UNIVERSITY OF EDUCATION, WINNEBA

EFFECT OF MULTIMODAL INSTRUCTIONAL APPROACHES ON SENIOR HIGH SCHOOL STUDENTS' COGNITIVE ACHIEVEMENT IN SELECTED BIOLOGY CONCEPTS

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OCTOBER, 2021

DECLARATION

STUDENT'S DECLARATION

I, Caroline Asantewaa Biritwum, 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 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.

NAME OF SUPERVISOR: PROFESSOR JOHN. K. EMINAH

SIGNATURE: ……

DATE: …….

DEDICATION

This dissertation is dedicated to my beloved father the late Mr. Emmanuel Addae Biritwum and my mother, Mrs. Florence Aboagyewaa Biritwum.

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ABSTRACT

The study investigated the effect of multimodal instructional approaches on the academic achievements of selected senior high school students on selected topics in biology (Mammalian anatomy and physiology). It was carried out in the New Juaben South Municipality in the eastern region of Ghana. The research study adopted the quasi-experimental research design using the pre and post-test design. The sample comprised of 80 students from Koforidua Senior High Technical School (KSTHS) and Oti Boateng Senior High School (OBOSS) both in the New Juaben South Municipality. Students from KSHTS were 40 (forty) in number comprising twenty-eight (28) males and twelve (12) females. They formed the control group of the research. Another forty students were drawn from OBOSS to form the experimental group. They comprised 18 males and twenty-two (22) females. In totality, the research was made up of forty-six (46) males and thirty-four (34) females. A pre-test was administered to all the participants to be sure of their homogeneity. Treatment was administered to the experimental group using multimodal instructional approaches and the control group was taught using the lecture method of teaching. After the treatment, a post-test was administered to both groups to determine the effectiveness of the treatment. The pre-test and post-test scores of the students in both groups were used for data analysis. The results of the post-test revealed that the use of multimodal instructional approaches in teaching the concept of mammalian anatomy and physiology was effective. When the results of the two methods were compared, the Multimodal instructional approach was found to be effective than the lecture method. Questionnaires were also administered to students of the experimental group to determine their perception of multimodal instructional approaches. Students' responses to the questionnaire proved that majority of students agreed that the multimodal instructional approach is an effective method of teaching Mammalian Anatomy and Physiology. It was therefore recommended that Biology teachers adopt multimodal instructional approaches in teaching and should be made to attend workshops, seminars and conferences to update their knowledge of the methods of teaching concepts in biology.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This present study seeks to investigate the effect of multimodal instructional approach (MMIA) on the cognitive achievement of students on selected topics in biology. Chapter one of the study presents the background to the study, i.e., the occurrences that occasioned this study. Included in this chapter are also the; statement of the problem, purpose of the study, objectives, research questions, significance of the study, delimitation and limitations of the study. Finally, the chapter also presents how the remaining chapters of the study will be organized.

1.1 Background to the Study

The method of instruction in teaching and learning is very important especially when the teacher wants learners (students) performance academically to be improved. Over the years, with the exception of mathematics, the commonly used method of teaching has been the lecture method, especially at the Senior High School level. In teaching, the learners‟ ability to think critically and be creative is considered when selecting the method or mode of lesson delivery. To do this, the teacher has to use a method of delivery that will involve the use of all the senses of the learner to achieve academic success. The widely used lecture method makes use of only one sense that is hearing or listening and this hinders the learners‟ academic success. Based on this, biology teachers have to use instructional strategies that will improve the teaching and learning of biology at the Senior High School level. The students in the classroom have different styles of learning and all of those has to be considered before the teacher chooses a method of teaching or lesson delivery. That notwithstanding, the

differences in the students‟ learning style still makes them feel comfortable, learn and perform better when they learn in an environment that takes care of their predominant styles of learning (Cronin, 2009). When the learning style of the students are taken into consideration, it helps to meet the needs of all the students in class.

Not quite long ago, there was the introduction of Information Communication Technology (ICT) into our school system. This has gone a long way to help teachers in the design their approaches of instructional approaches that can motivate the students to learn better and improve their academic achievements.

There is an increasing body of evidence which submits that multimodal teaching approach (MMIA) is an active, student-centered approach in which students select the resources mostly relevant to them (Mayer, 2010). This implies that students become responsible for organizing learning content such as words and images into coherent verbal and visual models comprising their mental schemata and conceptual structures (Mayer, 2010). The essence of MMIA, therefore, is to provide different types of resources to the student for stimulating learning in meaningful ways within and across disciplines. MMIA is described as an approach drawn with an emphasis on communication and representation; MMIA in today‟s classrooms refers to „Multiple‟ modes of representation, with combined elements of print, visual images and design (Jewitt, 2013).

Multiple modes of representation include capabilities of combinations of oral and written language, visual, gestural, tactile and spatial representations (Cope & Kalantzis, 2019). According to Ameyaw and Tenkorang (2018), MMIA has provided many opportunities to present multiple representations of content (text, video, audio, images, interactive elements) to cater more effectively for the different learning styles

of an increasingly diverse student body. The authors note that Multi-modal learning environments allow instructional elements to be presented in more than one sensory mode (visual, aural, written). In turn, materials that are presented in a variety of presentation modes may lead learners to perceive that it is easier to learn and improve attention, thus leading to improved learning performance; in particular, for lower-achieving students. According to Farwell (n. d.), 20 to 30 percent of learners remember through hearing, 40 percent retain information visually, and the rest either have higher memory retention after writing something down or through real-life activities. This shows that, instructional strategies that give students or learners the opportunity to use more than one of their senses in learning will lead to better understanding of the concept presented to them and will finally result in significant academic improvement. To a larger extent, MMIA has a positive impact on students‟ performance or academic achievement. This is because, it is the instructional approach that deals with multiple ways of presenting content knowledge to students or learners taking into consideration much of their senses.

