained during learning. Cognitive, emotional, environmental as well as prior experiences, influences in understanding of a world view is acquired or changed and how knowledge and skills are retained. Various theories of learning have been suggested, and these theories differ for a variety of reasons.

Behaviorists look at learning as an aspect of conditioning and advocate a system of rewards and targets in education. Educators who embrace cognitive theory believe that the definition of learning as a change in behavior is too narrow and prefer to study the learner rather than their environment and in particular the complexities of human memory. Transformative learning theory focuses upon the often necessary change that is required in a learner's preconceptions and world view. Those who advocate constructivism believe that a learner's ability to learn relies to a large extent on what he already knows and understands, and the acquisition of knowledge should be an individually tailored process of construction (Mayes & de Freitas, 2004).

Constructivism founded by Piaget emphasizes the importance of the active involvement of learners in constructing knowledge for themselves. Students are thought to use background knowledge and concepts to assist them in their acquisition of novel information. When such new information is approached, the learner faces a loss of equilibrium with their previous understanding which demands a change in cognitive structure. This change effectively combines previous and novel information to form an improved cognitive schema. Constructivism can be both subjectively and contextually based. Constructivism asks why students do not learn deeply by listening to a teacher, or reading from a textbook (Mayes & de Freitas, 2004).

The learning theories of John Dewey, Maria Montessori and David A. Kolb serve as the foundation of the application of constructivist learning theory in the classroom (Lombardi, 2011). Constructivism has many varieties such as active learning, discovery learning and knowledge building, but all versions promote a student's free exploration within a given framework or structure (Devries & Zan, 2003). The teacher acts as a facilitator who encourages students to discover principles for

themselves and to construct knowledge by working answering open-ended questions and solving real-world problems. To do this, a teacher should encourage curiosity and discussion among his/her students as well as promoting their autonomy. In scientific areas in the classroom, constructivist teachers provide raw data and physical materials for the students to work with and analyze (Jacqueline, Brooks & Martin, 1999).

Theoretical Framework

This study was based on constructive learning theories relating to the use of simulations. Several constructive theories in particular lend support to the use of simulations which help students construct and retain knowledge. The constructivist theory is rooted in the idea that the learner actively constructs his knowledge, not that it is passively acquired from without, that is learning is something the learner does, not that it is imposed on the learner (Taber, 2006). The learner uses ideas as tools to understand many phenomena presented to him by the teacher.

Constructivist theory in education has long been associated with advanced pedagogy on the basis that it champions a learner-centered approach to teaching, advocates learning in meaningful contexts, and promotes problem-based activities where learners construct their knowledge through interaction with their peers (Nikitina, 2010). Huang (2002) stated that in constructivism, the teacher is seen as a facilitator/guide instead of being a director, in that learning allows for creative intercourse with the teacher, instead of teaching based on outcomes. Discovery is seen to direct the learner to construct his own knowledge.

According to (Driver and Easly,1978 cited in Onyesolu, Nwasor, Obiajulu, Ositanwosu & Iwegbuna, 2013), the concrete ideas brought in as "Entry Behaviour" by children to the learning environment, helped to change the research agenda in science education to encompass constructivist patterns in which learners construct their own knowledge as pot-pouri of ideas (self-generated from teachers). Knowles, Holton & Swanson (2011) gave impetus to this position by adding that constructivism emphasizes knowledge as being bound by context, giving room for individuals to make meaning out of their respective learning experiences.

This research is akin to the Constructivist Learning Environments. With "constructivists" approach, emphasis is strongly placed on the learner as an active agent in the knowledge acquisition process and developments is followed and encouraged by the computer based learning environments, such as programmed instruction, tutorials, and drill and practice programs (Alessi & Trollip, 1985). Theoretical support for such a learner centered approach has been provided by the work of educational psychologists such as Piaget (1963), Vygotsky (1978) and Bruner (1967, 1977). Vygotsky, for instance, stated that learners build new knowledge on to existing knowledge by developing conceptual maps, provided that the new learning falls within the learners‟ zone of proximal development (ZPD), in other words, the learners are challenged and stretched, but not too much. Vygotsky again stated that students‟ active participation in their learning can be facilitated by "scaffolding", whereby the learners are given structured support in the form of exemplars, strategies, guiding questions and similar pedagogical devices, by teachers, peers and learning resources. As a science teacher, I think this approach is appropriate for the study, as carefully structured learning support is supplied through the software program.

According to Byrne, Catrambone & Stasko (1999) the new generation of students, surrounded from an early age by computers, animations, computer games and graphics, and dominated by virtual interactions, can conveniently and effectively learn when they interact, visually observe, and actively participate in learning processes. This implies that, innovative teaching would be hard to imagine without the support and use of technology tools such as audio-visual and virtual interactive tools and environments simulation, visualization, animation, and immersive game-based approaches. Computers have certainly allowed the evolution of simulation a quantum leap forward, they are no means the only type of simulation used today (Seay, 1997).

The Aims of Biology Education at the Senior High School Level in Ghana

Biology is one of the essential science subjects that occupy a unique position in the school curriculum. According to Onyesolu, Nwasor, Obiajulu, Ositanwosu & Iwegbuna (2013), a teacher has not taught no matter how well the teacher knows, unless he is successful in promoting the learning of science by the students. This implies that whatever the teacher does and how he teaches is more important in stimulating learning, rather than the mere curriculum framework. The general aim of the Senior High School (SHS) biology in Ghana curriculum was categorized into concept domain, process approach, creativity domain, attitudinal, application and connection domains.

The concept domain aims at grouping the observable universe into manageable units for study and to describe any physical and biological relationships existing in the units (Yager, 1992). Both the 2008 and 2010 Senior High School (SHS) biology syllabuses advocates this and it comprises facts, concepts, laws and existing hypotheses and theories being used by biologists. A number of information are usually classified into

manageable topics such as cells, diversity of living things, life processes, genetics and evolution, etc. The process skill approach reveals some of the processes of science such as observing and describing; classifying and organizing, measuring and charting, communicating, predicting and inferring, hypothesizing, hypothesis testing, identifying and controlling variables, interpreting data and constructing instruments. All these processes can be achieved through effective instructional methods. The biology syllabus seeks to make students more creative and cause them to use their own initiatives to solve problems of life. Agboala (1984), is of the view that some of the specific important human abilities in this domain are visualizing, thus producing mental images, combining objects and ideas in new ways; offering explanation for objects and events encountered, questioning, producing alternate or visual uses of objects, solving problems and puzzles, designing devices and machines, producing ideas and devising tests for explanations. The development of the above domain will not be achieved if multimedia instruction method is not effectively utilized during biology lessons.

Attitudinal domains such as values, human feelings and decision making skills are also important to be addressed at the senior high school level. Simulations and games are designed to enable students develop positive attitudes towards themselves, positive attitudes towards biology and science in general and science teachers. The students also get better understanding of difficult biological concepts, become sensitive towards misconceptions about certain topics and understand nature.

In the application and connections domain, Adedapo (1976) observed that science is related to everything, especially other curricula areas such as mathematics, the social sciences, vocational subjects and the humanities. Inclusion of multimedia elements in

learning of biology reinforces the message and delivery which leads to a better learning rate. According to Neo and Neo (2000) the use of multimedia such as simulations introduces important changes in our educational system and impact the way teachers communicate information to the learners. With this software program, biology teachers can cover more topics within a short time; learners become active in the learning process instead of being passive learners in the teaching and learning process. The use of simulation as pedagogical tool in biology lessons improves the quality of teaching and learning as students acquire knowledge of scientific concepts in everyday life and also apply the learned biology concepts and skills to everyday social problems, understanding scientific and technological principles involved easily.

The ever expanding scope of „skills" is not only the substantial variation in the conception of skill across countries, there is also a recent tendency for researchers and policy makers, especially in Anglophone countries, to expand the range of tasks, knowledge and abilities that are deemed to be required to deal with new technologies and pace of innovation (Schleicher, 2014). This research finds out whether Ghanaian science teachers use these technologies and innovation to help students understand and achieve the aims of the biology curriculum.

The Use of Computer Simulations in Science and Biology Education

The use of computer simulations in science teaching and learning, especially in Biology education is more popular in the developed countries. Research literature shows that it is frequently used in some African countries like South Africa, India. Kenya, and other countries (Shaw, 2010).

Types of Simulations

Types of computer simulations have been identified as realistic and non-realistic simulations.

