UNIVERSITY OF EDUCATION, WINNEBA

THE IMPACT OF MULTIMEDIA INSTRUCTIONAL APPROACHES ON THE ACADEMIC PERFORMANCE OF SHS STUDENTS IN GENETICS

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A dissertation in the Department of Science Education, Faculty of Science Education, submitted to the School of Graduate Studies in partial fulfilment

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May, 2022

DECLARATION

STUDENT'S DECLARATION

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

SIGNATURE: …………………………………

DATE: ……………………………….

SUPERVISOR'S DECLARATION

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

DR. JAMES AWUNI AZURE (SUPERVISOR)

SIGNATURE: ……………………………………

DATE: …………………………………………...

DEDICATION

I dedicate this work to God Almighty, Dr. (Mrs.) Hagar Bampoh-Addo who have been an inspiration to this work, my parents, Mr. Daniel Osei Attafuah and Madam Mabel Nyarkoa, and my siblings, Ernest Nketia Attafuah and Bernice Serwa Attafuah, and to my family.

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LIST OF ABBREVIATIONS

SHS	Senior High School
DNA	Deoxyribonucleic acid
RNA	Ribonucleic acid
SKGT	Students' Knowledge of Genetics Test
SAGT	Students' Achievement in Genetics Test

ABSTRACT

The study examined the comparative effectiveness of teaching through the use of multimedia and conventional teaching methods in biology on student‘s performance of selected biology students in Winneba Senior High School. The pre-test post-test non-equivalent quasi experimental design was adopted for this study. Two second year intact science classes in the Winneba Senior High School which comprised of twenty-three (23) students each who had biology as one of their elective subjects were selected for the study. They were later categorized into control group and experimental group. Students in the experimental group were taught using the multimedia approaches whiles those in the control group were taught using the conventional or traditional approach. Two tests namely, ―Students‘ Knowledge of Genetics Test" – SKGT and ―Students‘ Achievement in Genetics Test" – SAGT, which were both developed by the Researcher were used as the pre-test and post-test instruments respectively. Questionnaires were also administered to participants of the study to elicit information on participants‘ perception on the use of multimedia instructional approach. The moderating effects of the teaching approaches and gender were also tested. The results showed that there was a statistically significant effect of treatment on students' achievement Genetics in Biology ($P < 0.05$). Also, gender had no significant main effect on students' performance ($P > 0.05$). It was therefore concluded that multimedia instructional approaches significantly enhanced students learning of Genetics in biology than the conventional teaching approach, regardless of gender and the preferred learning style of students. Therefore, it was recommended that more multimedia instructional tools should be designed and used by biology teachers in lesson delivery for effective and efficient teaching and learning of Biology.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter presents the background to the study. It also states the problem, the purpose of the study, the objectives of the study, the research questions that will guide the study and the significance of the study. It also contains delimitations, limitations, operational definitions of terms. The organisation of the study is also included in this chapter.

1.1 Background to the study

Biology is a natural science that deals with the living world: how the world is structured, how it functions and what these functions are, how it develops, how living things came into existence, and how they react to one another and with their environment (Umar, 2011). It is a pre-requisite subject for many fields of learning that contributes immensely to the technological growth of the nation. This includes medicines, pharmacy, nursing, agriculture, forestry, biotechnology, nanotechnology, and many other areas (Ahmed & Abimbola, 2011).

According to Taiwo and Emeke (2014), biology exposes the students to the world of knowledge of self, the immediate and distant environment. Biology is an essential component of science and one of the fundamental foundational science courses to which students are exposed in order to prepare them for future scientific endeavours (Amanso & Bassey, 2017). Biology has long been a vital subject in science, as it has been linked to nearly every aspect of human life, including food, water, health, ecosystem management, agriculture, and conservation, to name a few.

According to Moll and Allen (2014), genetics is the study of genes, genetic variation, and heredity in living organisms. It is generally considered a field of Biology. Davar (2012) infer that genetic information lies within the cell nucleus of each living cell in the body. The information can be considered to be retained in a book for example. Part of the book with the genetic information comes from the father while the other part comes from the mother. Genetics has given rise to a number of subfields, including epigenetic and population genetics. Organisms studied within the broad field span the domain of life, including bacteria, plants, animals, and humans. Genetic processes work in combination with an organism‘s environment and experiences to influence development and behaviour, often referred to as nature versus nurture. The intracellular or extracellular environment of a cell or organism may switch gene transcription (Dillon, 2013). Genetics is one of the topics taught in biology at senior secondary school level. The topic covers the following aspects: variations, mitosis and meiosis, monohybrid crossings, sex-determination, co-dominance and mutation etc. Previous studies in Nigeria have shown that genetics is perceived as a challenging topic for some students and teachers. For example, in a study by Rugumayo (2012), teachers cited genetics as one of the topics they needed help in order to teach it effectively.

Science is regarded as the bedrock of modern-day technology. Countries all over the world especially developing ones like Ghana are making lots of efforts to develop technologically and scientifically. This has become necessary because the world is turning ―scientific" (Quarcoo-Nelson, Buabeng & Osafo, 2012). To achieve the laudable objectives of teaching and learning biology in the SHS, the teaching of biology should be well strategized to bring about meaningful learning which could improve students‘ performance. Teaching for understanding and to bring about meaningful learning in Biology may involve the use of appropriate methods.

Since the current teaching strategies commonly used for teaching science have failed to enhance problem-solving skills, curiosity and critical and logical thinking among the science students (Shah & Khan, 2015), there is a great demand to shift to technology integration strategies as a new form of pedagogy. Most especially paradigm shift of integration of Information and Communication Technology (ICT) since teaching principally involves the passage of information through communication. Information and Communication Technology (ICT) is not something new nowadays. Somehow, ICT appears to be a force that has changed lots of aspects of life. We are all living in the era of Information and Communication Technology, ICT. ICT is more innovative and could enrich approaches for meaningful learning. Communication technology comprises of all forms of technology to create, store, exchange information (such as business data, video, audio, still images, text, pictures, etc) with high-speed communication links carrying data, sound and video. When more than one of these are utilized in the communication process, it is referred to as multimedia.

The use of multimedia to enhance learning is beneficial because it allows for an easier and broader variety of teaching styles with which information can be obtained; it promotes interactive learning and, as a result, encourages greater enthusiasm toward education in both students and teachers (Shieh, 2012). In laboratory science, the use of video technology is particularly useful, as it enables the visualization of procedures, and allows for deeper comprehension than that obtained through a textual presentation. In a study by Matemu (2014), students were introduced to various teaching principles verbally, which were then reinforced by one of four methods: the principle accompanied by a text example; the principle accompanied by a video example; the principle accompanied by a visual example from the teacher; or the principle not accompanied by any example. Each student was then given a conceptual test, an application test, and an opinion-based survey. Students who were provided with video or in-person visualization showed enhanced interest, as well as a stronger grasp of the material. Contrarily, students who were not given a further explanation, and those who were given explanation through text did not show a difference in enthusiasm or comprehension of the material compared to the control group.

Multimedia technology today uses various forms of communication or promotional media such as videos, computers, and still images, and is now widespread throughout the modern world. This insurgence of multimedia into the world of information technology has resulted in a significant decrease of information being presented in plain text, replacing it instead with combinations of computer-produced digital media, such as graphic images, photographs, videos, animations, and audio (Reiser, 2001). Since multimedia technology allows information to be demonstrated in so many different ways, it enables teaching styles that can be directed toward a broadened range of learning preferences (Pippert & Moore, 1999). Multimedia technologies can help educators present their material in both clear and creative ways to students, allowing students to better understand the concepts and materials presented. Numerous studies, such as those conducted by Pryor and Bitter (2008), Bockholt, West & Bllenbacher (2003), McDaniel, Lister, Hanna, & Roy (2007), and Ziv (1988), affirm that the addition of multimedia to education results in more thorough comprehension of material when compared to the traditional text and lecture formats. For that reason, incorporating multimedia as a teaching practice has been an important step forward in the world of education.

1.2 Statement of the Problem

Many factors have been adduced to the poor performance of students in biology. Such factors include teacher quality (Akinsolu, 2010; Anita, 2013), school factors (Mushtaq & Khan, 2016), types of textbooks (MeenuDev, 2016), teaching methodology (Owusu, Monney, Appiah, & Wilmot, 2010). Reports have shown that the major cause of the poor performance of students in science subjects is due to the use of the lecture method of teaching (Ukoh & Adewale, 2014). In most schools, the traditional method of teaching in which the teacher is the repertoire of knowledge is still the order of the day, and this method is used to teach even science subjects such as Biology which naturally, is full of abstract concepts and phenomenon. The prevailing method used by the majority of teachers in Ghana is the conventional teaching method (Owusu *et al*, 2010).

Although multimedia as a tool cannot replace hands-on learning, it can enhance and strengthen the impact of activities in the field and the science classroom. We can use new information tools, such as podcasts, blogs, and streaming video and audio, to engage our students and effectively demonstrate science concepts as well as to reinforce media literacy technologies.

According to Ezechi (2021), he noticed that the challenges that students and teachers perceive in learning and teaching genetics, are not isolated problems. Students face problems representing genetics texts into schemes and symbols, and vice versa in reading schemes and symbols. Knowledge of the extensive genetic terminology is required for understanding a classical genetic problem. Moreover, they have to do mathematical calculations with those symbols in solving the problem.

Reports have shown that the major cause of the poor performance of students in biology of which genetics is a major concept is due to the frequent use of the conventional method of teaching (Ukoh & Adewale, 2014). Lecture method which is one of the teaching methods of science has been criticized by many researchers as having the tendency to render the learner passive in the learning process and it does not help students construct their own understanding (Ebira, 2000; Okwilagwe, 2002; Oke, 2005).

In view of this, the study sought to investigate the impact of multimedia instructional approaches on the academic achievement of SHS students in genetics

1.3 Purpose of the Study

The study sought to examine the impact of the multimedia instructional approaches on students' academic performance in genetics.

1.4 Objectives of the Study

The objectives of the study are to:

1. Identify the knowledge level of the students in the concept of genetics in biology.
2. Examine the impact of the multimedia instructional approach on the academic performance of students taught using the multimedia and conventional approaches.
3. Examine the difference in academic performance between male and female students treated with the multimedia instructional approach.
4. Determine the perceptions of students on the use of the multimedia instructional approaches.

1.5 Research Questions

1. What is the knowledge level of the control and experimental groups in the concept genetics?
2. What is the difference in performance between control and experimental groups on post-test scores on genetics when they are taught using multimedia and conventional approaches?
3. What is the difference in academic performance on the concept genetics between females and their male counterparts taught using multimedia instructional approach?
4. What are the perceptions of students who have been exposed to multimedia instruction about the approach for teaching and learning genetics?

1.6 Null Hypotheses

Ho1: There is no statistically significant difference between the academic achievement of students of control and experimental groups on pre-test in genetics.

Ho2: There is no statistically significant difference between post-test scores of students taught genetics by a conventional method and those taught genetics by using multimedia technology.

Ho3: There is no statistically significant difference between the academic achievement of male and female students taught by using the multimedia approach.

1.7 Significance of the Study

This research would provide empirical evidence on the impact of the use of multimedia in the teaching and learning of biology. The outcome of the study would motivate biology instructors to incorporate the approach into the teaching and learning of biology which would improve the performance of students in biology. The study would help students to develop a more positive attitude towards the learning of biology, and also improve their performance in biology. Findings would augment the pool of data required by other educational researchers in their bid to design interventions to solve educational problems in the sciences in general and biology in particular.

1.8 Delimitations of the Study

Only one senior high school from the Effutu Municipality was used for the study. Again, the study focused on only second-year students of the selected school in the opted district. The study also focuses on Genetics out of the many concepts in biology.

1.9 Limitations

Absenteeism of some of the students during the period of the study meant that some of the students would not benefit from the intervention that was designed. The results cannot be generalised to the entire region because the sample was from only one district and one school.

1.10 Organisation of the Study Report

The study is organised into six (6) different chapters. Each chapter begins with a brief overview dealing with what the chapter entails followed by the main content of the chapter. In the first chapter, the study presents the background to the study, the statement of the problem, the purpose of the study. The chapter also deals with the research objectives, research questions and significance of the study. The chapter ends with delimitations, limitations, operational definitions of terms and organization of the study. Chapter two deals with the review of the related literature. This covers the topical issues raised in the research questions and the purpose of the study. It ends with a summary of the literature reviewed.

In chapter three, the study focuses on the methodology of the study. It describes the type of research design to be adopted and the rationale for the design. It also consists of sample and sampling procedure, research instruments, data collection procedures and data analysis. The fourth chapter deals with the presentation and analysis of the findings in the study. The fifth chapter discusses the data that have been analysed. The last chapter presents the summary of findings, conclusions, suggestions and recommendations based on the outcome of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter deliberates on the literature relevant to the study. The chapter reviews relevant literature that provides support for the study under the following subheadings: Traditional or conventional Teaching Method, Pros of traditional teaching approach, Cons of the traditional teaching approach, Use of Technology-based Instruction, Multimedia Usage in the Teaching and Learning Process, Effects of Multimedia on Biology Instruction, Multimedia Evaluation Techniques, Gender issues in Multimedia Instruction, Pros of Multimedia Usage in Education, Cons of Multimedia Usage in Education, Comparing traditional and multimedia teaching approaches, Concepts and theoretical findings on Genetics .

2.1 Traditional or Conventional Teaching Method

In Traditional Method of teaching, the instructor is viewed as the pivot in the classroom, responsible for all actions and guaranteeing that all class room message goes through him or the deductive strategy for instructing. Conventional technique is content focus. In this, instructor remains more dynamic, more subjective and less affective (Singh, 2004). Conventional techniques are concerned with the review of true information and mainly disregard higher levels of rational outcomes (Rao, 2001). The traditional teaching technique comprises primarily conveying addresses by the instructors and pupils are mentally dynamic, however, physically sit without moving. Learners might be involved in note taking (Haghighi, Vakil, & Weitba, 2005). In classroom teaching learning sessions, the main physical task done by the students is either note-taking or remaining on the seat to answer any inquiry of the teacher. The teachers are ignorant of the current investigations in the field of dialect educating. The part of instructor inside the class is dictator with the minimum contribution of the learners" (Behlol, 2009, pp.2-3).

Traditional teaching is concerned with the teacher being the controller of the learning environment. Power and responsibility are held by the teacher and they play the role of instructor (in the form of lectures) and decision maker (in regards to curriculum content and specific outcomes). They regard students as having ‗knowledge holes' that need to be filled with information. In short, the traditional teacher views that it is the teacher that causes learning to occur (Novak, 1998). Learning is chiefly associated within the classroom and is often competitive. The lesson's content and delivery are considered to be most important and students master knowledge through drill and practice such as rote learning, Hawkar (2014).

Conventional teaching or traditional teaching as a teaching method involve instructors and the students interacting in a face-to-face manner in the classroom. These instructors initiate discussions in the classroom, and focus exclusively on knowing content in textbooks and notes. Students receive the information passively and reiterate the information memorized in the exams (McCarthy & Anderson, 2000). Technology in education is not something new in today's classrooms, but many education systems are still limited by conventional teaching and learning methods (Laurillard, 2013). Many teachers are still teaching their students in the same manner as how they were taught and how their own teachers were taught, not much of progress in terms of the teaching perspectives (Anglin, & Anglin, 2008). Transformation to less conventional methods of teaching results is in fear and reluctance from teachers, who find the change hard and risky (Chiang, Chapman, & Elder, 2010).

Devinder and Zaitun (2006) noted that many lecturers are still using conventional teaching and have noted that in conventional teaching classrooms, while the lecturer is explaining and writing on the board, students will be copying the same thing onto their notes, some day-dreaming and some sleeping. It would be difficult to stop students from copying the notes from the board and at the same time ensured that every student was paying attention in the class because the lecturer was too busy explaining the lecture. Conventional teaching is also limiting the room for more creative thinking and also seldom considering individual differences. It is necessary to realize these limitations in conventional teaching and take a step to move forward.

2.1.1 Pros of traditional teaching approach:

Total participation: According to Abidoye (2015), students will have direct contact with teachers and will be able to ask questions or receive additional explanations on topics they don't grasp, boosting active learning.

Face-to-face interaction: Students can easily hold face-to-face interactions with their classmates and work on challenging tasks in groups (Mayer, 2001).

Traditional methods have a set timetable that must be adhered to by all students. Knoll, Otabi and Van Horn (2017) asserted that this aids in the preparation of pupils for future duties.

2.1.2 Cons of the traditional teaching approach

Traveling costs: Using the traditional education system according to Calsmith (2007) is more costly due to the increased expense of commuting to school and also seeking for housing inside the school setting.

Study hours are not flexible: Due to the tight timetables of traditional SHS and universities, those who work may find it impossible to study. Ahmed and Abimbola

(2011) inferred that the application of new methods can help students overcome their difficulties. Students have less time to pursue other projects because they must organize their daily tasks according to the class attendance schedule, which leaves them with less time to pursue other tasks.

Lack of motivation: Students may believe that traditional educational systems deny them the opportunity to exhibit their interests and skills. They see going to school as a chore they must fulfil rather than something they enjoy (Cimermanova, 2018).

According to Hawkar (2014), students in traditional institutions just absorb the knowledge delivered in class thereby becoming passive listeners. Students are expected to listen to their teachers, yet due to a lack of interest in the lecturer, they can become passive listeners.

2.2 Use of Technology-based Instruction

According to Aloraini (2012), overcrowding, over-knowledge, education philosophy growth, and the changing role of the teacher, as well as the rise of illiteracy, a lack of staff, and technical improvements and mass media, all pose problems to education in modern times.

This prompted educators to employ modern teaching technologies to address some of the most pressing issues confronting education and its productivity, such as raising the learning level, which can be accomplished by providing equal opportunities for all people, whenever and wherever they are, while taking into account individual differences among students (Wilkinson, 1986).