Worldwide, MMIA is affecting the educational landscape and has been labelled as a tool that can enhance effective and efficient teaching and learning (Jewitt, 2013). However, while it is increasingly used in many developed countries in computer-based narrated animations, videos, audios and images observations (Mukherjee, 2018), the use of MMIA in developing countries such as Ghana to teach secondary school students is still a thing of novelty due to the serious lack of ICT equipments to facilitate this method of teaching. Although pieces of research (Ameyaw & Tenkorang, 2018; Jewitt, 2013; Farwell, n. d.; Munir, 2018; Moussa-Inaty, Atallah, & Causapin, 2019) have shown the importance of MMIA, yet all these studies were either conducted in colleges (Ameyaw & Tenkorang, 2018; Jewitt, 2013; Munir,

2018) or in basic schools (Farwell, n. d; Moussa-Inaty, Atallah, & Causapin, 2019).Indeed, it appears information on exploring the effectiveness of MMIA at the senior high school level is rare, and therefore, this has become an important area of research. As a result, this study develops a multimodal presentation to teach selected concepts in biology at the senior high level. In addition, the study will explore the effect of this interactive instructional activity on performance and learning achievements of senior high school students in biology.

1.2 Statement of the Problem

Chief Examiners report over the years (2016-2019) revealed that students do not perform well in Mammalian Anatomy and Physiology as a concept. Many reasons including modes of instruction were assigned. Although literature has extensively elaborated the benefits of MMIA (Ameyaw & Tenkorang, 2018; Jewitt, 2013; Munir, 2018; Moussa-Inaty, Atallah, & Causapin, 2019) it is not too widely used in Ghanaian senior high schools (Mukherjee, 2018). In most senior high 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 (Mukherjee, 2018). Several studies have identified the traditional teaching strategy as a factor contributing to students‟ failure (Ahmed & Abimbola, 2011; Cimer, 2012; Hawkar, 2014) and therefore, it has become imperative on teachers to explore a change in teaching strategy hence this study.

1.3 Purpose of the Study

This study aims to investigate the effect of multimodal instructional approaches on students' cognitive achievement in selected topics in biology.

1.4 Objectives of the Study

Objectives of this study are to:

1. determine students‟ cognitive achievement (performance) on the selected biology concepts before the treatment.
2. determine whether or not the control group and experimental group of students will perform equally well after the treatment.
3. investigate students‟ perceptions about the use of MMIA in teaching the biology concepts.

1.5 Research Questions

The research questions are:

1. what is the student‟s cognitive achievement (performance) in the selected biology concepts before the treatment?
2. what are the relative differences in the performance of the control and experimental groups after the treatment?
3. what are the students‟ perceptions on the use of MMIA in teaching the biology concepts?

1.7 Significance of the Study

This study will be significant as the academic performance of students in biology in this study may be improved. Also, the findings from this study may motivate other biology teachers in the school where the study is conducted to adopt multimodal instructional approach to enhance the academic achievement of their students. Finally, the study may contribute to existing literature on the use of multimodal instructional approach in biology education at the senior high school level.

1.8 Limitations of the Study

Test anxiety of the participants was very likely to limit the findings of this study.

1.9 Delimitations of the Study

This study will be conducted in Koforidua Senior High Technical School and Oti Boateng SHS within the New Juaben South Municipality. Only second–year science students will be sampled to participate in the study; the study will focus only on the concepts in some selected topics in biology. The scope of this study will be narrowed down to second–year students only because they had already covered this topic in biology hence, this will form a good basis for pre-assessment. The third years have also treated those topics but at the time of the study, they were preparing for their final mock examination and WASSCE as well.

1.10 Definition of Terms

Some terms will be used in this study that may have a different contextual meaning. It is prudent to define those terms at this stage.

Mode and Media: A mode, quite simply, is a means of communicating (Arola, Sheppard & Ball, 2014). According to the New London Group, as cited in Arola *et al*. (2014), there are five modes of communication: visual, linguistic, spatial, aural, and gestural. A mode is different from a medium, which is the substance through which communication is conveyed. Example of a visual medium, for instance, would be photography, painting, or film.

Multimodal: When a text makes use of more than one mode of communication, the text can be characterized as multimodal.

Multimedia: Multimedia is a form of communication that combine different content forms such as texts, audios, image, animation, or video into a single presentation, such as printed materials or audio recordings (Arola *et al*., 2014).

Sex: Sex is a trait that determines an individual‟s reproductive function, male or female (Stevenson & Waite, 2011).

Experimental group: A group of students on whom the treatment is administered. They were the group taught with the multimodal instructional approaches.

Control group: A group of students whose performance is compared to that of the experimental group. They were taught using the discussion method of teaching.

1.11 Abbreviations and Acronyms

OBOSS: Oti Boateng Senior High School.

KSHTS: Koforidua Senior High Technical School.

MMIA: Multimodal Instructional Approaches.

WAEC: West African Examination Council.

WASSCE: West African Senior School Certificate Examination.

1.12 Organization of the Study Report

This study will be organized into five chapters. The outline of chapter one has already been presented. Chapter two will comprise the review of related literature. It will begin with an overview of the chapter and then a review of related literature under

various strands. Chapter three consist of the research methodology. It is divided into the overview, the design of the study, population and sampling procedure, instrumentation, the validity of the instruments, the reliability of the instruments, data collection, data analysis, pre-treatment findings, treatment, post-treatment and implementation. Chapter four shall contain presentation and analysis of results. Chapter five will cover the summary of findings, conclusion, recommendations and suggestions for further study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter discusses literature related to the study. Relevant literature that gives support to the study are discussed under certain sub headings such as learning and learning theories, learning styles of the students, traditional method of teaching biology, traditional classroom, constructivist classroom and their differences and many more.