Realistic simulation

Simulations play a major role in education not only because they provide realistic models with which students can interact to acquire real world experiences, but also because they constitute safe environments in which students can repeat processes without any risk in order to perceive easier concepts and theories.

Realistic simulation is a 3-dimensional computer programme that involves the act of imitating the behaviour of some situation or process by means of suitable analogues, especially for the purpose of study or personal training simulation (Shin, 2002). Realistic simulations consist of multimedia elements which create real learning environment (Wang & Reeves, 2007; Zhang, 2007). Realistic simulations are widely recognized as a significant technological advancement that can facilitate learning process through the development of highly realistic 3-D simulations supporting immersive and interactive features (Georgiou, Dimitropoulos & Manitsaris, 2007).

Non-realistic simulation

Non-realistic simulation is 3-Dimensional desktop virtual reality representing the real world by a computer program (www.freedictionary.com). A desktop virtual reality simulation is semi-immersive, less interactive and does not create a realistic learning environment (Shin, 2002; Mikropoulos, Katsikis, Nikolou & Tsakalis, 2003).

Studies on Computer Simulations in Science and Biology Education

Studies have shown that, computer simulations enhance students experience in the classroom by showing them the real concepts on the topic being treated. It does not only aid students visual learning but it makes learning more interactive so that students can make their own deduction making the instructional process become more fun as they are motivated by what they see.

Lindgren and Schwartz (2009) also emphasized that visual based teaching and learning process enhance students‟ understandings about learned concepts. Understanding of learned concepts enhances students‟ performance and achievement.

Realistic simulation create real learning environment and bring reality to the Biology classroom. Realistic learning environment provide learning experience among students (Laurillard, 2002). Lesson content and the information received in a realistic learning environment raise motivation among students (Akpan, 2002). A study by White, Kahriman, Luberice & Idleh (2010) showed that 3-D visualization and simulation-based teaching method is more efficient compared to traditional teaching methods for learning protein structure concept in Biology. Buckley (2000) explained that simulation and multimedia-based teaching method in Biology promote constructivism learning environment among students and encourage students to develop their own learning goals and increase their concentration toward Biology lesson while interacting with simulation presentation. He confirms this through the use of simulations and multimedia resources as Educational model to teach the topic Blood Circulation System in his study. In addition, some researchers and users of computer simulations have other views about them for example; Shute and Glaser (1990) are of the view that simulations are programs that contain a model of a system

natural or artificial or a process. They further distinguish between the types of simulations-simulations containing a conceptual model, and those based on an operational model. To them conceptual simulation models hold principles, concepts, and facts related to the class of system(s) being simulated. Operational simulation models include sequences of cognitive and non-cognitive operations or procedures that can be applied to the class of simulated system(s). There is a wide range of complexity of simulations from simulation games to computerized role play animations.

Research literature supports the utility of simulations for science instruction. The evolution of such experiential learning approach can be traced from the 1960s, that these methods address the limitation of more traditional teaching. Simulations offer strong benefits in science and education. Not only has it facilitated constructivist and socio-constructivist learning activities but also supported different types of learners such as those who are visually oriented and disabled, Georgiou, Dimitropoulos & Manitsaris (2007) explained. Simulation can be described as a reproduction of a situation or action for study or training purposes. The emphasis in simulation is on reproducing the action of something else, not its appearance. A simulation is a useful teaching and learning tool, it represents a real structure for the purpose of explaining how something works (Cohen & Manion, 1997). Simulations work best when it is not possible or desirable to see the action in real life they emphasized. The more realistic the simulation, the less explanation will be required, but as long as the intended action is clearly reproduced, the simulation should impart the desired learning. Indeed, the teacher demonstrates or carries out a simulation for the students, who gather around to watch, he can explain what is being simulated, either through the questioning

technique (the preferred method) or by explaining simulation, especially if it is dramatic, students are likely to be curious about what is really happening, and are ready for unusual questions. Creative simulations make the learning of science unlike anything else students learn in school.

Biology is a central course on which many sciences related courses such agriculture, medicine, pharmacy, nursing, biochemistry and so on hinged on in-depth knowledge in biological concepts (Yusuf & Afolabi, 2010). Indeed, it is obvious that students who want to study these disciplines cannot do without biology. These and many factors have drawn the attention of researchers and curriculum designers towards biology as a subject in the school curriculum (Kareem, 2003). However, if Senior High School curriculum designers knew students‟ misconceptions, it might be helpful to prepare effective teaching strategies. Teachers can play an important role in teaching scientific concepts and, from a constructivist perspective, students should gain meaningful knowledge about biological concepts like cell division; and biologically literate students should be able to use and apply basic biological concepts when considering biological problems or issues. Simulation approach offers several advantages. In science and biology laboratories, everyday there are some risks that students encounter because of hazardous substances. Also, some of lab experiments are expensive and too much time consuming for classroom use. In such case, very high quality computer simulations can reduce these risks.

In the study of cell biology, simulation is recognized to allow more realistic observation of the cell division process or complex concept models in general. It allows an analysis of the dynamics of chromosomes movement and leads to an observation of the exchange of genetic materials and the behavior of the nucleus with

time. Moreover, it helps to analyze the organizational processes of the chromatids, the interdependencies between the stages, the consistency between the coordination chromosome, chromatids, homologous chromosomes, haploid and diploid cells, and the relationships between such concepts (Atilboz, 2004).

Computer simulation is one of the educational software programmes. Simulation teaching and learning method is based on constructivist learning and it supports students of different learning styles such as visual, auditory and kinesthetic (Jimoyiannis, 2009). Rutten, Van Joolingen & Van Derveen (2012) indicated that most of the research findings show that the integration of simulation in traditional teaching methods lead to positive changes in cognitive and affective domains.

Kiboss, Ndirangu & Wekesa, (2004) explain that simulation can show the dynamic nature of cell division process through animated colored graphics and involve use of various senses. They emphasized that learning environment designed using computer simulation for Cell Division topic in Biology is effective in improving students‟ understandings, knowledge and achievement and encourage students to engage actively in the learning process. Kiboss et. al. (2004) further noted that computer simulation-based teaching and learning method for learning Cell Division topic is interactive and the dynamic characteristics of the computer presentation that combined with verbal code with graphical representation and animation provides variety of interesting learning activities about the concepts that they have learned, it encourages students to interact openly with teaching materials and facilitate students‟ understandings. Combination of graphical representation, animation and simulation in computer simulation-based instructions also increase the acceptance and understandings of the cell division process that they have learned in the form of

illustrations. According to Gelbart, Brill & Yarden (2009) computer simulations have a positive influence on learning outcomes when compared with effects of regular teaching method without use of computer simulation for Genetic topics in Biology. Riess & Mischo (2010) in their study also identified that computer simulation-based learning is an effective teaching method. It has positive impact on Biology students‟ understandings and achievements which were analyzed through students‟ ability in answering questions regarding forest ecosystem topic with correct explanation and their score. Teacher centered teaching approach in the traditional teaching method affect students‟ Biology achievement. Findings of previous studies by Kiboss (2002); Kiboss & Ogunniyi (2003); Tanui (2003) explained that students perform better and score higher when taught with computer based instructional method whereas students who are taught with traditional teaching method are unable to perform well.

In another study, Varma & Linn (2012) examined the use of interactive technology to support students‟ understandings of the greenhouse effect and global warming in Biology. They reported that, student‟s understandings increased after they conducted experiments using virtual visualization. The results showed that students‟ knowledge and understanding increased when students are actively involved in the learning process and their achievement also showed that there was an increase in their post-test scores compare to their pre-test scores.

Another research conducted on the teaching of Plant Cell Biology and Photosynthesis using virtual reality software known as 'Superscape', revealed that all trainee teachers who were involved in the study recognized that virtual reality is a powerful educational tool. It encourages students to actively and creatively engage in the learning process, supports visualization of complex phenomena and elements that are difficult to observe without being confused with real objects and situations

(Mikropoulos, Katsikis, Nikolou & Tsakalis, 2003). According to Oztas, Ozay & Oztas (2003), Cell division constitutes the basics for genetics, growth, development and molecular biology as such the teaching of the cell division in biology must be made interesting and very understandable by students. The Cell division process involves two important processes; mitosis and meiosis. Mitosis and meiosis form a continuous process and findings by She & Chen (2009) indicated that majority of students and teachers evaluated on the topics such as chromosome, cell division and gene as difficult topics to learn. Studies by Flores, Tovar & Gallegos (2003); Kruger, Fleige & Riemeier (2006) revealed that students generally focus on the increase occurring with number of the cells, as a result of cell division and disregard the growth occurring in the cells, this in effect results in difficulties experienced during understanding such concepts and how students‟ will overcome this by learning activities that researchers have developed.