The Chalk and talk method of teaching which involve too much conversation in teaching has lost its efficacy and reduced students' interest in the teaching and learning process. From online free teaching, it was stated that the advancement in instructional and has strongly influenced the field of education. It was discovered that teaching and learning are being influenced by a numerous media such as the interaction between the students and programmed instruction that give room for manipulation which might not be possible by using any other medium. Students can learn new information due to multimedia provision of easiness and facilities in education. Semerci and Keser (1999) expressed the fact that the message via multimedia reaches the receivers in various ways, this provides an enabled learning environment. The subjects being taught could be transmitted to the students with web-based audio, visuals, video and animations in a way that might not be taught in classrooms with other techniques. Students can gain the knowledge and information that would not be able to get from other ways of teaching, besides students could have the opportunity to prepare their products with multimedia techniques. With that information, it could be asserted that the use of multimedia helps students with different skills and learning styles.

The impact of the use of multimedia on students‘ learning is two folds: the enormous and easy availability of textual and audio visual content to be used for teaching can make lessons completer and more attractive; then self-production of content that information and communication technology offer can help teachers customize the teaching more effectively. In an evaluation of the ―Laptops for teachers" program of the British Government (2004-2007), teachers who had been equipped with a laptop reported having extended their capacity to access resources and save time for lesson planning and preparation. The use of multimedia might affect education positively when designed properly compared to traditional instruction in terms of academic achievement. By considering the facts gathered from the literature, it could be asserted that multimedia apart from the ease and objectified learning, it makes the learner active and every one of them contribute their quota and makes the learning of mathematics more interesting.

Harris and West (1993) stated that multimedia programs are an efficient and effective means of training for technical skill and conceptual development. They indicated that by using multimedia programs, trainers could save time, increase retention, and increase the motivation of learners by involving them in the learning process. Harris and Cannon (1995) also pointed out that an instruction format should be reviewed carefully from the perspective of the individuals being educated, because the format affected their involvement in the instruction session, and their motivation and commitment to learning.

A significant number of emerging educational technologies derived changes in the delivery of the entire curriculum. Kasavana (1993), for example, urged that some portion of hospitality curricula would be taught with several emerging technologies: distance learning, virtual reality, simulation, and audio graphics. These technologies ultimately increased learners‘ retention by facilitating more active learning environments (Astin, 1985, as cited in Feinstein, Raab & Stefanelli, 2005b).

2.3 Multimedia Usage in the Teaching and Learning Process

Multimedia has been defined in a variety of ways. For example, Mayer (2001) defined it as the presentation of learning media employing both graphical and verbal forms such as spoken and printed materials. Multimedia is having an impact on the educational environment around the world, and it has been labelled as a tool that can improve effective and efficient teaching and learning. However, while it is increasingly employed in computer-based narrated animations in many industrialized countries, observations have indicated that it is not widely used in developing countries.

Multimedia, according to Khasawneh (2009), is the "design, implementation, manipulation, storing, and proper delivery of various types of media to interested users‘‘. Mukherjee (2018) emphasized that multimedia should be interactive and controllable by the user.

The concept of multimedia came into existence in the early 1990s (Abdulrahaman, Faruk, Oloyede, Surajudeen-Bakinde, Olawoyin, Mejabi & Azeez, 2020). Multimedia also refers to computer media. Multimedia is the integration of multiple forms of media. This includes text, graphics, audio, video, etc. For example, a presentation involving audio and video clips would be considered a ‗multimedia presentation.' Educational software that involves animations, sound, and text is called ‗multimedia software'. As the information is presented in various formats, multimedia enhances the user experience and makes it easier and faster to grasp. The old days of an educational institution having an isolated audio-visual department are long gone! The growth in the use of multimedia within the education sector has accelerated in recent years and looks set for continued expansion in the future (Abdulrahaman *et al.*, 2020).

Teachers primarily require access to learning resources, which can support concept development by learners in a variety of ways to meet individual learning needs. The development of multimedia technologies for learning offers new ways in which learning can take place in schools as well as at home. Teachers have access to multimedia learning resources, which support constructive concept development, allowing the teacher to focus more on being a facilitator in learning while working with individual students. Due to advances in computers and electronic media, the potential for quality education has been elevated with the appearance of innovative instructional methods employing multimedia equipment and resources (Abdulrahaman *et al.*, 2020). The multimedia approach to teaching and learning has become standard form of education.

The classroom has become digital and is called s smart class. Smart class is a comprehensive solution designed to assist teachers in private schools in meeting day to day classroom challenges and enhancing students‘ academic performance with simple, practical and meaningful use of technology. It also enables teachers to instantly assess and evaluate the learning achieved by their students in class. Smart class is powered by a vast repository of digital instructional materials exactly mapped to meet the specific objectives laid out by different state learning standards. The content repository consists of thousands of highly animated, lesson specific, 2D and 3D multimedia modules built with an instructor-led design that allows the teacher to effectively transact the lesson in a typical classroom of a diverse set of learners. Educational videos from Eureka and Discovery channel are available for teachers to use in the classroom.

The modules are embedded in a template that allows the teachers to teach a chosen lesson in class, frame by frame, with an engaging and interactive sound animated set of visuals while retaining complete control on the pace of delivery. The Smart Class Multimedia System helps in establishing an easy yet effective control and communications system for teachers in the computer lab and ensures that teachers have uninterrupted quality time with students while dealing with learning concepts. This solution will enrich teaching methods with modern technology and introduce the children to a wealth of information and interactive learning techniques to improve the overall education experience.

Many research has been conducted in Ghana as well as aboard, in the area of multimedia. Acha (2009), Jadal (2011), Kumar (2011) and others have conducted research by using multimedia in the teaching of English and found positive results. Ellaisamy (2007) also conducted a study by using the multimedia approach to teach Science and found that teaching through multimedia is effective. Many experiments have been done in various subject areas to date to find the effectiveness of multimedia in teaching.

Past studies are necessary in order to provide certain scientific data that are relevant to the study. Many academicians were interested in determining the impact of multimedia use on students' academic achievement and attitudes.

Some of the well-known studies are listed below.

Hong, Thong, Wong and Tam (2001) assert in their research which was conducted to determine the impact of multimedia software on students' academic accomplishment in key astrology concepts, as well as their capacity to learn complex and basic problem-solving abilities. The study sample comprised of 238 ninth-grade students who were interested in astrology and studied in a practical class near Austin City.

The study sample was haphazardly divided into two groups: one is experimental, in which students studied using educational software (named The Astrological Village), which attempts to educate them the basic concepts of astrology while also presenting some of the current astrological issues. Pre and post tests were created, and the research was based on the study hypothesis testing. The findings revealed the following: Statistically significant disparities between the average marks of the experimental and control groups' achievement in favour of the experimental group. It was clear that (The Astrological Village) software is a useful tool for pupils to develop problem-solving skills as they learn to apply problem-solving techniques to new similar surroundings and scenarios.

Atawaim (2000) conducted a study titled "The Effect of Using Computer in the Arabic Language Curriculum on 6th Grade Primary Students." The purpose of this study is to see how using a computer as an instructional tool affects students' academic progress in Arabic grammar, which is taught to 6th grade primary students in Riyadh. The study sample consisted of 30 students in an experimental group who studied using a computer and 30 students in a control group who studied using the traditional approach. The study found substantial statistical differences in students' average academic achievement in the level of remembrance between the two groups, but no significant statistical differences in the level of academic achievement and application, or the total test level.

The effect of employing a computer as an instructional instrument in teaching statistics curriculum on the development of statistical skills among third-grade commercial secondary school students was the subject of Salem's study (2000). The purpose of this study was to determine the impact of employing a computer as an instructional instrument in teaching statistics curriculum on the development of statistical skills among third-grade commercial secondary school students in Egypt's Arab Republic. 30 students in the experimental group and 30 students in the control group participated in the study.

The experimental group received computer-assisted instruction, while the control group received traditional instruction. The results of the investigation revealed significant statistical disparities between the experimental and control groups' average grades.

The study "The effectiveness of multimedia software to teach Geometry in the second grade of preparatory schools" by Abu Yunis (2005) sought to determine how much multimedia software aids in the academic accomplishment of preparatory school pupils in the topic of Geometry and its recollection. The experimental study sample consisted of 300 male and female students who were separated into two experimental and control groups, each with 150 male and female students. The experimental group was taught using a multimedia software package that contained content from the Syrian Arab Republic's Ministry of Education's Geometry unit. The findings of the test done following the intervention revealed significant statistical differences in the average academic achievement of the experimental and control groups.

Obaid (2001) did a study named "A program using multimedia packs to enhance the requisite competency of the high school mathematics head teacher". The goal of this study is to determine the efficacy of a program that uses multimedia bags to create 41 necessary educational competences for the mathematics head teacher in a high school in the Arab Republic of Egypt. The experiment was carried out on a single experimental group of 30 resident mathematics principals. Before and after the test, the children were given an academic achievement test. The study's findings revealed significant statistical differences between pre and post testing, with the post-test coming out on top.

Nasr (2005) conducted research into the "Effectiveness of using multimedia computer technology in teaching Geometry to third preparatory grade children on academic achievement and the development of innovative thinking". The researcher used an experimental method based on the creation of two equal groups: one experimental group that studied the two units of the proposed program that is based on interactive multimedia technology in the "Unit of the Circle" in Geometry book taught to third preparatory grade students, and the other control group that taught the same content using traditional methods. Before the trial, each group was given an academic achievement test as well as an inventive thinking test. They were likewise divided into two groups. As a result of the research, the following conclusions were reached:

Due to the pattern of the program used, which is based on interactive multimedia technology, there are statistically significant differences between the average grades of the two study groups (experimental and control groups) at the level of academic achievement in Geometry at a significance level of 0.01 in favour of the experimental group. Most of the results show positive outcomes, with students being enthusiastic about new methods of learning. Most of the experiments suggest that the multimedia approach to teaching is more effective than the traditional approach to teaching. Taking the findings of such experiments into account, many schools have also started using the multimedia approach to teaching in their classrooms.

As multimedia teaching technologies become more widely advocated and employed in education, researchers strive to understand the influence of such technologies on student learning. Advances in technology enable pedagogical enhancements that some belief can revolutionize traditional methods of teaching and learning. When viewed collectively, these studies reported that advanced technologies, especially multimedia instruction, which often involves introducing or enhancing the visual aspects of the presentation of course contents, created an active learning environment, improved students' performance, fostered positive attitudes toward learning complex concepts, increased communication and could be adapted to all learning styles and levels of instruction. Researchers suggest that compared to classes with a traditional teacher-leading approach, those using multimedia are better liked by students and yield slight but statistically significant improvements in student learning as measured by both student self-report and objective outcome testing (Abdulrahaman *et al.*, 2020). Such encouraging findings have precipitated the adoption of these technologies on a widespread basis. Therefore, there is a need to further educators' understanding of the effect of multimedia technologies on students' learning quality.

The combined outcomes of the majority of studies across disciplines indicated that multimedia-based delivery systems offered ways to optimize the advantages and minimize the disadvantages of traditional methods of teaching and learning. These are expected to be true in biology. Biology laboratories are designed to help students understand the basic concepts and their applications by experiments, collecting specimens, using specimens to know the parts and functions, and drawing and writing a laboratory report. Many factors such as the time limit for setting up, the unavailability of specimens in the traditional laboratories. However, the disadvantages elicited by these factors can be addressed with the use of multimedia-based delivery systems.

2.4 Effects of Multimedia on Biology Instruction

Biology occupies a unique position in the school curriculum. Biology is central to many sciences related courses such as medicine, pharmacy, agriculture, nursing, biochemistry, genetics and so on. No student intending to study these disciplines can do without Biology. These factors, among others, have drawn the attention of researchers and curriculum planners towards Biology as a subject in the school curriculum (Kareem, 2003). Despite of the importance and popularity of Biology among students, performance at the secondary school level had been poor (Ahmed, 2008). The desire to know the causes of the poor performance in Biology has been the focus of researchers for some time now. It has been observed that poor performance in the sciences is caused by the poor quality of science teachers, overcrowded classrooms, and lack of suitable and adequate science equipment, among others (Yusuf & Afolabi, 2010).

Students perform poorly in Biology because the biology classes are usually too large and heterogeneous in terms of ability level. In addition, the laboratories are ill-equipped and the biology syllabus is overloaded (Ahmed, 2008; Ajayi, 1998). As multimedia teaching technologies become more widely advocated and employed in education, researchers strive to understand the influence of such technologies on student learning. Advances in technology enable pedagogical enhancements that some belief can revolutionize traditional methods of teaching and learning (Gatlin-Watts, Arn, Kordsmeier, 1999; Persin, 2002). Studies of multimedia-based instruction report a variety of outcomes.

When viewed collectively, these studies reported that advanced technologies, especially multimedia instruction, which often involves introducing or enhancing the visual aspects of the presentation of course contents, created an active learning environment, improved students' performance, fostered positive attitudes toward learning complex concepts, increased communication, and could be adapted to all learning styles and levels of instruction (Harris, 2002). Researchers suggest that, compared to classes with a traditional teacher-leading approach, those using multimedia are better liked by students and yield slight but statistically significant improvements in student learning as measured by both student self-report and objective outcome testing , the majority of experimental investigations emphasize the effective use of multimedia as a facilitating approach, which aids in the delivery of instructional information to students and has a beneficial role in enhancing the general trend toward the use of computers in education. Multimedia has a positive impact on cognitive, academic, understanding, and application outcomes. The current study is an attempt to back up earlier research that has used the experimental approach to investigate factors (Dimitrov, McGee, & Howard, 2002; Feeg, Bashatah, & Langley, 2005). Such encouraging findings have precipitated the adoption of these technologies on a widespread basis.

Despite many studies suggesting that multimedia instruction benefits students, some found no significant differences between multimedia classes and traditional classes (Everhart, Harshaw, Everhart, Kernodle, & Stubblefield, 2002; Homer, Susskind, Alpert, Owusu, Schneider, Rappaport & Ruben, 2000). Therefore, there is a need to further educators' understanding of the effect of multimedia technologies on students' learning quality. Thus, to ascertain the effectiveness of Multimedia it would be reasonable to compare it with classroom instruction (Rusanganwa, 2013). Several studies (cited in Najjar, 1998) have been conducted in the area to ascertain the effectiveness of multimedia instruction. Analysis has been done by examining over 200 studies (Najjar, 1998). The information included sciences, foreign languages and electronics. The control group normally learnt the information via classroom or lecture combined with hands-on experiments. The comparison group learnt information via interactive video discs or computer-based instruction. The achievement of learning was measured via tests taken at the end of the lessons. Over this wide range of students, meta-analysis found that learning was higher when computer-based education was used. Learning also appeared to take less time when multimedia instruction was used.

2.5 Gender Issues and Multimedia Instruction

The world of today promotes gender equity by improving access to education especially to females through girl-child education programmes. Gender gap exists in education in sub-Saharan Africa, and out-of-school children, more of whom are girls, are deprived of any opportunity to gain ICT related knowledge and skill in school. African girls have the lowest enrolment rates in the world of science and technology education at all levels. Studies had established that females tend to be less interested in computers and use them less often in their spare time (Schaumburg, 2001). A study conducted in four African countries identified that while in principle, girls are given the same opportunity as boys to access the computer, gender equity does not exist in practice. It established that girls are less confident than boys in their computer skills, and that some international studies have found that boys scored better than girls in computer-related knowledge and skills in the vast majority of countries.

In addition, the three-computer related occupation (computer scientists, computer engineers and system analysts, and computer science and engineering) are the top career choices for boys (Derbyshire, 2008). The findings of Idowu, Ogunmodede and Idowu (2003) in their study of gender differences in computer literacy showed that there is a gender difference in computer study and experience. Tomte and Hatlevik (2011) pointed out factors such as access to the use of the internet, community, parents‛ influence, peer influence, social media, gaming, are responsible for the difference in gender in the use of ICT.

Abdul-Raheem (2012) found no significant difference in the achievement of male and female students in mathematics. Contrary to the findings of Schumacher and Martin (2001) showing that female is less experienced with ICTs and are more likely than males to have negative attitudes towards computers. Furthermore, more male students prefer to study courses that require computer use more than female students and they show interest in programming and games playing. They were also more experience at the ICT‛s use than girls, apart from e-mails where no significant differences were reported. Moreover, Colley and Comber (2003) in their study on age and gender difference in computer use and attitudes among secondary school students found out that boys have a higher frequency of use of computers than girls.

The study carried out by Anyamene, Nwokolo, Anyachebelu and Anemelu (2012) on the effect of Computer Assisted Instruction (CAI) packages on the performance of senior secondary students in mathematics, history and physics respectively revealed that no significant difference exists in the post-test performance scores of male and female students taught using this package. The findings of Soule, Shell and Kleen (2003) suggested that male college student internet users spend more time online than female college student internet users. Jackson (2007) emphasized that ―masculinist ideologies of mastery and control" have strongly and consistently informed technological innovation.

2.6 Multimedia Evaluation Techniques

Evaluation entails assessing whether a multimedia programme fulfils the purposes set including being useful for its target audience. Kennedy and Judd (2007) make the point that developers of multimedia tools have expectations about the way they will be used which could be functional (focused on the interface) or educational (involving the learning designs, processes and outcomes). It is important to note that there are different methods used in the evaluation of multimedia and most evaluations entail experiments, comparisons and surveys. The primary goal is to balance assessment validity with the efficiency of the evaluation process (Mayer, 2005).

Survey research has two common key features – questionnaires (or interviews) and sampling, and is ideally suited for collecting data from a population that is too large to observe directly and is economical in terms of researcher time, cost and effort when compared to experimental research. However, survey research is subject to biases from the questionnaire design and sampling including non-response, social desirability and recall and may not allow researchers to have an in-depth understanding of the underlying reasons for respondent behaviour (West, 2019; Kelley, Clark, Brown & Sitzia, 2003). Generally, comparison studies follow the format of comparing outcomes from an experimental group using the multimedia being evaluated against a control group. This method has been criticized for having inadequate treatment definition, not specifying all treatment dimensions and failure to measure treatment implementation, among others (Yildiz & Atkins, 1993).