2.1 Conceptual Framework

Instruction in multiple formats allows students to activate different cognitive skills to understand and remember the lessons they have been taught. Instruction can be given using a combination of text, visuals, gestures, or audios to facilitate retention in short- and long-term memory. Teachers can employ a variety of techniques to complement verbal instruction so that students attend to and remember the directions they need to carry out. For example, teachers can reference visuals, posters, or texts on boards to rehash important aspects of their speech. They can also use hand signals as another representation form to communicate multiple steps.

The five modes of communication proposed by the New London Group, cited in Arola *et al*. (2014) is shown in figure 1.

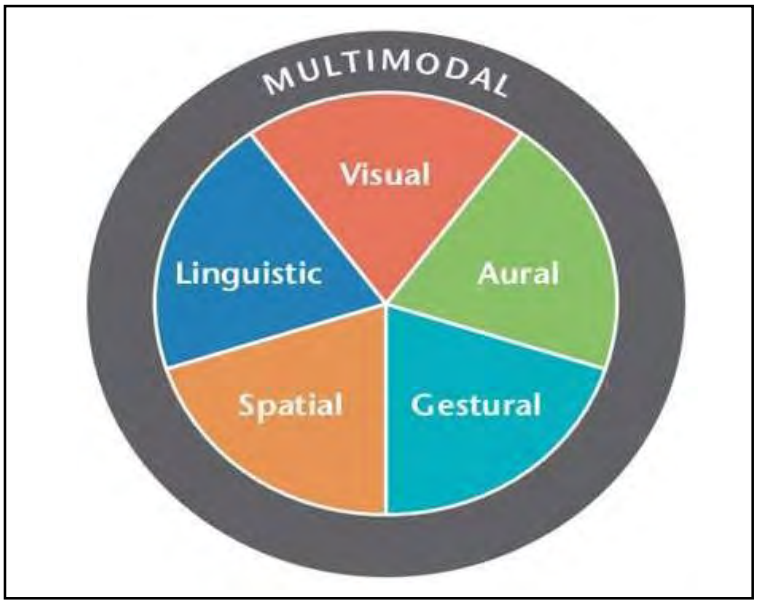

Figure 1: **The Five Modes of Communication (Adopted from Arola et al., 2014)**

2.2 Learning

It can be defined as changes with behavior of an organism (learner) that result from regularities with environment of that organism. It is also defined as a quantitative whereas in knowledge, memorizing of facts, skills and methods that can be retained and used as necessary.

2.3 Learning theories

Learning theory describes how students receive, process and retain knowledge during learning. It is also known as set of different concepts that observe, describe, explain and guide the learning process of people and everything that relate to this process.

There are many different approaches to learning. There are three basic types of learning theory: behaviorist theory, cognitivist theory and constructivist theory.

The behaviorist theory is based on the fact that knowledge is independent and on the exterior of the learner. In this theory, the learner is in a blank state that should be

provided with the information to be learnt. It involves repeated actions, verbal reinforcement and incentives to take part.

The cognitivist theory focuses on the idea that students (learners) process information they receive rather than just responding to a stimulus as with behaviorism. There is still behaviour change but this is in response to thinking and processing information.

Constructivist theory is based on the premise that learners construct new ideas based on their own prior knowledge and experiences. Learning is therefore unique to the individual learner. Students adapt their models of understanding either by reflecting on prior theories or resolving misconceptions. Learners need to have a prior base of knowledge for constructivist approaches to be effective (Brunner‟s Spiral Curriculum). Constructivism in the classroom includes problem based learning, research and creative projects and group collaborations

2.4 Learning styles of students

Learning is acquiring new knowledge, behaviour, skills, values, preferences or understanding to aid the individual to realize his/her academic, vocational, social and personal goals (Namale & Buku, 2011). The ways through which all the above mentioned are obtained by the learners is termed as the learning style. According to Soundariya, Deepika and Kalaiselvan (2017), learning style is refered to as the learner‟s way to perceive, process and retain the information, in terms of sensory modalities. As a classroom teacher, you should know the learning styles of your students so that an instructional strategy or approach that will be beneficial to your learners is selected and used during lesson delivery.

Learning styles can be categorized into three main types according to Awla (2014) and they are; cognitive, personality and sensory. These are further broken down into four types. These are visual, tactile/kinesthetic, auditory/verbal and audio-visual. There are other schools of the thought that break down learning styles further into six or seven styles. For the purpose of this study, the researcher limited herself to the four types of learning styles as stated above; visual, tactile/kinesthetic, auditory/verbal and audio-visual.

2.41 Auditory Learners

In auditory learning learners of this category learn through hastening and they do so best through lectures, talking to others, listening to others and discussions (Namale & Buku, 2011). Also, Fatt (2000), came out that auditory learners would prefer lectures, seminars, tapes and discussion. Auditory learners learn best by hearing, explanation and discussion according to Olufunminyi (2015). He also termed them as verbal learners. This category of learners learns best and easily when they are presented with a verbally oriented environment and are also provided with an opportunity of listening (Sethi, Lomte & Shinde, 2017).

2.4.2 Visual Learners

In visual learning, learners learn by seeing. In the classroom, such learners need to see the facial expression of the teacher or the instructor as well as his/her body expression or language (Namale & Buku, 2011). According to Olufunminiyi (2015) visual learners get more information from visual images (schematics, graph, diagrams, pictures and demonstrations). This category of learners prefers to think in pictures and

obtain information through visual means. They also do so best through watching movies, filmstrips, pictures and graphs which help integrate the subject.

