UNIVERSITY OF CAPE COAST

EFFECT OF 5E LEARNING CYCLE MODEL, COMPUTER ASSISTED INSTRUCTION AND CONVENTIONAL APPROACHES ON STUDENTS' ACHIEVEMENT IN CELL DIVISION

SAMUEL AGBENE

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BY

SAMUEL AGBENE

Thesis submitted to the Department of Science Education of the Faculty of Science and Technology Education, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy degree in Science Education

APRIL, 2021

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: .... Date: ....

Name: ……………………………………………………………………….

Supervisors' Declaration

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature: .... Date: ....

Name: Dr. Deodat Charles Otami

ABSTRACT

This study explores the effectiveness of 5E Learning Cycle Model and Computer Assisted Instruction on senior high school students' achievement in Cell Division. To achieve this, the embedded mixed method designed was used. A total of 117 third / final year students were selected through multistage sampling technique to participate in the study. Three intact biology classes from three senior high schools in Gomoa East and Gomoa West Districts which offered the general science programme were selectd through simple random sampling technique. A pre-test-post-test non-equivalent control group quasi-experimental design with two experimental groups was employed to generate quantitative data. The students in all the groups were pretested before and post tested after going through the instruction with 30-item Cell Division Concept Achievement Tests (CDCAT). The qualitative data were obtained with interviews to gauge the views of the students' after being instructed with the 5E learning cycle and computer-assisted teaching approaches. Analysis of Variance (ANOVA) was used to analyse the quantitative data whilst open coding and constant comparison was used to analyse the qualitative data. The results showed no statistically significant difference in achievements among the study groups on the post-test. However, the students exposed to the 5E learning cycle and computer-assisted approaches showed positive attitudes towards the interventaional instructional approaches when they were interviewed. It was suggested that teachers could use the learning cycle and computer-assisted approaches to teach concepts students find difficult in Biology.

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DEDICATION

To my daughter, Asuumayah Sharon Sumneeya and my wife Irene.

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CHAPTER ONE

INTRODUCTION

Overview

This chapter covers the following areas: The study's background, the Problem Statement, the study's Purpose, the research questions and hypotheses, the study's Significance, delimitations, limitations, and organization, as well as the explanation or definition of terminologies.

Background to the Study

Cell division, a key concept in biology, provides the basis for understanding or comprehension of other topics such as reproduction, genetics, growth and development (Williams, Debarger, Montgomery, Zhou, & Tate, 2012). Cell division consists of five (5) stages / processess which include Interphase, Prophase, Metaphase, Anaphase, and Telophase.These stages of meiosis and mitosis play a significant role on students understanding of genetic inheritance and reproduction and this makes cell division an important concept in biology (Williams et al., 2012). The chromosomal orientation during the meiosis cell division impact learners grasps or comprehension of the process of cell division and genetics. In Ghana, the elective biology syllabus for Senior High Schools (SHS) prescribes cell division to be taught to students in Senior High School (SHS 3) Form 3. According to the syllabus, the aim of teaching cell division is to equip students with requisite knowledge necessary for better understanding of other concepts such as reproduction (sexual and asexual) and genetics.

In spite of the light knowledge of cell division shed on our lives, studies in the last two decades have constantly revealed it is a well-established problem area for tutors and students as well (Çimer, 2012; Buah & Akuffo, 2017; Etobro & Fabinu, 2017). Students at senior high school level show poor understanding of concepts in cell division, that is, mitosis and meiosis (Arslan, Geban, & Saglam,2015; Ezeaghasi, & Obochi, 2018). Students' difficulty in comprehension or understanding and thus, poor achievement in cell division stem from the instructional approaches employed by biology teachers to teach it (Umar, 2011; Çimer 2012; Etobro & Fabinu, 2017; Buah & Akuffo, 2017). Ahmed and Abimbola (2011) also reported that senior high school biology teaching is done largely through the lecture method which contributed to students' poor achievement in cell division. According to Adegoke, (2011) and Paul, (2018), over reliance on the lecture (conventional) approach which has characterised the teaching of biology concepts in the classrooms only encourages students to become passive learners and remembers of scientific facts without understanding. Hence, it is not unreasonable to conclude that teachers' teaching approaches have an effect on students' understanding and learning outcome in cell division. Based on the knowledge cell division shed on our lives such as how growth and development occur in human, it is necessary to explore other teaching approaches which have the potential of improving students understanding and learning outcome in mitosis and meiosis (Abell, Appleton & Hanuscin, 2010).

Though the Ghanaian Biology syllabus for senior high schools prescribes discussion (student-centered) approaches for teachers which is based on the Constructivist learning theories. The syllabus however, falls short of indicating a particular student-centered / constructivist approach that should be used for effective teaching of cell division to improve students' understanding and achievement. Since no specific discussion (student-centered) procedure or strategy has been recommended or layed down for teachers to used, it presupposes that teachers end up taken the center stage of the discussion which becomes teacher-centered (conventional) approach instead of student-centered.Therefore, to help students develop their critical thinking ability,problem-solving ability as well as their academic achievement in difficult biology concept,teachers should employ teaching strategies that will allow students to be in charge of their own learning and knowledge construction (Li, Cheng, & Liu, 2013). Since the 5E learning cycle model and computer-assisted instruction are student-centered approaches, and are reported to be effective for improving students' academic achievement in science concepts (Owusu, Monney, Appiah & Wilmot, 2010; Kausar, Choudhry, &Gujjar 2008 Ajaja,2013; Ameyaw,2015; Arslan, Geban & Sağlam,2015; Ahmad, Shaheen & Gohar,2018), it is necessary they are employed in teaching cell division in order to determine their effects on students' achievement.

Literature on the 5E learning cycle reported that, it is an inquiry-based learning that promotes students' interest, conceptual change and attitude towards science (Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, & Landes, 2006; Turkrmen, 2006). The 5E learning cycle provide students with real learning experience of science leading to better understanding of the nature of science (Bybee, et al., 2006; Turkrmen,2006; Ajaja, 2013; Arslan, et al., 2015). The 5E learning cycle is a learning strategy that increases the likelihood of learners engaging in critical thinking that constructivists claim is required for effective learning outcome.

On the other hand, the computer-assisted instruction has been reported to have the ability to engage and motivate students to discover knowledge through searching for information on their own (Gambari, Yaki & Olowe, 2013; Koseoglu & Efendioglu,2015) which improves students' achievement in biology. Computer-assisted instruction (CAI) mostly involves the use of audios, aminations, videos, pictures and texts and this makes CAI an effective approach for motivating and encouraging students to learn difficult biological concepts (Moos and Marroquin,2010; Elliot, Wilson & Boyle, 2014). Furthermore, CAI is a type of cognitive tool that allows students to test theories and more typically, get a cognitive grasp of their own behaviour in a given situation (Thomas & Milligan, 2004; Gandolf, Ferdig & Immel, 2018). Based on the tenets of the biology syllabus with respect to the teaching approach that teachers should adopt to teach the topics, there is the need for further exploration to find effective approaches to teach abstract and difficult concepts such as cell division. The study therefore, aimed at exploring the effects of the computer-assisted teaching approach, the 5E learning cycle model, and the conventional teaching methods on improving students' grasp of cell division and their achievement in the concept at the senior high school level.

Furthermore, this study did not only seek to explore the effects of 5E learning cycle and the computer-assisted instruction on students learning outcome but to also investigate their attitude towards these two new approaches. The investigation of students' attitude towards the two new approaches in this study is important because students learning outcome to an extend depends on their attitude towards the instructional strategies used in teaching and learning (Johnson, 2016; Uiboleht, Karm, & Postareff, 2019). According to Bhardwaj and Pal (2012), an approach becomes appropriate and effective if it meets the needs and interest of learners as well as the context in which it is utilised. As elaborated by Yoon, Suh and Park, (2014), investigation of students' attitude about a particular instructional strategy will bring to light their views on the approach which can influence the acceptance of the approach in the classroom. This implies that student's attitude towards an instructional strategy employed in the classroom has an effect on their learning outcome. Therefore, the need to explore students' attitude with regards to the computer-assisted instruction and 5E learning cycle approach in this study.

Statement of the Problem

Cell division is one of the areas in biology where students have challenges and weaknesses in answering questions, according to the West African Examination Council's Chief Examiner's reports of the Senior High School Certificate Examination for Elective Biology (WAEC,2008, 2009 2011, 2013, 2014, 2015, 2016, 2017, 2018 ,2019). For example, in 2009, the Chief Examiner stated that many candidates could not describe the processes involved in different stages of mitosis and meiosis and those candidates who attempted cell divison question "generally performed poorly." Again, in 2019, the Chief Examiner reported that majority of the candidates scored "unsatisfactory marks" in cell division related questions. According to the Chief Examiner's (WAEC, 2019) majority of the students could not "even explain chromosomes" and many of the students could not also relate their "knowledge of haploid number of chromosomes in mitosis and diploid number of chromosomes in meiosis to fill in correctly the number of chromosomes for man, mouse and Rhesus monkey".Students inability to answer questions in cell division as shown in the Chief Examiner's report are evidence that students have difficulties in understanding cell division.

Cell division is a complex and abstract concept for students to understand because of the invisible nature of how cells divide through the phases of both mitosis and meiosis (Tekkaya, Özkan & Sungur, 2001). For instance, the mechanism involved in cell division especially how crossing over of chromosomes leads to sharing of genetic information and how the double helix of the DNA separates during the replication processes posed a challenge to students understanding. Also, students rcognitions of the various stages of mitosis and meiosis and what happens in each stage is fundamental to their understanding and achievement in cell division (Williams et al., 2012). Based the identification of cell division as one of the areas in biology, which students have difficulties (Ezeaghasi, & Obochi, 2018) and considering the importance of cell division on our daily lives, there is the need to help students to overcome their difficulties in cell division. This can only be achieved through utilisation of an effective teaching approach (Abell, Appleton & Hanuscin, 2010). Therefore, the need to explore the 5E learning cycle which is one of constructivist approach and the computer-assisted instruction to help improve students learning outcome in cell division in Ghana.The 5E learning cycle approach provide opportunity for students to explore, thus carry out scientific investigation under the guidance of a facilitator which enable them to construct their knowledge (Bybee, etal., 2006). Even though the 5E learning cycle has been reported in literature to be an effective approach for learning science, there is still lack of agreement among researchers on the utilisation of the 5E learning cycle approach to sufficiently improve learners' encounter with science concepts.This is because Ajaja, (2013), Ameyaw, (2015), Arslan, etal., (2015), Sam, Owusu & Anthony-Krueger, (2018) have found the 5E learning cycle approach to be effective in terms of students' academic achievement than the conventional approach,while other studies also found it otherwise (Dean &Kuhn, 2007; Arslan, 2014; Chase & Klahr, 2017; Caras, 2019).Again,in the Ghanaian context,it appears only a few studies have explore the effects of this approach in fostering students understanding in science concepts.

Similarly, due to the rapid advancement of technology, the educational system must be changed to encourage students to seek information and solve problems on a daily basis (Aka, Güven, & Aydodu, 2010). As elaborated by Tareef (2014), learners are more involved in the learning process leading to knowledge construction, and development of problem-solving abilities when computer-assisted instruction is employed. Due to the of benefit of ICT in education, most Africa countiries especially Ghana have integrated information communication and technology (ICT) into almost all level of their educational system. However, it appears much emphasis is been placed on providing basic technological knowledge to students than using it as an instructional tool (NEPADs, 2001). However, incorporating ICT into the curriculum does not assure students' academic success because having basic technological knowledge alone is insufficient for improving teaching and learning in the classroom (Chai, Koh, & Tsai, 2010; So, & Kim, 2009; Hardy, 2010). Therefore, the need to explore the effects of computer-assisted instruction, 5E learning cycle model, and conventional approach in cell division which posed a challenged to students in senior high schools in Ghana.

Purpose of the Study

The purpose of this study was to explored the effects of computer assisted instruction, 5E learning cycle technique and conventional strategy on students' academic achievement in cell division concept at the senior high school in Ghana.

Hypothesis and research Questions

A null hypothesis and two research questions served as the study's guiding principles.

H01: There is no statistically significant difference in achievement scores among students who were taught cell division using the 5E learning cycle model computer-assisted approach and the conventional technique.

1. What are students' attitude towards the use of computer-assisted approach in teaching biology?
2. What are students' attitude towards the 5E learning cycle approach in teaching biology?

Significance of the Study

The study has significance for policy formulation and implementation in Ghana with respect to the teaching of concepts related to cell division. By gaining insights into the effects of Computer Assisted Instruction, 5E Learning Cycle Instructional Approaches, the study contributes to knowledge in the following ways: First, it brings to the fore the effect of the selected instructional approaches on students' achievement in concepts in cell division. This might give the Ghana Education Service (GES) and the Ministry of Education (MOE) with information on how biology teachers could teach cell division to students who are having difficulty understanding it.

Second, the information gained from the study would provide insights into what other instructional strategies have the potential to improve SHS students' achievement in cell division. This would provide valuable information on how curriculum could be restructure in the future and teacher preparation programmes could better fulfill the needs and aspirations of schools.

Finally, the findings of this study may show students' opinions or attutide toward computer instruction and the 5E learning cycle as a teaching approach in biology which might be useful to curriculum writers and teachers in developing biology syllabuses and enacting lessons.

Delimitations of the study

Though there are many topics or concepts in biology that senior high school students find difficult, this study focuses solely on cell division, which has been noted as a difficulty for both instructors and students according to the West African Senior School Certificate Examination (WASSCE) report from 2008 to 2019 and other researchers. Again, though a lot of teaching approaches are reported in the literature to be effective for science teaching but in this study the computer assisted instruction, 5E learning cycle and the conventional approaches which is normally used by teachers to teach biology in classrooms were compared to explore their effects on students' achievement in cell division. Since the topic which was explored in this study was to be taught to the third-year senior high school students as prescribed by the syllabus, only final year (Form 3) students offering biology in the selected schools in the Central region were used.

Limitations of the study

Individual differences in students' understanding of cell division, such as their maturity level, experience, and prior information on the subject, may influence their comprehension of the topic, and hence the studys' internal validity may be affected. The absence of some students during data collection may have an impact on the study's sample size, as well as the external validity of the results. Again, the study's findings will have limited application and can only be applied to schools within the selected district schools. Another limitation to this study was the inability of students in the 5E learning cycle group to have field experience or move out and inquiry about the concept under consideration on their own due to COVID-19 restrictions at the time of the study.

Organisation of the Study

This research is divided into five chapters that follow the University of Cape Coast's thesis presentation guidelines.Chapter One contains the background to the study, the statement of the problem, the objective or purpose of the investigation, the research questions, the significance of the study, the delimitation and limitation of the study, the organization of the study, and the definition of terminologies.The second chapter of the study contains a survey of the relevant literature link to the study and it is situated on constructivist and behaviourist theories of learning, and the learning cycle teaching technique, as well as the computer assisted and conventional teaching approaches.

The research methodology and study design are covered in Chapter Three, as well as the population, sampling and sampling strategies employed, instruments, data gathering procedures, and data analysis procedures. The fourth chapter presents the study's outcome as well as discussions of the findings. The important findings, conclusions, recommendations, and proposals /suggestions for further study are summarised in Chapter Five.

Definition of Terms

Constructivist approach: This is a learning method situated on the concept that successful learning occurs when students actively participate in the teaching and learning process.

Conventional teaching approach: Describes a teaching method in which teachers spoon-feed students with factual knowledge while students remain passive in the teaching and learning process.

Computer-assisted instruction: It describes the strategies or approaches that teacher use to facilitate instruction with the help of a computer.