Faced with the subjective nature of surveys and the limitations from comparison studies, eye tracking and other student behaviour such as emotional response, provides information not consciously controlled by the student or researcher and is used as an objective data-gathering technique. Eye-tracking research is a multi-disciplinary field that tracks eye movements in response to visual stimuli (Horsley, Eliot, Knight & Reilly, 2014). Data from eye-tracking allows researchers to validate empirically and objectively, how learners comprehend the multimedia content, the attention of the learner while analysing the multimedia content, and the cognitive demand of the content (Molina, Navarro, Ortega & Lacruz, 2018). Eye-tracking is quite interesting as it provides a useful source of information in the case of children. This is because gathering information using the traditional techniques is more difficult especially when it involves children's interests and preferences (Molina et al., 2018).

Earlier attempts at analysing student behaviour while engaging with online material included analysing student access computer logs, and the frequency of participation and duration of participation (Morris, Finnegan & Wu, 2005). Nie and Zhe (2020) demonstrated that the conventional method of manually analysing student behaviour is gradually becoming less effective compared to online classroom visual tracking.

They found that the online classroom visual tracking behaviour can be divided into several components: selection, presentation, mapping, analysis and collection, as well as the analysis from students' facial expressions.

Several works exist that use student behaviour tracking to examine how students interact with multimedia learning tools. For instance, Agulla, Rúa, Castro, Jimenez and Rifon (2009), incorporated in a learning management system (LMS), student behaviour tracking that provided information on how much time the student spent in front of the computer examining the contents. They did so through the use of face tracking, fingerprint and speaker verification. Alemdag and Cagiltay (2018) conducted a systematic review of eye-tracking research on multimedia learning and found that while this research method was on the rise it was mainly used to understand the effects of multimedia use among higher education students. They also identified that although eye movements were linked to how students select, organise and integrate information presented through multimedia technologies, metacognition and emotions were rarely investigated with eye movements.

Molina et al. (2018) used eye-tracking in evaluating multimedia use by primary school children. Some studies have used a combination of eye-tracking data and verbal data to gain insight into the learners' cognitions during learning and how they perceived the learning material (Stark, Brünken, & Park, 2018). As much as eye-tracking and other behavioural research present opportunities for objective evaluation, the difficulty of interpretation is one of the limitations of eye-movement data (Miller, 2015), and it is not surprising that the traditional methods of evaluation through questionnaire administration and surveys are still commonly used.

2.7 Conceptual Framework of the Study

When students are exposed to confusing or complex concepts, they are thrown into a state of disequilibrium (Ayittey, 2015). Multimedia instructional packages, however, seems to enable students to develop cognitive structures or mental models or reorganise their already existing ones to better understand confusing and complex concepts in biology and other subjects.(Von Glasersfeld, 1993; Yeboah, 2010; Ayittey, 2015), have noted that the constructivists' position that students should have access to multiple viewpoints and representations of information is partially satisfied by well-constructed simulations and other multimedia packages. Ramasundarm, Grunwald, Mangeot, Comerford and Bliss (2005) and Cholmsky (2003) have also observed that simulations have the potential to make learning of confusing and complex or difficult concepts more interactive, authentic, and meaningful. Computer simulations and multimedia instructional packages, therefore, seem to give students experiences that facilitate conceptual development leading to increased understanding of difficult concepts.

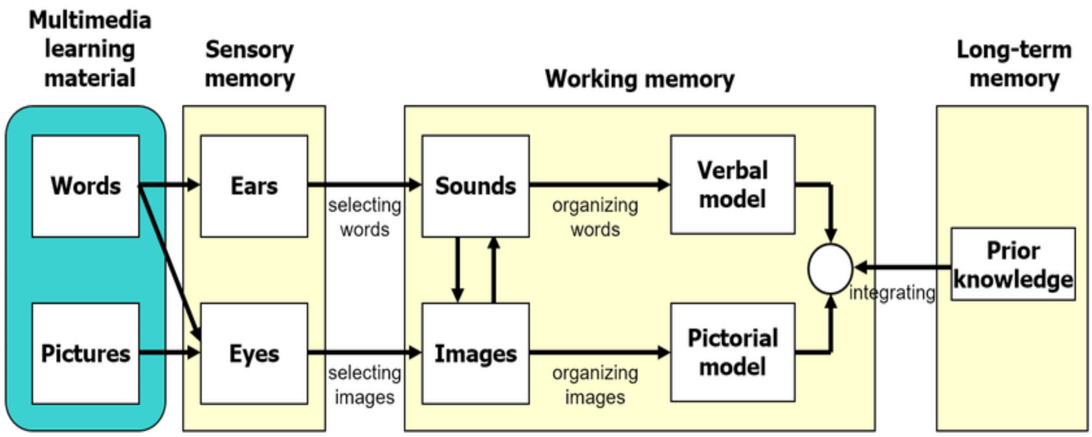

Figure 1: Framework of Multimedia Instruction (source: Mayer, 2001).

2.8 Theoretical Framework of the Study

The cognitive theory of multimedia learning which was popularised by the work of Richard E. Mayer and other cognitive researchers is what forms the basis for the theoretical framework of this study. They argue that multimedia supports the way that the human brain learns (Mayer, 2005; Ayittey, 2015). They assert that people learn more deeply from words and pictures than from words alone, which is referred to as the multimedia principle (Mayer, 2005; Ayittey, 2015). Multimedia researchers generally define multimedia as the combination of text and pictures; and suggest that multimedia learning occurs when we build mental representations from these words and pictures (Mayer, 2005; Ayittey, 2015). The words can be spoken or written, and the pictures can be any form of graphical imagery including illustrations, photos, animations, or videos. Multimedia instructional design attempts to use cognitive research to combine words and pictures in ways that maximize learning effectiveness.

The theoretical foundation for the cognitive theory of multimedia learning (CTML) draws from several cognitive theories including Baddeley‘s model of working memory, Paivio‘s dual coding theory, and Sweller‘s Theory of Cognitive Load. As a cognitive theory of learning, it falls under the larger framework of cognitive science and the information-processing model of cognition. The information processing model suggests several information stores (memory) that are governed by processes that convert stimuli to information (Moore, Burton & Myers, 2004). Cognitive science studies the nature of the brain and how it learns by drawing from research in some areas including psychology, neuroscience, artificial intelligence, computer science, linguistics, philosophy, and biology (Ayittey, 2015). The term cognitive refers to perceiving and knowing. Cognitive scientists seek to understand mental processes such as perceiving, thinking, remembering, understanding language, and learning

(Stillings, Weisler, Chase, Feinstein, Garfield, & Rissland, 1995). As such, cognitive science can provide powerful insight into human nature, and, more importantly, the potential of humans to develop more efficient methods using instructional technology (Sorden, 2005). The cognitive theory of multimedia learning (CTML) centres on the idea that learners attempt to build meaningful connections between words and pictures and that they learn more deeply than they could have with words or pictures alone (Mayer, 2009). According to CTML, one of the principals aims of multimedia instruction is to encourage the learner to build a coherent mental representation from the presented material. The learner‘s job is to make sense of the presented material as an active participant, ultimately constructing new knowledge.

According to Moreno and Mayer (2000) and Mayer (2003), CTML is based on three assumptions: the dual-channel assumption, the limited capacity assumption, and the active processing assumption. The dual-channel assumption is that working memory has auditory and visual channels based on Baddeley‘s (1986) theory of working memory and Paivio‘s (1986) Clark and Paivio‘s (1991) dual coding theory. Second, the limited capacity assumption is based on cognitive load theory (Sweller, 1994) and states that each subsystem of working memory has a limited capacity. The third assumption is the active processing assumption which suggests that people construct knowledge in meaningful ways when they pay attention to the relevant material, organize it into a coherent mental structure, and integrate it with their prior knowledge (Mayer, 1999).

Multimedia is a term frequently heard and discussed among educational technologists today. Unless clearly defined, the term can alternately mean a judicious mix of various mass media such as print, audio and video or it may mean the development of computer-based hardware and software packages produced on a mass scale and yet allow individualized use and learning. In essence, multimedia merges multiple levels of learning into an educational tool that allows for diversity in curricula presentation. Multimedia is the exciting combination of computer hardware and software that allows you to integrate video, animation, audio, graphics, and test resources to develop effective presentations on an affordable desktop computer (Fenrich, 1997).

Multimedia is characterized by the presence of text, pictures, sound, animation and video; some or all of which are organized into some coherent program (Phillips, 1997). Today's multimedia is a carefully woven combination of text, graphic art, sound, animation, and video elements. When you allow an end-user, i.e., the viewer of a multimedia project, to control 'what' and 'when' and 'how' of the elements that are delivered and presented, it becomes interactive multimedia. As such, multimedia can be defined as an integration of multiple media elements (audio, video, graphics, text, animation etc.) into one synergetic and symbiotic whole that results in more benefits for the end-user than any one of the media elements can provide individually. Besides being a powerful tool for making presentations, multimedia offers unique advantages in the field of education. Multimedia enables teachers to provide a way by which learners can experience their subject vicariously. The key to providing this experience is having simultaneous graphic, video and audio, rather than in a sequential manner. The appeal of multimedia learning is best illustrated by the popularity of the video games currently available in the market. These are multimedia programs combining text, audio, video, and animated graphics in an easy-to-use fashion. With multimedia, the process of learning can become more goal-oriented, more participatory, and flexible in time and space, unaffected by distances and tailored to individual learning styles, and increase collaboration between teachers and students. Multimedia enables learning to become fun and friendly, without fear of inadequacies or failure.

It is possible to say that the introduction of multimedia into the classroom has a profound impact on styles of teaching and learning (Slack, 1999). Students are seen to be more motivated when using multimedia, which one teacher described as ‗using the multimedia ―hook". According to Slack (1999), teachers have stated that multimedia enables students to work at a different pace, and some packages can be tailored to student needs. Teachers have also suggested that they regard students as learning co-operatively when multimedia is used. The teacher becomes a facilitator, problem setter and guides as opposed to taking a central role.

2.9.1 Pros of Multimedia Usage in Education

Education implies the empowerment of the learners with the intellectual tools of their culture. In many cultures, multimedia can be seen as an important intellectual tool. Multimedia, according to a study conducted by Aloraini (2012), is one of the best instructional strategies since it addresses more than one sense at the same time, as it does with the senses of sight and hearing.

The following are some of the advantages of multimedia teaching approaches:

- Presenting various sketches and photos helps to clarify concepts and communicate information.
- Moving seamlessly from one topic to the next allows for plenty of opportunities for questions and conversations.
- According to Aloraini (2012), using various presentations, such as video clips in conjunction with other images or other types of presentations, helps to bring the information closer to reality. The addition of music clarifies the concept and draws the learners' attention to what is being taught

- They increase student engagement and interaction with the educational content. (Qandeel, 1998)
- They give teachers a fresh way of teaching and stimulate inquiry and curiosity in students (Holsinger, 1995).
- According to Alfar (2009), they assist students in remembering and transferring information easily.

Multimedia as an instructional approach seems too powerful is mainly used for the following as opined by Andresen and van den Brink (2013):

- Communicating ideas and information representation;
- Handling information;
- Modelling;
- Measurement and control.

These four aspects should support a certain level of conceptual understanding as well as genuine creative productions. Using multimedia as a powerful cultural tool the learner has the opportunity to look into a certain subject and gain new insights.

1) Communicating ideas and information representation. For communicating information, it is necessary to develop, organize, structure, and store ideas in visual and oral forms by desktop publishing.

2) Handling information. Multimedia provides many possibilities for handling information. Information handling software can search, sort and represent information in graphs and charts, and it can deal with a broad range of media including pictures and sounds. On the elementary level, databases in the manner of a card-index archive can be used.

3) Modelling. Multimedia-based modelling provides support in learning to handle abstract concepts, especially subject matters such as physics, mathematics and biology – all science subjects can use multimedia modelling very effectively. At the elementary level, spreadsheets are a useful tool, which presents rows and columns in the form of a table. The software calculates and recalculates data automatically and therefore, the learner can concentrate on the presented scientific concepts and does not waste time on calculating. ‗Spreadsheets enable learners to operate a high level of abstraction in setting up the model and understanding how a table with changing numbers represents a system in the natural world' (Davis, Desforge, Jessels, Somekh, Taylor, & Vaughan, 2004). Simulations and, more specifically, modelling tools, are generated by spreadsheets. Here, the learner can interact with the model by controlling factors, which will have an impact on the program. One limiting aspect is the fact that simulations can only represent a rule-governed system and are not able to handle unpredictable factors. However, the modelling demands the learner's critical confrontation within one's limits. Then, the simulation might stimulate the understanding of the presented model and this decreases the possibility of misunderstanding. Modelling provides many possibilities for ‗What if?' questions such as ‗What if gravity was zero?' Cognitive tools are a special form of modelling. The term ‗cognitive tools' is used when the software application provides an opportunity for constructing knowledge by the user through direct manipulation. Jonassen (1992) defines cognitive tools as mind tools or problem exploration tools. According to him, the true potential of hypertext structures may lie in their capacity as a study aid or a cognitive learning tool. ‗A cognitive learning tool is any activity (that may or may not be supported by computers) that fosters or facilitates a deeper or more meaningful level of information processing in learners... the act of creating the

systems engages the learner in a level of analysis and depth of learning that is not elicited by other instructional or learning strategies.

4) Measurement and control. Multimedia can be used for demonstrating complicated processes such as the human circulatory system or the weather system (cloud development). Furthermore, the learner can use the multimedia to take many more accurate measurements and explore creatively a phenomenon and consider additional factors than would otherwise have been possible. The learner can understand complex interrelationships. He or she can control the learning process.

The classroom situation in which educational multimedia instructions are used, provides opportunities for self-regulation and autonomous activities, for high learner control with the programs and others, and multi-perspective presentations of content corresponding to the programs (Andresen & van den Brink, 2012). Teachers can support pupils in this situation by counselling on the use of adequate strategies, and by showing them the possibility of more than one perspective, etc. The use of educational multimedia applications that provide characters with which pupils can identify themselves – of the same sex, age, race and religion – can be supportive (Andresen & van den Brink, 2013). The content should be based on life themes, which are important to learners and depict intense action and feeling. The design should be user-friendly, well-structured and appropriate to the target group. The use of productive tools, where learners actively create an engaging platform for knowledge representation or communication, improves learners' motivation if the teacher provides appropriate and continuous support to them (Andresen et al, 2012).

Multimedia also encourages active learning. Active learning is one of the most crucial requirements of current learning theories. Active learning means to be engaged actively within the learning processes as an active agent and not just as a passive learner digesting what teachers provide. Over three decades, the teaching and learning processes in schools have changed: learners gain more and more control over their learning processes and activities; teachers turn into facilitators of learning, leaving their role of the only knowledgeable ones, behind (Merill, 1980). Multimedia in classroom situations provides learners and course trainers with a learning environment within which the learners are allowed to learn actively. Many studies have suggested that high learner control over the learning process within multimedia instruction is associated with qualitatively better learning. This allows the student to study course material at a speed that suits his/her needs which helps to improve their knowledge retention. According to Gagné (1970), the learner‘s control of the pace of instruction provides the learner with the opportunity to encode information. When the learners control the content and the order in which the content is presented, motivation and learning are increasing. According to Keller (1983), the learning process becomes more relevant to the learner, if he can control the learning process.

Furthermore, the ability to provide feedback tailored to the needs of students distinguishes the interactive multimedia from any other media without a human presence. However, many aspects need to be taken into account when using multimedia in education. Even though multimedia is offered worldwide, access to learning materials and computing equipment differs from country to country. The use of multimedia by students needs to be supported by very skilled teachers. They must guide students through the learning process and provide them with appropriate and effective learning strategies. Like the use of textbooks, the use of educational multimedia fosters teaching strategies, where the teacher‘s role is not just that of information provider but one of a guide, supporter and facilitator. Multimedia offers a variety of media usually combined in a meaningful manner. This allows using the computer for the presentation of ideas in different ways, including through images, including scanned photographs, drawings, maps and slides; Sounds, e.g., recordings of voice, noise and music; Video, including complex procedures and ‗talking heads'; Animation and simulations; Discussions among learners (social networks, online discussions, blogs, etc.). Often, presentations supported by attractive images or animations are visually more appealing than static texts, and they can support the appearance of emotions to complement the information presented. Multimedia can appeal to many types of learning preferences – some students profit more from learning by reading, some by hearing and some by watching, etc. In addition, the use of multimedia allows for different ways of working – students can decide on their own how to explore the materials as well as how to use interactive and collaborative tools.

For deaf students, the visual presentation of content improves their motivation to learn (Andresen & van den Brink, 2013). The computer can noticeably improve student access to information. Such delivery platforms as the World Wide Web provide 24-hour access to information. Moreover, it is relatively easy to update web-based educational materials, i.e., to change the design, content, instruction methods, etc.

2.9.2 Cons of Multimedia Usage in Education

Although there are enormous advantages of the use of multimedia on students' academic achievement, it is not without disadvantages.

- Overuse of multimedia in the classroom

According to Cyril (2016) Some teachers believe that computer-assisted instruction is a must-have instrument for modernizing education and reforming the teaching model.

As a result, regardless of the real requirement, teachers use computers from the beginning to the end of class, transforming the old teaching model from cramming education to cramming electronic model (Anderson, 2010)

On the contrary, Patel (2013) stated that according to educational psychologists, excessive use of computer-aided instruction in the classroom may divert students' attention; the more unintended attention of students, the greater the disruption in the teaching information transmission process; this is of no use to the students in receiving information.