2.4.3 Kinesthetic/tactile learner

Learners in this category learn through experiencing or hands-on activities. Through touching and moving objects, dismantling objects, assembling them, they learn very well.

Fatt (2000) came up with the fact that individuals who are considered to be kinesthetic learners prefer to learn by doing. Also, by giving test with task-oriented questions, such leaners would have a better result.

2.4.4 Audio-visual learners

This category of learners learn by listening and seeing at the same time. As they learn, they always watch the instructor or the teacher and listen to him/her as well. They learn best by watching videos as well as the teacher going through some demonstrations during the teaching and learning period. Anytime such learners are presented with information both verbal and visually, they tend to learn very well (Sethi, Lomte & Shinde, 2017).

2.5 Methods of teaching biology

Method of teaching has to do with the strategies, means and approaches adopted by a teacher in order to execute the function of teaching. According to Burden and Byrd (2010), teaching methods are approaches to teaching and learning in which concepts, patterns and abstractions are taught in the context of strategies that emphasize concept learning, inquiry learning and problem solving learning. Teaching methods comprises the principles and methods used by teachers or instructors to enable students learn

(Azure, 2018). He further argued that these strategies are determined partly by the subject matter to be taught and partly by the learner. Therefore, for a particular method of teaching to be effective and appropriate, it has to be in relation with the students‟ characteristics and the type of learning it is supposed to bring out or achieved. Also the student or the learner and the subject matter to be taught are taken into consideration before the teacher chooses a particular teaching method. Generally, the strategies or approaches used in teaching science are categorized into either teacher-centered method or learners-centered method. In the teacher-centered method, the teacher takes full control of the teaching and learning process. He or she does so by classifying the learners as vessels that are empty and are ready to receive information from him or her. It is also seen as the traditional form of teaching using the lecture method. This method of teaching does not promote learning because it does not consider the learning styles of the students being taught. To lay more emphasis, Abubakar and Arshad (2015), said traditional method of teaching is a method of instruction where the teachers dominate the entire learning process with "talk and chalk" and perceived their roles as sole dispensers of knowledge and the students‟ passive listening role as a mark of respect for teachers‟ authority.

In student-centered strategy of teaching, the student and the teacher play an equal role in the teaching and learning process. In this situation, the teacher is to guide, facilitate and coach students learning. With this approach, teaching and learning are connected that is students learning is continuously measured throughout the instructional period.

Methods of teaching used in presenting scientific information, skills or principles to students include: demonstration, discovery, lecture, peer teaching, laboratory, project, enquiry, field trips and concept mapping methods. Each of the above-named methods

have specific activities that need to be carried out when any is being used during a teaching and learning period and those specific activities are to be carried out by both the teacher and the learner. Azure (2018), is of the view that, modern theories of learning and trends in education emphasizes teaching methods which are learner-centered as opposed to those that are teacher-centered.

2.5.1 The Discussion Method

According to Radman et al. (2011), discussion is a process whereby two or more people express, clarify, and pool their knowledge, experiences, opinions and feelings. The individuals involved in this process can be a teacher and a student or between two students or even more. This method is based on shared conversations and exchange of ideas or information in class or the learning area. The discussion method is also an active method of teaching and this is so because it enables students to explore issues of interest, opinions, and ideas (Hackathorn, Solomon, Balnkmeyer, Tennial, & Garczynski, 2011). The teacher in this method of teaching plays the role of a facilitator and act as a catalyst to tilt learners mind into thinking and reflecting on the topic

2.5.2 The Demonstration Method

This is a teaching method used to communicate an idea with the aid of visuals such as flip charts, posters, power point etc. It is also a process of teaching someone how to make or do something in a step-by-step process. As you show how, you "tell" what you are doing. According to Akinbobola and Ikidte (2011), demonstration strategy is a method of teaching concepts, principles of real things by combining explanation with handling or manipulation of real things or equipments. Demonstration during a

lesson often occurs when students have a hard time connecting theories to actual practice or when students are unable to understand applications of theories.

Demonstrations are useful for facilitating and developing learning since they promote students interests in the lessons and provide teachers with greater variety of pedagogical tools (Basheer, Hugerat, Kortam, & Hoftsein, 2017).

2.5.3 The Discovery/ Inquiry Method

Discovery method of instruction has to do with giving information to students in the form which requires them to discuss relationships (Ajaja, 2013). It also engages students in many activities and thinking processes that scientists use to produce knowledge (Abdi, 2014). The main objective of inquiry learning is helping students to develop intellectually disciplined and thinking skills by providing questions and getting on the basis of curiosity (Andrini, 2016). When a student or learner is curious of what is taught, he or she tends to participate more in the teaching and learning process by contributing more to it. It also helps them to understand more in their own way and relate it to their immediate environment as well.

2.5.4 The Lecture Method

This method of teaching is the most popular and traditional method of instruction used by instructors as they present information, concepts, ideas, principles just to name a few. The lecture method is a one-way communication, the students do the listening as the teacher does the talking. According to Marmah (2014), the lecture method is based on the transmission teaching model, that is, knowledge is an object that can be transferred from teacher to learner. The lecture method promotes learning in students who are auditory learners and leaves the rest. The main objective or advantage of the lecture method is that it helps the teacher to cover more content

material within a short period of time (Ajaja, 2013). It also makes the students passive which does not help to promote or develop critical thinking skills and creative ability in students or learner (Alaagib, Musa, & Saeed, 2019).