Use of Simulations to Reduce Students' Misconceptions of Biological Concepts

Misconceptions about abstract concepts in Biology affect students‟ achievement. Thus, the problem of misconception should be considered in the learning process of an individual (Yenilmez & Tekkaya, 2006). Students have misconceptions and lack of understanding the topic, Cell Division, due to the use of many educational methods that require memorization of the concepts (Ozcan, Yildirim & Ozgur, 2012). Students‟ misconception is difficult to replace if teachers use traditional teaching methods alone (Yenilmez & Tekkaya, 2006). The cell division processes serve as the basis for understanding about the molecular events of mitosis and meiosis which are difficult to observe with the naked eyes. Understanding and construction of the knowledge about the concepts mitosis and meiosis at the molecular level depends on

the ability of the students‟ visualization of the movement of chromosomes during mitosis and meiosis (She & Chen, 2009).

Riemeier & Gropengiesser (2008) analyzed the difficulties in learning as experienced by the 9th grade students regarding cell division, and their conceptual understanding within teaching experiments. Their results showed that well planned teaching activities for cell biology might enhance the conceptual development process and might contribute to conceptual learning by the students. It is obvious from these revelations that misconceptions related to the cell division processes lead to a series of problems for biology teaching and learning. This implies that when attending biology classes, students bring their perceptions, prejudices, and former experiences which may be in conflict with the scientific facts. This situation may negatively influence the learning of the topic. Keeping knowledge or conceptual frames of the students in line with the scientific facts can only be possible with effective conceptual teaching they noted. The use of simulations is the most likely effective conceptual teaching approach to consider.

Again a study of Meir, Perry, Stal, Maruca & Klopfer (2005) also reported that there was an increase in students‟ understandings and reduced students‟ misconceptions when students conducted experiments to learn about the concept of diffusion and osmosis in the virtual laboratory named as 'Osmo Beaker'. They therefore concluded that the virtual simulation-based learning environment enhances learning among students.

Teachers' and Students' Attitude towards the Teaching and Learning of Cell Division

In the Ghanaian senior high school system, the topic „cell division" forms part of the second year biology syllabus (Biology syllabus, 2010). The topic embraces concepts such as the division of the nucleus (karyokinesis) division of the cytoplasm (cytokinesis) doubling (replication), pairing (synapses), separating (disjunction), replicated chromosomes, un-replicated chromosomes, etc. The placement of this topic in the second year biology syllabus, instead of the first and third year content is informed by the fact that the topic is relatively complex. As explained by Oztas, Ozay & Oztas (2003) cell division is one of the abstract concepts in biology for students to understand. Students and teachers consistently place cell division near the top of these "ladders" of difficulty. It has been reported that cell division processes are poorly understood at all ages and levels of studies (Smith, 1991; Lewis & Wood-Robinson, 2000). This topic is taught by starting with primary school levels.

Revelations from Ghana Association of Science Teachers (GAST) conferences over the past decade indicate that cell division is a difficult topic to be taught. It is also perceived by most teachers to be one of the most problematic concepts in biology (Oztas et al., 2004), and Biology students are confused about the concepts related to mitosis and meiosis. The misconceptions related to mitosis and meiosis might also originate from the textbooks and explanations given in the classrooms. Cook (2008) indicates that some illustrations contained in textbooks related to meiosis lead to understanding difficulties for students. It is a well-known fact that it is not an easy task to eliminate these misconceptions by means of traditional teaching methods. An alternative way for overcoming problems related to these misconceptions might be to

employ computer-aided educational materials for teaching mitosis and meiosis and other biology topics (Cepni, Tas & Kose, 2006; Yesilyurt & Kara, 2007).

Due to the difficulty nature of the cell division topic some educators suggested the use of games (Gilbert, 2005) others suggested diagrams, kits, songs etc. Saraiya, North and Duca (2005) emphasized, visualization systems are required to effectively enhance the exploratory analysis of such complex concept. It was in the light of this that the Ghana Education Services employ the use of computer programmes could be thought as the panacea in the teaching of cell division. This coupled with other instructional methods should be able to help students understand and develop mental skills to enhance their future in biology related careers. Hence, computer simulation-based teaching method supports students from different learning styles, creates constructivism learning environment in which the role of students in the learning process is higher than the teacher‟s and enhances students‟ understandings, ability of thinking and achievement.

Summary of Literature Review

Studies in science education indicate that the challenges students encounter in the acquisition of scientific concepts such as Cell division is due to its abstract nature. This in turn has adverse effect on the performance and attitude towards science and Biology in particular.

Ghanaian students in SHS science courses have difficulties in understanding certain biological concept such as Cell division (Flores, Tovar, & Gallegos (2003); Kruger et.al.(2006). The difficulties students encounter with regard to the topic Cell division calls on all science teachers to adopt new and innovative approach of teaching in making this concept more meaningful and easier for students. An innovative

instructional approach in science involves the use of non-conventional methods and approaches in the teaching of this concept. One of such approaches is the use of simulations and virtual labs. Simulations according Shim et.al.(2003) provides fascinating challenges to students. It makes lessons active and helps students to achieve the mastery of the subject matter and also provide a unique opportunity for integrating the domains of learning. It is obvious that the literature is full of enough evidence to suggest that simulations are important instructional facility in the teaching and learning of science, particularly biology. It must therefore be explored in the teaching of science to the benefit of the students and the stated.

CHAPTER THREE

METHODOLOGY

Overview

This chapter discusses the methodology used in the study. The research design, the target population, the sample and sampling procedure have been described. It also presents the instruments that were used in data collection, the validity and reliability of the instruments, and data analysis procedure.

Research Design

The research design was quasi-experimental involving a case study of one school in the Sekyere South District. This was used in order to elicit as much as possible in-depth information on the effects of using realistic simulation and non- realistic simulation instructional methods on students‟ achievement on the topic cell division in the school. Quasi–experimental method is described by some authorities as „compromised experimental design‟ because of lack of randomization. This design was considered appropriate for the study, because it involves measurement of two variables such as dependent variable and independent variables, dependent variable is the variable being predicted and independent variable is the variable upon which the predictor is based.

The dependent variable is Biology students‟ achievement and the independent variables are realistic simulation based teaching method and non-realistic simulation based teaching method.

Population

The target population was all second-year students in the school. The accessible population however comprised the second year elective biology students in the school. The choice of the second year students is due to the fact that the topic Cell Division is in the syllabus of the second year elective biology, i.e. year 2, elective biology syllabus, Section 2, unit 4, page (62).

Sample and Sampling Procedures

The sample was made up of two intact classes with a total of 74 students. Indeed, random selection of the students for the study was not practicable in this situation because intact classes were used. Intact classes were used to avoid distortions of the academic activities in the participating school. Selection of the school will be based on non-probability sampling technique this is because it assumed that the population to be will be homogenous in characteristics and non-probability selection in such a case would not make any difference. In addition to that the selected school will have to meet the following conditions:

i) The school should be offering elective biology as one of its course subjects.

ii) The selected school should be easily accessible to the researcher.

Based on the above criteria, the school that was eligible for the study was selected. A pre-test was conducted the mean scores of the eligible classes were used for the study.

Demographic Description of Respondents

Demographic description may be referred to as how people are classified into groups using common characteristics such as race, gender, income level or age. Demographic information provides data regarding research participants and is necessary for the determination of whether the individuals in a particular study are a representative

sample of the target population for generalization purposes (Lee & Schuele, 2010). The profile of the respondents in this study is looked upon in terms of age and gender. Majority of the students were 16 years of age representing 54.1%, 17 years of age recorded 19representing 25.6% while only 15 are 15 years representing 20.3%. Hence majority of the students fall within the standard age for their academic level.

The SHS two (2) science class is a male dominated class. Out of the total of 74 students, 46 (62.1%) are boys while only 28 (37.9%) are boys. Since the introduction of Science as a course into the second cycle educational system of Ghana, the enrolment of boys has always been higher in science classes compared to girls, even though girls are gradually showing and appreciable level of interest in the study of science.