Attitude: Is a personal opinion or feeling about something which can be negative or positive.

CHAPTER TWO

LITERATURE REVIEW

Overview

Theoretical framework underpinning this study, 5E learning cycle teaching approach, Computer assisted teaching approach, Conventional teaching approach and studies on students' attitude towards 5E learning and Computer-assisted instruction were all examined in this chapter.

Theoretical framework

This study is underpinned by both Constructivist and Behaviourists theories of learning and teaching strategies. Learning theory based on constructivism and the Behaviourism theory of learning are thought to have inspired the 5E learning cycle model and computer-assisted instruction, respectively. Therefore, detailed description of what the Constructivist learning theory and the Behaviorist learning theory entails with regards to the learning cycle strategy and Computer approach were provided.

Constructivist learning and Behavourist learning theories

Constructivism is a learning theory derived from educational psychology that describes how people actively participate in the process of learning to expand their knowledge (Fosnot, 1996; Steffe & Gale, 1995; Merriam, Caffarella, & Baumgartner 2007). Constructivists think that students are not a "blank slate" and that students should be encouraged to actively develop their own knowledge by drawing on existing information, and reflect on their individual experiences in order to improve their academic achievement (Dewey,1938; Merriam et al., 2007; Hmelo-Silver, Duncan, & Chinn, 2007; Piaget, 2001; Sjoberg, 2007). Proulx (2006) defines constructivism as a theory of learning rather than a teaching philosophy, and due to that, constructivist places a strong emphasis on student-centered learning rather than teacher-centered approaches. Constructivists believe that a learner-centered approach can help learners develop their intellectual capacities such as talents in critical thinking and curiosity (Li, Cheng, & Liu, 2013; Henson, 2003; Huang, 2002). Therefore, teachers should focus on recognising students' achievements in order to encourage, motivate and challenge them to reach their full learning potential. Learning is defined as the process of adapting our cognitive architecture/ structures to accommodate new learning experiences while actively exploring and developing our own knowledge (Rummel, 2008). In contrast to behaviorism's theory of learning, constructivists think that information is gained through useful and real-life experiences that allow for a personalised search for information as the student interacts with classmates and their environment (Piaget, 1977; Vygotsky,1978; Rummel, 2008).

Constructivists think the learner should be in charge or take full responsibility of the learning process. Teacher's responsibility is to actively involve students in experience-based learning activities that will have the greatest impact on them, as well as to be aware of their needs and learning difference (Merriam et al., 2007; Spigner-Littles & Anderson, 1999). As a result, science syllabus or curriculum could be created from the learner's perspective and be relevant to the student in order to encourage or stimulate them to study (Garrnston, 1996). Constructivist learning strategies can help students have a better understanding of abstract and challenging topics in science (Hewson, 1992). Therefore, it is not a stretch to suggest that the most effective learning and teaching techniques is one that encourages students to think beyond what they have been instructed in the classroom. Constructivist theory of learning especially Vygotsky's social constructivist school of thought has contributed to the formulation of stuent-centered learning and teaching strategies. This is because social constructivists believe that knowledge is learnt through social interaction rather than individual experiences, which leads to the development of higher mental processes and knowledge sharing among learners (Kukla, 2000; Leeds-Hurwitz, 2009).Knowledge is expected to be obtained by the collective effort of learners through dialogic engagement, social interaction in a socio-cultural setting at a specific time, rather than inside an individual's cognitive structures (Barak, 2016).The ideologies of constructivist theory of learning leads to the formulation of the 5E learning cycle where students are allowed to actively participate as individual or group to explore their learning through field investigation. In addition to the 5E learning cycle, constructivist theory has also evolved into cooperative learning paradigm that accentuate the importance of peer connections in educational performance (Leidner & Jarvenpaa 1995). As people interact with each other through communication and discussions, they contribute their knowledge to the topic under consideration resulting in mutual understanding. The teacher's role in a social constructivist classroom is to facilitate rather than lecture or spoon-feed knowledge to students (Brownstein, 2001). Therefore, it is possible to conclude that the new Basic School Curriculum's development and implementation in Ghana in 2019 are based on a social constructivist perspective, in which Ghanaian teachers are now referred to as facilitators, with the sole responsibility of assisting students in gaining their own knowledge.

Despite the contributions of constructivism theory to the development of the inquiry or 5E learning cycle technigue, this theory of learning has some flaws. The constructivist emphasis on practical learning or activities-based learning is an "educational disaster," because teachers must provide resources that are" behaviorally active rather than intellectually/cognitive active" during instructions (Mayer, 2004). Furthermore, the constructivist emphasis on learner-centered teaching in the acquisition of knowledge may lead to epistemological flaws in the way science knowledge is obtained, and this learning theory may be a defective instructional technique (Osborne, 1996). Constructivist learning theory, according to Kirschner, Sweller, and Clark (2006), encourages teaching practices that placed much emphasis on limited guided instructions, and as a result, learners feel irritated and lose concentration in the learning process. In Piagetian ideas of cognitive development, contextual components such as learning resources, student preferences, and technical characteristics that produce a conducive learning environment for the acquisition of knowledge are not taken into account (Ackermann, 2001).Again, Gupta (2011) argued that constructivist emphasis on cooperative learning only encourages group thinking instead of individual thinking in decision making, and some intelligent students may gain complete control of the interaction while the average students are neglected. Constructivism advocators stated that providing learners with opportunities / chance to generate their own information by guiding them through the scaffolding process promotes successful learning (Vygotsky,1978). However, it may also be argued that providing learners with more information increases their academic success (Kirschner, etal. 2006).

On the other hand, learning, according to behaviourists, occurs only when the learner's behaviour changes as a result of his or her environment's influence (Chunk, 2012; Bush, 2006). In a behaviourist's classroom, students are considered as passive learners and "tubula rasa," with the ability to change their behaviour solely through reinforcement and motivation (Watson, 2013; Skinner, 2011). Skinner postulated the idea of positive reinforcement and negative reinforcement, both of which he believed could be used to improve a specific behaviour. According to Skinner (1968), positive reinforcement improves a behaviour by delivering a rewarding consequence whereas chastisement /punishment reduces the occurency of a habit by offering negative outcome that the student dislikes. Teachers motivate or offer a stimulus to a student after he or she demonstrates a desired behaviour in order to encourage the student to repeat the activity or the behaviour and this is considered to be positive reinforcement. Negative reinforcement happens when the teacher removes a stimulus after the student exhibits an unwanted action (Skinner, 1968). The teacher's duty in a behaviourist classroom is to act as a role model and provide stimulus to help pupils respond to the learning experience.

Behaviourism learning theory has contributed to the development of teaching strategies such as technology which premises on motivating students to learn science better (Tabassum, 2004).This is because Skinner's reinforcement theory which aimed at providing stimulus or rewards to encourage students to put up their best serves as the foundation for computerassited instruction in science education(Tabassum, 2004). During computer-assisted instruction, audio-visual and graphics are employed which serves reinforcement to drives learners/students to participate actively in the learning process (Alessi & Trollip, 2001; Gambari, 2010). It is hardly surprising that until recently, technology, particularly computer-assisted instruction (CAI) was seen to be intimately associated with behaviourist. Essentially, due to the notions of practice and reinforcement, it may be claimed that the implementation of CAI in science education stems mostly from the behaviourist philosophy of learning (Tabassum, 2004). While other scholars follow the behaviourist tradition, Skinner's writings have had the most impact on current improvements in computer-assisted teaching systems (Edwards, 1970).

Skinner who was a behaviourist, formulated the idea of CAI by working with programmed learning machines which were the first forms of computer-based learning. Skinner developed his idea of using teaching machines or computer-assisted instruction to motivate learners after doing trials (operant conditioning) with animals in a “Skinner Cage”. Skinner demonstrated that pigeons might be taught to do rather sophisticated behaviours by rewarding some desirable responses that occurred at random at first with appropriate stimuli. Because operant conditioning theory has proven to be effective in animal training, Skinner was confident that his principles could be applied to complex human behaviour, particularly in young people for successful learning. Therefore, it maybe refreshing to argue that computer-assisted instruction has its root from the behaviourism point of view. This is because computer-assisted instruction is noted for its ability to motivate and reinforces students learning (Alessi & Trollip, 2001) which have similarities with behaviourist philosophy of learning.

The 5E learning cycle approach

Roger Bybee established the 5E learning cycle as part of the Biological Sciences Curriculum Study (BSCS), which consists of five (5) stages for facilitating learning outcome in biology (Bybee, 2001). The 5E learning cycle provide teachers with successful teaching approaches while also assisting students with a formula for effective learning and knowledge acquisition. The 5E learning cycle has been one of the most effective and prominent constructivist teaching approaches in science education since its inception in the early 1990s by the Biological Sciences Curriculum Study (BSCS) (Turkrmen, 2006). The 5E learning cycle has been described as an activity-based learning process that provide learners with real learning experiences in biology (Bybee, 2001). The learning cycle is a learner-centered strategy that gives students the opportunity to experience activity-based learning rather than relying solely on teachers for information (Lawson, 2001). The 5E learning cycle is divided into five stages which include the engagement stage, exploration stage, explanation stage, elaboration stage, with the evaluation been the last stage of the learning process (Bybee, 2001; Bybee et al., 2006; Eisenkraft, 2003; Bybee, 2009).

Engagement phase

Engagement stage of the learning cycle is a stage where teachers try to review their students' past knowledge and identify any misconceptions in order to introduce the new topic or learning. In this stage, teachers present learners with questions, challenges, or situations that would arouse their enthusiasm and curiosity to enable them to uncover their current knowledge level (Hanuscin & Lee, 2007). The major goal of the engagement phase is to motivate students to actively participate in the teaching and learning process (Duran, & Duran, 2004).

Exploration stage

During this stage, students actively explore the new topic through hands-on activities or practical experience. Teachers guide and pose questions to learners to encourage cooperative learning through scientific research or field work on the topic under consideration (Bybee, etal.,2006). The exploration phase of the learning cycle is the most crucial stage because, it allows students to "explore, discover, investigate" and actively participate in cooperative group discussion to produce meaninful learning outcome (Lindgren & Bleicher,2005).

Explanation phase

Students can share their findings and exhibit their conceptual comprehension of the concepts under investigation during the explanation phase. Teachers may point out students' misconceptions and guide them to a better understanding of their discoveries from the exploration phase (Bybee et al, 2006).

Elaboration phase

In this phase, students are given the opportunity to apply what they have gain or learnt in the engagement and exploration stages to additional concepts that are similar but different (Bybee et al, 2006). This phase also provides students who still have misconceptions about the new concept with opportunity to clear them up and fine-tune their knowledge of the ideas being studied (Bybee et al, 2006).

Evaluation phase

The evaluation phase is the final phase of the 5E learning cycle and it allows students to assess their grasp of the content learned during the previous phases (Campbell, 2000). Teachers can also formally assess students' grasp of the concept by administering tests with open-ended questions or conduct demonstrations on the concept at the conclusion of the learning session (Bybee et al, 2006).

Previous research on 5E learning cycle approach

Studies have proven that the 5E learning cycle is superior and successful instructional model for teaching difficult science topics than the conventional approach in which students are passive participants in the teaching and learning process (Ajaja, 2013; Ameyaw, 2015; Arslan, etal., 2015). Pulat (2009), for example, investigated the impact of the 5E learning cycle on students' mathematics achievement and attitude toward mathematics. The finding revealed that students' mathematics achievement improved after they were instructed through the 5E learning cycle. Students grasped science topics better and acquired knowledge more easily when taught with a learning cycle (Lee, 2003). Cardak, Dikmenli, and Santa (2008) investigated the impact of the 5E learning cycle on students' achievements in biology, specifically the circulatory system. They found that the experimental (5E learning cycle) and control (conventional approach) groups performed similarly in the pretest but the experimental (5E learning cycle) group performed significantly better in the posttest. This means that student’s achievement in the post-test scores was as the results of the effect of treatment with the 5E learning cycle instructional tactics and not by coincidence. Ajaja (2012) looked into the impact of 5E learning on students' biology and chemistry grades. The findings revealed that the learning cycle had a considerable impact on students' biology and chemistry academic progress. He claimed that students who were taught using the 5E learning cycle scored higher on the post-test in biology and chemistry than those who were taught using the conventional technique. Ajaja (2013) conducted another study to determine which technique is best for biology education. He used four different methodologies in the research. These approaches include; concept mapping, cooperative learning, the 5E learning cycle, and the conventional method. Students in the 5E learning cycle and cooperative learning groups outperformed those in the concept mapping and conventional learning groups, according to the study. He stated that 5E learning and cooperative learning may be appropriate for teaching and learning biology because there was no significant difference between those in the 5E learning group and those in the cooperative group.

The 5E learning cycle has also been shown to be effective in not only teaching and improving students' performance in mathematics and physics, but also in all other subjects when properly integrated into classroom teaching. Ameyaw (2015), for example, conducted a study on the 5E learning cycle approach for effective teaching and learning of glycolysis and the Krebs cycle which is considered as one of the most difficult and abstract concepts in biology due to their complex mechanisms involving a large number of enzymatic activities. The 5E learning group (experimental group) did better on the posttest after being instructed using the 5E learning cycle than those who were instructed using the conventional method. This indicated that the learning cycle was more successful for improving students' performance in glycolysis and Krebs cycle than the conventional approach. According to Turkrmen (2006), the learning cycle instructional model is more effective than traditional approaches for teaching science topics because it allows students to participate in activities that make learning more real. Geban and Salam (2015) found that the 5E learning cycle is superior to the lecture technique in encouraging students' conceptual change and boosting their comprehension of cell division. In his study titled "A better way to biology teaching," Lawson (1988) stated that proper utilisation of the learning cycle allows students to reveal their prior knowledge or misconceptions, test those misconceptions, and develop adequate conceptions and scientific reasoning for meaningful science learning. Majority of studies on the learning cycle concluded that it has the power to generate conceptual transformation as well as assist students to cultivate positive attitudes and increase their curiosity about science (Bybee & Van Scotter, 2007; Bulbul, 2010).

Due to its nature of hands-on-activity and scientific exploration, the 5E learning cycle has the potential to improve students' understanding of concepts and academic accomplishment in science (Bulbul, 2010; Cakiroglu, 2006; Balci, Cakiroglu, & Tekkaya, 2006). Sam, Owusu and Anothy-Krueger (2018) conducted a study using 3E, 5E learning cycle, and conventional approach on students' achievement in senior high school biology and found that the learning cycle is superior to the conventional approach in terms of students' academic achievement in biology. Based on their pretest scores, they divided the participants into low achievers and high achievers. However, they found that the 3E learning cycle was more effective than the 5E learning cycle in boosting academic achievement of low achievers in biology. Similarly, Wilson, Taylor, Kowalski, and Carlson (2010) investigated the effectiveness of the 5E learning cycle on students' achievement in science. The students were randomly separated into two classes. Wilson et al. (2010) found that students taught using the 5E instructional paradigm had significantly higher scientific achievement than students taught using the lecture method. Hokkanen (2011) also investigated the impact of the 5E learning cycle on 7th grade students' scientific achievement in atoms, force, speed, and motion graphing. The intervention lasted three weeks and the students' progress was measured using the 57-item Illinois State Achievement Test.The findings indicated that when students were taught using the 5E model, the average percentage of progress for each question was higher for the 5E learning cycle than for the traditional technique. Ahmad, Shaheen and Gohar (2018) conducted experimental research in the field of general science with 5th grade students.The study's main findings were that the experimental group taught with the 5E instructional approach significantly outperformed the control group in terms of overall academic achievement.Their research also discovered significant improvements in the cognitive domain of student learning such as application, understanding, and ability growth skills when students were taught using the 5E instructional approach.