2.5.5 Concept Mapping

Concept is an idea or intervention to help sell or publicize a commodity. A concept map is a diagram showing relationships among concepts (Joel & Kamji, 2016). Concept mapping method is a well-structured method of teaching. It seeks to develop better understanding in learners.

2.5.6 Field trips or Excursions Method.

Field trip is an activity-based teaching method that gives opportunity to the learner to get first-hand information on things, people and places in order to concretize their learning experience (Estawul, Sababa & Filgona, 2016). According to Behrendt and Franklin (2014), effective methods to develop students‟ interest include experiential activities and fieldtrips which create authentic learning opportunities for students regardless of the content area. Namale and Buku (2011), stated that, the main purpose of field trip is to provide students with accurate first-hand information in their original situation or natural environment.

Indeed, field-trips are very important in the teaching and learning process because it makes the work of the teacher easy since students are moved away from learning things in abstract to interacting with the things they are taught in their natural environment. The only set back with this teaching method is that it‟s expensive. This is because student‟s have to be transported from one point to another.

2.5.7 Project based learning/project method

According to the teaching syllabus provided by Ghana education service, much emphasis has been laid on giving student‟s much project works to work on. It also promotes learning. According to Copon and Kuhn (2004), project-based learning pedagogy is an instructional technique that transforms learning from "teacher-telling" to "student‟s doing" in which students are provided tasks based on challenging questions or problems that involves that student‟s problem-solving, decision-making, meaning-making, investigative skills and reflection, which requires teacher facilitation and not direction. Project method of instruction enables learners to acquire knowledge and skills to solve real problems through investigation. It is a learner centered type of instruction. It makes student‟s to be responsible for their learning process as they learn privately with very little assistance from the teacher (Abubakar & Arshad, 2015).

2.5.8 Laboratory Method

This method of teaching is an activity-based method for individuals or a group of learners targeted for making personal observation of a process, product or an event (Azure, 2018). Laboratory method of instruction engages students in activities such as observing, measuring, counting, experimenting, analyzing, recording and drawing conclusion. In the laboratory, students work in smaller groups or individually on a hypothesis, problem or a question (Hamidu, Ibrahim & Mohammed, 2014). They continued to further state that, it enables students to translate what they have read in their textbooks into reality, thereby enhancing their understanding of the learnt concepts. This teaching method has advantages and disadvantages. For the advantages; it helps students to learn how to use laboratory tools and equipment, develop experimental skills, communicate effectively, create a sense of responsibility

in them as well as making them become conversant with scientific process of observing, classifying, inferring, hypothesizing, data interpretation, measuring and drawing conclusion. The disadvantages of this method of teaching is that, it‟s very expensive and not all schools can afford since it‟s not all schools that have laboratories. Also, in the case of larger class sizes, it becomes very difficult to organize one.

2.6 Traditional, Constructivist Classroom and their Differences

In a traditional classroom, the focus is on the teacher who is placed at the centre of the teaching and learning process. In such a classroom, the teacher transfers knowledge to the students. This makes the students passive learners. The teaching method used in the traditional classroom is based on the objective view of the knowledge which is grounded in assumption that knowledge is objective, universal and complete and can be transferred from the head of the teacher to the head of the students. A teacher in a traditional classroom is seen as a transmitter of knowledge. In a constructivist classroom, the attention is on the student or the learner. They are not encouraged to actively get involved in the teaching and learning process and the teacher is only seen as a coach. Learning in a constructivist classroom is effective in the sense that, the learner (student) is given the opportunity to construct knowledge through interaction with each other on the basis of previous knowledge (Sharma & Pooman,2016). Also, in such a classroom, learning is a mental process and students learn from previously built knowledge by building on that knowledge in a collaborative environment and learners are provided with minimal instructions (Alanazi,2016). The traditional classroom is totally different from the constructivist classroom and their differences are presented in a table 1.

Table 1: Differences between the traditional classroom and constructivist classroom

TRADITIONAL CLASSROOM	CONSTRUCTIVIST CLASSROOM
Students work individually.	Students work in groups.
Knowledge is inert.	Knowledge is dynamic.
Information is sent from teacher to student.	Teacher have dialogue with students by helping them to construct their own knowledge.
Teachers‟ role is directive, rooted in authority.	Teacher interacts with students.

2.7 Benefits of Constructive Teaching and Learning

Constructivism helps to develop advanced skills like critical thinking, analysis, evaluation and so on. It helps students to learn more on their own since it is learner centered where students are actively engaged rather than being passive learners (Singh & Yaduvanshi, 2015). Constructivism promotes a sense of personal agency as students have ownership of the learning and assessment (McLeod, 2019). According to Shermila (2011), the following benefits of constructivism teaching and learning were outlined: a) constructivism learning is transferable, b) children (students) learn more and enjoy learning when they are actively involved, c) education works best when it concentrates on thinking and understanding rather than on rote memorization. Students in constructivist classroom learn to question things and to apply their natural curiosity to the world. Constructivism helps students to develop social and

communication skills by creating a classroom environment that place more emphasis on collaboration and exchange of ideas.

2.8 Modes and Media

The difference between multimodal and multimedia is largely a difference between "modes" and "media". Modes can be understood as ways of representing information, or the semiotic channels we use to compose a text (Kress & Van Leeuwen, 2001). Examples of modes include words, sounds, still and moving images, animation and colour. Media, on the other hand, are the "tools and material resources" used to produce and disseminate texts. Examples of media include books, radio, television, computers, paint brush and canvas, and human voices.

Both the definitions of modes and media are concerned with the representation of information, which makes them quite similar to one another. Often times in the context of education, these terms are not only defined similarly, they are also used interchangeably.