Data Collection Instruments

The instruments that were used for data collection were „tests". Two tests namely pre-test and post-test were constructed by the researcher for this purpose. The description of each of these test follow.

Pre-Test: This test was tagged Students" Basic Knowledge of Biological Concept Test (SBKBC). The purpose of this test was to assess all the biology classes of the school that was selected to determine the level of students" understanding in some basic biological concepts. This was to help to identify which classes could best match and also to ensure the credibility of the findings of the study (Cohen, Manion & Morrison, 2011). There were twenty (20) objective test items, covering some basic concepts in biology such as genetics, endocrine system, photosynthesis, respiration, etc. Section A comprised of Fifteen (15) of the 20 questions as multiple choice items and section B comprised five (5) True / False statements. Each of the fifteen (15)

multiple choice items had a stem of four (4) options and one correct answer and three (3) plausible detractors. One mark was given for each correct answer circled. The items appeared as question 1 to 15. The five statements (questions 16-20) required that the students indicate whether a particular statement was true or false by underling the correct answer. The test lasted for 30 minutes. Copies of pre-test and its marking scheme are presented as Appendices A and B.

Post-Test: The post test was tagged Students Achievement Test on Cell Division (SATCD). This test was aimed at assessing students‟ knowledge and understanding on the topic „œll division‟. It comprised of two sections, A and B. This was to help to researcher have fair assessment of students‟ achievement on the topic. There were twenty (20) objective test items, covering the cell theory concept, the stages and processes involved in mitosis and meiosis. Fifteen (15) out of the 20 questions in Section A were multiple choice items and section B comprised of five (5) **True / False** statements. Each of the fifteen (15) multiple choice items had a stem of four (4) options: one correct answer and three (3) plausible detractors. One mark was given for each correct answer circled. The items appeared as questions 1 to 15. The five statements (questions 16-20) required students to indicate whether a particular statement was true or false by underling the correct answer. The questions were carefully set such that students require understanding of the subject matter to choose answer from the options given. The (SATCD) was used to assess students‟ performance on the concept of cell division after the implementation of the interventions. A comparable standard was used and their comparability was established by the means of their pretest-scores which assessed students‟ basic knowledge in biological concepts. Copies of post-test and its marking scheme are presented as Appendices C and D. `

Validity of the Instruments

Validity of both the pre-test and post-test were assured by comparing the demands of the questions to the demands of the biology syllabus. Set of questions that have been prepared for the pre-test and post-test achievement were given to experts in science education as well the researcher‟s supervisor to determine the validity of the questions that were constructed. The tests were also validated by two different teachers from two schools in Sekyere South who have more than seven years of experience in the field of Biology Education to ensure that the prepared items were appropriate for students‟ thinking level and ability, comprised correct Biology terms, non-ambiguous and easy to understand.

Reliability of Instruments

The internal consistencies of both the pre-test and post-test were also determined through pilot testing. Twenty (20) Biology students of Adu-Gyamfi Senior High School were used in both cases. The school was chosen because it was outside the accessible population. Besides, there was homogeneity in characteristics between the accessible and the pilot school populations. The reliabilities of the two tests were calculated using Kuder-Richardson Formula 20/21 method and were found to be 0.76 and 0.79 respectively. Therefore, the reliability of the tests used in this study were analyzed by using Kuder-Richardson Formula 20 (K-R 20) method and reliabilities (internal consistencies) of the two tests were determined and the reliability coefficients are summarized in Tables 1and 2.

Table 1 shows the Kuder-Richardson computation of the reliability coefficient of the research instruments.

Table 1: Reliability Coefficient for Pre-test and Post Achievement Test

Research Instruments	Method	Mean	Standard Deviation	Reliability Coefficient	Number of Test Items
Pre - Test	K-R 20	10.6	4.74 7	0.76 9	20
Post Test	K-R 20	10.8	3.64	0.79	20

Table 2 shows the summary of the reliability coefficient of the research instruments

Table 2: Summary of Reliability Coefficient of the Research Instruments

Type of the Instrument	Reliability Coefficient
Test	
• Pre-test (SBKBC)	0.76
• Post-test (SATCD)	0.79

Borg, Gall and Gall (1993) indicated that, coefficient of reliability values above 0.75 are considered reliable. Therefore, the above reliability estimates gave an indication that the instruments were substantially reliable.

The intervention realistic simulation and non-realistic simulation were selected from existing software on the website which is freely accessible for educational purposes. Both realistic simulation (3-Dimensional multimedia simulation) and non-realistic simulation (desktop virtual reality simulation) are 3-Dimensional simulations. Both realistic simulation and non-realistic simulation consist of four main concepts of Cell Division which are cell cycle, mitosis, meiosis I and meiosis II. Realistic simulation can be played in any video software like RealPlayer, Window Media Player and VLC Media Player. Meanwhile, non-realistic simulation can be played in a computer desktop if the computer has installed 3-Dimensional software such as Cortona 3-dimensional, Cosmo Player Setup and many more.

Data Collection Procedure

Pre-intervention

To ensure effective study, at least three familiarization visits was made to the selected school with a formal introductory letter and also to seek permission from the appropriate authorities before the study was carried out the study in the school. In the course of these visits intensive negotiations were made with the school authorities about the conduct of the study and the benefits that would be derived by the students, teachers and the school as a whole. The indulgence of the subject teachers was of great help. A copy of the biology time table was obtained which enabled the researcher to know the number of contact hours per class and plan accordingly. The study lasted for four weeks; it started in the second week and ended in the sixth week of the third term of 2014/2015 academic year. Before the start of the actual study, the head of Department introduced the researcher to the biology classes in the first day of the first week. The researcher then interacts with the classes after the introduction schedule for the pre-test was made. The pre-test developed by the researcher was administered target classes at the same time to respond to the items in the presence of the researcher with the help of the biology teachers for 20 minutes. This was to ensure about 100% collection of the instruments. The scripts were marked and the results obtained were used for the intervention.

Intervention

The two intact classes were taught the cell division topic for four weeks (each class had at least six periods with forty minutes per lesson) after which the post–test was conducted. The teaching as well as the final assessment (post-testing) in each sampled

class took four weeks to be completed. Hence each class had same length of exposure in the teaching and learning process, after which the post-test was conducted.

Post Intervention Data Collection

The researcher administered and supervised the data collection. All participating students completed post-tests consisting of twenty multiple-choice questions. The students seemed very motivated to have been exposed to both methods of instruction. Scripts were marked and scores tallied and recorded.

Data Analysis

After the administration of the pre-test to the biology students in the selected school, the statistical analysis of the tests (pre-test and post-test)-mean, standard deviation and T-test of the realistic and non-realistic groups were computed. T-test was used to investigate whether any difference that existed in the scores between the experimental group and the control group. Data collected from the tests were analyzed to provide answers to the research questions and hypotheses. The outcomes of the analyses were used to support inferences drawn from the study.

The over -all research procedure is presented as figure 1.