- Ignore the Course Content's Specifics

The use of a multimedia device as emphasized by Sahalu (2008), can make a statement of knowledge more apparent, imaginable, and thorough; yet, this can lead teachers to believe that extra explanations, examples, and conclusions are unnecessary given the multimedia's extensive, systematic, and detailed information.

In fact, multimedia courseware cannot explicitly and vividly explain definition, theorem, problem calculation procedure, calculation method, and technique (Slack, 1999).

In general, if only the basic topic of the lesson is delivered, the teacher cannot be substituted for the specific content illustration.

Amanso and Bassey (2017) infer that student have a general comprehension of the topic through courseware, but without a deep understanding of the crucial, challenging aspects, there is no question that they will struggle.

- Ignore the students' subjectivity

According to Oghenevwede (2019) in teaching activities, teachers take the lead, but students are the centre of attention in cognitive activities. The teaching process is a teaching environment in which according to Abdul-Majid (2002), teachers and students interact and affect one another, resulting in the development of cognitive activity. Although multimedia can provide a wealth of multimedia information and is superior to traditional teaching methods in terms of information transmission, it cannot fulfil emotional teaching objectives or replace traditional teaching. Multimedia teaching dulls the classroom atmosphere, lacks emotion interaction, and does not engage students in self-directed learning, so teaching effectiveness cannot be guaranteed (Alfar, 2009).

Ayittey (2015) also pointed out the following as disadvantages of multimedia usage in education.

Self-regulated learning: Some learners are not able to handle the freedom provided by hypertext-based multimedia. Distraction: Often, confusing presentations of the material can cause distraction due to conflicting messages. Non-linear structured multimedia allows the user to follow the supplied links, which can distract from the topic to be learned. The massive amount of information provided by multimedia applications may distract our attention during learning. The human short-term memory is limited; usually, it can hold around 7 pieces of information. When several media are presented at the same time, the learner can only concentrate on some of them and ignore others. This could result in ignoring important information. Human beings cannot use all channels available simultaneously, and this can prevent us from realizing the full potential of multimedia.

Low interactivity: Even though the interactivity between the learner and multimedia applications is increasing, it is still considered restricted compared to the elaborated human interactivity. No selective feedback: Feedback is generally very limited within computer-assisted learning packages. Generally, computers can't substitute for person-topers on teaching, only enhance it. Often, the feedback provided is limited to right/wrong, and it does not support learning strategies or further content explanations. Multimedia applications cannot identify individual needs or problems of the learner, so they cannot respond like people.

Simulations are often not enough: It may be important for students to have true hands-on experience. For example, for studying insects in biology it is necessary to go out in nature, to see insects living in their natural environments.

Lack of skills: Pupils and teachers: Students, particularly mature-age students, may not be ICT literate. Also, teachers may lack some personal skills, which are needed to teach effectively with multimedia.

Difficult to do: Creating audio, video and graphical materials can be more challenging than creating ordinary texts.

Time-consuming: Using multimedia can be time consuming. Especially the production of multimedia takes much time.

Access: Not all students have appropriate access to proper hardware and the Internet. This may limit the scope of teaching.

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

Equipment problems: Hardware and software need to be configured in a way that their usage is as simple as straight forwarded as possible.

Bandwidth issue: Limited bandwidth means slow performance for sound, graphics and video, interrupting streaming and causing long waits for download that can affect the ease of learning.

Multimedia is not portable: Paper-based notes can be read everywhere, on the bus, at the beach, etc., but web-based materials or multimedia materials require specific hardware devices.

Computer screens are not paper: The content on screens may not be as easy to read as the content on paper. If there are large chunks of information that need to be read from top to bottom, it is probably best to view such a document on paper. Books and journal articles may still be better to read on paper. End users often prefer to use technology to search for information, but when it comes to reading, they tend to read from print-outs.

2.10 Studies Conducted on Multimedia Integration in Education

Some studies indicated that the use of multimedia and technology positively affects students' attitude, motivation and attention towards the lesson. In the study where the effect of the multimedia technique on students' academic success was analysed, no significant difference exists between the experimental and control groups in the web-based studies of Karadeniz and Akpinar (2015). The situation is also in parallel with Çoruk and Çakir's (2015) studies. They stated that students who were instructed with multimedia are more successful compared to students instructed in traditional ways which are in line with the result of this study. They further asserted that the academic success level of the classroom using multimedia was higher than the classroom which did not use. In Çoruk and Çakir (2015) study, ―The Effect of Multimedia on Primary School Students on Academic Achievement and anxiety" there was no difference in the result. They highlighted that multimedia increases student success. In all these studies, it has been indicated that instructions with multimedia use increased student achievement.

Arici and Yekta (2005), on the other hand, found no significant difference between but found multimedia as neutral effect on the academic achievement of the students. Akin and Çeçen (2015) observed that student motivation increased after the implementation of multimedia in the study. It has been found in research that the use of multimedia in the learning process does not only increase the success level of the students but create positive changes in the attitudes of the students towards lessons. Acikalin and Duru (2005) stated the use of multimedia positively affects 7th-grade students' attitudes towards social studies lessons. In the same sense, Yünkül and Er (2014) found students' attitudes toward lessons were positively affected by the use of multimedia as the students in the experimental group. However, Altinişik and Orhan (2002) found reverse results as having no significant difference in the results. Altinişik and Orhan (2002) further explained the reason for this non difference situation as it was students' first experience of multimedia use and time limitation. Moreover, Aytan and Başal (2015) found teacher attitudes toward web 2.0 tools were positive, these tools improve critical thinking and ICT skills, information exchange feedback process in their study web 2.0 tools effects were investigated. Tomte and Hatlevik (2011) pointed out factors such as access to the use of the internet, community, parents' influence, peer influence, social media, gaming etc., are responsible for gender differences in the use of ICT. Abdul-Raheem (2012) revealed that there is no significant difference between the mean achievement of male and female students in both experimental and control groups; this was also in agreement with the findings of this study.

Additionally, the authors include suggestions for future research on the use of virtual Biology laboratories in the online setting. Hennessy, Deaney and Ruthven (2006) discussed ways teachers make use of computer-based technologies to support the learning of science, and suggested that technology supports stepwise knowledge building and application. Such applications have implications for both curriculum-related science activities and emerging computer-based learning technologies. Technology helps students construct links between theories and phenomena by extending the human capacity.

Chi-Yan and Treagust (2004) suggested that Biology educators are increasingly using technology to supplement their teaching. A variety of computer technologies has been used over the past two decades to enhance student learning of many of the biological sciences in colleges and universities. Computer technology and educational software have provided new learning opportunities that can change the look and feel of traditional science classrooms. This does not necessarily imply that learning in traditional education is ineffective. However, traditional methods sometimes fail to reflect the skills and interests of students who have grown up in the digital age. Technology can enhance learning environments and increase opportunities for authentic hands-on experiences (Zumbach, Schmitt, Reimann & Starkloff, 2006). Computer technologies support the development and implementation of teaching and learning strategies that support many important science skills (Maor & Fraser, 1996).

Angadi and Ganihar (2015) mentioned that technology and multimedia facilitate the knowledge-construction process for students by allowing learners to construct links among their prior knowledge and the new concepts. This assertion supports research suggesting that science education should include both constructivist methodologies and technology integration as a natural part of its ideology. Computerized magnification systems and video-based virtual experiences have been studied in an attempt to improve areas such as the ease of viewing, interactivity, and improvement of group learning activities within the context of science education. Susanne (2002) has studied cancer cell Biology and has experienced a student-centred instructional module exploring the use of multimedia to enrich interactive, constructivist learning of science. Multimedia has the potential of providing bioscience education novel learning environments and pedagogy applications to foster student interest, involve students in the research process, advance critical thinking/problem-solving skills, and develop conceptual understanding of biological topics.

Klein and Koroghlanian (2004) have investigated the effects of audio, animation, and spatial ability in a multimedia computer program for high school Biology. The study examined the effects of instructional mode (text vs. audio), illustration mode (static illustration vs. animation) and spatial ability (low vs. high) on practice and post-test achievement, attitude and time. Results indicated that spatial ability was significantly related to practice achievement and attitude. Participants with high spatial ability performed better on the practice items than those with low spatial ability. Participants with low spatial ability responded more positively than those with high spatial ability to attitude items concerning concentration, interest and amount of invested mental effort. Findings also revealed that participants who received animation spent significantly more time on the program than those who received static illustrations. Implications for the design of multimedia are discussed.

According to Cline (2007), the role of technology in the classroom is not to replace traditional educational methods, it does act as an enhancement for teaching students to think critically, communicate creatively and solve problems in analytically. Students can learn ―from" computers – where technology is used essentially as tutors and serves to increase students' basic skills and knowledge; and can learn ―with" computers- where technology is used as a tool that can be applied to a variety of goals in the learning process and can serve as a resource to help develop higher-order thinking, creativity and research skills.

Sivin-Kachala and Bialo (2000) reviewed 311 research studies on the effectiveness of technology on student achievement. Their findings revealed positive and consistent patterns when students were engaged in technology-rich environments, including significant gains and achievement in all subject areas, increased achievement in preschool through high school for both regular and special needs students, and improved attitude toward learning and increased self-esteem. Paris (2004) stated that e-Learning can improve school results. Furthermore, a simple multimedia presentation helped the students to better understand a subject without the help of a teacher particularly for shy and weak students.

Sangodoyin (2010) studied computer animation and the academic achievement of Nigerian senior secondary school students in Biology. This study investigated the effects of computer animation on the academic achievement of Nigerian senior secondary school students in Biology. The moderating effects of mental ability and gender were also investigated. The pre-test and post-test, control group, quasi-experimental design with a 2x2x2 factorial matrix was adopted for the study. One hundred and eighty-nine senior secondary school Year II Biology students from two randomly selected Federal Government Colleges in two states in Southwestern

Nigeria were the participants. Findings showed that there was a significant main effect of treatment on students' achievement in Biology. Computer animation was effective in improving students' achievement therefore, computer animation is recommended as a means of teaching Biology to students in Nigerian secondary schools.

According to Ali and Elfessi (2004), the significant role of technology in teaching and learning is limited as an instructional delivery medium and not a key determinant of learning. It can only support classroom learning. Thus, there is empirical evidence to suggest both the positive and negative effects of multimedia. The key issue is to analyse these findings and find out the precise reasons and the situations in which multimedia is useful and in which it is not. While Multimedia seems to be improving the learning rate, it is not a universal fact. In the next section contains a discussion on the main conditions in which multimedia would be useful. Today's teachers are concerned with how to use technology to enhance and enrich their learning environment.

2.11 The Concept of Genetics

Genetics is the study of DNA and hereditary changes in living organisms. The idea that species of organisms can change over time was first thought about and later published by the famous English naturalist, Charles Darwin in 1859. He wrote a book called ―On the Origin of Species", which continued to highlight views such as natural selection and survival of the fittest. These terms are now accepted by the wider community and are common phrases. At the time of writing the origin of species, DNA and other genetic science had not yet been discovered and it wasn't until 1953, nearly 100 years later, that Francis Crick and James Watson discovered the DNA molecule and nucleic acids.

2.11.1 Historical Background

Ancient Theories of Pangenesis and Blood in Heredity

Although scientific evidence for patterns of genetic inheritance did not appear until Mendel‘s work, history shows that humankind must have been interested in heredity long before the dawn of civilization. Curiosity must first have been based on human family resemblances, such as similarity in body structure, voice, gait, and gestures. Such notions were instrumental in the establishment of family and royal dynasties. Early nomadic tribes were interested in the qualities of the animals that they herded and domesticated and, undoubtedly, bred selectively.

The first human settlements that practised farming appear to have selected crop plants with favourable qualities. Ancient tomb paintings show racehorse breeding pedigrees containing clear depictions of the inheritance of several distinct physical traits in the horses. Despite this interest, the first recorded speculations on heredity did not exist until the time of the ancient Greeks; some aspects of their ideas are still considered relevant today.

Hippocrates (c. 460–c. 375 BCE), known as the father of medicine, believed in the inheritance of acquired characteristics, and, to account for this, he devised the hypothesis known as pangenesis. He postulated that all organs of the body of a parent gave off invisible ―seeds," which were like miniaturized building components and were transmitted during sexual intercourse, reassembling themselves in the mother‘s womb to form a baby.

Aristotle (384–322 BCE) emphasized the importance of blood in heredity. He thought that the blood supplied generative material for building all parts of the adult body, and he reasoned that blood was the basis for passing on this generative power to the next generation. He believed that the male‘s semen was purified blood and that a woman‘s menstrual blood was her equivalent of semen. These male and female contributions united in the womb to produce a baby. The blood contained some type of hereditary essences, but he believed that the baby would develop under the influence of these essences, rather than being built from the essences themselves. Aristotle‘s ideas about the role of blood in procreation were probably the origin of the still prevalent notion that somehow the blood is involved in heredity. Today people still speak of certain traits as being ―in the blood” and of ―blood lines” and ―blood ties.” The Greek model of inheritance, in which a teeming multitude of substances was invoked, differed from that of the Mendelian model. Mendel‘s idea was that distinct differences between individuals are determined by differences in single yet powerful hereditary factors. These single hereditary factors were identified as genes. Copies of genes are transmitted through sperm and egg and guide the development of the offspring. Genes are also responsible for reproducing the distinct features of both parents that are visible in their children.

Preformation and Natural Selection

In the two millennia between the lives of Aristotle and Mendel, few new ideas were recorded on the nature of heredity. In the 17th and 18th centuries, the idea of preformation was introduced. Scientists using the newly developed microscopes imagined that they could see miniature replicas of human beings inside sperm heads. French biologist Jean-Baptiste Lamarck invoked the idea of ―the inheritance of acquired characters,” not as an explanation for heredity but as a model for evolution. He lived at a time when the fixity of species was taken for granted, yet he maintained that this fixity was only found in a constant environment.

He enunciated the law of use and disuse, which states that when certain organs become specially developed as a result of some environmental need, then that state of development is hereditary and can be passed on to progeny. He believed that in this way, over many generations, giraffes could arise from deer-like animals that had to keep stretching their necks to reach high leaves on trees. British naturalist Alfred Russel Wallace originally postulated the theory of evolution by natural selection. However, Charles Darwin‘s observations during his circumnavigation of the globe aboard the HMS Beagle (1831–36) provided evidence for natural selection and his suggestion that humans and animals shared a common ancestry. Many scientists at the time believed in a hereditary mechanism that was a version of the ancient Greek idea of pangenesis, and Darwin‘s ideas did not appear to fit with the theory of heredity that sprang from the experiments of Mendel.

The work of Mendel

Before Gregor Mendel, theories for a hereditary mechanism were based largely on logic and speculation, not on experimentation. In his monastery garden, Mendel carried out a large number of cross-pollination experiments between variants of the garden pea, which he obtained as pure-breeding lines. He crossed peas with yellow seeds to those with green seeds and observed that the progeny seeds (the first generation, F) were all yellow. When the F individuals were self-pollinated or crossed among themselves, their progeny (F) showed a ratio of 3:1 (3/4 yellow and 1/4 green). He deduced that, since the F generation contained some green individuals, the determinants of greenness must have been present in the F generation, although they were not expressed because yellow is dominant over the green. From the precise mathematical 3:1 ratio (of which he found several other examples), he deduced not only the existence of discrete hereditary units (genes) but also that the units were present in pairs in the pea plant and that the pairs separated during gamete formation. Hence, the two original lines of pea plants were proposed to be *YY* (yellow) and *yy* (green). The gametes from these were *Y* and *y*, thereby producing an F generation of *Yy* that were yellow in because of the dominance of *Y*. In the F generation, half the gametes were *Y* and the other half were *y*, making the F generation produced from random mating 1/4 *Yy*, 1/2 *YY*, and ¼ *yy*, thus explaining the 3:1 ratio. The forms of the pea colour genes, *Y* and *y*, are called alleles.

Mendel also analysed pure lines that differed in pairs of characters, such as seed colour (yellow versus green) and seed shape (round versus wrinkled). The cross of yellow round seeds with green wrinkled seeds resulted in an F generation that was all yellow and round, revealing the dominance of the yellow and round traits. However, the F generation produced by self-pollination of F plants showed a ratio of 9:3:3:1 (9/16 yellow round, 3/16 yellow wrinkled, 3/16 green round, and 1/16 green wrinkled; note that a 9:3:3:1 ratio is simply two 3:1 ratio combined). From this result and others like it, he deduced the independent assortment of separate gene pairs at gamete formation. Mendel‘s success can be attributed in part to his classic experimental approach. He chose his experimental organism well and performed many controlled experiments to collect data. From his results, he developed brilliant explanatory hypotheses and went on to test these hypotheses experimentally. Mendel‘s methodology established a prototype for genetics that is still used today for gene discovery and understanding the genetic properties of inheritance.

2.11.2 How the Gene Idea Became Reality

Mendel‘s genes were only hypothetical entities, factors that could be inferred to exist in to explain his results. The 20th century saw tremendous strides in the development of the understanding of the nature of genes and how they function. Mendel‘s publications lay unmentioned in the research literature until 1900, when the same conclusions were reached by several other investigators. Then there followed hundreds of papers showing Mendelian inheritance in a wide array of plants and animals, including humans. It seemed that Mendel‘s ideas were of general validity. Many biologists noted that the inheritance of genes closely paralleled the inheritance of chromosomes during nuclear divisions, called meiosis, that occur in the cell divisions just to gamete formation.

The discovery of linked genes

It seemed that genes were parts of chromosomes. In 1910 this idea was strengthened through the demonstration of parallel inheritance of certain Drosophila (a type of fruit fly) genes on sex-determining chromosomes by American zoologist and geneticist Thomas Hunt Morgan. Morgan and one of his students, Alfred Henry Sturtevant, showed not only those certain genes seemed to be linked on the same chromosome but that the distance between genes on the same chromosome could be calculated by measuring the frequency at which new chromosomal combinations arose (these were proposed to be caused by chromosomal breakage and reunion, also known as crossing over). In 1916 another student of Morgan‘s, Calvin Bridges, used fruit flies with an extra chromosome to prove beyond reasonable doubt that the only way to explain the abnormal inheritance of certain genes was if they were part of the extra chromosome.