Wilder and Shuttleworth (2004) analysed a report on the 5E learning cycle's impact on students' cell division achievement. High school biology students took part in the study. Students were asked to examine what they knew and understood at the start of the study and they were encouraged to be inspired. The students were exposed to real-life situations throughout the discovery process but during the interpretation phase, the instructor instructed them to scientifically explain their own results. They claimed that the 5E learning cycle helps them learn biology more effectively.

However, there is still no consensus among researchers on the effectiveness of the 5E learning cycle in science education with some finding it superior than the traditional approach and others finding it neutral (Tweedy, 2004; Garcia, 2005; Arslan, 2014). Tweedy (2004), for example, used pretest and posttest questions to assess the effectiveness of the 5E learning cycle to the conventional approach on students' achievement in diffusion and osmosis. In terms of students' performance in biology, the posttest scores shown no significant differences between the two techniques. Arslan (2014) investigated the influence of 5E instruction against traditional instruction on 10th grade students' understanding of cell division and reproduction. There was no statistically significant difference between the students' achievements in both approaches. Similarly, Pulat (2009) reported that no significant difference was found between students taught with 5E learning cycle and those taught with conventional approach on simple harmonic motion and simple pendulum principles. Caras (2019) compared the impact of inquiry (5E learning cycle), computer training, and traditional method on scientific students' achievement and found that inquiry learning outperformed the other two techniques in some concepts. Nonetheless, there was no statistically significant difference in science students' achievement among the three approaches indicating that computer assisted instruction and traditional training as well as inquiry instruction are both effective. These conflicting findings with regards to the effectiveness of 5E learning cycle in learning science implies that more research need to done in order to ascertain its effectiveness and acceptance in learning biology.

Flaws and criticisms of the learning cycle

Despite the learning cycle's superiority and efficacy in teaching and learning science topics as reported in literature, the learning cycle is not without flaws. The 5E learning cycle has been criticized for being time-consuming. The biology curricula or syllabuses expect teachers to cover all the curriculum's contents in a set amount of time before external exams like the West African Secondary School Certificate Examination leaving no time for teachers to explore the learning cycle in their classrooms (Stamp, O'Brien, 2005; Metin, Coskun, Birisci & Yilmaz, 2011; Wilson, Taylor, Kowalski, & Carlson, 2010). Other scholars have claimed that because the learning cycle places the student at the center of the lesson, children with low intellectual ability or low achievers who rely only on the teacher for information may have issues when they are taught using it (Ajaja,2013).

Previous studies on students' attitudes towards the 5E learning cycle

"An acquired predisposition or propensity on the side of a person to react positively or negatively to any item, condition, thought, or other person is referred to as attitude" (Aiken, 1970). When analysing students' attitudes and achievement on a concept in mathematics and science, Aiken (1970) indicated that the mentality and efficacy of the teachers in that subject area is crucial. The classroom conducts and teaching tactics or styles that instuctors utilised has the greatest impact on students' perception about science. Whilder and Shuttleworth (2004) study the efficacy of the 5E learning cycle and argued that learners were inspired by learning cycle model and they expressed a good attitude toward the 5E learning cycle in learning biology. Again, in environmental science undergraduate university students, Lord (1999) contrasted 5E instruction to the traditional approach. He discovered that while the control group considered the concept or topic dull, the treatment group found the lessons intriguing and enjoyable. Other researchers also found learners to have a good opinions /attutide toward learning cycle model after being taught through it (Balci, 2009; Billings, 2001; Saygin, 2009; Sam et al, 2018; Arslan, Geban, & Saglam, 2015). According to Saygn (2009), most of the learners enjoyed the activities base learning and study better with the inquiry approach compared to the lecture method.

Computer -assisted instruction

The concept of utilising CAI (computer-assisted instruction) in the classroom to teach dates back to the early 1960s (Morrell, 1992). In general, computer use in all of its forms appears to provide practically endless opportunities for teachers to deliver lesson (Bybee, Poewll, & Trowbridge,2008). The computer appears to be a tool that if well implemented into instruction, could result in improvement of learners' motivation particularly in biology teaching and learning (Cotton,1991). In wealthy countries, a major push has been made to integrate computers into every element of school life. For example, in the 1960s, the University of Illinois in the United States of America produced Program Logic for Automatic Training Operations (PLATO), which was the first attempt to integrate computers into classroom teaching (Molnar, 1997).

According to Bybee, Poewll, and Trowbridge (2008), computers can be employed in education in a variety of ways to increase teaching quality and learners' technological growth. They believe that by exposing students to fundamental computer skills, teachers may help students develop technical skills. This could include teaching computer science as a subject or teachers employing computers to deliver a material or content more effectively. As a teaching methodology, computer-assisted instruction is an educational strategy in which students are presented with instructional materials via a computer or computer software. Computer assisted instruction is when a teacher uses computer software in the classroom to support other instructional strategies in delivering knowledge to learners (Barot, 2009; Cotton, 2001; Yusuf & Afolabi, 2010).

Incorporating computers into classroom for educational purposes is no longer a difficulty for developed countries like the United States and the United Kingdom (Salaway, Caruso & Nelson, 2008). However, in most African schools, particularly in Ghana, the situation is different. Because of the rapid growth of technology in the twenty-first century, the educational system must be altered to stimulate students to seek for information and find solutions to everyday problems (Aka, Güven, & Aydodu, 2010). According to Gambari, Yaki, and Olowe (2013), using a computer to supplement traditional teaching yields more promising results than using a traditional teaching strategy only. Despite the fact that ICT is integrated into the basic school and senior high school curricula in Ghana's educational system, computers are rarely used as a teaching tool in the basic and senior high schools. As a result, the focus of this research was on how to successfully use ICT as an educational tool to teach students about cell division.

Types of Computer-Assisted Instructions

Over the last few decades, computer-assisted instruction has gradually improved, with the majority of study results indicating that computer as a tool for instruction as well as its various modes and softwares have the capacity to engage and encourage learners to learn (Douglas, 2000). These modes and softwares include the following:

Tutorial

Tutorials, according to Alessi and Trollip (2001), are utilised to give learners a complete content/ material that are akin to conventional/traditional classroom instruction and can give feedback on the learner's responses to questions or problems. A tutorial is a response-oriented engagement between learners and computers that involves problem solving and assessment that comprises of drill and practice (Alessi & Trollip, 2001). It is the most frequent type of computer-assisted instructional approach that offers valuable learning materials or information, allows the student to practice, and then evaluate the learner (Fraser & Walberg, 1995). Various textual content is displays along with questions, are sometimes used in the CAI tutorial approach. The information is presented in little chunks followed by questions. The system evaluates the student's response and provides feedback accordingly (Patel, 2013). Tutorials may be a strong tool for influencing new knowledge since they allow learners to practice and evaluate their learning.

Drill and practice

Drill and practice are suitable and is linked to the behaviourist model because they allowed for frequent use of cognitive craft/skills at basic level while simultaneously giving formal reinforcement of previously taught topics. A computer application called drill and practice asks learners questions and provides feedback on their responses (Trowbridge, Bybee & Powell, 2004; Barot,2009).

Simulation model

Computer simulation is one of the most effective computer-assisted instructional methods because it provides a positioned, realistic actions, learning feedbacks, and reinforcement while limiting any form of physical risk (Alessi & Trollip, 2001). Computer simulation is a type of cognitive tool that allows learners get immediate feedback and more commonly, get a grasp of their own actions in a given situation (Thomas & Milligan, 2004; Gandolf, Ferdig & Immel, 2018).

Multimedia model

Multimedia is an example of a computer technique that has been proved to increase students' productivity and enthusiasm for learning (Gambari, 2010). Computer multimedia just like computer simulation, delivers texts including sound/music, animation and videos to make teaching or learning dynamic and successful. As a result, a presentation that includes audio and video elements might be classified as a "multimedia presentation.".

Previous studies on computer assisted approach

Since the introduction of computers in the classroom in the early 1960s, a number of studies have been conducted around the world to assess the effectiveness of ICT as an instructional tool for teaching in the classroom (Morrell, 1992). Most of the studies on the efficiency of computers instruction tools have found that CAI has the potentials to deliver content or lessons to students effectively because of its capacity to engage and increases learners passion to study effectively (Ezeaghasi & Obochi,2018; Koseoglu & Efendioglu, 2015).However,others studies have also found CAI to have negative or neutral impact on students achievement, resulting in arguments among many experts or scholars regarding the effectiveness of computer application in biology instruction (Kikis, Scheuermann, & Villalba, 2009; Reeves, 2008; Trucano, 2005; Cartwright & Hammond, 2007; Cox & Marshall, 2007; ;Burns & Ungerleider, 2003). Ezeaghasi and Obochi (2018) investigate the efficacy of a computer- simulation on students' cell division learning outcome and retention in Nigerian institutes of education. A total of 176 students from colleges of education were sampled for the study. These learners were selected at random and placed into two groups. Cell division was taught to one group via computer simulation whereas the other was taught the traditional/ conventional way. According to the scores obtained for both the pretest and posttest, students who were taught via ICT performed better than those who were taught using the lecture method. The same posttest questions were given to both groups a few days later to determine their retentiveness and the scores once again demonstrated that learners who were instructed using ICT retained more knowledge about cell division than students who were taught using the lecture technique. As a result, they argued that the computer simulation model which is one type of computer teaching approach, had a good / positive impact on learners learning outcome in cell division in biology compared to the lecture technique. Most study on the efficiency of ICT in education has shown that CAL is more efficient in the delivery of instruction and learning than the lecture approach (Duyilemi, Olagunju, & Olumide,2014).

Students are frequently motivated and encouraged to study better in a classroom where audio-visuals including videos and texts are employed (Mayer,2003). The use of multimedia technologies in computer-assisted instruction has the potential to increase students' motivation to study complicated science subjects (Elliot, Wilson & Boyle 2014). Multimedia, hypermedia, and hypertext, according to Moos and Marroquin (2010), alter students' intrinsic and extrinsic motivation and allowed them to pursue their life aspirations, academic achievement, and self-efficacy. In a comparative study of the effectiveness of a computer-assisted approach and classroom lecture for computer science students, Kausar, Choudhry, and Gujjar (2008) discovered that the CAI was significantly superior to the classroom lecture in terms of information, review, and synthesis of Bloom's taxonomy. They discovered that the computer technique has proven to be helpful particularly in building evaluation and application skills. Their research suggests that a computer-assisted technique has an impact on students' performance and achievement more than a lecture method. According to Mbwesa (2002), incorporating ICT into the classroom can improve learning by reducing reliance on the teacher-centered teaching.This is because CAI provides students with the opportunity to search for majority of the learning material needed for meaningful learning hence optimising academic accomplishment in biology. Khan (2019) conducted a survey on the efficiency of computer approach in teaching circulatory system, a component of biology. His research revealed that students who were instructed using CAI outperformed those who were taught with traditional methods.

Teaching aids such as audiovisual aids, according to Jimoh (2009), should be used to support learning since they have the capacity to encourage and boost students' enthusiasm while maintaining their consciousness in the instruction and learning process. He goes on to say that audiovisual aids can assist break the cycle of chalk and talking. According to Gillani (2005), students who were taught biology using CAI were more attentive during the teaching and learning process because computer assisted instruction promotes interest and boosts students' motivation. According to Smeets and Mooij (2001), computer application in teaching can lead to a creative learning environment centered on students in which teachers function as coaches while keeping firm control over the learning process. There was also evidence which indicates that computer-assisted instruction increases students' thinking and problem-solving skills, builds strength, curiosity, and dedication, motivates and diversifies students' learning (Sibiya, 2003).

After reviewing numerous studies on the effectiveness of computer instruction in education, Cotton (2001) concluded that students who received teacher-directed instruction supplemented by computer instruction learned faster and retained more information than students who only received teacher-directed instruction.While some scholars argue that intelligently/ thoughtful designed computer instruction is typically successful in improving learning outcomes, Ranade (2001) discovered that some students prefer traditional fa ce-to-face teaching to computer instruction when the teacher is outstanding and knows the subject matter thoroughly. After reviewing literature on the use of computer-assisted instruction and its utility in various subjects, Chaudhari (2013) concluded that computer-assisted instruction is indeed very useful to students in the field of biology and can be used by teachers as a supplementary tool to solve scientific problems such as a lack of creativity and critical thinking. Although, computer-assiste instruction may not be able to replace effective teacher-instruction; rather, it complements it, allowing for a better and faster understanding of the information being taught. According to the findings of 75 studies conducted in the United States, natural science students who used computer tutorials performed significantly better on assessments, as noted in Mikre, (2011). Computers offer enormous potential in classroom instruction but this potential is likely undervalued due to teachers' unwillingness to employing them (Kondos, 2018). Çepni (2006), as cited in Paul (2018), examined the impact of computer integration into teaching and students learning outcome in photosynthesis. The study found that students in computer-assisted method group have significantly higher cumulative learning outcome in photosynthesis compared to students in the conventional approach. When the achievement of students in various cognitive areas was also examined, it was discovered that students in the computer method group did marginally better in the categories of interpretation and knowledge application than students in the conventional group.

Similarly, Mahmood (2005) found that conventional approach of teaching combined with computer approach teaching culminate in students achieving greater scores in science concepts than conventional teaching alone. Cell Division Achievement test scores of students improved as a result of tutorials and edutainment software and their biological attitudes improved as well (Kara & Yesilyurt, 2008). Some of the significant contributions of computer-assisted instruction to teaching and learning include; fostering positive student attitudes, shifting teaching and learning from teacher-centered to student-centered settings, encouraging collaborative learning, and fostering active teaching and learning outcome (Bhagwan, 2005). Jesse, Twoli, and Maundu (2014) investigated the effectiveness of a computer-assisted strategy in biology achievement among secondary high school learners. Findings from their investigation revealed that students who were instructed science using CAI did significantly well than those who were instructed using conventional techniques. Kareem (2015) demonstrated that using a computer-assisted technique in biology boosted students' academic achievement in biology as compared to using traditional approaches. Serin (2011) compared the learning outcome of 4th grade students in science using computer-based learning and conventional method. After examining the results of the pretest and posttest, Serin stated that students in computer-based learning achieved much better results than those in the control group.

In spite of the contribution of CAI to the improvement of students academic achievement in science as revealed in literature,other studies which compared the conventional methodology with computer application in teaching biology indicated that using computer-assisted instruction either had no significant difference in posttest scores or produced lower results than those taught using the conventional strategy (Jacobson, 2006; Reagan, 2004; Cox, 1999; Owusu etal., 2010). For instance, Cox (1999) claimed that using ICT distracts students and makes it harder for them to stay focused on their studies. Imhanlahimi and Imhanlahimi (2008) compared the effectiveness of computer-assisted instruction versus traditional instruction on students' biology achievement. After comparing the posttest scores of the two research groups, they discovered that the conventional instruction group outperformed the computer-assisted instruction group. Kathy (2009) investigated the effectiveness of computer-assisted teaching and discovered that the posttest ratings of students receiving traditional/ conventional and computer-assisted teaching were not significantly different.

Similarly, Tolbert (2015) compared the effects of a computer-assisted approach vs traditional / conventional techniques on students' achievement in biology. There was no significant difference in achievement between students who got computer-assisted instruction and those who received traditional instruction. Ahiatrogah, Madjoub, and Bervel (2013) also investigated the impact of CAI on primary school pupils' acquisition of technical skills. They claimed that no statistically significant difference was found in overall learning outcome between the intervention and control groups.