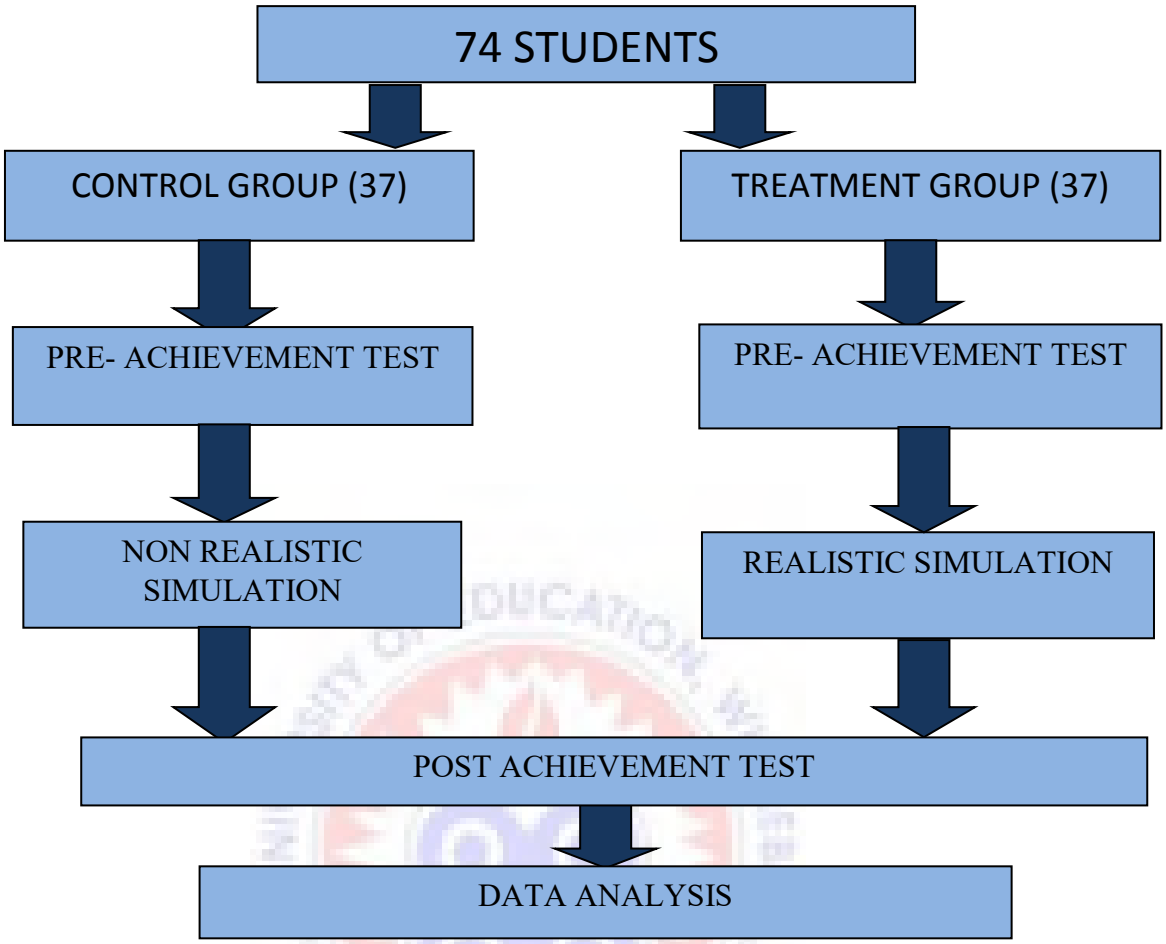

Figure 1: Procedure for the study

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

This chapter presents the statistical analysis of the research data. Inferential statistical evidences needed for drawing conclusions have been provided. Again, tested hypothesis interpreted results, as well as evidence-based answers to research questions have also been presented. This is followed by the discussion of the results, supported by research evidence.

Presentation of Results by Research Questions

The results were presented systematically guided by the research questions. They begin with research question one and ends with answer to research question three.

Research Question One

What is the difference in achievement in Cell Division of Form 2 SHS students‟ taught using realistic simulation?

This question sought to find out if the use of realistic simulation in teaching resulted in a difference in students‟ achievement between their pre-test and post-test after learning Cell Division. To determine whether the performance between students‟ scores in the pre-test and post-test were statistically significant, a paired sample T-test analysis was used to analyze the scores from the tests. This is presented in Table 3.

Table 3: Comparing Mean Values of Students Pre- and Post-Test in the Experimental Group

	Mean	N	Std. Deviation	Std. Error Mean
Pre-test Expt	13.51	37	2.765	.455
Post-test Expt	13.97	37	3.337	.549

*Pre-test Expt = Pre-test of Experimental group (Realistic Simulation)
*Post-test Expt = Post-test of Experimental Group (Non-realistic Simulation)

Table 3 shows the comparison of the pre- and post-tests of the experimental group thus the group which experienced an intervention of Realistic Simulation in teaching. The Table gives the means of each of the tests (pre and post-test). The mean of the pre-test of the experimental group was 13.51 while the post-test was 13.97. This indicate that there was a slight improvement in students" achievements in the post-test; this means that even though the students were exposed to the realistic simulation teaching strategy the performance of students was very minimal as compared to their pre-test. The standard deviation of the two tests also confirms what the means of the two tests have explained.

Table 4: Comparing Mean Values of Students Pre- and Post-test in the Experimental Group

	Mean	N	Std. Deviation	Std. Error Mean
Pre-test Expt	13.51	37	2.765	.455
Post-test Expt	13.97	37	3.337	.549

*Pre-test Expt = Pre-test of Experimental group (Realistic Simulation)
*Post-test Expt = Post-test of Experimental Group (Non-realistic Simulation)

Table 4 is showing the overall comparison of students in the experimental group pre and post-test. The mean in the Table 4 is -0.459 indicating that, more of the test scores were greater in the post-test than the pre-test but not with a wider margin. The

sig, (2-tailed) value is 0.483 which is also the p-value; in this study it is set at 0.05, significance ($\alpha = 0.05$). This shows that, in comparing the pre and the post-test of the experimental group (i.e. the group exposed to Realistic simulation) there was no major increase in their test scores. The null hypothesis set for research question one is;

- Ho_1: There is no significant difference between the mean scores of the students‟ pre-test and post-test using realistic simulation to teach the topic cell division.

  Taken the p-value into consideration which is set at 0.05($\alpha = 0.05$), the p-value from Table 4 is given by 0.48. This shows that there is no significant difference in the mean scores of the students‟ pre and post-test. Relating this result to the null hypothesis, we fail to reject the null hypothesis; therefore the null hypothesis is true and accepted.

Analysis of Test Results with Respect to Research Question Two

Research Question Two

What is the difference in achievement in Cell Division of Form 2 SHS students‟ taught using non-realistic simulation?

This question sought to find out if the use of non-realistic simulation in teaching made a difference in students‟ achievement between their pre-test and post-test after learning Cell Division. To determine whether the performance between students‟ scores in the pre-test and post-test showed they were statistically significant, a paired sample T-test analysis was used to analyze the scores from the tests. The results are presented as Table 5.

Table 5: Comparing Students Mean Values of Pre- and Post-test of the Control Group

	Mean	N	Std. Deviation	Std. Error Mean
Pre-test Control	10.70	37	3.562	.586
Post-test Control	13.70	37	2.184	.359

*Pre-test Control = Pre-test of Control Group (Non-realistic Simulation)
*Post-test Control = Post-test of Control Group (Non-realistic Simulation)

Table 5 shows the comparison of the pre- and post-tests of the control group, the group which experienced Non-realistic Simulation in learning Cell Division. The Table gives the means of each of the tests (pre and post-test). The mean of the pre-test of the control group was 10.76 whiles the post-test was 13.70. This shows that there was an improvement in students‟ achievements in the post-test compared to their pre-test. The Paired samples t-test showed that there were significant differences in achievement between pre- achievement test and post achievement test of control group students who were taught with non-realistic simulation, although the students were taught using Non-realistic teaching strategy, their performance in the post-test shows that the use of (Non-realistic simulation) was not very effective. The results are presented as Table 6

Table 6: Comparing of Pre-test and Post-test Scores of the Control Group

	Mean	Std. Deviation	T	Df	Sig. (2-tailed)
Post-test Control - Pre-test Control	2.946	3.726	4.809	36	0.000

*$p<0.05$ significance ($\alpha=0.05$)
*Pre-test Control = Pre-test of Control Group (Non-Realistic Simulation)
*Post-test Control = Post-test of Control Group (Non-Realistic Simulation)

Table 6 is showing the overall comparison of students in the control groups‟ pre and post-test scores. The mean is 2.946 indicating that, the test scores showed greater difference in the pre-test and the post-test with a wider margin. The sig, (2-tailed) is

given by 0.000 which is also the p-value; in this study it is set at 0.05, significance (α = 0.05). This shows that, in comparing the pre-test and the post-test scores of the control group (i.e. the group exposed to Non-realistic simulation) there was a major difference in the test scores. The null hypothesis set for research question two is;

- Ho_2: There is no significant difference among the mean scores of students‟ pre-test and post-test using Non-realistic simulation to teach the topic Cell Division.

Again from Table 6 the p-value which is set at 0.05(α = 0.05) is 000. This shows that there is a significant difference in the mean scores of the students‟ pre and post-test. Relating this result to the null hypothesis, we reject the null hypothesis. Therefore, the null hypothesis is false.

Analysis of test results with Respect to the Research Question Three

Research Question Three

How different are the achievement scores between the group of Form 2 SHS students taught with realistic simulation and those taught with non-realistic simulation?