American geneticist Hermann Joseph Müller showed that new alleles (called mutations) could be produced at high frequencies by treating cells with X-rays, the first demonstration of an environmental mutagenic agent (mutations can also arise spontaneously). In 1931 American botanist Harriet Creighton and American scientist Barbara McClintock demonstrated that new allelic combinations of linked genes were correlated with physically exchanged chromosome parts.

Early molecular genetics

In 1908 British physician Archibald Garrod proposed the important idea that the human disease alkaptonuria, and certain other hereditary diseases, were caused by inborn errors of metabolism, suggesting for the first time that linked genes had molecular action at the cell level. Molecular genetics did not begin in earnest until 1941 when American geneticist George Beadle and American biochemist Edward Tatum showed that the genes they were studying in the fungus *Neurospora crassa* acted by coding for catalytic proteins called enzymes. Subsequent studies in other organisms extended this idea to show that genes generally code for proteins. Soon afterwards, American bacteriologist Oswald Avery, Canadian American geneticist Colin M. MacLeod, and American biologist Maclyn McCarty showed that bacterial genes are made of DNA, a finding that was later extended to all organisms.

DNA and the genetic code

A major landmark was attained in 1953 when American geneticist and biophysicist James D. Watson and British biophysicists Francis Crick and Maurice Wilkins devised a double helix model for DNA structure. Their breakthrough was made possible by the work of British scientist Rosalind Franklin, whose X-ray diffraction studies of the DNA molecule shed light on its helical structure. The double helix model showed that DNA was capable of self-replication by separating its complementary strands and using them as templates for the synthesis of new DNA molecules. Each of the intertwined strands of DNA was proposed to beak chain of chemical groups called nucleotides, of which there were known to be four types. Because proteins are strings of amino acids, it was proposed that a specific nucleotide sequence of DNA could contain a code for an amino acid sequence and hence protein structure. In 1955 American molecular biologist Seymour Benzer, extending earlier studies in *Drosophila*, showed that the mutant sites within a gene could be mapped to each other. His linear map indicated that the gene itself is a linear structure. In 1958 the strand-separation method for DNA replication (called the semiconservative method) was demonstrated experimentally for the first time by American molecular biologist Matthew Meselson and American geneticist Franklin W. Stahl. In 1961 Crick and South African biologist Sydney Brenner showed that the genetic code must be read in triplets of nucleotides, called codons. American geneticist Charles Yanofsky showed that the positions of mutant sites within a gene matched perfectly the positions of altered amino acids in the amino acid sequence of the corresponding protein. In 1966 the complete genetic code of all 64 possible triplet coding units (codons), and the specific amino acids they code for, was deduced by American biochemists Marshall Nirenberg and Har Gobind Khorana. Subsequent studies in many organisms showed that the double-helical structure of DNA, the mode of its replication, and the genetic code are the same in virtually all organisms, including plants, animals, fungi, bacteria, and viruses. In 1961 French biologist François Jacob and French biochemist Jacques Monod established the prototypical model for gene regulation by showing that bacterial genes can be turned on (initiating transcription into RNA and protein synthesis) and off through the binding action of regulatory proteins to a region just upstream of the coding region of the gene.

Recombinant DNA technology and the polymerase chain reaction

Technical advances have played an important role in the advance of genetic understanding. In 1970 American microbiologists Daniel Nathans and Hamilton Othanel Smith discovered a specialized class of enzymes (called restriction enzymes) that cut DNA at specific nucleotide target sequences. That discovery allowed American biochemist Paul Berg in the early 1970s to make the first artificial recombinant DNA molecule by isolating DNA molecules from different sources, cutting them, and joining them together in a test tube. Shortly thereafter, American biochemists Herbert W. Boyer and Stanley N. Cohen came up with methods to produce recombinant plasmids (extra genomic circular DNA elements), which replicated naturally when inserted into bacterial cells. These advances allowed individual genes to be cloned (amplified to a high copy number) by splicing them into self-replicating DNA molecules, such as plasmids or viruses and inserting these into living bacterial cells. From these methodologies arose the field of recombinant DNA technology that came to dominate molecular genetics. In 1977 two different methods were invented for determining the nucleotide sequence of DNA: one by American molecular biologists Allan Maxam and Walter Gilbert and the other by English biochemist Fred Sanger. Such technologies made it possible to examine the structure of genes directly by nucleotide sequencing, resulting in the confirmation of many of the inferences about genes originally made indirectly.

In the 1970s Canadian biochemist, Michael Smith revolutionized the art of redesigning genes by devising a method for inducing specifically tailored mutations at defined sites within a gene, creating a technique known as site-directed mutagenesis. In 1983 American biochemist Kary B. Mullis invented the polymerase chain reaction, a method for rapidly detecting and amplifying a specific DNA sequence without cloning it. In the last decade of the 20th century, progress in recombinant DNA technology and the development of automated sequencing machines led to the elucidation of complete DNA sequences of several viruses, bacteria, plants, and animals. In 2001 the complete sequence of human DNA, approximately three billion nucleotide pairs, was made public.

2.11.3 Areas of study

Classical genetics

Classical genetics, which remains the foundation for all other areas in genetics, is concerned primarily with the method by which genetic traits—classified as dominant (always expressed), recessive (subordinate to a dominant trait), intermediate (partially expressed), or polygenic (due to multiple genes)—are transmitted in plants and animals. These traits may be sex-linked (resulting from the action of a gene on the sex, or X, chromosome) or autosomal (resulting from the action of a gene on a chromosome other than a sex chromosome). Classical genetics began with Mendel‘s study of inheritance in garden peas and continues with studies of inheritance in many different plants and animals. Today a prime reason for performing classical genetics is for gene discovery—the finding and assembling of a set of genes that affects a biological property of interest.

Cytogenetics

Cytogenetics, the microscopic study of chromosomes, blends the skills of cytologists, who study the structure and activities of cells, with those of geneticists, who study genes. Cytologists discovered chromosomes and how they duplicate and separate during cell division at about the same time that geneticists began to understand the behaviour of genes at the cellular level. The close correlation between the two disciplines led to their combination. Plant cytogenetics early became an important subdivision of cytogenetics because, as a general rule, plant chromosomes are larger than those of animals. Animal cytogenetics became important after the development of the so-called squash technique, in which entire cells are pressed flat on a piece of glass and observed through a microscope; the human chromosomes were numbered using this technique. Today there are multiple ways to attach molecular labels to specific genes and chromosomes, as well as to specific RNAs and proteins, that make these molecules easily discernible from other components of cells, thereby greatly facilitating cytogenetics research.

Microbial Genetics

Microorganisms were generally ignored by the early geneticists because they are small in size and were thought to lack variable traits and the sexual reproduction necessary for a mixing of genes from different organisms. After it was discovered that microorganisms have many different physical and physiological characteristics that are amenable to study, they became objects of great interest to geneticists because of their small size and the fact that they reproduce much more rapidly than larger organisms. Bacteria became important model organisms in genetic analysis, and many discoveries of general interest in genetics arose from their study. Bacterial genetics is the centre of cloning technology. Viral genetics is another key part of microbial genetics. The genetics of viruses that attack bacteria were the first to be elucidated. Since then, studies and findings of viral genetics have been applied to viruses pathogenic on plants and animals, including humans. Viruses are also used as vectors (agents that carry and introduce modified genetic material into an organism) in DNA technology.

Molecular Genetics

Molecular genetics is the study of the molecular structure of DNA, its cellular activities (including its replication), and its influence in determining the overall makeup of an organism. Molecular genetics relies heavily on genetic engineering (recombinant DNA technology), which can be used to modify organisms by adding foreign DNA, thereby forming transgenic organisms. Since the early 1980s, these techniques have been used extensively in basic biological research and are also fundamental to the biotechnology industry, which is devoted to the manufacture of agricultural and medical products. Transgenesis forms the basis of gene therapy, the attempt to cure genetic disease by addition of normally functioning genes from exogenous sources.

Genomics

The development of the technology to sequence the DNA of whole genomes on a routine basis has given rise to the discipline of genomics, which dominates genetics research today. Genomics is the study of the structure, function, and evolutionary comparison of whole genomes. Genomics has made it possible to study gene function at a broader level, revealing sets of genes that interact to impinge on some biological property of interest to the researcher. Bioinformatics is the computer-based discipline that deals with the analysis of such large sets of biological information, especially as it applies to genomic information.

Population Genetics

The study of genes in populations of animals, plants, and microbes provides information on past migrations, evolutionary relationships and extents of mixing among different varieties and species, and methods of adaptation to the environment. Statistical methods are used to analyse gene distributions and chromosomal variations in populations. Population genetics is based on the mathematics of the frequencies of alleles and genetic types in populations. For example, the Hardy-Weinberg formula, p2 + 2pq + q2 = 1, predicts the frequency of individuals with the respective homozygous dominant (AA), heterozygous (Aa), and homozygous recessive (aa) genotypes in a randomly mating population. Selection, mutation, and random changes can be incorporated into such mathematical models to explain and predict the course of evolutionary change at the population level. These methods can be used on alleles of known phenotypic effect, such as the recessive allele for albinism, or DNA segments of any type of known or unknown function. Human population geneticists have traced the origins and migration and invasion routes of modern humans, Homo sapiens. DNA comparisons between the present peoples on the planet have pointed to an African origin of Homo sapiens. Tracing specific forms of genes has allowed geneticists to deduce probable migration routes out of Africa to the areas colonized today. Similar studies show to what degree present populations have been mixed by recent patterns of travel.

Behaviour Genetics

Another aspect of genetics is the study of the influence of heredity on behaviour. Many aspects of animal behaviour are genetically determined and can therefore be treated as similar to other biological properties. This is the subject material of behaviour genetics; whose goal is to determine which genes control various aspects of behaviour in animals. Human behaviour is difficult to analyse because of the powerful effects of environmental factors, such as culture. Few cases of genetic determination of complex human behaviour are known. Genomics studies provide a useful way to explore the genetic factors involved in complex human traits such as behaviour.

Human Genetics

Some geneticists specialize in the hereditary processes of human genetics. Most of the emphasis is on understanding and treating genetic disease and genetically influenced ill health, areas collectively known as medical genetics. One broad area of activity is laboratory research dealing with the mechanisms of human gene function and malfunction and investigating pharmaceutical and other types of treatments. Since there is a high degree of evolutionary conservation between organisms, research on model organisms—such as bacteria, fungi, and fruit flies (Drosophila)—which are easier to study, often provides important insights into human gene function. Many single-gene diseases, caused by mutant alleles of a single gene, have been discovered.

Two well-characterized single-gene diseases include phenylketonuria (PKU) and Tay-Sachs's disease. Other diseases, such as heart disease, schizophrenia, and depression, are thought to have more complex heredity components that involve many different genes. These diseases are the focus of a great deal of research that is being carried out today. Another broad area of activity is clinical genetics, which centres on advising parents of the likelihood of their children being affected by genetic disease caused by mutant genes and abnormal chromosome structure and number. Such genetic counselling is based on examining individual and family medical records and on diagnostic procedures that can detect unexpressed, abnormal forms of genes. Counselling is carried out by physicians with a particular interest in this area or by specially trained physicians.

2.11.4 Methods in Genetics

Experimental Breeding

Genetically diverse lines of organisms can be crossed in such a way to produce different combinations of alleles in one line. For example, parental lines are crossed, producing an F generation, which is then allowed to undergo random mating to produce offspring that have pure breeding genotypes (i.e., AA, bb, cc, or DD). This type of experimental breeding is the origin of new plant and animal lines, which are an important part of making laboratory stocks for basic research. When applied to commerce, transgenic commercial lines produced experimentally are called genetically modified organisms (GMOs). Many of the plants and animals used by humans today (e.g., cows, pigs, chickens, sheep, wheat, corn (maize), potatoes, and rice) have been bred in this way.

Cytogenetic Techniques

Cytogenetics focuses on the microscopic examination of genetic components of the cell, including chromosomes, genes, and gene products. Older cytogenetic techniques involve placing cells in paraffin wax, slicing thin sections, and preparing them for microscopic study.

The newer and faster squash technique involves squashing entire cells and studying their contents. Dyes that selectively stain various parts of the cell are used; the genes, for example, may be located by selectively staining the DNA of which they are composed. Radioactive and fluorescent tags are valuable in determining the location of various genes and gene products in the cell. Tissue-culture techniques may be used to grow cells before squashing; white blood cells can be grown from samples of human blood and studied with the squash technique. One major application of cytogenetics in humans is in diagnosing abnormal chromosomal complements such as Down syndrome (caused by an extra copy of chromosome 21) and Klinefelter syndrome (occurring in males with an extra X chromosome). Some diagnosis is prenatal, performed on cell samples from amniotic fluid or the placenta.

Biochemical Techniques

Biochemistry is carried out at the cellular or subcellular level, generally on cell extracts. Biochemical methods are applied to the main chemical compounds of genetics—notably

DNA, RNA, and protein. Biochemical techniques are used to determine the activities of genes within cells and to analyse substrates and products of gene-controlled reactions. In one approach, cells are ground up and the substituent chemicals are fractionated for further analysis. Special techniques (e.g., chromatography and electrophoresis) are used to separate the components of proteins so that inherited differences in their structures can be revealed. For example, more than 100 different kinds of human haemoglobin molecules have been identified. Radioactively tagged compounds are valuable in studying the biochemistry of whole cells. For example, thymine is a compound found only in DNA; if radioactive thymine is placed in a tissue-culture medium in which cells are growing, genes use it to duplicate themselves. When cells containing radioactive thymine are analysed, the results show that, during duplication, the DNA molecule splits in half, and each half synthesizes its missing components. Chemical tests are used to distinguish certain inherited conditions of humans; e.g., urinalysis and blood analysis reveal the presence of certain inherited abnormalities—phenylketonuria (PKU), cystinuria, alkaptonuria, gout, and galactosemia. Genomics has provided a battery of diagnostic tests that can be carried out on an individual‘s DNA. Some of these tests can be applied to foetuses in utero.

Physiological Techniques

Physiological techniques, directed at exploring functional properties or organisms, are also used in genetic investigations. In microorganisms, most genetic variations involve some important cell function. Some strains of one bacterium (Escherichia coli), for example, can synthesize the vitamin thiamine from simple compounds;

others, which lack an enzyme necessary for this synthesis, cannot survive unless thiamine is already present. The two strains can be distinguished by placing them on a thiamine-free mixture: those that grow have the gene for the enzyme, those that fail to grow do not. The technique also is applied to human cells, since many inherited human abnormalities are caused by a faulty gene that fails to produce a vital enzyme; albinism, which results from an inability to produce the pigment melanin in the skin, hair, or iris of the eyes, is an example of an enzyme deficiency in man.

Molecular Techniques

Although overlapping with biochemical techniques, molecular genetics techniques are deeply involved with the direct study of DNA. This field has been revolutionized by the invention of recombinant DNA technology. The DNA of any gene of interest from a donor organism (such as a human) can be cut out of a chromosome and inserted into a vector to make recombinant DNA, which can then be amplified and manipulated, studied, or used to modify the genomes of other organisms by transgenesis. A fundamental step in recombinant DNA technology is amplification. This is carried out by inserting the recombinant DNA molecule into a bacterial cell, which replicates and produces many copies of the bacterial genome and the recombinant DNA molecule (constituting a DNA clone). A collection of large numbers of clones of recombinant donor DNA molecules is called a genomic library. Such libraries are the starting point for sequencing entire genomes such as the human genome. Today genomes can be scanned for small molecular variants called single nucleotide polymorphisms, or SNPs (―snips"), which act as chromosomal tags to associated specific regions of DNA that have a property of interest and may be involved in human disease or disorder.

Immunological Techniques

Many substances (e.g., proteins) are antigenic; i.e., when introduced into a vertebrate body, they stimulate the production of specific proteins called antibodies. Various antigens exist in red blood cells, including those that make up the major blood groups of man (A, B, AB, O). These and other antigens are genetically determined; their study constitutes immunogenetics. Blood antigens of man include inherited variations, and the particular combination of antigens in an individual is almost as unique as fingerprints and has been used in such areas as paternity testing (although this approach has been largely supplanted by DNA based techniques). Immunological techniques are used in blood group determinations in blood transfusions, organ transplants, and in determining Rhesus incompatibility in childbirth. Specific antigens of the human leukocyte antigen (HLA) genes are correlated with human diseases and disease predispositions. Antibodies also have a genetic basis, and their seemingly endless ability to match any antigen presented is based on special types of DNA shuffling processes between antibody genes. Immunology is also useful in identifying specific recombinant DNA clones that synthesize a specific protein of interest.

Mathematical Techniques

Because much of genetics is based on quantitative data, mathematical techniques are used extensively in genetics. The laws of probability apply to crossbreeding and are used to predict frequencies of specific genetic constitutions in offspring. Geneticists also use statistical methods to determine the significance of deviations from expected results in experimental analyses. In addition, population genetics is based largely on mathematical logic—for example, the Hardy-Weinberg equilibrium and its derivatives (see above). Bioinformatics uses computer-centred statistical techniques to handle and analyse the vast amounts of information accumulating from genome sequencing projects. The computer program scans the DNA looking for genes, determining their probable function based on other similar genes, and comparing different DNA molecules for evolutionary analysis Bioinformatics has made possible the discipline of systems biology, treating and analysing the genes and gene products of cells as a complete and integrated system.

2.11.5 Applied Genetics

Medicine

Genetic techniques are used in medicine to diagnose and treat inherited human disorders.