Students attitude towards computer-assisted instruction

Majority of research on influence of computer instruction and other innovative teaching on students learning outcomes also looks at the impact on students' attitude about computer instructional methods. Most researchers came to the conclusion that computer-assisted instruction leads in more favourable / good opinions of learners than traditional/ conventional teaching (Owusu, Monney, Appiah & Wilmot 2010; Akram & Malik, 2012). For instance, Akram and Malik (2012) conducted research on how senior high school biology teachers and students felt about using computer-assisted instruction in the classroom. They discovered that biology teachers and students have a good attitude about the use of CAI in the classroom. They also came to the conclusion that using audiovisual aids in biology classes is very effective because it increases student interest and enthusiasm for learning.

According to multiple empirical studies, students have a more receptive attitude towads CAI than direct instruction (Chiu, 2007; Hammouri, 2004). According to Reed, Drijvers, and Kirschner (2010), learners' attitude towards using CAI in the classroom were favorably related to their accomplishment especially students with lower intellectual abilities. The employment of a computer-assisted technique improved students' attitudes and level of achievement in biology more than the lecture method (Bassoppo-Moyo, 2010). After conducting interviews with computer-assisted learners, Bassoppo-Moyo (2010) found more than 87 percent of students who stated that they enjoyed learning biology using a computer-assisted instruction. Computer-assisted instruction (CAI) softwares could be utilised to make instruction more interesting in the classroom and to reduced boredom during instruction (Achuonye, 2011; Yusuf & Afolabi, 2010).Computer-assisted instruction (CAI) can be highly effective due to the demonstration (drill-and-practice) or simulation exercises provided either alone or as alternatives to teacher-led instruction (Cotton, 2001). Students work individually or in pairs in a computer assisted instruction classroom with assistance of software that effectively guides them via a series of interrelated activities , allowing them to learn effectively. It could also be argued that computer-assisted approaches add value to the knowledge students obtain in one way by allowing students to test theoretical concepts or hypotheses, and comprehend abstract biological principles (Cotton, 2001). Students have a positive perspective of computer-aided education, according to Hartley and Treagust (2014) and believe computer application to be a successful teaching strategy because it increased their participation in mathematics classes.

Conventional teaching strategies

The traditional/ conventional teaching strategy involves teachers providing pupils / learners with factual knowledge and students become inactive or passive during instructional activities (Umar, 2011). Students in conventional classrooms are taught science topics, then given concept-related assignments and occasionally participate in laboratory exercises. Teachers sometimes use diagrams to show students a topic, engage them in brief discussion and questioning and provide examples. Teacher-student dialogue is minimal with the teacher doing most of the talking. Wood (2007) discovered that students had identical notes in their notebooks when he reviewed books for biology classes. This implies that pupils received their notes directly from the biology teacher and that the instructor directed his or her lecture to the students without given them the opportunity to search for the information on their own.

Impact of conventional approach on learning outcome in biology

The results of studies about the impact of traditional or conventional instruction on students learning outcomes in biology have yielded conflicting findings. When most researchers investigated the efficacy of the conventional approach to other approaches such 5E learning and CAI on students' learning outcome, they discovered that students taught using the learning cycle and CAI achieved better results than students taught with the conventional method whereas other experts argued that conventional instruction is superior to CAI and the learning cycle methods. Dean and Kuhn (2007) looked at the effect of direct instruction on elementary students' comprehension of science. Traditional instruction was given to one group, inquiry-based instruction to another, and a combination of the two approaches was given to the third group. All three groups were taught the same subject but with different methods. The traditional technique outperformed the others. In a similar study, Imhanlahimi and Imhanlahimi (2008) compared the efficacy of computer application in teaching versus conventional teaching on learners' performance in biology. After careful analysis of the posttest scores of the participants, it was discovered that the control group (those who receieved conventional teaching) outperformed the treatment (computer teaching) group.

Using the learning cycle and traditional instructional methodologies, Klahr and Nigam (2004) investigated their efficacy on grade 3 and 4 pupils learning outcome in science concept. The traditional group was taught about the principles that influenced how the ramp worked as well as the ramp faults. The kids in the conventional group were taught the procedures to build a ramp with the help of a facilitator whereas the treatement group or learning cycle group was given a ramp building worksheet to build a ramp on their own. Both groups had participated in hands-on learning activities. Students in the traditional class were judged to have greatly improved their performance than the learning cycle group. Marin and Halpern (2010) conducted study on efficiency of traditional instruction on the progress of critical thinking abilities of pupils in high school.They said that their research was important since many pupils do not graduate from high school with the critical thinking abilities required for adult success.The two groups were assessed on their ability to recognise stereotypes after learning about a psychological concept.Their findings revealed that both groups improved their performance but students in the control group had much higher grades than students in the intervention or inquiry learning group.

Chase and Klahr (2017) looked at how 4th and 5th grade children in Pennsylvania learned about inventions using traditional/lecture method. The first group received conventional instruction on rocket building while the second group worked on the rocket only after learning about invention on their own which is akin to inquiry because children were allowed to work independently without the instructor. The inventive / treatment group employed trial and error learning to complete their task. The researchers discovered that the traditional group scored higher on the lesson's worksheet than the intervention group. Zendler and Klien (2018) compared students' performance in conventional classroom and online search learning classrooms. They attempted to address the existing state of ambiguity on the best instructional technique for science classes. They discovered that the conventional group outperformed the online quests group in terms of their scores on computer science examination or achievement test. Kruit, Oostdam, van den Berg, and Schuitema (2018) investigated the impact of traditional instruction on students' inquiry abilities. Before and after conventional instruction, the students' awareness of science inquiry skills was assessed. Students in the traditional class perform better than those in the non-traditional class.

However, Ezeaghasi and Obochi (2018) investigated the effects of simulation model on learning outcome of students in cell division in Nigerian educational institutions. Students who were taught utilising computer simulation achieved better results in the posttest compare to those taught using lecture approach. Similarly, Ahmad, Shaheen, and Gohar (2018) conducted a study at the primary or basic school level in general sciences. The study's major findings were that the experimental group's overall academic performance was much higher with the 5E instructional mode than with the traditional instructional approach. Zepeda, Richey, Ronevich, and Nokes-Malach (2015) investigated efficacy of traditional/conventional teaching on middle school students' understanding of science ideas. The courses were divided into two categories: physics concepts and puzzle solving. Before the intervention, the participants were given a pretest. The study took 30 weeks to complete, following which all of the groups were given a posttest and the results were analysed. Students who got intervention performed better than students who received traditional instruction.

When comparing the traditional approach to different instructional methods, other research findings revealed no significant differences in achievement. According to Boujaoude and Attieh (2008), no significant differences were found among students that were taught chemistry with the help of CAI and those taught with traditional technigue. In terms of boosting science students' performance, Caras (2019) contrasted the inquiry (5E learning cycle), computer teaching, and traditional strategy and found that inquiry learning group perform well in some sub-topics of the content than the other two strategies. However, no statistically significant difference in achievement between the three techniques was found in their overall scores of the test. Cobern, Schuster, Adams, Applegate, Skjold, Undreiu, Loving, and Gobert (2010) studied the impact of traditional and inquiry teaching on students' learning progress in a middle school science classroom. For two weeks, both groups in the 8th grade classroom took part in the study. Between the two teaching groups, there was no statistically significant difference in the achievement test. They came to the conclusion that other researchers have exaggerated the benefits of inquiry instruction over traditional methods. They claimed that any type of well-designed instructional strategy could be useful in biology instruction.

Summary of conventional teaching approach

Conventional teaching focuses on students' strengths and helps teachers’ better grasp students' abilities in the classroom. The research reviewed in this work found that when traditional instruction was employed instead of either the learning cycle or computer assisted instruction, there was a higher level of trust. According to literature, traditional instruction is also the best way for concepts that emphasise mastering basic abilities. Conventional instruction is however, inevitable when teaching youngsters at the basic school who require it to increase their grasps of the subject that they are learning. Using conventional methods in the classroom, according to Lopez-Agudo and Gutierrez (2017), allows teachers to track students' progress and provide feedback, allowing them to clarify their learning. Despite argument that traditional approach is to blame for students' poor understanding and achievement in cell division, it remains the preferred technigue of teaching in the Ghaianaian science classroom.

CHAPTER THREE

RESEARCH METHODS

Overview

This chapter explains the methodology used in the research. Participants and how they were selected are mentioned here as well as approach or the design. The chapter ends with description of the instrument used to gather data and how the data obtained were analysed to gain insights into the effects of computer instruction, 5E learning model and conventional instruction on students' achievement in cell division at the senior high schools in Ghana.

Research Design

This study followed an embedded mixed methods research design (Creswell, 2009; Creswell, Plano Clark, & Garrett, 2008). A qualitative component was incorporated into the main quantitative pretest-posttest non-equivalent control group design in this study. Quantitative data was collected using pretest-posttest non-equivalent control group quasi-experimental design to see if there was any significant difference in academic achievement between students taught with the 5E learning cycle, computer-assisted instruction, and those who were taught using the traditional approach. This design is suitable for comparing the achievement of two or more pretest-posttest groups by generating quantitative data to assess how successful a treatment is. When there exist intact groups and random assignment of individuals is not appropriate, the pretest-posttest non-equivalent control group quasi-experimental design is most commonly utilised (Cohen, Manion & Morrison, 2011; Ary, Jacobs & Razavieh, 1990). The qualitative aspect of this research aimed to explore the attitude of the learners towards the computer instruction and the 5E learning models (Creswell, 2009; Creswell, Plano Clark, & Garrett, 2008). The qualitative aspect of this study was therefore embedded in the main non-equivalent control group pretest-posttest experimental design. This embedded mixed method strategy was chosen for this study because it can help create complementary data that can help in gaining more in-depth comprehension of the study than a single design method (Patton, 1990). Table 1 depicts the non-equivalent control group pretest-posttest quasi-experimental design used in this investigation.

Table 1: Pretest- posttest control group quasi-experimental design

Groups	Pretest	Treatment	Posttest
Experimental group 1	01	CCA	02
Experimental group 2	03	LCIA	04
Control group	05	CTA	06

Where:

CAA=Computer- Assisted Approach

LCIA=Learning Cycle Instructional Approach

CTA=Conventional Teaching Approach

Population of the Study

The study's participants were form three (3) senior high school (SHS) students from three (3) public senior high schools in the Gomoa East and Gomoa West educational districts in the Central Region.

Sample of the Study

The study's sample includes 117 students drawn from three (3) public senior high schools offering biology in the Gomoa East and West educational districts of the Central Region. The 5E learning group, the computer-assisted approach group and the control group consisted of 40, 37 and 40 students respectively. Six (6) students each from the two experimental groups were selected for individual interview.

Sampling Procedure

This study made use of a multistage sampling strategy (Shaughnessis, Zechmeister, & Zechmeister, 1997). Multi-stage sampling refers to the use of more than one sampling approach in a single investigation. Four (4) public senior high schools out of the total of five schools in the Gomoa West and East Education Districts in the Central Region that offer the General Science Program were chosen to take part in the research because they accepted the researcher's request to conduct the study due to the corona virus pandemic. From the four schools who accepted to take part in the study, one school was then purposively chosen to participate in the computer-assisted instruction because it was the only one with a computer laboratory with enough computers that could support the computer assisted instructional approach. Two additional schools were chosen at random from the remaining three using computer-generated random numbers to particiapate in the 5E learning cycle and the conventional approach. This was done to ensure that all of the schools had an equal chance of being chosen for the study. Three intact elective biology classes were subsequently chosen from the schools used for the study. This was done through simple random selection using the computer-generated random numbers. The 5E learning cycle group and the conventional group were then assigned to the classrooms at random. The study participants include all the students in the three biology classrooms that were chosen.

To obtain qualitative data on students' attitude towards computer - assisted instruction and the learning cycle, stratified random sampling procedure was also utilised to choose six (6) participants each from the two experimental groups for individual interview. In selecting the students, consideration was given to sex (Male, Female) representation as well as the level of performance of the students as indicated by the classroom assessment and posttest scores of their respective schools.The students were categorised into high achievers, average and below average using their scores in oder to put them into strata.This was done in order to select students at each level of achievement or in each of the three categories so as to have fair idea on their attitude towards the two new approaches that they were exposed to. Gender was also considered during the selection in order to ensure equal representation in the interview. Participants were then notified prior to the interview that their information would be kept private and used solely for academic purposes. The experimental group I (computer) included 37 students (19 males and 18 females) whereas the experimental group II (5e learning group) had 40 participants (30 males and 10 females) and the control group had 40 students as well (25 males and 15 females).

Research Instrument

The instruments used to gather data were an achievement test (CDCAT and CAT) on students' comprehension of concepts in cell division and interview schedule to assess their opinions about the use of computer instruction and the 5E learning model to collect data for triangulation. The posttest and pretest questions were created using the biology syllabus and instructional objectives on cell cycle (cell division), and were designated as

CDCAT (Cell Division Concept Achievement Test) and CAT (Cell Achievement Test) respectively. The pretest and posttest were made up of thirty (30) multiple -choice questions with four options (A-D). The purpose of the pretest was to gauge students' prior knowledge of cells and the degree of group homogeneity. All of the participants took a post-intervention test to gauge their progress. A list of specific learning objectives was compiled before the posttest was drafted from topics like mitosis, meiosis, chromosomes, and genes. This acted as a guide for developing valid and trustworthy items to meet the researcher's objectives or to serve the intended purpose. My supervisor and two experienced biology teachers were given the test items to evaluate.

The researcher created interview guide centered on concerns about the instructional methods utilized in the treatment groups. The main purpose of using a semi-structured interview guide is to gather information on a concept under consideration from key informants who have personal experiences, habits, expectations, and opinions about it (Flick, 2009).

Validity

For content validity, the items were created based on the syllabus and intrustional objectives. Table of specification was used as a guide in developing the test items. The items then were given to my supervisor from the Department of Science Education as well as two experienced biology tutors from senior high school for their judgement and input.

Pilot Testing

To obtain the final version of the instruments used for collecting the data, based on the inputs of my supervisor and the two biology teachers, the items / instruments were pilot tested. The instruments were administered on students in a school in the Komenda Edina Aguafo (KEEA) educational district of the Central region of Ghana. This district had similar characteristics as the ones selected for the main study. The pilot testing of the instruments facilitated the determination of their validity and reliability. Hence, the KEEA educational district was not used in the main study.

Reliability

The test items were dichotomously scored (right or wrong). Hence, the KR-20 formula was used to determine their reliability (Creswell, 2009). For both the pretest and post-test, the reliability coefficients were 0.70 and 0.72, respectively. According to Nunnally (as cited in Ampiah, 2006), these values surpassed the reliability coefficient threshold value of 0.60 which is acceptable for research purposes.

Data Collection Procedure

Prior to data collection, the Department of Science Education provided a letter of approval to the head teachers of the schools where the study was conducted. I discussed the study's goal and methodology with the heads of the science departments at the selected schools as well as other biology and information communication and technology teachers. The data was gathered utilising the Cell Division Concept Achievement Test (CAT and CDCAT) pretest and posttest items as well as a semi-structured interview schedule. The posttest items were used to see if there was a significant difference in academic achievement among students who were taught with the learning cycle, computer-assisted instruction, and those who were taught using the conventional technique. Using learning cycle teaching strategies, computer-aided teaching approaches, and conventional teaching approaches, four (4) lesson plans were developed for teaching the same topic. One lesson plan for the conventional approach, one for CAI and two for the 5E learning cycle group.