2.9 Defining Multimodal

Multimodal is a term coined by members of the New London Group, including Cope and Kalantzis (2000), Kress (2003, 2005) and Kress and Van Leeuwen (2001). These scholars have argued that at this point in history, communication is not limited to one mode (such as text) and realised through one medium (such as the page or the book). Rather, as a result of digitisation, all modes can now be realized through a single binary code, and the medium of the screen is becoming the primary site where multiple modes can be composed to make meaning in dynamic ways. Essentially, as Kress and Van Leeuwen (2001) put it, all modes "can be operated by one multi-

skilled person, using one interface, one mode of physical manipulation, so that he or she can ask, at every point: „Shall I express this with sound or music? Shall I say this visually or verbally?" (p. 2). Multimodal texts are characterized by the mixed logics brought together through the combination of modes (such as images, text, colour, etc.).

Modes and media are independent of and interdependent on each other, meaning that although media and modes are different from each other, the media we use affects the ways in which we can realize meaning through various modes. For instance, the mode of communicating content is affected differently by the affordances and limitations of the medium of the whiteboard versus the medium of the screen (Kress, 2003). The notion of the teacher as a single, solitary voice communicating to his or her learners through the finished product of the whiteboard has been transformed as the communications media have opened up the possibilities for textual production to be non-linear, hyper textual, continuously revisable, and interactive. As teaching becomes an increasingly screen-based activity, the ways in which we teach necessarily make more fluid and transitory the role occupied by teachers. This change in the role of the teacher and thus in the way in which meaning can be communicated through text, was facilitated by technological advancement that allowed for a shift from the static medium of the page and whiteboard to the more fluid medium of the screen.

Selfe and Takayoshi (2007), defined multimodal texts as those that "exceed the alphabetic and may include still and moving images, animations, colour, words, music and sound". This definition, as one in which texts simply exceed the alphabetic, is much less complex and appeals to a broader audience of teachers who need not be

familiar with the nuances provided in the discussions of Kress (2003), Kress and Van Leeuwen (2001), and others to be able to imagine ways of facilitating such textual production in the classroom.

2.10 Defining Multimedia

Previous to multimodal entrance into the scholarly conversation, multimedia was the term primarily used to describe the expansion of composing practices in classrooms. Multimedia was used most frequently in the 1990‟s with the advent of the CD-ROM. It was a term that described texts composed by using a computer to integrate words and visuals as well as sound and video. In Hawisher, LeBlanc, Moran & Selfe, (1996), Jim Heid defined multimedia as "the integration of two or more communications media. It‟s the use of text and sounds, plus still and moving pictures, to convey ideas, sell products, educate, and/or entertain". Communications media as they are discussed in this definition (e.g., text, sounds and images) might today be considered modes, but the latter half of the definition puts an emphasis on the finished product and the intended uses of the product, which is more characteristic of multimedia and its use in industry than multimodal and its use in the classroom. Multimedia was preceded by the term "hypermedia," which described texts that assume a non-linear literary hypertext structure (Hawisher *et al*., 1996). As editing and web technologies became more accessible, the use of the term multimedia became more common. However, as a term, it tends to go much more frequently undefined in the scholarly literature, perhaps because it acts as a catch-all term for any text that is not an alphabetic print text.

Hofstettler (2000), provides one of the most precise definitions of multimedia. Hofstetter defined multimedia as "the use of a computer to present and combine text, graphics, audio, and video with links and tools that let the user navigate, interact, create, and communicate". In this definition there is a greater emphasis on the user and what the text will allow the user to do with it. Emphasis can also be placed on the teacher and the kinds of content a teacher might produce, as definitions of multimedia found on a variety of tech-oriented web sites show. As just one example, Multimedia (n.d.) defines multimedia as 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."

In this definition there is no reliance on how a user might consume or interact with a text for it to be considered multimedia. Rather, the definition focuses only on the choices an author makes in composing his or her text (i.e., Does the author include audio and video clips in the text? If so, then it is a multimedia text). Taken together, these definitions show multimedia to be a descriptive term able to support the practices of both authors and users as well as a wide array of technologies and texts. This helps explain its ability to remain a relevant term in both academic and non-academic or industry contexts throughout the multitude of technological changes that have occurred over the past several decades.

Whereas Briand"s (1970) notion of multimedia focused primarily on the multiple media he used in the classroom (projectors, recorders, etc.), these more recent definitions seem to suggest that multimedia texts are inherently multimodal texts because rather than being texts that combine various media (such as the book, radio,

television, and computer screen), they are texts that combine a variety of modes (such as image, animation, and sound) disseminated through a single medium (such as a computer screen). This change in emphasis has had little discernible effect in non-academic or industry uses of the term because multimedia has proven flexible enough to be adaptable to changes in technology or production that occur. However, in academic contexts, it opened the door for terms like multimodal to come about that more accurately describe the composing practices of students taking place in the classroom today.

2.11 The Architecture of the Multimodal Presentation System (MPS)

In multimodal learning environments, students are presented content knowledge with a verbal representation and one or more corresponding visual representations. According to the modality principle of instructional design, learning outcomes will be optimized by presenting the verbal and visual representations of the knowledge in auditory and visual modalities (Moreno & Mayer, 2007). An interactive multimodal learning environment is the one in which the presented words and pictures depend on the learner‟s actions and the communication is multidirectional during learning.