Knowledge of a family history of conditions such as cancer or various disorders may indicate a hereditary tendency to develop these afflictions. Cells from embryonic tissues reveal certain genetic abnormalities, including enzyme deficiencies, that may be present in new-born babies, thus permitting early treatment. Many countries require a blood test of new-born babies to determine the presence of an enzyme necessary to convert an amino acid, phenylalanine, into simpler products. Phenylketonuria (PKU), which results from lack of the enzyme, causes permanent brain damage if not treated soon after birth. Many different types of human genetic diseases can be detected in embryos as young as 12 weeks; the procedure involves removal and testing of a small amount of fluid from around the embryo (called amniocentesis) or of tissue from the placenta (called chorionic villus sampling). Gene therapy is based on modification of defective genotypes by adding functional genes made through recombinant DNA technology. Bioinformatics is being used to ―mine" the human genome for gene products that might be candidates for designer pharmaceutical drugs.

Agriculture and Animal Husbandry

Agriculture and animal husbandry apply genetic techniques to improve plants and animals. Breeding analysis and transgenic modification using recombinant DNA techniques are routinely used. Animal breeders use artificial insemination to propagate the genes of prize bulls. Prize cows can transmit their genes to hundreds of offspring by hormone treatment, which stimulates the release of many eggs that are collected, fertilized, and transplanted to foster mothers. Several types of mammals can be cloned, meaning that multiple identical copies can be produced of certain desirable types.

Plant geneticists use special techniques to produce new species, such as hybrid grains (i.e., produced by crossing wheat and rye), and plants resistant to destruction by insect and fungal pests. Plant breeders use the techniques of budding and grafting to maintain desirable gene combinations originally obtained from crossbreeding. Transgenic plant cells can be made into plants by growing the cells on special hormones. The use of the chemical compound colchicine, which causes chromosomes to double in number, has resulted in many new varieties of fruits, vegetables, and flowers. Many transgenic lines of crop plants are commercially advantageous and are being introduced into the market.

Industry

Various industries employ geneticists; the brewing industry, for example, may use geneticists to improve the strains of yeast that produce alcohol. The pharmaceutical industry has developed strains of moulds, bacteria, and other microorganisms high in antibiotic yield. Penicillin and cyclosporine from fungi, and streptomycin and ampicillin from bacteria, are some examples. Biotechnology, based on recombinant DNA technology, is now extensively used in industry. ―Designer" lines of transgenic bacteria, animals, or plants capable of manufacturing some commercial product is made and used routinely. Such products include pharmaceutical drugs and industrial chemicals such as citric acid.

2.12 Comparing traditional and multimedia teaching approaches

According to Salem (2000), traditional teaching methods have remained largely unchanged for thousands of years, but the advent of multimedia has prompted educators to research and develop new teaching devices in order to improve teaching methods and quality of instruction. Teachers are no longer required to stand on a platform shouting dull lectures while students sit there bored (Nasr, 2005). This teaching style boosts the teacher's intuition and encourages students' excitement for studying.

Callaway (1997) emphasized that multimedia instruction is helpful in implementing bidirectional instruction and increasing teaching efficiency.

Traditional teaching makes it impossible for teachers to communicate with every student, according to Atawaim (2000), however multimedia teaching may fully utilize the computer's interactional capability to implement bidirectional teaching.

The learning situation of each student can be exposed by receiving fast and high-quality computer feedback via human-computer connection.

In terms of knowledge, multimedia teaching can transform abstract knowledge into concrete, complex knowledge into simple knowledge, and tough knowledge into easy knowledge (Patel,2013). Computers disclose the essence of some inexplicable difficulties and so improve the efficiency of instruction. In his study, Holsinger (1995) stated that multimedia education increases the amount of time teachers spend in the classroom teaching, improves the quality of the content, and improves students' grasp and knowledge of the material.

This is also a challenge for teachers according to Slack (1999), because it takes far more time and effort for teachers to organize lessons and prepare courseware than traditional teaching methods, and it improves the quality of both the teachers and their teaching at the same time (Igbo, 2014). Patel (2013) identified that students benefit from a rich, relaxing learning environment created by multimedia teaching methods as opposed to traditional teaching approaches. Nworgu (2015) in his study stated that multimedia emphasizes the content's echoism, uses a variety of expressions to engage students' sensory systems in a variety of ways, and employs the situational teaching approach, resulting in a pleasant, vibrant learning environment for students. Students' exhaustion and tension after class can be reduced to some extent in this way, allowing intellectual and non-intellectual variables to interact to promote shared development for students to study independently and actively in good health, resulting in improved teaching results (Beichner, 1994). Multimedia teaching broadens the scope and application of instruction. Traditional teaching models emphasize face-to-face live lectures between teachers and students or small group lectures; nevertheless, the efficiency of instruction cannot be guaranteed in an intensive session (Zaitoun,2002). According to Sterling (1991), while multimedia teaching can be utilized for large-scale, distant teaching, it can relieve teachers of the stress of big classes and courses, thus improving teaching efficiency.

2.13 Summary

The media simply carries the teacher‘s message to the learner. For learning to occur, the message must be received and understood by the student. This is independent of the media. However, the media one uses can influence the amount of learning that can occur. If teachers combine the media's strengths with instructional methods that take advantage of these strengths, this can positively influence learning. Complete multimedia packages can, but should not necessarily, include all of the different media. Using too much media at one time can impede learning. Although multi-sensory learning experiences tend to be effective, learners can only process a limited amount of information at one time

The integration of ICT and multimedia in schools can change the existing learning principles tremendously. Using multimedia often means there are more student-centred work and flexible schedules. The teacher‘s role is often changing from being an authority or the source of knowledge to being a facilitator or a conductor of the learning process. Students have to find their access to the fast-changing world and, therefore, they need a huge pool of appropriate individualized strategies, which enable them to be active and critical learners. The ability to share knowledge collaboratively with others in a world where most products are the result of teamwork having the appropriate strategies and knowing why and how to apply them will be one of the most important qualifications in lifelong learning (Ayittey, 2015).

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

This chapter presents the methodology that was employed in the study. It includes the research design, area of the study, population, sample size and sampling technique, the instruments used, validity and reliability of instruments, data collection procedure and data analysis.

3.1 Research Design

Research design is a scheme, outline, or plan that is used to generate answers to research problems (Kombo & Delno, 2006). It is a detailed documentation of the plan for the collection, measurement and analysis of data. Research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose. It constitutes the blueprint for the collection, measurement, and analysis of data (Saunders, Lewis & Thornhill, 2007). This is used to structure the research, show how all the major parts of the research project, the samples or groups, measures, interventions, and methods of assignment work together to address the central research questions.

The quasi-experimental research design was espoused for this study. Specifically, the study has non-randomized control group pre-test post-test design. This design was considered appropriate because the researcher cannot randomly sample and assign his subjects, as this might have altered and disturb the schools' schedule of lessons. The study made use of two groups, the experimental group and the control group. The design is presented in the following table.

Table 1: Summary of Research Design

Sample Grouping	Research condition	Post testing
Experiment group	Treatment (+)	✓
Control group	Control (-)	✓

Key:

✓ = Students Achievement in Genetics Test (SAGT)

(+) = Use of multimedia instructional approach

(-) = Conventional method of teaching

According to Campbell and Stanley (1963) as cited by Ayittey (2015), several factors affect the internal and external validity of experimental designs. Relevant to internal validity, there are eight different factors. These include history, maturation testing, instrumentation, statistical regression, differential selection, experimental mortality and selection-maturation interaction. If these factors are not controlled in the design, they may produce adverse effects which confound the effects of the independent variables. As a way of controlling these factors, two groups will be used in the study instead of only one group, which would have suffered from the above factors.

Intact classes were used as experimental and control groups for the study. Participants in the experimental group were taught _Genetics', using the multimedia instructional approach, whiles those in the Control group taught the same concept in the SHS elective biology syllabus using the traditional instructional approach. The genetics courseware package and the video-based instructions used in this study were downloaded from the internet. The researcher, however, designed the PowerPoint presentation used in the research.

3.2 Study Area

Winneba Senior High School is located in Winneba, Central Region (Ghana). Winneba is a small coastal city in southern Ghana, with a population of close to 60,000 people. Winneba is the capital of Effutu Municipal. It is situated within GPS coordinates of 5° 21' 44.0244" N and 0° 37' 47.6112"W. The main industries of Winneba are fishing and services. Winneba has many neighbourhoods stretching from coastal areas to non-coastal areas. It also includes rural areas which provide farm power aside from the fishing activity employed by the inhabitants of the coasts.

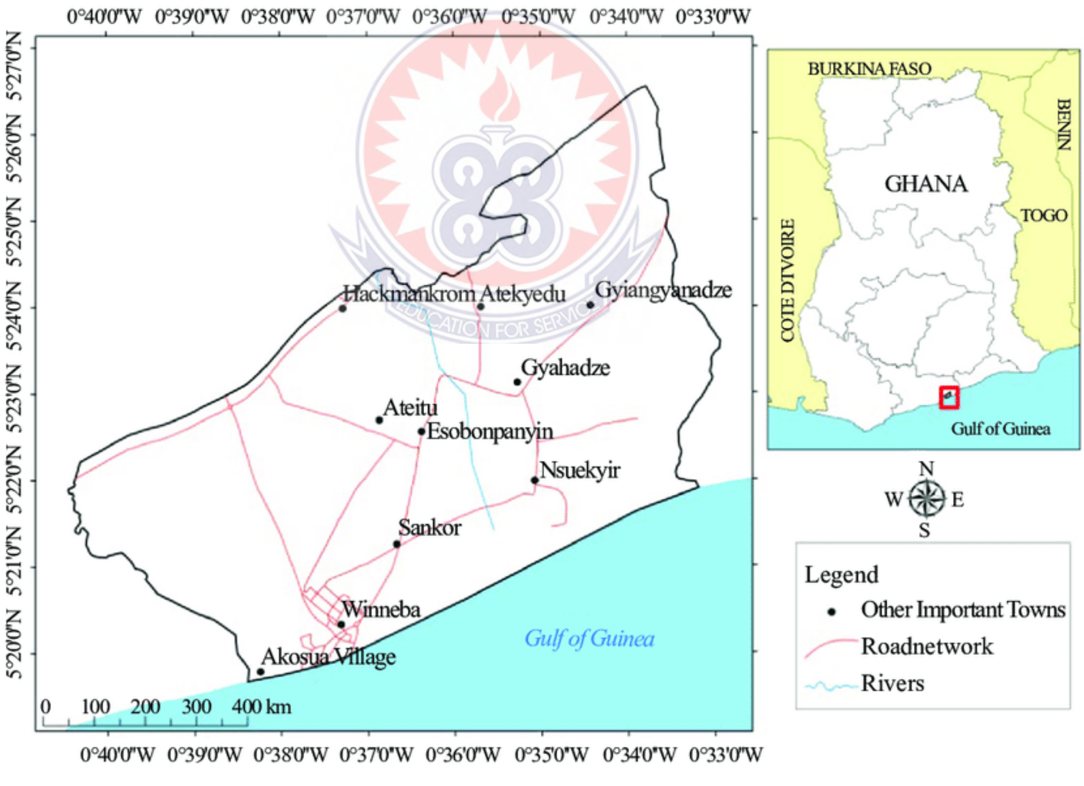

Figure 2: Map of Effutu Municipality

Source: Ghana Statistical Service, GIS

3.3 Population of the Study

The target population defines those units for which the finding of the study is meant to generalize (Lavrakas, 2008). Because the purpose of this study was to find out the impact of multimedia instruction in biology on senior high school students‘ achievement, the population of the study was all elective science students in Winneba senior high school. These students study Biology, Chemistry, Physics and Elective Mathematics aside from the core subjects. Other groups of students in the Senior High School such as Agricultural Science and Home Economics may study one or two of the science subjects. However, the target population was the elective science students who study elective biology.

The accessible population was made up of all the form two elective biology students from the selected school. From this population, the sample was selected for the study.

3.4 Sample and Sampling Technique

According to Pandey and Pandey, (2015), Sampling means selecting a given number of subjects from a defined population as representative of that population. It works to obtain accurate and reliable information about the population with a minimum of cost, time and energy and to set out the limits of accuracy of such estimates. It makes exhaustive and intensive study possible with much less time, money and material, (Pandey & Pandey, 2015).

Two SHS 2 science classes in the Winneba SHS were sampled by purposive sampling technique. Then, each of the two classes was placed into either the experimental or the control group for the study by simple balloting by a flip of a coin. This was necessary to give the two classes equal chances of being either the experimental or control group. Each class selected formed the intact group used for the study.

Students in both selected classes were yet to be taught ‗Genetics' in elective biology at the time the study commenced. Participants in this study were all of a similar educational background as they had all passed the Basic Education Certificate Examination (BECE) at the Junior High School (JHS) level as well as their year one integrated science and biology examinations. Also, they had some basic knowledge of the concept of genetics as they had been introduced to it both at the JHS and SHS levels in integrated science. Each intact group selected for the study had twenty-three students (23) students. The sample size was, therefore, twenty-three (23) in the control group and twenty-three (23 in the experimental group making a total of sixty (46) participants.

3.5 Research Instruments

Two test instruments of comparable standard, which were used to collect quantitative data from all participants for the study. The two tests were named ―Students' Knowledge of Genetics Test" – SKGT and ―Students' Achievement in Genetics Test" – SAGT, which were both developed by the Researcher. The SKGT and SAGT were used as the pre-test and post-test instruments respectively. The SKGT was used to assess the participants' knowledge and difficulty with the concept of ‗Genetics' in order to have a baseline about all participants before the implementation of the interventions. The SAGT was, however, designed to measure participants' achievement after the implementation of the treatment. The two tests were both made up of Multiple-Choice Test items consisting of twenty (20) questions covering the content in Genetics. Each of the multiple-choice items in the SKGT and SAGT has a stem about an aspect of the concept of genetics followed by four options or alternatives. The options comprised one correct answer and three plausible distracters. Each correct answer circled or chosen was awarded one mark, resulting in a total score of 20 marks. Preceding the test items of each test instrument was a portion that briefly stated the purpose of the test and also asked participants to provide personal data, such as, age and gender. This portion also contained instructions to answer the items. Questionnaires were also administered to participants of the study. The questionnaire was used to elicit information on participants' perception on the use of multimedia instructional approach.

3.6 Validity and Reliability of the Instruments

Before using the instrument, its validity and reliability were assessed to determine its accuracy and consistency. According to Cresswell (2015), the goal of good research is to have measures that are reliable and valid. Validity is concerned with whether the findings are really about what they appear to be about (Winter, 2000). According to Treagust, Won and Duit (2014), validity is based on the view that a particular instrument measures what it purports.

The instruments were subjected to face and content validity through experts' suggestion by the research supervisor on the basis of coverage, clarity or non-ambiguity, relevance and to the level of the students' knowledge in line with the research questions and hypotheses. The test was later polit-tested by administering the same test items to thirty elective biology students of the same level at Agona Fankobaa SHS. The scripts were scored and subjected to test item analysis to enable the researcher to eliminate and replace implausible items and responses.

Reliability, according to Dzakadzie (2015), is the degree of consistency of assessment results, that is, the degree to which assessment results are the same when the same tasks are completed on the same or different occasions or a different but equivalent task completed on the same or different occasions. To ensure the stability of the test results the test-retest method was applied to determine the reliability of the items. The test was administered and re-administered within a week interval, this ensured that the interval between the test and retest was short enough as a longer interval resulted in fading of ideas which may have produced a low-reliability coefficient. The results of both trials were analysed and yielded a reliability coefficient of .83 for the test. A reliability coefficient of .80 and .90 inclusive is considered appropriate (De Villiers, 1991). The Cronbach‘s alpha coefficient of .751 was obtained for the reliability of the questionnaire items which indicated that these items were dependable in terms of making analysis.

3.7 Data Collection Procedure

The data collection procedure was divided into three phases: pre-intervention phase, intervention phase and post-intervention phase. The SKGT was administered to the students of both control and experimental groups as the test to obtain relevant information about the knowledge level of students in both groups before the intervention. Research assistants were employed in the study. They were Biology tutors in the school used for the study. These teachers were exposed to the aim of the study and were taught how to teach using multimedia instructional approaches. Students of the experimental group were taught ‗Genetics-Concept of Inheritance' using the genetics courseware package and video-based instructions downloaded from the internet as well as a PowerPoint presentation on genetics designed by the researcher. Those in the control group, however, were taught using conventional methods and without multimedia. At the end of three weeks experimental teaching period, the SAGT was administered to students in both the experimental and control groups simultaneously with the help of the research assistants/teachers. The whole data collection procedure took a period of six weeks; one week each for the administration of the SKGT and SAGT, three weeks for the experimental teaching, and one week for the administration of the questionnaire to collect data on students' perception of multimedia instructional approach. The entire data collection process is summarized in the table below:

Table 2: Data Collection Process

Pre-treatment Phase	Treatment Phase	Post-treatment Phase
Pilot-Testing; Familiarization Visits; Administration of SKGT	Administration of Interventions	Administration of Post-Test Instrument – SAGT, Administration of Questionnaires

3.8 Data Processing and Analysis

The study collected only quantitative data and employed quantitative method of data analysis. Frequency distribution tables were used to present the data. The statistical package for social sciences (SPSS) and Microsoft data analysis tool pack were used to present descriptive statistics of the data such as mean, standard deviation and standard error. Also, data obtained from participants in both experimental and control groups on the SAGT were analysed statistically using an independent sample t-Test. The difference between the mean scores of both groups on the pre-test-post-test scores was tested at a 0.05 significant level. The independent sample t-Test was also used to investigate whether any differences existed between experimental and control groups' mean scores on the SAGT. This was done to answer the research questions and either reject or fail to reject the null hypotheses formulated for the study. Again, to verify the intervention effects on the male and female students of the groups, the independent sample t-test was applied. The table below shows the analysis framework for the study.