The computer-assisted approach lesson plan and the 5E learning cycle lesson plan were delivered to the two experimental groups respectively while the control group received the traditional method or conventional approach. Despite the fact that all three groups were taught the same topic, each group's teaching methods were different. Pretest was given to each of the three study groups before the start of the study to determine whether they were all performing at the same level and to assess their prior knowledge.

Two experienced biology teachers and one ICT teacher were then trained using the lesson plans to assist the researcher. This was done upon the request of the biology teachers in the selected schools to be taken through the lesson plan before the researcher can be allow to conduct the study. This was to ensure that the students would be taught the right concept as indicated in the syllabus. The 5E learning cycle group and conventional group were taught in the biology laboratory and classroom respectively by the researcher.The same teacher (researcher) taught the conventional group and the 5E learning cycle in order to ensure constant teacher personality on students' performance (Huang & Moon,2009).The CAI lesson plan together with the learning material was given to the ICT instructor.The learning materials were then program and put or installed into the computers in the computer lab. The computer group had their lesson in the computer lab with the assistance of the ICT instructor who was there to assist learners with technical challenges. Because they were studying for external examination, all the participants participated actively in the study. The 5E learning cycle group took 2 hours, 15 minutes to complete their session whereas the computer and conventional groups took 2 hours, 10 minutes. After the intervention, all of the study groups were given a post-test to see how well they did in cell division in relation to the instructional methods. After that, six (6) students from each of the two experimental groups were chosen based on gender and their scores in the classroom assessment for interviews. Prior to the interview, the interviewees were informed that their information would be kept confidential. The interview was recorded using an audio tape recorder and a mobile phone device. The study including teacher training took two weeks to complete.

Intervention (CAI group)

The CAI lesson plan was developed using computer softwares. The subject matter was taken from a biology curriculum for senior high school students. Microsoft Powerpoint 2016, text, macromedia flash, animation, and hyperlinks were some of the softwares used in the developing the CAI lesson. The CAI lesson was developed based on Alessi and Trollip (2001) tutorial model. Based on the instructional objectives given in the senior high school biology syllabus, the tutorial framework for the lesson plan was constructed in a systematic manner. Pictures and videos depicting the process of mitosis and meiosis also form part of the CAI lesson. The lesson was program into the computers and students were given numbers which they used as their index numbers to login into the computer to access the lesson. Three multiple choice questions were offered after each level of the lesson and learners advances to the next learning task by providing correct answers to the questions. Students were sent to the computer lab during the session and were taught by the computer which displayed the content to them. Students were permitted to work at their own pace for two (2) hours without interruption from the teacher, despite the presence of an ICT teacher to assist students with technical concerns.

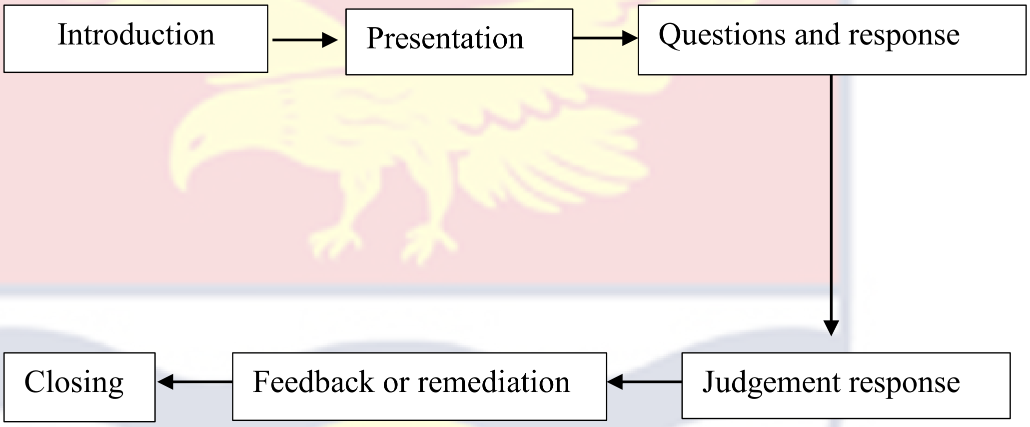

Figure 1: The tutorial model

Conventional approach lesson plan

The lesson plan was designed with the specific objectives of the content in mind. Using the concept of living cells, the teacher opens the lecture by reviewing relevant prior knowledge of the students. Lecture, discussions and intermediate questions and responses on each stage of cell division were also included in the lesson plan of the conventional teaching strategy. This is because the syllabus prescribes discussion methods for teaching cell division.

5E learning cycle lesson plan for mitosis (intervention)

A lesson plan based on hands-on activities was also created using the five phases of learning cycle instruction, which include:

Engagement p hase (reviewing relevant previous knowledge)

To arouse or stimulate students' interest and prepare their minds for the lesson, the teacher presented a video about persons with lung cancer and other cancer cells during the engagement phase. After seeing the three-minute video, the teacher addressed students' questions like "how do cancer cells develop?" to reveal their past experience and thoughts about living cells.

Exploration

Students were divided into four (4) groups and instructed to describe how living things such as plants and humans grow. Following that, each group received a microscope slide stained with onion root tip cell so they could watch or observe mitosis. Students were also given the task of designing four different cells based on what they saw through the microscope and calculating the number of daughter cells created after mitotic cell division. The teacher enhanced the students' learning by ensuring that all of the stages of mitosis were clearly visible. At the conclusion of their observation and drawing, each group presented their work. The exploration stage requires learners to carry out field investigation on their own in order to create their own knowledge, however, this was not done due to restrictions imposed by the schools as a result of COVID-19 pandemic.

Explanation stage

Students were given the opportunity to submit their drawings during the explanation phase. Following their presentation, the teacher highlighted their misunderstandings and then utilised leading questions to help students comprehend the happenings of each phase of mitosis by outlining the cell cycle and leading them to describe the stages of mitosis.

Elaboration stage

Students were asked questions in this phase that allowed them to apply what they had learned in the exploration phase to a range of situations.

Evaluation stage

During this phase, students were shown with real schematics or diagrams of each step of mitotic division and asked to identify each phase with reasons. The teacher then used conceptual questions to lead the students through a summary of the lesson.

Meiosis lesson plan.

Engagement phase

The teacher played a video about baby development or formation during the engagement phase. The teacher asked, "How does fertilization occur in humans?" after seeing the three-minute video. The topic of meiosis was then discussed by the researcher.

Exploration

At this point, the teacher started a conversation with the learners about what happened throughout each step of meiosis I. Following the discussion, the teacher distributed cards to each group containing descriptions of each step of meiosis as well as pictures depicting each phase without names or labeling. Students have to match the diagrams or pictures to the explanations precisely. They must read the card descriptions and figure out which of the diagrams the description corresponds to.

Activity 2: Students were given the responsibility of organizing their matching diagrams with descriptions in the order that they appeared. Students were also given clay of different colours to mould the various stages of meiosis.

Explanation stage

Students presented their work during the explanation phase. Each group gave a presentation of their work and described how it related to the others. They discussed about their projects and exchanged questions. The teacher took notice of their misunderstandings and try as much as possible to correct their mistakes.

Elaboration stage

During this phase, students were given questions that required them to apply what they had learned throughout the study to a range of scenarios or circumstances.

Evaluation stage

During this phase, students were shown diagrams of each step in the meiosis division process and were asked to identify each phase with reasons. The instructor or facilitator then used conceptual questions to lead the students through a summary of the lesson.

Data Analysis

One -way analysis of variance (ANOVA) was employed in analysing the quantitative data. This is due to the fact that it is useful when comparing the mean scores of two or more diverse (independent) groups of persons or conditions while thematic content analysis was also used to analysed the qualitative data.

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

This chapter presents and discusses the results of data analyses on the efficacy of computer instruction, the 5E learning cycle model, and the conventional teaching approach on senior high school cell division achievement with reference to the research questions and the null hypothesis stated in this study.

Assumptions

In order to find out if the data was normally distributed, the Kolmogorov-Smirnov and Shapiro-Wilk tests were utilized. Shapiro and Wilk state that data is normally distributed if the normality test has a significant result/value larger than 0.05. There were significant values of .200, .177, and .200 for all three groups' pretests and .08, .133, and .200 for all three groups' posttests in the Kolmogorov-Smirnov and Shapiro-Wilk tests respectively, all of which exceed 0.05 at the significant level for both tests. For the purpose of visualizing the data's normality, a standard Q-Q plot was used. The normal Q-Q plot simplifies the normality test by showing that if the data are normally distributed, the points will be near the diagonal line. According to the Normal Q-Q plot, the data were regularly distributed. Levene's test for equality of variance or homogeneity of variance was used to determine if the data was homogeneous or not. The pretest which was based on the mean of the three groups had a score of.786 while the posttest which was between the groups had a score of.367. The transcribed interviews were subjected to thematic content analysis for research. Thematic analysis is a type of qualitative data analysis in which the researcher looks for patterns and themes to learn more about the students' points of view, knowledge, and experiences (Flick, 2009).

Prior to the administration of the intervention, there was the need to explore if the students were operating at the same knowledge level. This was done using ANOVA (analysis of variance) to analyse the pretest scores. Table 2 reveals that there was no statistically significant difference in pretest scores among the study groups before the intervention [f (2,117) =1.84, p =. 16].

Table 2: ANOVA Results for Expt I, Expt II, and Control Group Pretest Scores.

Variable	Groups	N	Mean	SD	Df	F	P
	EXPT.I	37	63.96	12.66	2	1.84	.16
Pretest	EXPT.II	40	62.66	13.40			
	Control-grp	40	58.50	13.35			

*Not significant, since Sig. (P)>0.05

This revealed that prior to giving the intervention, participants in the treatment groups and the control group had similar knowledge level. It also implies that any changes that would occur after the intervention could be attributed to the teaching approaches used in teaching the topic under consideration.

Analysis of variance (ANOVA) was used to compared student achievement in the posttest mean scores of the three study groups in order to accept or reject the hypothesis that there is no statistically significant diference in achievement among students instructed with the 5E learning cycle model, computer-assisted instruction and the conventional approach in cell division as shown in Table 3.

Table 3: Shows the ANOVA results for the Experiment I, Experiment II, and Control Groups' Posttest Scores.

Grp	N	Mean	SD	F	Df	P
EXPT.II	40	48.75	18.16		2	.22
EXPT.I	37	43.06	15.82	1.53		
Control grp	40	49.42	17.95			

In Table 3, the results revealed that there was no statistically significant difference in learning outcome among the 5E learning group, the computer-assisted instruction group, and the conventional approach group [f (2,117) = 1.53, p=.22] at the 0.05 significant level. As a result, the null hypothesis which state that there is no statistically significant difference in achievement scores among the three study groups cannot be rejected.

This finding resonantes with Caras (2019) and Arslan (2014) who observed no statistically significant difference in achievement scores in biology concepts among the learning cycle model group, the conventional approach group, and the computer-assisted instruction group. The non-variations in achievement scores between the groups may be due to the variation in students' learning/students individual learning difference in the 5E learning cycle. The students were given a group task during the 5E learning cycle lessons which could have created a room for brilliant students in the groups to dominate the group findings thereby ignoring the average students which could have accounted for the non-effectiveness of the 5E learning model as seen in their post-test scores. This argument seems to agree with

Gupta (2011) that group learning promote group thinking to the expense of individual thinking.

Furthermore, the limitations ascribed to the 5E learning cycle may be the possible explanation for the insignificant difference in achievement scores between the study groups. The 5E learning cycle method involves as many as five phases and may not be suitable enough for achieving immediate lesson objectives. Hence, the insignificant difference in achievement among the 5E learning group, computer group and the conventional group.

The 5E learning cycle model lessons were most often field dependent or scientific investigation which require learners to discover knowledge on their own with minimal guidance from the teacher and average learners who usually depends on teachers for factual information were experiencing some difficulties using the microscope to view root tip cell of onion and matching the descriptions on the cards against the diagrams of meiosis. This could have resulted in the insignificant difference that was observed in their mean scores among the approaches used in teaching cell division to students.

However, findings from the current study contradict previous findings by Balci, (2009), Ajaja, (2012), Arslan, Geban, & Saglam, (2015), Ahmad, etal, (2018) who found that the 5E learning cycle is superior to the conventional approach. A lot of factors such as the resources they used for their studies, the kind of participants they engaged, and the instructors' knowledge of the subject matter could have accounted for the superiority of the 5E learning cycle to the conventional approach in students' achievement in biology as stated in their findings. The argument that 5E learning cycle instruction is superior to conventional instruction could be an overstatement by these researchers because biology teaching can be effective in any form of carefully designed lesson (Cobern et al., 2010).

This latest research adds to the growing body of evidence indicating that the 5E learning cycle and computer-assisted instruction do not improve students' understanding of biological subjects more than the lecture (traditional) technique. Furthermore, this study suggests that the usual method of teaching cell division is not flawed as reported by other studies and thus could not be a factor responsible for students' difficulty in understanding the concept and low performance in the biological concepts.

Although this study compared the effectiveness of three instructional strategies, but it is worth noting that this finding appears to be consistent with previous research that compared the effectiveness of computer-assisted instruction and the conventional approach and found no statistically significant difference in students' achievement (O'Bannon, Lubke & Britt, 2011; Ahiatrogah, Madjoub, &Bervel, 2013; Tolbert, 2015).The insignificant difference in the achievement scores between students in the computer-assisted instruction(CAI) and the conventional groups may be due to the absence of a biology teacher during CAI lesson. This may have influenced the students learning and understanding of the concepts negatively. This is because they were left alone with the ICT teacher in the computer laboratory without a biology teacher to clear their misconception on certain terminologies in cell division. This limitation of the computer-assisted instruction was revealed during the interview where some students express their frustration about being taught by the computer-assisted instruction without the presence of a biology teacher to offer further explanation.

The study's findings could have been influenced by the fact that students were distracted by the images, diagrams, and films on cell division which could have influenced their performance (Jacobson, 2006). However, this current finding on the effectiveness of computer assisted instruction, the conventional approach and the 5E learning cycle contradicts previous research by Owusu, etal., (2010), Imhanlahimi and Imhanlahimi (2008) Chase and Klahr (2017), Zendler and Klien (2018) and Kruit, etal, (2018) which suggests that the conventional approach is more effective in terms of students' achievement in biology than the CAI and the 5E learning cycle. The advantages ascribed to the conventional instruction could be the possible explanation for the significant difference in achievement in favor of the conventional instruction group over the computer-assisted instruction group in their research. For example, using traditional or conventional instruction rather than computer-assisted instruction allows teachers to keep track of students' progress in the classroom and give required explanations.

Again, finding from this current study is inconsistent with other studies which suggests that the computer-assisted approach is more effective than the conventional approach in terms of students' academic achievement in cell division and other biological concepts (Mayer 2001, Yusuf & Afolabi, 2010, Adegoke, 2011; Effiong, 2018; Ezeaghasi & Obochi, 2018; Khan, 2019). Based on the finding on this current study, it is not far fetched to conclude that the conventional approach which is considered by many researchers to be an outmoded method of teaching cell division is still effective as well as any other modern teaching strategies. Students' difficulties in understanding cell division therefore could be attributable to teachers' inadequate content knowledge rather than their pedagogical knowledge. Again, computer-assisted instruction should not be used in isolation but could be utilised to supplement the lecture /conventional instruction for better outcome in cell division.

Research question one (1): What are students' attitude towards the use of computer-assisted approach in teaching biology?