This question sought to find out if there were any difference in achievement scores of the groups after learning cell division through Realistic simulation and Non-realistic simulation. To determine whether the performance between students‟ scores in the post-test of experimental group and post-test of control group were statistically significant, T-Test: Two-Sample Assuming Unequal Variances was used to analyze the scores from the tests. The results are presented in Table 7.

Table 7: Comparing Students Mean Values of Post-Test of Control Group and Post-Test of Experimental Group

	Mean	N	Std. Deviation	Std. Error Mean
Post-test Control	10.76	37	3.562	0.586
Post-test Expt	13.97	37	3.337	0.549

*Pre-test Control = Pre-test of Control Group (Non-realistic Simulation)
*Post-test Expt = Post-test of Experimental Group (Realistic Simulation)

Table 7 shows the comparison of the post-test of the control group thus the group which experienced intervention of Non-realistic Simulation in teaching and the post-test of the experimental group, thus the group which was exposed to Realistic simulation teaching strategy. The mean of the post-test of the control group was 10.76 whiles the post-test of the experimental group was 13.97. This shows that there was an improvement in students‟ achievements in the post-test of the experimental group compared to the post-test of the control group. The standard deviation of the two tests also confirms what the means of the two tests have explained. The results in Table 7 are also presented as a graph in figure 2.

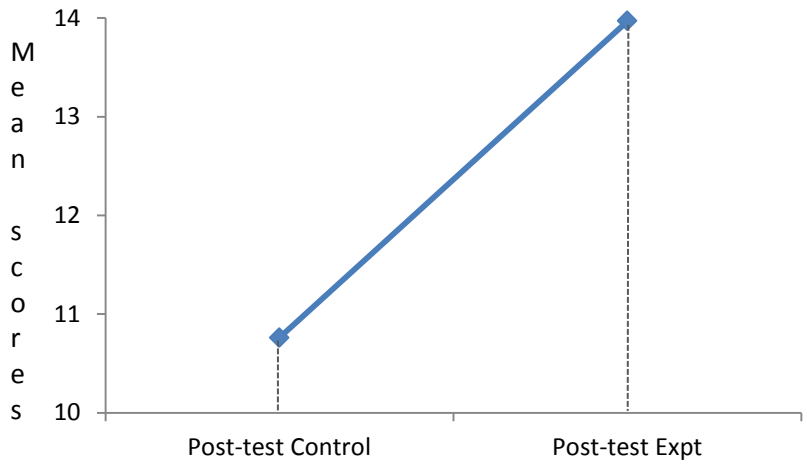

Figure 2: Graphical presentation of the means of Post-test both control and experimental group

Also from Figure 2, the mean scores are presented graphically to show the performance of students in both the control and experimental group. The mean score of the control group (10.76) is found below on the plotted line while that of the experimental group (13.97) is high. This graph confirms that realistic simulation had an impact on the students‟ academic performance in the post-test compared to that of the students who were exposed to non-realistic simulation in the control group.

Table 8 presents the statistical analysis of the Post-test Scores of Control Group and Experimental Groups.

Table 8: Comparing Statistical analysis of Post-test scores of the Control Group and Experimental Group

	Post-Test Control	Post-Test Expt
Mean	10.76	13.97
Variance	12.68	11.13
Observations	37	37
Df	72	
t Stat	-4.007822083	
P(T<=t) one-tail	7.3867E-05	
t Critical one-tail	1.666293696	
P(T<=t) two-tail	0.000147734	
t Critical two-tail	1.993463567	

*p<0.05 significance (α=0.05)
*Pre-test Control = Pre-test of Control Group (Non-realistic Simulation)
*Post-test Expt = Post-test of Experimental Group (Realistic Simulation)

Table 8 shows the overall comparison of analysis of students‟ post-tests score in the control group and that of the experimental group. The sig, (2-tailed) value is given by 0.000 which is also the p-value, in this study it is set at 0.05, significance ($\alpha = 0.05$). This shows that, in comparing the post-test of the control group (i.e. the group exposed to Non-realistic simulation teaching strategy) and the post-test of the experimental group (i.e. the group exposed to Realistic Simulation teaching strategy),

there was a major difference in the test scores. The null hypothesis set for the research question three is;

- Ho_3: There is no significant difference in achievement between students taught with realistic simulation and students taught with non-realistic simulation.

  Again from Table 8 the p-value which is set at 0.05($\alpha = 0.05$) is 000. This shows that there is a significant difference in the mean scores of the students" post-tests scores. Relating this result to the null hypothesis, we reject the null hypothesis. Therefore, the null hypothesis is false.

Discussions

The study set out to find out the effects of realistic simulations and non-realistic simulations in teaching the topic **'Cell Division'** at the Senior High School Level. In the earlier part of this chapter, results were mainly presented and analysed based on the specific research questions with brief comments on them. In this part, however, the results have been discussed in detail under three topics corresponding to the research questions set to guide the study. The findings are supported by research evidence reviewed in chapter two.

Based on the descriptive statistics, both control group and experimental group got higher scores in post-achievement test than pre-achievement test. However, experimental group students who were taught with realistic simulation gained a high mean score in post achievement test than the control group students who were taught Cell Division topic using non-realistic simulation. The mean score differences between treatment group and control group for post achievement test was 3.21. The results show that realistic simulation is more effective teaching method than non-

realistic simulation for Cell Division topic. Based on the inferential statistics such as paired samples t-test results, two out of the three null hypotheses were rejected and one accepted.

Impact of realistic simulation on achievement in cell division of the experimental group

Results with respect to research question one indicated that the students‟ scores in the post-test of the experimental group (students exposed to realistic simulation) did not have a huge margin compared to their pre-test scores. The means of the pre- and post-tests were very close to each other such that there was no significant difference between the means and even the scores. The null hypothesis was also not rejected because the resulting p-value in the pre- and post-test was 0.486 meaning that there is no significant difference in the mean scores of the students‟ pre and post-test in the experimental group. It can be explained that even though the results indicated that realistic simulation teaching method in Cell Division enhances experimental group students‟ understandings and improve their performance in Biology, there was no major increase in their test scores due to the fact that, the impact of the realistic simulations could not be felt by the experimental group within the stipulated time with wider margin. Through the activities of the realistic simulation, it was revealed that students‟ performance was improved due to intense student-student interactions, active participation of all students in the lessons, maximum teacher supports and increased teacher-student interaction. From the study, it revealed that the student introduced to realistic simulation teaching strategy enjoyed the lesson and participated actively in the lessons.

Impact of non-realistic simulation on achievement in cell division of the control group

With respect to research question two, the question sought to find out if the use of non-realistic simulation in teaching brought difference in students‟ achievement between their pre-test and post-test after learning Cell Division. Results in Table 5, showed that there was difference between the means of the pre-test and post-test of the control group. The descriptive statistics about results for the control group reveals that their mean scores have increased by 2.94 in post achievement test than pre achievement test. These results indicate that non-realistic simulation teaching method in Cell Division topic enhance control group students‟ understandings and improve their performance in Biology. This is supported by several studies such as study of Varma & Linn (2012), reported that non-realistic simulation increase students‟ knowledge, understandings and achievement. Mikropoulos, Katsikis, Nikolou & Tsakalis (2003) also reported that teaching and learning with non-realistic simulation method foster students to engage actively and creatively in Biology learning and promote better understandings among students about the difficult concepts through visualization. Study of Meir, Perry, Stal, Maruca & Klopfer (2005) also indicated that non-realistic simulation enhance students‟ understanding as well as reduce their misconceptions about learned Biology concepts.

Overall assessment of the impact of realistic simulation and non-realistic simulation on achievement of students in cell division

Analyzing research question three, it showed that the students‟ performance in the post-test of the control group showed a significant difference compared to the post-test of the experimental group. From Table 8, the p-value which was 0.000 signifies

that there is a significant difference in the mean scores of the students‟ post-tests in the control group and that of the experimental group. Relating this result to the null hypothesis, we reject the null hypothesis which is there is no significant difference in achievement between students taught with realistic simulation and students taught with non-realistic simulation for the topic Cell Division; therefore the null hypothesis is false. The estimated marginal mean scores showed that the experimental group (*M*=13.97) performed better and gained mean scores of 3.21 compared to the control group (*M*=10.76) in the post achievement test. This result reveals that realistic simulation is more effective than the non-realistic simulation in enhancing Biology students‟ achievement. This result shows that realistic simulation is more effective than the non-realistic simulation in enhancing students‟ memory retention for learned abstract Biology concepts. Kiboss, Ndirangu & Wekesa (2006) also reported similar finding and emphasized that the combination of graphic representation, animation and simulation in instructional computer simulation enhances Biology students‟ long term memory retention about the cell division concepts which learned in the form of illustrations. The key explanation to their improved performance could also be due to active participation in the lessons and the highly nature of the lessons.