Table 3: Framework of Data Analysis

Research Questions	Nature	Unit of Analysis	Statistical Tool (S)
1	Quantitative	SKGT	Mean, standard deviation, Standard, Error t-test
2	Quantitative	SAGT	Simple percentages, Bar chart t-test
3	Quantitative	SKGT and SAGT	Mean, standard deviation, Standard Error, t-test
4	Quantitative	Questionnaire	Simple percentages

3.9 Ethical Consideration

To gain access to the students in the selected school, permission was obtained from the school head. In this regard, a letter was written explaining the purpose of the study and why the data was needed from the students. Permission was subsequently granted for data to be collected. Furthermore, during the familiarisation visits, the researcher explained the purpose of the study to the participants, and assured them of anonymity and confidentiality of information that would be given.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.0 Overview

This chapter presents data gathered in the study. It discusses the results yielded at the pre-intervention and post-intervention levels of the study.

4.1 Demographic Characteristics of Participants

This section of the study presents the preliminary analysis of the profile of the participants. The biographic data reflects the profile of the participants in terms of their age and gender.

Table 4: Biodata of the Participants

	Frequency (Percentage, %)		
	Control	**Experimental**	**Total**
Gender			
Male	14 (53.8)	12(46.2)	26 (100.0)
Female	9 (45.0)	11 (55.0)	20 (100.0)
Age			
Less than 14 years	3 (60.0)	2 (40.0)	5 (100.0)
14 - 17 years	13 (44.8)	16 (55.2)	29 (100.0)
18 - 21 years	5 (62.5)	3 (37.5)	8 (100.0)
More than 21 years	2 (50.0)	2 (50.0)	4 (100.0)

Source: Field Study (2021)

From Table 4 above, it can be seen that out of the total participants used for the analysis, twenty-six were male students where 14 (53.8%) were in the control group whiles 12 (46.2%) were in the experimental group. Also, there were 9 (45.0%) and 11 (55.0%) female students in the control and experimental groups respectively. This gave a total of twenty (20) female students who participated in the study. It can be concluded that more male students participated in the study than female students. It can also be seen that the ages of the students range from below 14 years to above 21 years. With which the most frequent age range was those within the age bracket of 14-17 years with a frequency of 13 (44.8%) in the control group and 16 (55.2%) in the experimental group, giving a total of twenty-nine students of the total sample under study. This shows that most of the students who participated in this study were adolescents.

4.2 Students Marks at Pre-Test for Control and Experimental Groups

Research Question One: What is the difference in performance between control and experimental groups on pre-test scores on the concept genetics?

The tables below were obtained when 15 test items on genetics named Student Knowledge in Genetic Test (SKGT) was administered to the control and experimental groups. The data contains the raw scores in class intervals of 5, their corresponding frequency and respective percentages. It was intended to answer the following research question: ―What is the difference in performance between control and experimental groups on pre-test scores?"

Table 5: Students' Performance at Pre-test in Genetics

Group	N	0-5 (%)	6-10 (%)	11-15 (%)	Total (%)
Experimental	23	52.2	43.5	4.3	100
Control	23	56.5	34.8	8.7	100

Source: Field Study (2021)

From table 5 above, the highest marks between the intervals of 11-15 were scored by 8.7 % of control group students, whiles 4.3 % of the experimental group students score within the same range. Thirty-four per cent (34.8 %) of students in the control group scored marks ranging between 6-10, whiles 43.5 % of experimental students score within this range. This translate to mean that 34.8 % and 43.5% of the students in control and experimental groups respectively scored marks that could be considered as average. The lowest marks ranging from 0 to 5 were scored by 67.9% of students in the control group and 52.2% of students in the experimental group. It could be seen from the results shown above that majority of students from the control and experimental groups failed the test before the intervention.

4.3 T-test Analysis of Pre-test

With the administration of the Student Knowledge in Genetic Test (SKGT), the researcher was interested in finding out whether students from both groups (control and experimental) had equal understanding of genetics before implementation of the multimedia instructional strategy in teaching the experimental group. Therefore, T-test analysis was performed on the SKGT scores to determine whether there is a significant difference between the mean scores of the groups.

Table 6: T-test Analysis of Control and Experimental groups at Pre-test in Genetics

Group	N	Mean	S. D	df	t	P-value
Experimental	23	5.43	2.37	44	.396	.694
Control	23	5.13	2.82			

Significance at 0.05; $p<0.05$ **Source: Field Study (2021)**

Table 6 shows some statistical tendencies of the pre-test. Students in the experimental group had mean with standard deviation (Mean=5.43; SD=2.37). That of the control group gave a mean and standard deviation (Mean=5.31; SD=2.82). So, the mean score of the test results shows the low knowledge students had on the concept of genetics before the use of the traditional method of teaching.

The first hypothesis states that there is no statistically significant difference between the academic achievement of students of control and experimental groups on the pre-test. Results from the t-test analysis shown in table 4.3 above give a t-value of 0.396 and a P-value of 0.694 at a 95% significance level. Since the P-value (0.694) is greater than the level of significance (0.05), we fail to reject the null hypothesis, implying that there was actually no significant difference between control and experimental groups before the implementation of the experiment.

4.4 Students Marks at Post-Test for Control and Experimental Groups

Research Question Two: What is the difference in performance between control and experimental groups on post-test scores on genetics when they are taught using multimedia and conventional approaches?

The test named Student Achievement in Genetic Test (SAGT) was administered to the control and experimental groups to ascertain their achievement after the experimental process. It consisted of fifteen multiple-choice questions and was based on the content that has been taught. The data contains the raw scores in class intervals of 5 and their corresponding percentages. It was intended to answer the following research question: ―What is the difference in performance between control and experimental groups on post-test scores when they are taught using multimedia and conventional approaches?”

Table 7: Students' Performance at Post-test in Genetics

Group	N	0-5 (%)	6-10 (%)	11-15 (%)	Total (%)
Experimental	23	8.7	26.1	65.2	100
Control	23	39.1	43.5	17.4	100

Source: Field Study (2021)

From table 7 above, the highest marks between the intervals of 11-15 were scored by 17.4 % of control group students. 65.2 % of the experimental group students score within the same range. 43.5 % of students in the control group scored marks ranging between 6-10, whiles 26.1 % of experimental students score within this range. This in essence means that 34.8 % and 43.5% of the students in control and experimental groups respectively scored marks that could be considered as average. The lowest marks ranging from 0 to 5 were scored by 39.1% of students in the control group and 8.7% of students in the experimental group. Thus, approximately half of the sample scored average marks whiles a substantial percentage of students failed. The results observed above clearly indicate that many of the students in the control group failed the test after the use of the traditional method of teaching. Also, the analysis above shows that about 90 % of the students in the experimental group passed the test after the use of the multimedia in teaching the concept. This is an indication of the effectiveness of the multimedia approach in teaching genetics.

4.5 T-test Analysis of Post-test

This was done to determine whether there is a significant difference between the mean scores of the control and experimental groups after they were taught using conventional and multimedia approaches respectively.

Table 8: T-test Analysis of Control and Experimental groups at Post-test in Genetics

Group	N	Mean	S. D	df	t	P-value
Experimental	23	10.26	2.51	44	4.26	0.0001
Control	23	6.65	3.14			

Significance at 0.05; $p<0.05$ **Source: Field Study (2021)**

The results from the table 8 above revealed a mean of 6.65 and the standard deviation was 3.140 for students in the control group. A mean of 10.26 and a standard deviation of 2.51 was obtained for students in the experimental group. This indicates low knowledge students in the control group had on the concept after the use of the traditional method of teaching. Similarly, the results show the high knowledge students in the experimental group had gained on the concept upon the use of the multimedia approach. The control group had a mean score of 6.65, Standard Deviation of 3.140 and Standard Error of 0.667. The above table gives a T-value of 4.26 and a P-value of 0.0001. Since the P-value is less than the level of significance (0.05), we reject the null hypothesis, which states that there is no statistically significant difference between academic achievement in the genetics of students taught by conventional method and those taught using multimedia technologies with respect to their post-test scores. This implies that there is significant difference between the control and experimental groups after the implementation of the instructional strategies.

4.6 Analysis on Performance of Male and Female Students Exposed to Multimedia Instructions

Research Question Three: What is the difference in academic performance on the concept genetics between females and their male counterparts taught using multimedia instructional approach?

Table 9 below gives a summary of the performance of male and female students after they were exposed to the treatment. This was done to ascertain the effects that multimedia instructional approaches have on male and female students separately and to answer the following research question: ―What is the difference in academic performance between females and their male counterparts taught using multimedia instructional approach?"

Table 9: Experimental Group Students Performance Based on Gender

	Frequency	
Sore Range	**Male**	**Female**
0 to 5	2	1
6 to 10	5	3
11 to 15	5	7
Total	12	11

Source: Field Study (2021)

The table 9 above suggests that while the performance of all students in the experimental group improved significantly after they were exposed to the intervention, five of the male students scored in the range of 11-15 as against seven female students scoring within the same range. Whilst three females scored in the range 6-10, five males scored in this range.

In Figure 4.1, a comparison of the performance of male and female students in the experimental group after they were exposed to multimedia instruction.

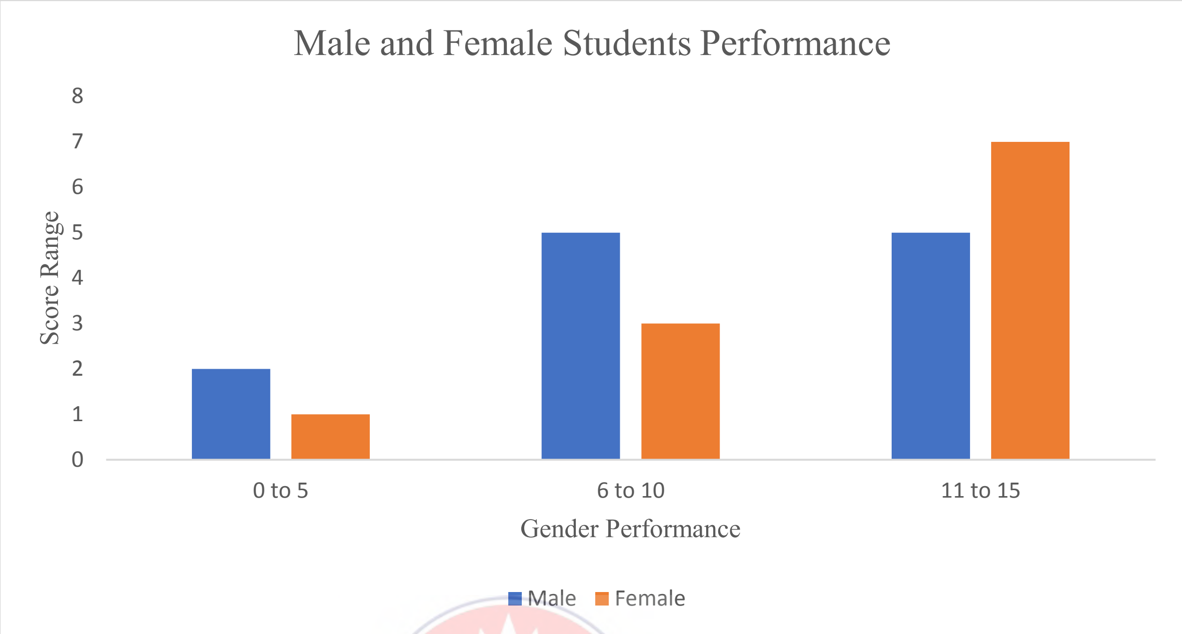

Figure 3: Comparison performance of male and female students in the experimental group

From the figure above, one female and two males scored marks ranging from 0 to 5. Five males and three females scored average marks, while seven females and five males scored marks ranging from 11 to 15. This shows that both males and females performed well when they were thought with multimedia instructional approaches.

Table 10: Gender means value of post-test in experimental group

Gender	N	Mean	SD	Standard Error
Male	12	9.417	2.937	0.848
Female	11	10.545	2.423	0.731

Source: Field Study (2021)

Female students recorded a slightly higher mean of 10.545 than that of male students of 9.417. The standard deviation was 2.423 and 2.937 for female and male students respectively.   Hence the mean score of the test results shows high knowledge both genders had gained on the concept upon the intervention used to teach genetics.

4.7 T-test Analysis of Gender Performance

This was done to determine whether there is a significant difference between the mean scores of the male and female students in the experimental group after the intervention process.

Table 11: Two sample T-test with unequal variances of significant differences between male and female experimental group students at post-test results

Group	N	Mean	Mean Difference	T	DF	P(2-Tailed)
Male	12	9.417	0.818	1.008	21	0.325
Female	11	10.545				

Significance at 0.05; p<0.05; **Source: Field Study (2021)**

The average score for male students was 9.417, with a standard deviation of 2.937. The average score for female students was 10.545, with a standard deviation of 2.423. The mean difference in the table above is 1.128, with a T-value of 1.008 and a p-value of 0.325. We fail to reject the null hypothesis, which claims that there is no statistically significant difference in academic achievement between male and female students taught using the multimedia technique because the P-value is greater than the level of significance (0.05). This means that multimedia training had an equal influence on male and female students' knowledge.

4.8 Students' Perception About the Use of Multimedia Instruction

Research Question Four: What are the perceptions of students who have been exposed to multimedia instruction about the approach for teaching and learning genetics?

The following section gathered data regarding students' perception of the use of the multimedia approaches in teaching genetics. The data obtained also aided in answering the following research question: ―What are the perceptions of students who have been exposed to multimedia instruction about the approach?"

Table 12: Students' Perception About Multimedia Instruction

S/N	Items	Responses			
		Yes		No	
		Freq.	%	Freq.	%
1.	I learn more when taught with a multimedia approach	18	78.3	5	21.7
2.	Having a class in Multimedia lessons improves my understanding	23	100.0	0.0	0.0
3.	I expect higher performance after Multimedia lessons	19	82.6	4	17.4
4.	My instructor is interested in individual needs & interests	10	43.4	13	56.5
5.	I feel encouraged to participate in the lesson when taught through multimedia	18	78.3	5	21.7
6.	My instructor holds my interest when teaching through multimedia approach	21	91.3	2	8.7
7.	Given the chance, I would choose to be taught through multimedia instructions mostly	23	100.0	0.0	0.0

Source: Field Study (2021)

According to the table above, the majority (78.3 per cent) of respondents believe they learn more when they are taught via multimedia instructions. All respondents (100%) agree that taking multimedia classes increases their understanding and are willing to choose multimedia instruction over other instructional styles. However, just 43.4 per cent of respondents believe that their instructor is concerned about their specific needs and interests by using multimedia instructions. Meanwhile, 91.3 per cent of them claimed that their instructor piques their interest when using multimedia in the classroom, and 78.3 per cent report that they are encouraged to engage in the lesson when using multimedia in the classroom. Furthermore, 82.6 per cent of respondents indicated that they expected improved performance as a result of multimedia teaching.

CHAPTER FIVE

DISCUSSION OF FINDINGS

5.0 Overview

This chapter presents a thorough discussion of the results obtained from this study and also answers the various research questions.

5.1 Students' Performance Before Treatment

Research Question One: What is the difference in performance between control and experimental groups on pre-test scores on the concept genetics?

The pre-test was administered to establish the difference in performance between the control and experimental groups before the intervention. The results obtained from the test indicated the control group had a mean score of 5.13 and the experimental group had a mean score of 5.43. A t-test analysis gave a p-value of 0.694, far greater than the level of significance (0.05), and therefore failed to reject the null hypothesis, which states that there is no statistically significant difference between the academic achievement of students in control and experimental groups on the pre-test. This indicates the magnitude of the students' shortcomings in both groups in understanding the concept.

5.2 Students' Performance After Treatment

Research Question Two: What is the difference in performance between control and experimental groups on post-test scores on genetics when they are taught using multimedia and conventional approaches?

The average score in the control group was 6.65, with a standard deviation of 3.140 and a standard error of 0.667. The average score in the experimental group was 10.26, with a standard deviation of 2.508 and a standard error of 0.523. The p-value for this outcome was 0.0001. The null hypothesis, which states that there is no statistically significant difference in academic achievement in genetics between students taught using traditional methods and those taught using multimedia technologies in terms of post-test scores was rejected because the P-value was less than the level of significance (0.05). The results of Hypothesis Two revealed that there was in fact significant difference among students' achievements in favour of the experimental group against the control group. The results indicated that students exposed to multimedia instructions outperformed those exposed to the conventional teaching methods. This backs up Mayer's (2003) findings, which argue that students learn more thoroughly from a combination of words and visuals than from just words; this is referred to as the "multimedia impact". Shah and Freedman (2003) also mention a variety of advantages of employing visualisations in learning contexts, including: encouraging learning by presenting an external representation of the knowledge. This is also consistent with the findings of Pruet, Ang and Farzin (2016), who discovered that computer animation learning courseware had a good influence on students' academic performance and accomplishment levels (high and low), as well as their learning styles. These findings revealed a substantial difference in retention achievement among students taught biology using video-based multimedia educational packages. These findings are consistent with those of Achebe (2008), as well as Tabbers and Martens and Van Merriënboer (2004), and Starbek, Starčič Erjavec and Peklaj (2010), who discovered that students taught genetics with multimedia acquired greater knowledge, retention, and improved comprehension skills than other groups. However, the findings contradict those Saibu (2002), who discovered that students taught using the traditional teaching approach attained a slightly higher mean post-test score than those taught using the audio-tutorial method.

5.3 Impact of Multimedia Instruction

During the implementation of the interventional strategies, as a researcher, observation of students' behaviour during teaching and learning of the topic was as paramount in determining the impact of the strategy used as conducting an achievement test to determine the same. Students' class participation, behaviour, and posture were used as benchmarks for determining their involvement in the lesson, which was considered partly tantamount to the effects of the teaching strategy used. Students were actively engaged in discussions and eager to contribute by asking questions because the approach sparked their curiosity and appealed to their visual impressions as well. These engagements increased their level of understanding and contributed to the success of the lesson. This was observed in the results obtained in the experimental group after conducting a post-intervention test. The test revealed that the students' performance improved significantly after the intervention strategies. When a student's interest, understanding, and retention abilities improve (Gilakjani, 2012), there is a propensity for academic accomplishment and attitude to improve. This is consistent with Mantei (2000) observation that using power point presentations to teach science increases students' attitudes toward science.