Semi-structured interviews were conducted after they have been taught with computer-assisted instruction to determine the students' attitudes or opinions about the computer-assisted approach in teaching biology. The students' responses were analysed using the thematic analysis technique. After being exposed to computer-assisted instruction during the lesson, students were asked to indicate if they think using a computer to teach biology is appropriate. Students' views were then grouped into two themes. These themes include easy understanding of cell division (makes learning real and exciting), interesting and motivating. The six students that were interviewed after the intervention stated that the computer-assisted instruction made the lesson more understandable, real and exciting. In teaching biology, teachers/facilitators should try to present the concepts in a manner that would enable learners to conceptualise and understand the concepts easily. It is therefore refreshing to state that five out of the six students that were interviewed had the view that computer-assisted instruction helped them to comprehend the lesson better than what their teacher has been teaching them with. In explaining how the computer-assisted instruction helped them, for instance, Student A noted that he got the understanding of the lesson ''*Sure, materials are easily captured, you know, with pictures, diagrams as well as videos showing how cell division occurs, chromosomes meet at the poles or* *equators. Having all this image in mind, create a mental picture of the whole concept making it easier to understand*''. This view was not expressed by Student A alone since Student B also stated that "*yes, it is appropriate because there are some concepts that the teacher struggles to explain to my understanding; sometimes I don't want to participate in class discussion; however, I get excited looking at pictures of cells, their shapes, colors, and videos of how something happens, which greatly improves my understanding of cell division.*" Student C was very confident about the level of her understanding in cell division that she has learnt and accentuated that she has understood the lesson very well, "*yes, computer-assisted education is appropriate for teaching biology because the lesson is presented in a systematical way to enhance easy understanding of the learn topic. The images and videos provided are enticing and attractive. As a result, it sticks in my mind more than reading from a textbook."* Another Student labelled D was very excited about how computer makes the lesson so real and visual which gives him a clear picture of the topic been taught "*yes, since we recall things, we see more easily than things we read. Despite the fact that I didn't read all of the writing on the computer, I have a vivid and clear picture of what I saw on the video, and I remember what I see more than what I read in books*". Student E was very confident that he understood the lesson and can answer questions without the need to memorise what has been taught *"I do consider the use of computer in teaching cell division because cell division deals with the separation of the cell and therefore becomes very difficult to memorise during examination but with videos, coloured diagrams helps to get the* *picture of cell division very well that I do not need to memorise during examination''.*

However, one of the six students that were interviewed did not believe that using a computer to teach biology, particularly cell division was a good idea. The student labeled F stated that certain terms in cell division require further explanation and that the computer should only be used to enhance the teacher's explanation of the topic. *"No, because one needs more explanation, especially when it comes to biological terms. When I was learning it on the computer, I became more confused during the lesson because there was no biology teacher to explain things to me. Therefore, if a teacher is teaching in front of the students, it will be better because they will be able to ask questions and receive good explanations at their level of English they understand."*

Most of the students (5) found the computer-assisted approach to be engaging, interesting and motivating and challenging them to conduct their own research on the subject or concept taught for more information on the topic by themselves. The students asserted that the computer-assisted instruction moved away from abstract learning to real and visual learning. Most of the students also noted that this approach is more student-centered than the teacher-led teaching where factual information on concepts is provided by the teacher. *''I would like my biology teacher to use computer in teaching most of the topics in biology because it is a form of visual learning.it is kind of interesting and lessons are not easily forgotten''* is how Student A captured his view about computer-assisted instruction when asked whether he will recommend his biology teacher to be using computer-assisted instruction in teaching difficult and abstract concepts in biology. From the perspective of

Student *B “computer-assisted instruction motivated me to learn biology and therefore I will recommend that all biology teachers should employed the computer-assisted instruction in teaching biology*.’’ Student C argued that *“computer-assisted instruction is more interesting, real, engaging and motivating and I got more understanding of the topic and explored much about cell division during lesson. I wish that my teacher will continue using this approach in teaching biology’’*. Another Student labelled D noted that *“oh yes, I will wish my teacher use computer to teach some of these topics just like we did the last time, it was so fun and interesting to see how cell divides*”. Student E stated that, “*using computer in teaching biology is good and I will like my biology teacher to do same like we did the other time.”* Student F argued that *“computer-assisted instruction makes learning interesting but it should be used to augment the teacher usual classroom teaching.’’*

Almost all of the participants had a favorable attitude towards computer instruction and did not show any negative view about it. When they were asked to give any suggestion, they might have about computer-assisted instruction. Student A alluded that *“for this approach, I couldn’t see anything bad about it. “I think that we should be educated on the value of information technology and its manipulations, not only for teaching and learning, but also to make life easier in this computer age."* Student D felt “*computers should be made accessible to all students during biology lesson so as to improve our understanding.’’* Student E seemed to have agreed with his colleagues that there was nothing negative about the new teaching approach used to teach them *“I think this method of teaching biology is the best and should be introduced in other subjects like integrated science and others”.*

The researcher observed that even though the computer approach motivated learners to study on their own pace, discover more information on their own and the instructional activities were student-centered instead of teacher-centered, the approach frustrates some students who usually rely on factual information from their teachers.

Five (5) of the six students interviewed thought computer assisted instruction was superior to conventional instruction. They claim that computer-assisted approach is more entertaining and easier to learn than using conventional methods. This indicates that learners have a favorable or positive impression of computers as instructional tools and wish that their teachers shoud utilise computer instruction to supplement classroom teaching. These results of the current study agree with the research by Hartley and Treagust (2014) when they conducted a semi-structured interview on students' attitude towards computer-assisted approach after they have been taught concepts in biology using computer-assisted instruction. The finding from their research showed that the learners have positive impression toward the computer-assisted instruction in that it has made the lesson easy to understand. A similar result was obtained by Owusu eta l, (2010) when they explored the effect of computer instruction on students' learning outcome in cell cycle and then conducted a semi-structured interview on the students' perception about the computer-assisted instruction. Students viewed computer-assisted instruction as making the topic they were taught understandable, relevant to everyday life, inspiring, enjoyable, and engaging, according to the thematic content analysis of the interviews conducted by Owusu et al. (2010).

Some students commented in the comments section that while employing computer-assisted instruction, an instructor should be on standby to assist with explanations they might not comprehend well with the computer alone. This remark agrees with Cline's (2007) earlier assertion that the computer's role in the classroom should not be seen as a replacement for the traditional approach but rather as a tool to augment the traditional approach in boosting students' critical thinking.

Again, the interview results which revealed that learners viewed computer approach as a good step in teaching cell division contradicts earlier findings by Tolbert (2015), which found that students' overall attitude towards computer approach in teaching biology were neutral and negative.

Research question two (2): What are students' attitude towards the 5E learning cycle approach in teaching biology?

To determine learners' attitude towards 5E learning cycle model, semi-structured interviews were conducted after they had been taught biology using 5E learning cycle, and students' responses were analysed using a thematic content analysis technique. Students were asked whether or not they considered the learning cycle as an appropriate technigue to teach and learn biology. For instance, do you consider the use of this learning approach (5E learning cycle) in cell division adequate? If yes, explain why and if no why? Students' views about the 5E learning cycle were put into three themes. These themes are understanding (fun, engaging, more practical and interesting), motivating and group work (sharing of information).

The 5E learning cycle, according to the students who were interviewed, made the lessons more understandable. It is therefore reassuring to learn that all the six students that were interviewed believed that the 5E learning cycle used to teach them had aided them in understanding the topic under consideration. Student A said, for example, that *"It felt like we were conducting a practical because we were using the microscope and comparing the diagrams on the card to their descriptions was fun. Being able to match meiosis diagrams to their descriptions has really aided my comprehension of cell division."* This viewpoint was not shared solely by student A, as Student B said, *"for the time being, my understanding of cell division has really improved"*. Another Student labelled C was very confident in his grasp of the concept he had learned, emphasing that *"using the meiosis description cards and matching them helps me comprehend the topic better. You will be able to match the description to the diagrams if you can read and understand the description. This gives me a more in-depth understanding of what I was learning because I understood it better than the theoretical version, and this is a kind of practical work*." Student D argued that *"the 5E learning cycle gives the knowledge about the process which happen in every stage of cell division. Knowing the process which happens at each stage of cell division improve my ability to understand and remember whatever that was taught thereby making learning seem easy to understand for me"*. Another Student labelled E was very excited and confident about the potential of the 5E learning cycle in motivating students to learn biology. She said, *"I like this kind of teaching and learning cell division because, it makes me active in class, I always sleep during biology lesson because it is kind of boring to me but this teaching process motivate me because of the microscope and the drawings''. "You made us work on our own and this approach is good because it creates a* *mental picture of what is being taught and it really releases tension making us feel free on the topic since it adds fun to learning''* is how Student F captured his view about the 5E learning cycle instruction.

As a learner-centered strategy, 5E learning cycle model emphasises sharing of ideas among students. AS a result, learners were put into groups during the delivery of the lesson. According to four (4) of the six students interviewed, the 5E learning cycle model benefited them in sharing knowledge among themselves. Student A, for example, said that *"learning in groups for biology enable us to share ideas and to ask questions that we may feel bad asking a teacher"*. The teamwork effort was much appreciated by Student B who stated that, *"learning with others in a group makes one gain more understanding from so many dimensions. We have different views so as we were learning as a group, we shared our views together which helped us to get solution to the questions. I think group learning is a very good act in studying biology"*. Although some students may be passive in group work if precautions are not taken, most learners in the learning cycle treatment group emphasised teamwork during the instruction, as Student C put it, *"group learning is very good because everyone in my team brought his ideas and we add them together, we also question our group people to explain things we don't understand''*. Student D stated that, *"yes, I will like to study in groups so that we can share ideas*". However, few students had a problem about the 5E learning cycle particularly on it emphasises on group work. Student E asserted that *"for me I don't like learning in groups because some of us are annoying and will not give you opportunity to express yourself". "I did not fully participate in the group work because I was lazy and less active because my* *group members did not give me any chance to express myself"* is how student E captured his view about the group work aspect of the 5E learning cycle.

New learning becomes meaningful when it can be linked to previous learning as a form of anchorage. As a result, most teachers strive to make a link between new ideas being presented and the learners' prior knowledge. In the 5E learning cycle strategy, students were taught to connect concepts to previous learning. The idea of connecting new concepts to prior knowledge was well received by the students in this study. Student A expressed his thoughts about the 5E learning strategy by saying, *"in the beginning of the lesson, you showed us a video on how cancer cells developed and baby formation which we have already been taught in form 1, which motivated us and make the topic simple"*. Student B also asserted *that "we have already learned the cell 1(one) in form one (1) and introducing it again at the beginning of the lesson alongside with videos really motivated me and made the learning became easier for me to learn the concept, cell division"*.

All of the six (6) students that were interviewed had a positive attitude towards the 5E learning cycle and did not hold any negative attitude about it. When they were asked during the interview to give any comments, they might have about the 5E learning cycle, Student B alluded that *"for the lessons, it was interesting and fun, I couldn't see any negative thing about it"*. Student C felt *"the 5E learning cycle instructional approach was perfect. It was more practical and I have seen nothing wrong with this teaching approach"*.

Students have a positive attitude toward using the learning cycle strategy in biology classes, according to the results of the interview. They stated that they appreciate the lesson because of the hands-on activities and the opportunity to share ideas with one another. The 5E learning cycle method was enjoyable, fun, and interesting to them. The current study's finding is consistent with Arslan, Geban, & Saglam, (2015) when they conducted a semi-structured interview on senior high school students' attitude towards the 5E learning cycle after they have been taught concepts on cell division with the learning cycle model. Their study showed that the students perceived the learning cycle instruction to have increased their achievement in cell division. Saygin (2009) found a similar result when he looked at the effects of using the learning cycle on secondary school students' understanding of nucleic acids and protein synthesis. According to the thematic content analysis of Saygin's interviews, majority of the students in the learning cycle community appreciated the learning cycle training activities and learned more with the learning cycle. As a result, they considered the 5E learning cycle approach as having made the concepts they were taught understandable and relevant to everyday life.

Students' reactions to computer-assisted instruction and the 5E learning instructional method demonstrated that they had a good attitude toward both instructional approaches and considered them as appropriate for teaching and learning biology. The 5E learning cycle and computer-assisted technique are deemed effective in teaching and learning biology by students because of their potential to make learning enjoyable, engaging, and motivating for students.

Teachers should be encouraged to use these tactics/ strategies in biology lessons in order to make learning meaningful.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter concludes with a summary, conclusions, and recommendations. The summary emphasises the most important findings, and conclusions and recommendations are drawn from them. There's also a field for future research that's been recommended.

Summary

Overview of the study

This research examined the effects of the 5E learning cycle, computer-assisted instruction, and the traditional technique on the cell division achievement of senior high school students in two educational districts in the Central Region. The study was guided by two research questions and a null hypothesis. The study followed the combination of quantitative and qualitative (mixed methods) which uses pretest-posttest control group non-equivalent quasi experimental design. Both the quantitative and qualitative were obtained using Achievement Test and Interview schedule**.** Multistage sampling technique were utilised in selecting schools and participants (classes) for the study. The quantitative data were gathered through the scores on the Achievement Test on the topic under consideration. The quantitative data were analysed using ANOVA. The data for the qualitative aspect of this study were collected from interviews with some selected students from the computer-assisted instruction group and the 5E learning cycle group on issues pertaining to the use of those two methods of teaching cell division. The selection of the students was base on their gender and performance in the classroom. The qualitative data was analyzed using themes derived from interview responses to questions about the use of computer and the 5E learning cycle in teaching.

Key Findings

The study revealed the following:

1. Though none of the teaching approaches used in teaching cell division was superior over each other in terms their effectiveness in improving students' achievement in cell division, however, students' preference is on the 5E learning cycle and the computer-assisted instruction because of hands-on activity nature and their ability to make learning more visual, interesting and motivating.
2. Majority of the sudents interviewed (5 out of 6) had positive opinion / attitude or were in favor of using computer-assisted approach in learning cell division because of its ability to present visual images and give immediate feedbacks which enable them to have better understanding of the concept.
3. According to findings from the interview, almost all of the students had good attitude regarding using the 5E learning cycle to study cell division as it presented opportunity for them to have hands on activity which makes learning cell division interesting and fun. However, two of the six students have express negative attitude about the group component of the learning cycle instruction in cell division.

Conclusions

The goal of this research was to compare the effects of computer instructional technique, the 5E learning cycle, and conventional approach on senior high school students' achievement in cell division in the Central Region of Ghana. None of the three methodologies used in the study were found to be superior in terms of students' learning outcomes in cell division. The 5E learning technique, CAI and the conventional teaching style had no statistically significant differences in achievement scores of the students. This finding is consistent with Arslan, (2014) and Caras (2019), who discovered that the learning cycle is not superior to the conventional approach in teaching cell division. This finding also seems to agree with Mayer (2004) who stated that the 5E learning cycle instrcuctional technigue is not superior to the conventional approach in teaching science, since teachers create materials that are "behaviorally active" rather than "cognitively active" when providing instructions.

Despite no significant difference found in learning outcome in cell division among the study groups, the responses from the interview indicate that students preferred the application of computer and the 5E learning cycle technique in teaching cell division than the conventional approach. Therefore, all the six students interviewed on the 5E learning cycle have shown positive attitude towards the 5E learning cycle model and five (5) out of six have also shown positive attitude towards computer-assisted instruction on cell division. This finding supports the findings of Owusu et al. (2010), who found that students have a good attitude toward computer-assisted instruction in biology.

The outcomes of this study add to the argument in literature that computer instruction and the 5E learning cycle instructional model are superior to the conventional strategy in teaching abstract biological concepts.

Recommendations

Based on the finding, the following recommendations were made.