This multimodal presentation system was designed to bring students to the interactive whiteboard, more directly involving them in the lesson. If students took an active part in a lesson, then they would invariably produce better learning outcomes that can form the basis for judging the effectiveness of a lesson (Shih *et al*., 2012). According to Johnson *et al* (2010), multimodal presentation systems produce more effective lessons. In general, learning effectiveness can be measured using two variables; academic achievement (e.g., semester grade, test score) (Alavi, Wheeler & Valacich, 2015) and learning satisfaction (Knowles, 2016; Maki, Maki, Patterson & Whittaker,

2011; Piccoli, Ahmad & Ives, 2014). Correspondingly, the study of Maki *et al*., (2011) took academic achievement and learning satisfaction as two criteria for measuring student‟s learning effectiveness. Learning satisfaction can be regarded as the learners‟ feeling (Knowles, 2016), the learners‟ attitude (Long, 2015), or the learners‟ sense of pleasure (Johnson *et al*., 2010) toward their learning activities. Piccoli *et al*. (2014) and Maki *et al*. (2011) believed that learning satisfaction expresses learners‟ satisfaction derived from the learning process and learning results. Hence, learning satisfaction is a very suitable criterion for assessing learners‟ satisfaction with classroom learning. In essence, we can obtain better understanding of a student‟s learning effectiveness according to both academic achievement and learning satisfaction. As such, academic achievement and learning satisfaction are considered as two important criteria for measuring student‟s learning effectiveness in this study.

2.12 Multimodality, Pedagogical Approaches and Digital Technologies for Teaching and Learning

The advent of digital technologies for supporting teaching and learning has supplemented or amplified conventional non-digital activities (Beetham & Sharpe, 2013). Digitization of administrative and routine tasks such as storing, transferring and retrieving information supplements traditional teaching and learning in the sense that the digital modalities used do not resemble or offer something novel to the way current teaching and learning processes and strategies are practiced. Indeed, learning technologies should help students to increase their capacities for innovation, leadership, multi-and inter-disciplinary collaboration, emotional intelligence, critical skills and collective problem solving in a participatory digital learning environment (Greenhow, Robelia & Hughes, 2009). Multimedia resources and tools in these

environments may include for example, interactive videos and images, recorded lecture presentations, online quizzes, discussion forums (synchronous and asynchronous), visual representations of student data to depict progress and on what the student is doing to learn (Sharples, 2016). Currently many teachers tend to use digital technologies to support teacher-directed approaches with the aim of improving the quality of lecture presentations by using Interactive Whiteboards; PowerPoint for lecture notes and asynchronous discussion forums for the recreation of face-to-face tutorial discussions (Beetham & Sharpe, 2013). The affordances of the aforementioned technologies in these cases are mainly exploited to explain and visualize content knowledge or for engaging students in activities that require visualization to absorb and manipulate information more actively than before.

Mayer (2009), argues that student"s learning becomes more meaningful when an array of interactive tools and resources are deployed rather using text alone. Moreover, the visual representation of content is vital for communicating subject matter and improving students" understanding.

There is increasing research on collaborative multimedia learning in different subject domains (Bell, Urhahne, Schanze & Ploetzner, 2010). Studies have shown that collaboration can enhance the quality of the learning process, hence the importance of achieving specific learning outcomes combining multimedia content with collaborative learning may lead to engaging, interactive and powerful multimedia learning environments (Dillenbourg, 1999). Students working collaboratively in groups have the opportunity to share their thoughts and prior knowledge. Collaborative dialogue supports learning by clarifying thinking and consolidating ideas (Hmelo-Silver, 2002). Multimodal collaborative learning promotes the idea of

creating a learning community with a shared purpose of making sense of scientific ideas and practices (Harris & Rooks, 2010). Teachers, although still reluctant in using technology in pedagogically driven ways, have slowly started to integrate new educational teaching and learning practices (Miller & McVee, 2013) including but not limited to learning games, collaborative editing and online media manipulation. In this study, multimodality for teaching and learning is examined in terms of experiences on using different modalities (oral and written language, visual, gestural and tactile representations), technologies and teaching strategies (e.g. transmitting information, collaborative learning, informal learning).

2.13 Multimodal and Multimedia Design

Multimodality and its related multimedia format are beneficial for the science classroom because as McGinnis (2007) expresses, students enter the classroom each having different levels of expertise with the content. This diversity naturally allows for students to interact and learn from each other while providing the teacher multiple opportunities to differentiate not only content but instructional approach. It is equally important to consider the social worlds of students as these multimodal practices are connected to broader social, cultural, and global contexts. One overarching goal of science education is to prepare students with skills and science knowledge for interaction in the global landscape of the future. As Gainer (2010) articulates, "we live in a multimedia age where the majority of information people receive comes less often from print sources and more typically form highly constructed visual images, complex sound arrangements, and multiple media formats". By providing learning environments that are multimodal in nature within the classroom, students are best adapted for the diverse and ever changing learning environments that they are most likely to encounter in education, the workforce, and society.

Once students are exposed, familiar, and versed in multimodal and multimedia construction, this approach is likely to add to the skill set of critical thinking and inquiry. Arguably, equally important to critical thinking and inquiry skills is creativity. Creativity has strong connections with motivation which results in students that are engaged with the curriculum and learning in general. When considering creativity, Walsh (2007) proposes that youth have the skills and experience to combine their imagination with the many modes of the classroom, in essence it appears that the youth are natural multimodal learners. The use of print, visual, and digital modes help students to apply their knowledge in new educational contexts. When teachers are able to capitalize and bring in students non-content skills to facilitate learning of the content, students may have a greater ownership in their learning. Furthermore, this idea of elevating many modes in the classroom helps students to connect their previous knowledge and skills to new contexts. Walsh (2007) states that, students are multimodal designers and with opportunities for creativity, it allows students to develop critical responses to the curriculum. To engage and challenge students to be involved and interact with the curriculum in a complex way is a trademark of effective teaching.