Both realistic and non-realistic simulations have positive impacts on students‟ post-achievement when compare with students‟ pre-achievement scores. Students gained scores in their post achievement test after taught with realistic and non-realistic simulation. However, based on the overall statistics, realistic simulation is the most effective teaching method in learning Cell Division topic. Kiboss, Ndirangu & Wekesa (2006) findings supported the present study that, realistic simulation has positive impacts on student‟s performance, achievement and understandings of the

Cell Division process that they learnt in visual form. Kiboss (2004), Kiboss & Ogunniyi (2003) as well as Tanui (2003) also reported that realistic simulation helps students to understand clearly about the learned Biology concepts through visualization and improve their achievement than the students those taught by traditional teaching method.

Based on the findings of the previous studies and present study, both realistic simulation and non-realistic simulation can improve biology students‟ achievement. However, realistic simulation teaching method is a more effective teaching method than the non-realistic simulation teaching method for Cell Division topic. Shim, Park, Kim, Kim, Park, & Ryu (2003) had conducted a study to investigate the effectiveness of 2-Dimensional media and virtual reality simulation. They reported that students show more interest in realistic simulations in learning than non-realistic multimedia teaching method and students assume that realistic simulations are very helpful in learning science subjects especially Biology.

These findings have significant implications since they suggest that incorporating realistic simulation into Biology courses may be a tool for narrowing the performance gap of majority of students. Data from the research instruments used for this study indicated that there had been significant improvements in the students‟ performance after they had been exposed to the realistic simulation teaching strategy. This is to show that teachers are encouraged to adapt such teaching strategy especially in the teaching of challenging Biological concepts.

CHAPTER FIVE

SUMMARYOF FINDINGS, CONCLUSION, IMPLICATIONS AND SUGGESTIONS

Overview

This chapter focuses on the summary of the study, conclusion and recommendations based on the findings of the study.

Summary of the Study

This research was primarily designed to help improve students‟ academic performance in Adventist Senior High School in the Sekyere South District towards the study of Cell Division in Biology. A case study quasi-experimental design was used for this study. In this design the researcher put students into two groups; experimental and control groups. The researcher developed two interventions realistic and non-realistic simulation teaching approach to teach the topic, Cell Division. The experimental group was exposed to realistic simulation teaching strategy and the control group experienced non-realistic simulation teaching strategy. The students were assessed before and after the lesson and the marked scores recorded as pre-test and post-test scores respectively. A paired sample T-test analysis was used to analyze the scores from the tests, thus the pre-test and post-test of both the experimental and control group.

In the experimental group the p-value gave 0.486 which showed that there was no significant difference between the means of the pre and post-test of the experimental group. The control group recorded a p-value of 0.000 meaning there was significant difference between the pre and post-test results of the students.

The T-Test: Two-Sample Assuming Unequal Variances was used to analyze the post-test of experimental group and post-test of control group which showed there was statistically significant difference among the two, where $p = 0.000$ ($\alpha = 0.05$). It was concluded that the use of realistic simulation instructional approach and should be integrated in the teaching of challenging Biology concepts at the senior high school level in Ghana.

List of Major Findings

- The use of simulations in general improved students‟ performance in Biology.
- Non-realistic simulations improved students‟ performance in Cell Division.
- Realistic simulations improved students‟ performance better than non-realistic simulations.

Conclusions

The presents study showed that, 37 students who experienced realistic simulations instructional method performed better than the 37 other students who experienced non-realistic simulations instructional method in conceptual understanding of the Cell Division topic. This resulted from the practical nature of the teaching approach. Since the lesson was activity oriented, the students learn collaboratively and this provided opportunity for them to interact and discuss their views with their colleagues intensively.

The results of the study indicated that realistic simulation is one of the most effective teaching approach than non-realistic teaching approach. Further in the study it was found that integration of realistic simulation in cell division topics helps students to

visualize the abstract concepts to clearly understand how the process takes place and avoid misconceptions. Students understand more if they learn abstract concepts through observations. It is evident from these results that biology students‟ achievement can be improved if teachers continuously use realistic simulation in the teaching and learning processes as the main instructional approach.

In conclusion, an instructional method that employs realistic simulations has positive impacts on learning difficult science concepts. The results of the present study indicated that realistic simulation is one of the most effective Biology instructional method than non-realistic simulation. It is evident from the results that Biology students‟ achievement can be improve if teachers continuously use realistic simulation in the teaching and learning process.

Implications

The findings have implications since they suggest that incorporating realistic simulation into biology course is a tool for narrowing the performance gap of majority of students. Data from the research instruments used for this study indicated that there had been significant improvement in the students‟ performance after they had been exposed to the realistic simulation teaching strategy. This is to show that teachers are encouraged to adapt such instructional method especially in the teaching of challenging Biological concepts**.**

Recommendations

Recommendations for Teachers Biology at the Agona Adventist Senior High Schools Who Want to Use interactive simulation Instructional Approaches in the Teaching and Learning Process.

- A common problem with many biology students in the school is their laziness towards learning especially in the Science subjects. This study revealed that one effective measure teachers could use to nip this performance of students in the bud is to adapt the use of realistic simulations in every lesson, this would make them prepare adequately before coming to class. Also, students‟ participation in the teaching and learning process and teachers‟ support could make students adopt positive attitudes towards Biology teaching and learning and therefore maximize their performance.
- Teachers should ensure that students are made more responsible for their own learning through group activities and discussions, sharing of ideas and cooperating with peers with some guidance from the teacher. This implies that Biology teachers in the school should model their instructions to enforce student-student interactions. This is most effectively achieved by using realistic simulation instructional packages that will enhance group discussions or active learning among students.

Suggestions for CRDD, the Ghana Education Service, the Ministry of Education and all other Stakeholders Associated with Science Education in Ghana

- The Curriculum Research Development Division (CRDD) should ensure that the syllabus is not loaded to the extent that teachers have to concentrate on the theory aspect alone but would also include a lot of practical lesson.
- Curriculum planners and developers as well as all stake holders associated with Science Education in Ghana should introduce more innovative methods such realistic simulations instructional method to help students

quit rote learning in favour of meaningful learning. This would motivate the Biology students to develop positive attitude towards the subject.

- The Ghana Education Service (GES) should also make adequate provisions for training programmes such as innovative teaching seminars and other professional training workshops for science teachers so that they can competent and well-endowed with current technologies to teach effectively in the classroom.
- More science laboratories should be built and well equipped with current equipment to ensure effective teaching and learning of Biology lessons as well as other subjects.
- Furthermore, computers should be provided to every student or three students in a group sharing one computer during teaching and learning process to encourage students explore and learn on their own.

Suggestions for Further Research

Reflecting on the findings of this study, the following recommendations are made for further research with respect to the use of interactive simulation instructional packages on Biology teaching:

- The sample size was quite small due to the focus of this study. It is therefore recommended that the study be replicated using larger samples to provide a basis for more generalisations of the conclusions drawn from the findings of the study about the effectiveness of interactive simulation instructional packages in the teaching and learning of Cell Division.
- Similar studies should extend the intervention period using realistic simulation and non-realistic simulation-based teaching and learning

process for more than six weeks to see the long term positive impacts of realistic simulation and non-realistic simulation in several difficult topics of Biology.

- Future research may include the use of realistic simulations in solving problems of misconceptions by students in Cell Division.

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APPENDICES

APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

STUDENTS' BASIC KNOWLEDGE OF BIOLOGICAL CONCEPT TEST

(SBKBC) PRE-TEST (SBKBC) QUESTIONS

Dear Students,

This test is aimed at assessing your fundamental knowledge in Biology. This is to enable your teacher adopt the most appropriate and effective teaching approach to help you get excellent tuition in biology in the subsequent days. Results of this test will be treated confidentially.

Thank you.

Student code.....

School: .....

Form: .....