1. It is recommended that biology teachers can integrate any of the three teaching approaches in enacting lessons in cell division since none of the three approaches is superior over each other in terms of students' achievement in cell division.
2. Although none of the three approaches is superior in enhancing students learning outcome in cell division, tutors should learn and try their best to integrate the learning cycle approach and CAI in teaching cell division since students seems to preferred learning with them.

Suggestion for Future Research

This study compared the effects of computer-assisted instruction, the 5E learning cycle instruction, and the conventional technique on students' learning outcomes in cell division at the senior high school level. Only three intact classes from three senior high schools in two educational districts in the Central Region were used in this study. Because this study's sample size was so small, it is proposed that a similar study be replicated in other regions with a bigger sample size.

Future studies should also look into the effectiveness of teacher-directed instruction combined with computer-assisted instruction as opposed to the conventional technique. This when done can mitigate the problem associated with the absence of a biology teacher as revealed by students in the computer-assisted instruction alone learning situation.

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APPENDICES

APPENDIX A

UNIVERSITY OF CAPE COAST

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

INTERVIEW GUIDE FOR STUDENTS

Students interview questions.

Dear Respondent,

These questions are designed to gather information from students to determine their attitude on the use of the 5E learning (activity base learning) method used in teaching cell division.

Your responses will be treated as confidential and will be used solely for academic purposes.

You are being requested to listen carefully and respond to the questions as frankly and objectively as possible.

1. Do you consider the use of this 5E learning approach in cell division adequate and why?
2. Would you like to study in cooperative groups for biology? Why?
3. What could be the impact of the use of this model in cell division on your understanding of biology?

APPENDIX B

UNIVERSITY OF CAPE COAST

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

INTERVIEW GUIDE

Dear Respondent,

These questions are designed to gather information from students to determine their attitude on the use of the computer-assisted instruction in teaching cell division.

Your responses will be treated as confidential and will be used solely for academic purposes.

You are being requested to listen carefully and respond to the questions as frankly and objectively as possible.

1. Do you consider the use of computer in teaching biology appropriate and why?
2. Would you recommend your teacher to be using computer in teaching biological concepts? If yes, why and if no, why?
3. Please is there any other comments or suggestions that you have about computer-assisted instructions?

APPENDIX C

CELL DIVISION CONCEPT ACHIEVEMENT TEST (CDCAT) - POST TEST

PLEASE READ THE FOLLOWING INSTRUCTIONS:

1. **This test has nothing to do with your final grade.**
2. **Please think carefully and answer the questions accurately and as best as possible.**
3. **Attempt all the questions. There is only one correct answer for each item.**

Each question is followed by four options lettered A to D. Find the correct option for each question and circle it with pencil on your question sheet.

1. In mitosis, the number of cells is……………………

   a. Halved

   b. Doubled

   c. Unchanged

   d. Tripled

2. Meiosis occur in……………………

   a. Somatic cells

   b. All types of cells

   c. Sperm cells only

   d. Germ cells

3. Separation of sister chromatids during meiosis occurs in…………………

   a. Metaphase II

   b. Anaphase II

   c. Prophase II

   d. Telophase II

4. 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 the two daughter cells are genetically identical

d. brings about growth in multicellular organisms

5. A newly developed variety of rice has a chromosome number of 12 in the zygote. What is its diploid number?

a. 6

b. 12

c. 18

d. 24

6. Which of the following statements about chromosome 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. They are neatly arranged in the cytoplasm of the cell

d. They bear ribosomes on their outer membrane

7. Meiosis takes place………………

a. during growth and development

b. during gamete formation

c. during asexual reproduction

d. in somatic cells

8. Which of the following features is typical of mitotic metaphase?

a. Homologous chromosomes pair up

b. Nuclear membrane is visible

c. Crossing over occurs

d. Chromatids arrange themselves in the equator.

9. Which of the following types of cells is replaced most frequently?

a. Bone cell

b. Cheek cell

c. Nerve cell

d. Sperm cell

10. The correct order of the stages in mitosis is………?

a. Anaphase-prophase-metaphase-telophase

b. Anaphase-metaphase-prophase-telophase

c. Prophase-anaphase-metaphase-telophase

d. Prophase-metaphase-anaphase-telophase

11. DNA replication occurs in a cell during……………

a. Interphase of mitosis

b. Metaphase of meiosis I

c. Anaphase of mitosis

d. Prophase of mitosis

12. Which of the following statements about mitosis is false?

a. Four daughter cells are produced

b. Chaismata are not formed

c. Bivalents are not formed

d. The process does not lead to variation

13. If the haploid number of chromosomes in an organism is 26, then the chromosome number of each sperm is……..?

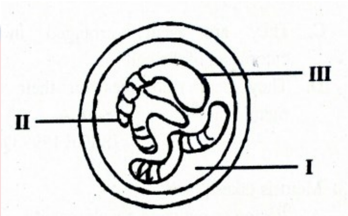
a. 13

b. 26

c. 52

d. 78

Use the diagram on meiosis in the figure below to answer 14-17



14. What is the name of the part labeled I?

a. Cell membrane

b. Endoplasmic reticulum

c. Nuclear membrane

d. Spindle fibre

15. The stage of meiosis shown is……………………

a. Anaphase I

b. Anaphase II

c. Metaphase I

d. Metaphase II

16. The part labeled II is…………………

a. Centriole

b. Chiasma

c. Chromatid

d. Chromosome

17. The part labeled III is evidence of ……………….

a. Crossing over

b. Inversion

c. Mutation

d. Synapsis

18. The organelle of animal cell which form spindle fibres during cell division is the ……………

a. Centriole

b. Lysosome

c. Endoplasmic reticulum

d. Golgi apparatus

19. The two strands that make up a single chromosome are called……………………

a. Chromatins

b. Centromeres

c. Tetrads

d. Chromatids

20. At what stage of the process of mitosis are the chromatids arranged along the equator of the spindle?

a. Anaphase

b. Interphase

c. Metaphase

d. Telophase

21. Which of the following statements best describe the metaphase of mitosis?

a. The daughter chromatids separate and become mature

b. The spindle forms and chromosomes become attached at the center

c. The nuclear membrane disappears and the chromosomes thicken

d. Two daughter cells are formed

22. Sexual reproduction in higher plants and animals is brought about by the fusion of a…….

a. diploid male gamete with haploid female gamete

b. haploid female gamete with a diploid male gamete

c. haploid male gamete with a haploid female gamete

d. diploid male gamete with a diploid female gamete

23. The function of the mitotic spindle is to ………………..

a. holds cells together

b. separate cells from each other

c. link the cell plate and the nuclear membrane

d. pulls the chromosomes to the poles

24. If telophase fails to occur during mitosis in a dividing diploid cell, which of the following consequences will take place?

a. Spindle fibres will not be formed

b. Chromatids will not migrate to the poles

c. No new cells will be formed

d. The cells will shrink

25. Meiotic division will not take place in the…………

a. mammalian ovary

b. pollen grain

c. ovary of flowering plant

d. mammalian bladder

26. The following events occur during mitosis in a cell

I-Chromatids separate

II-Chromosomes become visible

III-Chromosomes align at the equator

IV-Cytoplasm divides (Cytokinesis)

The correct sequence of the events is………………

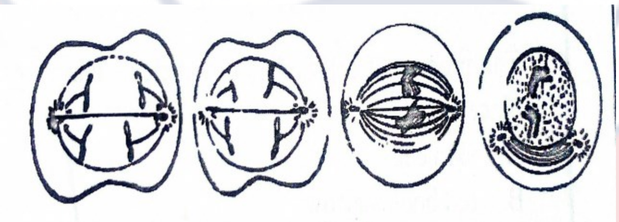
a. III, II, IV, I

b. II, III, I, IV

c. II, I, III, IV

d. II, IV, I, III

27. The following drawing shows the sequence of events in early cell division



In which of the following cells is this division likely to take place?

a. Sperm cell

b. Blood cell

c. Muscle cell

d. Uterine cell

28. Protein synthesis in living cells occur on the……………

a. Golgi apparatus

b. Endoplasmic reticulum

c. Mitochondria

d. Ribosomes

29. When chromosomes replicate, they produce…………...

a. Tissues

b. Nuclei

c. Chromatids

d. Somatic cells

30. An apple plant can reproduce sexually and asexually and it has 40 chromosomes in its leaf. How many chromosomes would be in each gamete and somatic cell of the apple plant?

a. 20 chromosomes in the gamete and 10 in the somatic cells

b. 40 chromosomes in the gamete and 20 in the somatic cells

c. 20 chromosomes in the gamete and 40 in the somatic cells

d. 40 chromosomes in the gamete and 40 in the somatic cells

APPENDIX D

CELL CONCEPT ACHIEVEMENT TEST (CAT)

PLEASE READ THE FOLLOWING INSTRUCTIONS:

1. This test has nothing to do with your final grade.
2. Please think carefully and answer the questions accurately and as best as possible.
3. Attempt all the questions. There is only one correct answer for each item.
4. Each question is followed by four options lettered A to D. Find the correct option for each question and circle it with pencil on your question sheet.

1. Which of the following is NOT a premise of cell theory?

   I. All cells arise from other cells.

   II. All living cells require water for survival.

   III. All living things are only composed of cells.

   A I only

   B II only

   C I and II

   D II and III

2. Which of the following are not found in plant cells?
   a) Mitochondria
   b) Glyoxysomes
   c) Centrosomes
   d) Golgi apparatus
3. Which of the following statements is correct?
   a) Animal and fungal cells contain chloroplasts.
   b) Animal and plant cells do not contain mitochondria.
   c) Plant, animal and fungal cells possess mitochondria.
   d) All plant cells contain chloroplasts.

4. The overall shape of a bacterial cell is determined by which of the following?
    a) Cytoskeleton
    b) Cell wall
    c) Nucleoid
    d) Cell surface membrane
5. Which one of the following is associated with bacterial cells?
    a) Ribosomes
    b) Nucleus
    c) Chloroplasts
    d) Lysosomes
6. The Cell was discovered by…………
    A Leeuwenhoek
    B Robert Hooke
    C Robert Swanson
    D Robert Brown
7. The spherical structured organelle that contains the genetic material is…….
    A Cell walls
    B Ribosomes
    C Nucleus
    D Mitochondria
8. Protoplasm found inside the nucleus is known as……………
    A Amyloplast
    B Nucleoplasm
    C cytoplasm
    D Elaioplast
9. Which of the following statements are true about Endoplasmic Reticulum? (a) Smooth Endoplasmic Reticulum makes lipids. (b) It is also called the control center of the cell. (c) It processes carbohydrates. (d) It modifies chemicals that are toxic to the cell.
    A (a), (b) and (c)
    B (a), (c) and (d)
    C only (a) and (d)
    D all are correct

10. 10 Which of the following statements are true about Eukaryotes? (a) They are cells with a nucleus. (b) They are found both in humans and multicellular organisms. (c) Endoplasmic reticulum is present in Eukaryotes. (d) They have chemically complexed cell wall.

    A (a), (b) and (c)
    B (a), (c) and (d)
    C (a), (b) and (d)
    D all are correct

11. Which one of the following organelles digests the old organelles that are no longer useful to the cells?

    A Ribosomes
    B Mitochondria
    C Lysosomes
    D Chromatin

12. Plasmodesmata are located in narrow areas of _______.

    A Cell walls
    B Protoplasm
    C Cellulose
    D Nuclei

13. What do prokaryotic cells lack?

    A Cell membrane
    B Cytoplasm
    C Cell wall
    D membrane-bound nucleus

14. Which of the following is an example of cell devoid of nuclear membrane and mitochondria?

    A Bacterial cell
    B Sperm
    C Protist
    D Sponge cell

15. Which one of the following is not considered as a part of the endomembrane system?
    - A Vacuole
    - B Lysosome
    - C Golgi complex
    - D Peroxisome
16. Animal cell differs from plant cells in possessing………..
    - A Plastid
    - B Golgi body
    - C Vacuole
    - D Centrosome
17. The function of ribosomes in cells is ………
    - A. protein synthesis
    - B. starch synthesis
    - C. transport of materials
    - D. lipid storage
18. Which of these structures is found in plant cells but not in animal cells?
    - A Cell membrane
    - B. Nucleus
    - C. Cell wall
    - D. Cytoplasm
19. Which structure does NOT play a part in the motion of cells?
    - A. Microvilli
    - B. Cilia
    - C. flagella
    - D. pseudopodia
20. The chromosomes of a eukaryotic cell are located in the
    - A. Nucleus
    - B. ribosome
    - C . Mitochondria
    - D . Endoplasmic reticulum

21. Which of the organelles is the site of energy production?
    - A. endoplasmic reticulum.
    - B. mitochondria.
    - C. nucleolus.
    - D. golgi body.
22. Lysosomes are known as "suicidal bags" because …..
    - A. it parasitic activity
    - B. presence of food vacuole
    - C. hydrolytic activity
    - D. catalytic activity
23. Which of the following is not found in the animal cell?
    - A. cytoplasm.
    - B. water.
    - C. nucleus.
    - D. cellulose
24. The protoplasm of the cell consists of the…….
    - A. cytoplasm only.
    - B. nucleus only.
    - C. nucleus and cytoplasm only
    - D. nucleus, cytoplasm and membrane.
25. When red blood cells are placed in hypertonic solutions, the cells will…………
    - A. absorbs ions.
    - B. become turgid.
    - C. become wrinkled.
    - D. undergo heamolysis.
26. One important function of the cell membrane 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

27. The characteristic component of plant cell wall is ………

A. cellulose

B. lignin

C. pectin

D. tannin 15.

28. Which of the following organisms does not obey the cell theory

A. Virus

B. bacteria

C. Fungi

D. Plants

29. DNA formation is associated with…….

A. golgi bodies,

B. nucleus

C. lysosome

D. mitochondria

30. A cell is said to be plamolysed if …………

A. it loses its water content and dries up

B. it imbibes water and swells up

C. the cytoplasm pulls away from the cell wall

D. the nuclear membrane ruptures to release its content

APPENDIX E

BIOLOGY

COMPUTER ASSISTED APPROACH LESSON PLAN

Instructional Objectives:

By the end of the lesson, students will be able to:

1. Explain the terms: meiosis and mitosis
2. Identify the various stages of meiosis and mitosis
3. Describe the location and appearance of chromosomes on each phase of meiosis and mitosis.
4. Describe chromosomal movement during mitosis and meiosis.

Relevant Previous Knowledge

Students have learnt cells before

ADVANCE PREPARATION

Downloading videos on the lesson, preparing power point

REFERENCES

CRDD (2010): Teaching Syllabus for Senior High School Biology, Accra: Ministry of Education.

Yeboah, O. (2010): Excellent Biology for Senior High Schools. Accra: Excellent publication.