This highlights the tremendous power and usefulness of computers in teaching. Although computers are powerful in terms of their ability to handle vast amounts of data, their effective use in education is based on some elements, including the teacher's technological pedagogical subject understanding. This is because new approaches are required when facilitating educational transactions through technology. Tukur, Yunusa and Isiyaku (2014) discovered contradicting findings in the current investigation. Their study discovered no significant difference between computer-assisted training and traditional teaching, implying that multimedia did not influence on students' learning when compared to traditional instruction. Their findings, however, were attributed to students' experience with computers and cognitive techniques. This means that computer-assisted instruction is just as effective as traditional teaching methods (Tukur, Yunusa, & Isiyaku, 2014). The demographics of students are important in assessing the effectiveness of teaching strategies.

5.3.1 Impact of Multimedia Instructions on Male and Female Students

Research Question Three: What is the difference in academic performance on the concept genetics between females and their male counterparts taught using a multimedia instructional approach?

The study also looked into the impact of gender on students' achievement after the interventions were implemented. The goal was to see if there were any variations in achievement scores between male and female students who were taught using the multimedia technique and those who were taught using the standard lecture style. The t-test (t=1.004; p=0.325) results suggest that gender had no significant effect on the learners' learning with multimedia. At a 0.05 level of significance, P (2-tailed) = 0.325. Although the mean scores of males (M = 9.417, SD = 2.937) and females (M = 10.545, SD = 2.423) appear to vary on the surface, the difference was not statistically significant. As a result, it may be argued that this did not affect students' post-test scores regarding genders. The combined effect of multimedia and gender on students' learning results found that they have no influence. This is consistent with the submission of Ebo (2017). However, this study contradicts the findings of Bosede (2010), who found that gender influences students' academic achievement in science and technology courses in computer-mediated instruction, with male students outperforming their female counterparts.

5.4 Students' Perception on Multimedia Instructions

Research Question Four: What are the perceptions of students who have been exposed to multimedia instruction about the approach for teaching and learning genetics?

According to the analysis of results on students' perceptions, students had more positive perceptions of the instruction in general. This suggests that after being exposed to new technology-based educational resources, students' attitudes toward instruction improved. This is consistent with the findings of Perry and Perry (1998), surveyed of 109 college students enrolled in two classes: computer information systems and teacher education. They determined that students preferred to attend lessons with multimedia presentations since it made the classes more interesting and entertaining. According to the authors, multimedia can have a favourable impact on learning. According to a multimedia opinion poll, when multimedia elements were used, (i) students felt more content was covered, (ii) students felt they learnt and kept course material better, and (3) students felt they grasped challenging ideas better. Furthermore, Kim and Kim (2005) discovered that, when comparing a set of five teaching resources for teaching sanitation principles (course Website, didactic lectures in class, laboratory activities, assignments, and textbook), students perceived technology-mediated instruction (course Website) as the most effective teaching resource to improve students' knowledge, followed by cooking lab activities, a textbook, didactic lectures in class, and assignments related to food sanitation.

Price, Lukhard and Postel (2005) also compared the educational outcomes of students who received standard lecture training with those who received multimedia instruction. Although they discovered that students preferred traditional lecture instruction, they hypothesized that when given the option of total self-instruction, students who knew they learned well using this method of instruction chose it, but there were always students who preferred traditional lecture instruction. To meet students' different learning needs and improve their computer abilities, the authors concluded that offering courses that blend traditional lecture methods of instruction with multimedia instructions would be advantageous.

CHAPTER SIX

SUMMARY, CONCLUSION, RECOMMENDATION AND SUGGESTION

6.0 Overview

This chapter deals with a summary of this research work, the conclusion, recommendations proposed by the researcher and suggestions for further studies.

6.1 Summary of the Study

A quasi-experimental research design was espoused for this study. The main objective of the study was to assess the impact of a multimedia instructional approach on biology students�given achievement at Winneba Senior High School. A sample of 46 students was taken; 23 students each in the experimental and control groups. The instruments used for the study were the Student Knowledge in Genetics Test (SKGT) and the Student Achievement in Genetics Test (SAGT). SKGT was used to measure the level of students�' difficulty before the intervention activities. During the intervention measure, the students in the experimental group were taken through multimedia instruction while those in the control group were taken through traditional teaching. A post-intervention test (SAGT) was conducted to measure and compare the level of improvement in students‘ performance in both groups after the intervention strategy had been implemented. This was also evaluated to determine the effectiveness of the approach used and its impact on students of different genders. SPSS and the Microsoft data analysis tool pack were used to present descriptive statistics of the data such as: mean, standard deviation, and standard error. Also, an inferential statistical tool (t-test) was employed to summarize the overall trends in the students′ performance in both control and experimental groups and test the hypotheses. Students‘ performance was below average in both experimental and control groups before the intervention strategies were implemented. Post-test results from the control group who were taught with the traditional method of teaching indicated that only 17.4% performed above average while a substantial percentage of students failed. In the experimental group, the multimedia instructional approach aroused students‘ interest and sustained their attention throughout the teaching and learning process. This increased their level of understanding and, therefore, increased their performance in the post-intervention test. About 90% of the students in the experimental group passed the test, with about 65.2% of them performing above average and the remaining 34.8 with average performance. However, there was no significant difference in the performance of male and female students in the experimental group, implying that multimedia instructions impacted the understanding of male and female students equally. It was therefore noted that when multimedia instructional methods supplant the traditional method of teaching together with the use of appropriate teaching and learning materials in teaching biology, better results are achieved.

6.2 Conclusion

The goal of the research was to see how the multimedia instructional approach affected students' performance in genetics. According to the findings of the studies, the multimedia method, which is a new kind of instructional approach, improves students' academic progress. The findings also demonstrated that this instructional strategy was effective for the high-performance levels of the students who used it. It is reasonable to conclude that using a multimedia approach to teaching can increase senior high school biology students' performance. This also implies that using multimedia to teach genetics at the SHS level is an effective technique of education because students were able to learn quickly.

As a result, multimedia training is successful at piquing students' interests, increasing class involvement, and developing deeper knowledge of ideas. It can also be argued that using multimedia in the classroom can help students learn concepts and improve their academic performance in genetics. Science teachers should help students understand biology concepts that describe complicated, hard-to-visualize systems with interacting elements by employing well developed rich multimedia tools.

6.3 Recommendation

From the findings and conclusion of the study, the following recommendations are made:

It is recommended that science teachers of the school and educators encourage the adoption of the multimedia method in science education because the approach holds more potential in terms of student achievement in science.

Again, science educators of the district should use learning methods that involve students in the teaching and learning process rather than simply giving them data that may or may not be useful.

Circuit supervisors of the district should encourage biology and other science teachers to incorporate computer instructional packages into their classroom instructions in order to improve students' performance in biology.

Ministries of Education should collaborate with various academic stakeholders to develop a platform, such as workshops and seminars, to successfully impart teachers' required competences when using multimedia in the classroom.

Providing SHS teachers with training in the use of multimedia in the classroom, provided that these courses are available throughout the academic year.

6.4 Suggestion for Further Researchers

It is urged that this study be replicated in different settings to substantiate the functionality and effectiveness of the intervention strategies applied.

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APPENDICES

Appendix A

Student Knowledge in Genetics Test (SKGT)

Time: 30 minutes

School: ……………………………………………………………………………...

Age: ……………… **Class: ……………** **Sex M [ ] F[ ]**

1. Which of the following is not controlled by genes?
A. Eye colour
B. Ability to play piano
C. Shape of the ear lobe
D. Ability to roll the tongue

2. Two alternatives form of the same gene are known as
A. Alleles
B. Genotype
C. Heterozygous
D. Phenotype

3. A change in gene frequency normally leads to
A. Variation
B. Mutation
C. Epistasis
D. Natural selection

4. Which of the following characteristics is a non-heritable variation?
A. Shape of ear
B. Ability to roll tongue
C. Intonation of the speech
D. Skin colour

5. The F1 generation of a cross between a red cock and a white hen were all white because the gene for the
A. White colour did not segregate
B. Red colour was dominant
C. White colour was dominant
D. Red colour was recessive

6. The phenotypic ratio for selfing the offspring of a cross between homozygous tall and homozygous dwarf pea plant is
A. 1:2:1
B. 2:1:1
C. 1:3
D. 3:1

7. Which of the following represent co-dominance?
A. AB blood group
B. Dwarfism
C. Polyploidy
D. Sickle cell anaemia

8. What is the probability of a woman of blood group AB married to a man of blood group O producing a child of blood group O?
   A. 75%
   B. 50%
   C. 25%
   D. 0%

9. A dominant gene refers to a gene
A. Which is prevalent in all populations
B. That suppresses the effects of is alternate gene
C. That is resistant to mutation
D. Which occur in healthy individuals

10. A homozygous recessive plant is crossed with a heterozygote plant. The phenotypic ration of the progeny will be
A. 0:2
B. 1:1
C. 2:1
D. 3:1

11. The first person to explain inheritance by doing experiment with peas was
A. Hugo de Vias
B. Gregor Mendel
C. Charles Darwin
D. Thomas Morgan

12. The result of a cross between two heterozygous is
A. 50% recessive 50% dominant
B. 100% recessive
C. 100% dominant
D. 25% recessive and 75% dominant

13. A child that can receive blood from anybody belongs to blood group
A. O
B. A
C. B
D. AB

14. The number of chromosomes in a human gamete is
A. 23
B. 32
C. 46
D. 52
15. In genetics, test cross is performed to determine
A. Crossing over
B. Genetic linkage
C. Genotypic composition
D. Phenotypic composition

ANSWERS

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

Appendix B

Student Achievement in Genetics Test (SAGT) **Time: 30 minutes**

School: ……………………………………………………………………………...

Age: ……………… **Class: ……………** **Sex M [ ] F [ ]**

1. Which of the following diseases can be inherited?
A. Pneumonia
B. AIDS
C. Sickle cell anaemia
D. Goitre

2. In dihybrid inheritance Mendel considered
A. A pair of contrasting character
B. Two pairs of contrasting character
C. Three pars of contrasting character
D. Four pairs of contrasting character

3. Differences in characteristics that exist among individuals of the same species is referred to as
A. Genetics
B. Dominance
C. Hybrid
D. Variation

4. Scientists who study genetics are known as
A. Genealogists
B. Geneticists
C. Mendelists
D. Gene scientists

5. Which of the following scientists did not contribute towards the development of genetics?
A. Wilhem Johannsen
B. Thomas Morgan
C. Gregor Mendel
D. Felix Durjahadin

6. A dark-skinned couple with no traces of fairness in their individual lineages produces a very fair skinned child. This could be due to
A. Genetic mismatch
B. Mutation of genes
C. X-ray exposure
D. Environmental condition

7. The greatest contribution to genetic studies was made by
A. Thomas Morgan
B. Gregor Mendel
C. Charles Darwin
D. Robert Hooke

8. The exchange of genes between homologous chromosomes is called
A. Test cross
B. Back cross
C. Crossing over
D. Mutation

9. The structure of a DNA molecule may be changed through
A. Evolution
B. Heredity
C. Variation
D. Mutation

10. A change in gene frequency normally leads to
A. Variation
B. Epistasis
C. Mutation
D. Natural selection

11. Which of the following traits is sex linked?
A. Albinism
B. Colour blindness
C. Night blindness
D. Tongue rolling

12. Which of the following notations implies that an individual is a carrier of the sickle cell?
A. AB
B. AO
C. AS
D. SS

13. Outbreeding may lead to
A. Hybrid vigour
B. Few offspring being produced
C. Identical individuals in populations
D. More offspring being produced

14. One of the genetic phenomena that causes variation is
A. Dominance
B. Hybrid vigour
C. Independent assortment
D. Mitosis

15. An individual that has identical alleles for a trait is
A. Carrier
B. Hybrid
C. Heterozygous
D. True-breeding

ANSWERS

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

Appendix C

QUESTIONNAIRE

(Students' Perception About Multimedia Instructions)

Age: ………………   Class: ……………   Sex M [ ]   F [   ]

Dear Student,

This questionnaire is designed to obtain information for the purpose of thesis writing at the University of Education, Winneba. The information you will provide will be treated as confidential and your anonymity is highly assured.

NOTE: You are requested to read each statement and sincerely provide the required information. The information provided will be strictly used only for this study.
Yes or No is provided beside each statement. You are to respond by ticking the option that applies. Please answer the questions as frankly as possible.

S/N	Questions	Responses	
		Yes	No
1.	I learn more when taught with multimedia approach		
2.	Having a class in Multimedia lesson improves my understanding		
3.	I expect higher performance after Multimedia lessons		
4.	My instructor is interested in individual needs & interests		
5.	I feel encouraged to participate in the lesson when taught through multimedia		
6.	My instructor holds my interest when teaching through multimedia approach		
7.	Given the chance, I would choose to be taught through multimedia instructions mostly		

Appendix D
Raw Scores for Experimental and Control Groups During Pre-Test and Post-test

PRETEST POSTTEST

Control	Experimental	Control	Experimental
9	2	4	12
7	6	8	12
4	4	7	14
2	3	11	9
3	5	3	8
5	6	13	9
1	3	7	7
4	7	5	11
7	4	12	9
11	5	8	11
11	8	9	10
6	7	2	12
6	9	5	9
3	5	3	11
4	3	2	10
0	2	8	12
6	6	4	11
5	6	7	12
2	3	4	5
6	7	12	13
7	6	6	4
4	12	7	13
5	5	6	12

Appendix E

Summary Statistics and T-test for Pre-test Analysis

Control			*Experimental*	
Mean	5.130434783		Mean	5.434782609
Standard Error	0.587432101		Standard Error	0.494339848
Median	5		Median	6
Mode	4		Mode	6
Standard Deviation	2.817225389		Standard Deviation	2.370770626
Sample Variance	7.936758893		Sample Variance	5.62055336
Kurtosis	0.204225415		Kurtosis	1.287189934
Skewness	0.428875332		Skewness	0.795130203
Range	11		Range	10
Minimum	0		Minimum	2
Maximum	11		Maximum	12
Sum	118		Sum	125
Count	23		Count	23

t-Test: Two-Sample Assuming Equal Variances		
	Control	*Experimental*
Mean	5.130434783	5.434782609
Variance	7.936758893	5.62055336
Observations	23	23
Pooled Variance	6.778656126	
Hypothesized Mean Difference	0	
Df	44	
t Stat	-0.396412484	
P(T<=t) one-tail	0.346858395	
t Critical one-tail	1.680229977	
P(T<=t) two-tail	0.69371679	
t Critical two-tail	2.015367574	

Appendix F

Summary Statistics and T-test for Post-test Analysis

Control			*Experimental*	
Mean	6.652173913		Mean	10.26086957
Standard Error	0.6671534		Standard Error	0.523054994
Median	7		Median	11
Mode	7		Mode	12
Standard Deviation	3.199555305		Standard Deviation	2.508483629
Sample Variance	10.23715415		Sample Variance	6.292490119
Kurtosis	-0.542199431		Kurtosis	0.791506302
Skewness	0.455937602		Skewness	-1.005310709
Range	11		Range	10
Minimum	2		Minimum	4
Maximum	13		Maximum	14
Sum	153		Sum	236
Count	23		Count	23

t-Test: Two-Sample Assuming Equal Variances		
	Control	*Experimental*
Mean	6.652173913	10.26086957
Variance	10.23715415	6.292490119
Observations	23	23
Pooled Variance	8.264822134	
Hypothesized Mean Difference	0	
Df	44	
t Stat	-4.256791912	
P(T<=t) one-tail	5.35185E-05	
t Critical one-tail	1.680229977	
P(T<=t) two-tail	0.000107037	
t Critical two-tail	2.015367574	

Appendix G

Summary Statistics and T-test for Gender Analysis

Male		*Female*	
Mean	9.416666667	Mean	10.54545455
Standard Error	0.847977392	Standard Error	0.730673865
Median	9.5	Median	11
Mode	9	Mode	12
Standard Deviation	2.937479852	Standard Deviation	2.423371056
Sample Variance	8.628787879	Sample Variance	5.872727273
Kurtosis	-0.18446938	Kurtosis	1.572046123
Skewness	-0.518681756	Skewness	-1.304377514
Range	10	Range	8
Minimum	4	Minimum	5
Maximum	14	Maximum	13
Sum	113	Sum	116
Count	12	Count	11

t-Test: Two-Sample Assuming Unequal Variances		
	Male	*Female*
Mean	9.416666667	10.54545455
Variance	8.628787879	5.872727273
Observations	12	11
Hypothesized Mean Difference	0	
df	21	
t Stat	-1.008429345	
P(T<=t) one-tail	0.162363694	
t Critical one-tail	1.720742903	
P(T<=t) two-tail	0.324727387	
t Critical two-tail	2.079613845	

Appendix H

UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF SCIENCE EDUCATION
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Our ref. No.: ISED/PG.1/Vol.1/21
Your ref. No.:

Date: 5th November, 2021

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF INTRODUCTION
MR OSEI, HENRY ATTAFUAH

We write to introduce, Mr Osei is a postgraduate student of the Department of Integrated Science Education, University of Education, Winneba, who is conducting a research titled:

The impact of multimedia instructional approaches on the academic achievement of SHS students in genetics

We would be very grateful if you could give him the assistance required.

Thank you.

Yours faithfully,

ALEXANDRA N. DOWUONA
PRINCIPAL ADMIN. ASSISTANT
For : HEAD OF DEPARTMENT

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