TIME: 20MINUTES

SECTION A [Multiple – Choice Objective Test]

Instruction: Each question in this section is followed by four options lettered „A" to „D". Choose the most appropriate option for your answer 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. Plants obtain their food through

   A. Respiration B. Absorption

   C. Photosynthesis D. Excretion

2. All the following are enzymes **except**

   A. Protease B. Maltase

   C. Lactose D. Lipase

3. Whereas animal cell is surrounded by only cell membrane, plant cell is surrounded by a cell wall made of

   A. Chitin B. Lipids

   C. Cytoplasm D. Cellulose

4. The pituitary gland is referred to as the "master gland" because

   A. Its secretes a host of hormones

   B. its secrets growth hormones

   C. its hormones may cause gigantism

   D. it controls the other members of the endocrine system

5. One important function of membranes is to

   A. offer protection against mechanical injury

   B. regulate the movement of substance to and from the cell

   C. gives a definite shape to the cell

   D. provide site for chemical processes

6. Deficiency of Iodine humans may cause

   A. cretinism B. goiter

   C. night blindness D. sterility

7. What is the probability of producing a child of Blood Group O by a Woman of blood Group O and a man of Blood Group AB?

   A. 0% B.25%

   C. 50% D.75%

8. Which of the following Organelles is responsible for energy production in the Cell?

   A. Mitochondrion B. Vacuole

   C. Chloroplast D. Nucleus

9. Organisms that are active during the day are referred to as……

   A. Mitochondrion B. Vacuole

   C. Chloroplast D. Nucleus

10. In testing for starch in leaf, the leaf is boiled in alcohol to

    A. kill the cells B. soften the leaf

    C. remove the chlorophyll D. expose the starch

11. The immediate source of energy for cell metabolism is

    A. sunlight energy B. ATP

    C. kinetic energy D. glucose

12. Excess sugar stored in plants as

A. glycogen B. galactose

C. starch D. maltose

13. All the following are unicellular organism **except**

A. amoeba B. Euglena

C. Paramecium D. spermatozoa

14. The protoplasm of the cell is made up of the nucleus and the

A. cell wall B. cytoplasm

C. plasma membrane D. vacuole

15. The scientific name of an organism is derived from the

A. class and species B. family and species

C. genus and species D. order and species

SECTION 'B' [TRUE/FALSE]

Instructions: Read each given statement carefully and indicate whether it is true or false by underlining your choice from the two options given.

16. Spirogyras exist as a cell organism. True/False

17. The protoplasm of the cell is made of nucleus and the cell wall. True/False

18. Every photosynthetic organism is a plant. True/ False

19. Amoeba reproduces asexually by a process known as binary fusion. True /False

20. Plant and animal growth are controlled by hormones. True/False

APPENDIX B

MARKING SCHEME FOR PRE-TEST

SECTION A

ANSWERS (1MARK EACH)

1. C
2. C
3. D
4. D
5. A
6. B
7. D
8. A
9. B
10. B
11. B
12. A
13. D
14. B
15. C

SECTION B

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

TOTAL MARKS = 20

APPENDIX C

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

STUDENTS ACHIEVEMENT TEST IN CELL DIVISION

(POST-TEST (SATCD) QUESTIONS

Dear Students,

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

Thank you

.

SCIENCE 2: GROUP A

Student code: .....

School: .....

Form: .....

TIME: 20MINUTES

SECTION A [Multiple – Choice Objective Test]

Instruction: Each question in this section is followed by four options lettered „A" to „D". Choose the most appropriate option for your answer 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. Which of these is not a statement of cell theory?
   A. All living things are made up cells
   B. The cell is a structural and functional unit of all living things
   C. Complex organisms evolved from single cells
   D. New cells arise from preexisting cells
2. Centrioles play specific roles during division of the
   A. ribosome

B. nucleus

C. mitochondrion

D. chloroplast

3. The failure of homologous chromosomes to separate during meiosis is known as

A. cross over

B. non-disjunction

C. synapses

D. transcription

4. DNA replication occurs in cells during

A. inter-phase of mitosis

B. metaphase of meiosis **I**

C. anaphase of mitosis

D. prophase of mitosis

5. Which of the following statements about chromosomes is true?

A. all the chromosomes of a species are the same in shape

B. the number of chromosomes present in a species is constant

C. chromosomes are neatly arranged in the cytoplasm of the cell

D. chromosomes bear ribosome on the outer membrane

6. Meiosis plays a more significant role in evolution because

A. Bivalents are produced B. crossing over occurs

C. homologous chromosomes pair up D. the division occurs twice

7. Meiosis occurs in

A. somatic cells B. all types of cells

C. sperm cells only D. germ cells

8. Separation of sister chromatids during meiosis occurs in

A. metaphase II B. anaphase II

C. prophase II D. telophase II

9. Meiosis is important because it

A. maintains the number of chromosomes in successive generations

B. is the means of asexual reproduction in flowering plants

C. ensures that two daughter cells are genetically identical

D. brings about growth in multicellular organisms

10. Chromosomal aberration known as deletion is said to have occurred when part of chromosome
    A. becomes detached and then joined
    B. breaks away and is lost
    C. breaks away and attaches itself to another chromosome
    D. breaks away and attaches itself to non-homologous chromosomes.
11. What is the function of chromosomes in the body?
    A. getting rid of metabolic waste B. releasing energy in the cell
    C. breaking a cell after death D. determining the characteristic of organism
12. A matured seed which has germinated into a seedling has gone through
    A. meiosis, enlargement and differentiation
    B. mitosis, meiosis and differentiation
    C. mitosis, meiosis and enlargement
    D. mitosis, enlargement and differentiation
13. Which of the following features is a typical of mitotic metaphase?
    A. homologous chromosome pair up
    B. nuclear membrane is visible
    C. crossing over occurs
    D. chromatids arrange themselves on the equator
14. Which of the following represents the correct order of stages in mitosis?
    A. Metaphase-Prophase –Telophase-Anaphase
    B. Prophase-Metaphase-Anaphase-Telophase
    C. Prophase –Telophase-Anaphase- Metaphase
    D. Prophase- Anaphase- Metaphase-Telophase
15. Cell division is required for organisms to
    A. grow, developed and mature
    B. grow, mature and maintain tissue
    C. reproduce, mature and maintain tissue
    D. reproduce, grow and die

SECTION 'B' [TRUE/FALSE]

Instruction: Read each given statement carefully and indicate whether it is true or false by underlining your choice of the two options given.

16. Mitosis does not lead to reproduction. True /False
17. Meiosis is to somatic cells as mitosis is to gamete. True/ False
18. The zygote of humans contains 23 chromosomes. True/False
19. The number of chromosome at end of meiosis is diploid. True/False
20. Cytokinases occurs at metaphase. True/False

APPENDIX D

MARKING SCHEME FOR POST-TEST

SECTION A

ANSWERS (1MARK EACH)

1. C
2. B
3. B
4. A
5. B
6. B
7. D
8. B
9. A
10. D
11. D
12. A
13. D
14. B
15. C

SECTION B

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

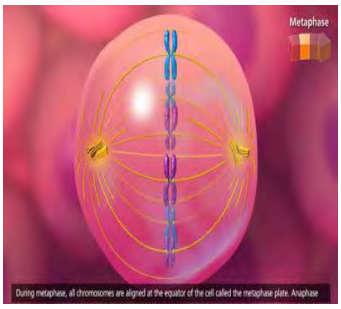
TOTAL MARKS= 20

APPENDIX F

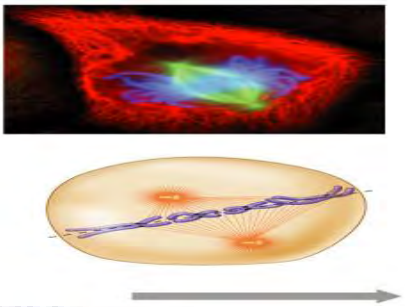
Snapshots of realistic simulation and non-realistic simulation about the Cell Division topic are shown in Figure 3:

MITOSIS CONCEPT

REALISTIC

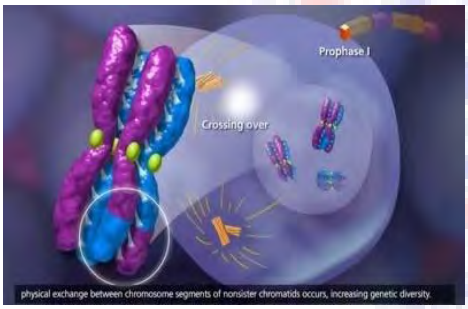


NON-REALISTIC



MEIOSIS CONCEPT

REALISTIC



NON-REALISTIC