STAGE,STEP,CONTENT, ITEM(ESTIMATED TIME)	MATERIALS	TEACHER ACTIVITY	STUDENT ACTIVITY	MAIN IDEAS
INTRODUCTION(10 minute)	Power point Desktop computers	Teacher started the power point by stating specific objectives.	Students read the learning objectives and note what is required of them after the lesson.	
STEP 1 Explanation of meiosis and mitosis (30minute)	Desktop computers, power point	Teacher used power point to present key points on meiosis and mitosis. Difference between mitosis and meiosis as well as their importance and a diagram of cell cycle depicting how the cell starts division. Three objectives questions for students to answer	Students read the explanations on their desktop computers and take note of salient points.	A cell divides by pinching into two. Each of two daughter cells produced contains genetic material inherited from the original (parent) cell. When cell division begins, DNA coils around the proteins forming visible structures called

		correctly before they can proceed to the next stage. **Sample question** In mitosis the number of cells is…. A. halve B. Double C. Triple D. unchanged		chromosomes. Mitosis is the division of a cell to form two daughter cells each containing the same number of chromosomes as the parent cell.
STEP 2 Mitosis phases (30MIN)	Power point Desktop computers	Teacher present a power on the various phases of mitosis with concise descriptions of the events that occurs during this cell division which is installed on desktop computers in the lab. After the power point presentation, next is a video on mitosis, depicting all the events that occur	Students read the power point and note down salient point. Student then proceed to view the video by pressing on the play button to better understand the process in real sense. Students	The phases of mitosis are: prophase, metaphase, Anaphase and telophase. **Chromosomes** are thread-like structures and they contain the genes. They exist in pairs in what is called homologues. **Homologous**

		in each phase of mitosis including chromosomal movement, their locations and appearance on each of the phases. Three objectives questions for students to answer correctly before they can proceed to the next stage.	answer the three objectives questions correctly before he/she is allow to move the next stage.	**Chromosomes** Diploid cells have two copies of each chromosome (except the sex chromosomes). Each pair of chromosomes is homologous. **A chromatid** is a single DNA strand. (one of the two strands of a duplicated chromosome joined at the centromere). Double-stranded chromosomes have two chromatids; normally, each one is identical to the other.
STEP 3 Meiosis phases (30minute)	Power point Desktop computers	Teacher present a power on the various phases of meiosis I(one) because	Students read the power point and note down salient point.	**Prophase** I: the nucleolus and nuclear membrane bread down.

		meiosis ii phases is similar to mitosis phases with concise descriptions of the events that occurs during this cell division which is installed on desktop computers in the lab. After the power point presentation, next is a video on meiosis, depicting all the events that occur in each phase of mitosis including chromosomal movement, their locations and appearance on each of the phases. Three objectives questions for students to answer correctly before they can proceed to the next	Student then proceed to view the video by pressing on the play button to better understand the process in real sense. Students answer the three objectives questions correctly before he/she is allow to move the next stage.	Homologous of chromosome lie together forming a bivalent which thickens and shortens. As prophase proceeds, chromosomes coil round each other and the chromatids may break and rejoin at certain points called chiasmata resulting in exchange of parts of the chromatids, a process known as crossing over. **Metaphase** I: Homologous pairs of chromosomes align themselves at the equator with the centromeres of the pairs pointing towards opposite poles.

		stage.		**Anaphase** I: The homologous chromosomes move apart towards opposite poles of the spindle. **Telophase** I: Chromosomes reach the pole of the spindle and cell membrane constricts forming daughter cells. In plant cell, cell plate formation takes place.
Application/ evaluation (10 minute)		The last slide contains theory questions where students are supposed to apply what they have learned from the previous. Samples questions: How do you understand by the	Students respond to the questions on their pace of time.	

		terms: i. Chromosomal replication? ii. Reduction cell division		

APPENDIX F

THE 5E LEARNING CYCLE LESSON PLAN-MEIOSIS

Instructional Objectives:

By the end of the lesson, students will be able to:

1. Explain the term meiosis
2. Identify the various stages of meiosis
3. Describe the events that happens at each phase of meiosis.
4. Draw the different stages of meiosis in order of division
5. Describe the events that happens at each stage of meiotic cell division

Relevant Previous Knowledge

Students have learnt cells before

ADVANCE PREPARATION

Downloading videos on the lesson, preparing power point

REFERENCES

CRDD (2010): Teaching Syllabus for Senior High School Biology, Accra: Ministry of Education.

Yeboah, O. (2010): Excellent Biology for Senior High Schools. Accra: Excellent publication.

STAGE,STEP, CONTENT, ITEM(ESTIMATED TIME)	MATERIALS	TEACHER ACTIVITY	STUDENT ACTIVITY	MAIN IDEAS
Engagement phase (15MIN)	PROJECTOR, LAPTOP MARKER BOARD	Teacher project videos on the formation of a baby to stimulate students' curiosity in the engagement phase. After the videos, teacher uses questions to review students' previous knowledge and ideas about meiosis to introduce the lesson. **Sample question:** How is a baby form? Based from the students' response, teacher then stated that baby formation occurs of meiotic	Students watch the videos carefully and observe the growth of cancer cells. **Expected response**: A baby is formed by the fusion male and female sex cell (diploid).	

		cell division. Teacher then introduced certain terms associated cell division such as chromosomes, chromatin, chromatids, etc.		
Exploration Phase Activity (50 minute)	Projector, laptop Cards, Color pencils, clay / bead	Teacher project videos on meiosis and mitosis and tasked students to observed the two process carefully. After the videos teacher put students into groups and provided each group with activity sheet and a series of cards depicting the phases of meiosis and description of each phase.	Students observed the videos carefully and note down the difference between meiosis and mitosis on their work sheet. Students then match the phases with the descriptions on the cards.	

		Teacher then asked students to match each phases on the card with the description on another card. Students were also asked on the activity to arrange the phases with their descriptions in order in which they occur. Teacher asked students to used outline drawing of cells of the stages and use color pencil to draw chromosomes and trace the sequence of events in meiosis. Teacher then asked students to make meiosis model		

		using clay or beads.		
Explanation phase 30 MIN		Teacher asked students to present their work then initiate discussion using leading questions to help students conceptualized the events of each phase of meiosis by describing the events of the cell cycle and also asked them to name phase. During the explanation phase, teacher note down students' misconceptions and try to cleared them with charts containing the various phases of meiosis.	Students present their finding and discussion them. Students also asked questions for clarification and try to find a correct explanation on their own but under the guidance of the teacher.	

Elaboration Phase 25MIN		Teacher asked students questions that gives them opportunity to apply what the learned during exploration. **Sample questions** **How is meiosis different from mitosis?**	Students then discuss the questions and used the knowledge gained in the exploration and explanation phases in different situation	

Evaluation **Phase** **15MIN**		Teacher to summarize all their finding. After that teacher provide opportunity for students to demonstrate their understanding and make sense of the learning through questioning them.	Students respond to the questions using the knowledge they have gained.	

REMARKS:………………………………………………………………………

APPENDIX G

THE 5E LEARNING CYCLE LESSON PLAN -MITOSIS

Instructional Objectives:

By the end of the lesson, students will be able to:

6. Explain the term mitosis
7. Describe why cells in the body undergo mitosis
8. List the steps of the Cell Cycle in order and state the parts involved in Mitosis.
9. Draw the different stages of mitosis in order of division
10. Describe the events that happens at each stage of mitotic cell division
11. Describe location and appearance of chromosomes and chromosome movement during mitosis.

Relevant Previous Knowledge

Students have learnt cells before

ADVANCE PREPARATION

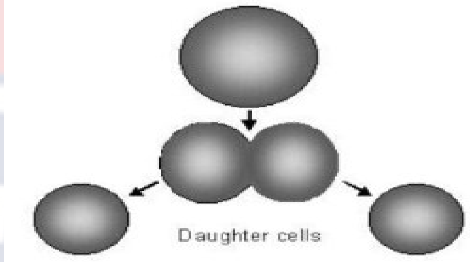
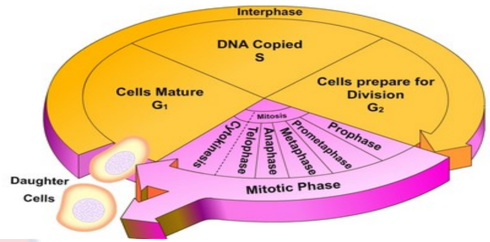
Downloading videos on the lesson, preparing power point

REFERENCES

CRDD (2010): Teaching Syllabus for Senior High School Biology, Accra: Ministry of Education.

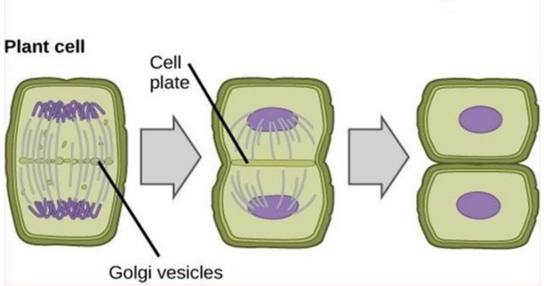
Yeboah, O. (2010): Excellent Biology for Senior High Schools. Accra: Excellent publication.

STAGE,STEP, CONTENT, ITEM (ESTIMATED TIME)	MATERIALS	TEACHER ACTIVITY	STUDENT ACTIVITY	MAIN IDEAS
Engagement phase (20MIN)	PROJECTOR, LAPTOP MARKER BOARD	Teacher project videos related to people with lung cancer and other cancer cells and to stimulate students' curiosity in the engagement phase. After the videos, teacher uses questions to review students' previous knowledge and ideas about cells to introduce the lesson. **Sample question:** How does cancer cells develop? Based from the students' response, teacher then stated that the process by which cell multiple itself is call cell division.	Students watch the videos carefully and observe the growth of cancer cells. **Expected response**: The development of cells might be based a faulty cell dividing itself to many cells	
Exploration	Fresh onion root tip cell,	Teacher put students into groups on the topic cell cycle	Students follow the procedure provided and	A cell divides by pinching into two. Each of two daughter cells produced contains genetic material

Phase **Activity 1** **(50 minute)**	Microscope Slide, coverslip, droppers, forceps,Acetocarmine stain,	and cell division and discuss how the body grows. Teacher then provide all the materials needed and list of activity sheet for each group to observe mitosis in onion root tip cell. Students were asked on the activity sheet to locate and draw five cells in the various phases of mitosis. Also find out how many daughter cells are produce after cell division.	observed the onion root tip cell under compound microscope. Each group make a drawing of what they see during the experiment. Each group also took notes of their observation and difficulties they faced during the experiment.	inherited from the original (parent) cell. When cell division begins, DNA coils around the proteins forming visible structures called chromosomes.  life of a cell is spent in interphase. Interphase consist of three stages call G1, S and G2. 
Activity 2 **(40minute)**	Mitosis modelling play doh/ dough Beads with varying colors	Teacher play a video on play doh modelling.Teacher provide the materials needed for each group and asked them to make models of what they see in activity 1.Teacher did not interfere in students models.	Students follow the activity sheet and make models of their observations.	

Explanation phase 30 MIN		Teacher asked students to present their observations and models and then initiate discussion using leading questions to help students conceptualized the events of each phase of mitosis by describing the events of the cell cycle and also asked them to name phase. During the explanation phase, teacher note down students' misconceptions and used them as questions to help them find correct explanation.	Students present their finding and discussion them. Students also asked questions for clarification and try to find a correct explanation on their own by under the guidance of the teacher.	**Prophase** Replicated chromosomes appear as thick coiled and shorten threads called chromatin. Each chromosome now consists of a pair of sister chromatids. The chromatids are held together by a centromere. During this phase the nuclear membrane will break down and toward the latter part cannot be seen. **Metaphase** In metaphase, the chromosomes line up across the equator of the cell. Spindle fibers from each pole attach to the pair of chromatids. **Anaphase** The spindle fibers shorten, pulling the chromatids toward the poles of the cell. The sister chromatids separate and move toward opposite poles of the cell.

				Telophase Each set of chromatids begin to uncoil and return to chromatin. A new nuclear membrane forms around each set of chromosomes,
Elaboration Phase 25MIN		Teacher asked students questions that gives them opportunity to apply what the learned during exploration. **Sample questions** What changes takes place in our body during cell division? Why is cell division important to living organisms? Describe how cell division occurs in plants that do not have centrosomes. Teacher discuss mitosis in plant cells and introduced other technical terms to students.	Students then discuss the questions and used the knowledge gained in the exploration and explanation phases in different situation	Most plants do not contain centrioles, but they do have microtubule clusters that function to direct the distribution of chromosomes for the cell division. Plant cells divide through open mitosis. The cell will produce two new cells that are identical to each other and to the parent cell. The growth and division process is called the cell cycle. The cycle starts as the number of organelles within the cell starts to increase. This is to ensure that each of the two new cells receives copies of all the organelles. Then the plant cell forms a wall in the middle to divide the structure. When complete, each side has a proper copy of the chromosomes. In the animal cell, the cell in pinched in the middle to divide the cell. In plant cells, a wall is built in the middle to divide the cell.

				
Evaluation **Phase** **15MIN**		Teacher then show real diagrams of each phase of mitotic division and asked students to identify each phase with reason. Teacher also made students summarized what they have learned using conceptual questions.	Students respond to the questions using the knowledge they have gained.	

REMARKS:………

APPENDIX H

DESCRIPTIVE

%_Pretest

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum	Between-Component Variance
EI		37	63.9640	12.66466	2.08206	59.7414	68.1866	36.67	96.67	
EII		40	62.6667	13.40153	2.11897	58.3806	66.9527	36.67	86.67	
Control		40	58.5000	13.35362	2.11139	54.2293	62.7707	30.00	90.00	
Total		117	61.6524	13.25136	1.22509	59.2260	64.0789	30.00	96.67	
Model	Fixe Effects			13.15663	1.21633	59.2429	64.0620			
	Random Effects				1.64983	54.5538	68.7510			3.72249

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
%_Pretest	Based on Mean	.242	2	114	.786
	Based on Median	.210	2	114	.811
	Based on Median and with adjusted df	.210	2	113.106	.811
	Based on trimmed mean	.232	2	114	.794

ANOVA

%_Pretest

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	636.358	2	318.179	1.838	.164
Within Groups	19733.063	114	173.097		
Total	20369.421	116			

```
T-TEST GROUPS=Group(1 3)
  /MISSING=ANALYSIS
  /VARIABLES=@_Posttest
```

Frequencies

Statistics

Sex

N	Valid	117
	Missing	0

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	F	43	36.8	36.8	36.8
	M	74	63.2	63.2	100.0
	Total	117	100.0	100.0	

Frequencies

Group = EI

Sex[a]

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	F	18	48.6	48.6	48.6
	M	19	51.4	51.4	100.0
	Total	37	100.0	100.0	

a. Group = EI

Group = EII

Sex[a]

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	F	10	25.0	25.0	25.0
	M	30	75.0	75.0	100.0
	Total	40	100.0	100.0	

a. Group = EII

Group = Control

Sex[a]

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	F	15	37.5	37.5	37.5
	M	25	62.5	62.5	100.0
	Total	40	100.0	100.0	

a. Group = Control

Descriptives

%_Post-test

			ean	td. Deviation	td. Error	95% Confidence Interval for Mean ower Bound	pper Bound	inimum	aximum	Between-Component Variance
1		7	3.0635	5.81876	.60059	7.7893	8.3378	6.67	6.67	
2		0	8.7500	8.15857	.87112	2.9426	4.5574	6.67	3.33	
3		0	9.4163	7.97186	.84160	3.6686	5.1639	0.00	3.33	
Total		17	7.1795	7.46675	.61480	3.9812	0.3778	6.67	3.33	
odel	ixed Effects			7.38736	.60746	3.9951	0.3639			
	andom Effects				.98955	8.6191	5.7398			4.11770

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
%_Post-test	Based on Mean	1.010	2	114	.367
	Based on Median	1.088	2	114	.340
	Based on Median and with adjusted df	1.088	2	112.596	.340
	Based on trimmed mean	1.077	2	114	.344

ANOVA

%_Post-test

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	925.611	2	462.805	1.531	.221
Within Groups	34464.532	114	302.320		
Total	35390.143	116			

Robust Tests of Equality of Means

%_Post-test

	Statistic[a]	df1	df2	Sig.
Welch	1.672	2	75.993	.195
Brown-Forsythe	1.541	2	113.488	.219

a. Asymptotically F distributed.

Means Plots