Though approaches such as inquiry and technology are crucial to student interaction with the curriculum and naturally involve multimodal aspects, explicitly incorporating modes within each of these settings will afford a more complete representation of the content and can naturally differentiate the learning. Understandings explained through Jewitt"s (2008) research, that all modes are communication but all modes are partial, underscores the fact that modes not only construct meanings in different ways, but also relay and transfer various meanings through their distinctive affordances. Furthermore, Jewitt proposes that non-linguistic representations have significant

impacts for the traditional understanding and view of literacy and communication with implications for effective pedagogy. Movement between modes such as print to visual, visual to written, or print to kinaesthetic, can challenge students in new ways, that a singular approach or mode alone cannot achieve. Technology itself has many modes that are constantly changing and it is precisely this technology that can provide an engaging, differentiated, multimodal learning environment to facilitate learning as students manoeuvre their understanding through various modes.

2.14 Multi-literacy

Literacy involves more than a set of conventions to be learned, either through print or technological formats. Literacy enables people to negotiate meaning. With these negotiations often occurring in technological settings and engaging students‟ values and identities (Jewitt, 2008). The New London Group (1996) has proposed the concept of *multi-literacies*, which views literacy as continual, supplemental, and enhancing or modifying established literacy teaching and learning rather than replacing traditional practices (Rowsell, Kosnik & Beck, 2008). Multi-literacies recognize both the increasing cultural and linguistic diversity in the new globalized society and the new variety of text forms from multiple communicative technologies. There is also the need for new skills to operate successfully in the changing literate and increasingly diversified classroom environment. The New London Group (1996) argues that to be relevant, learning processes need to recruit, rather than attempt to ignore and erase, the different subjectivities, interests, intentions, commitments, and purposes that students bring to learning. They must also respond to the different media and modes in which students operate. Teachers need new knowledge that reflects these varying and multiple discourses. This huge shift from traditional print-based literacy to 21st century multi-literacies reflect the impact of communication

technologies and multimedia on the evolving nature of texts, as well as the skills and dispositions associated with the consumption, production, evaluation, and distribution of those texts. (Borsheim, Meritt & Reed, 2008). With literacy continually growing and expanding, there remains a need to support pre-service and practicing teachers‟ conceptions and understanding of multi-literacies. To support this mandate for educators, the New London Group (1996) advocates for a multi-literacy pedagogy that includes four components. The first, situated practice, draws on experience of meaning-making in specific contexts. This meaning-making is unique and authentic to the participants and their contexts. The second component, overt instruction, develops an explicit meta-language to support active interventions that scaffold student learning. Critical framing makes sense of situated practice and overt instruction by interpreting the social contexts and purposes related to meaning making. The goal is to enact transformed practice where students, as meaning makers, become designers themselves and not just consumers.

A multi-literacy perspective also adopts a pedagogy of design (New London Group, 1996), where teachers and managers are seen as designers of learning processes and environments, not as bosses dictating what those in their charge should think and do. This pedagogy includes examining available designs, redesigning them with available and appropriate technologies, and creating the redesigned texts through a process of critical reflection. Individuals in the designing process are seen as transformers of sets of representational resources, rather than as users of stable systems in a situation where multiplicity of representational modes are brought into textual compositions (Kress, 2005). Teachers need to equip students with the necessary skills to successfully participate as transformation agents in the design process. These skills and literacies associated with technologies and students‟ out-of-school abilities

require teachers and teacher educators to develop nuanced and critical understandings of these technologies and the literacies with which they are associated (Swenson, Rozema, Young, McGrail & Whitin, 2006). Examining these practices is, therefore, crucial in understanding scientific concepts in a constantly changing world.

2.15 Implications for the Science Classroom

Other affordances that an explicit multimodal approach in the science classroom can provide, includes helping to reach each students‟ interests and learning styles. By committing to developing engaging lessons and designing laboratory experiences in which students make the connections and assess discrepancies across varied forms of representation, high levels of learning can occur. Not only does a multimodal approach more closely align with a students‟ social learning world outside the classroom, but educators can use this link to transfer students knowledge into the lesser used modes such as reading and writing (Bezemer & Kress, 2008).

A multimodal approach can significantly affect student engagement, perceptions, and learning because there are many opportunities to resonate the content with students. As Jewitt (2008) explains; meanings are made, distributed, interpreted, and remade. Therefore, much more than just presenting information in multiple ways, but requiring students to seek out learning through these many modes will provide opportunities for students to use their skills and tap their interests while interacting with the content. If teachers can achieve this broad approach on information gathering and activation, student perceptions about learning are likely to expand. If educators can alter how students become engaged with content knowledge or challenge their perception of what is acceptable knowledge beyond simply a correct answer, then students may be exposed to the complete process of learning, enhancing a variety of

skills that are valued beyond the pages of a text or the walls of the classroom. Thus, this process or cycle; engagement-perceptions-learning can be expanded in which students can critically examine resources, formats, and representations not only to communicate more effectively but to challenge how knowledge has been represented and, in a way, personalize their learning.

A drawback to incorporating media and technology via various modes into the classroom is that this approach, to be carried out well, may be time consuming. In an age where the requirements of teachers and students are increasing and changing, adding another element to designing curriculum may not be valued when the time required to carry out this aspect is considered. Also, with the recent focus on the importance and need for students to develop better reading and writing skills, in a climate of high stakes testing environment, a multimodal approach may not be viewed as giving just time to these tested and necessary skills. However, it could be argued that the elegant incorporation of a variety of modes via a multimodal instructional approach would not only activate but also re-energize students‟ desire to communicate through reading and writing. The idea that literacy is expanding to include other modes besides text and written communication does not ignore the importance of continuing to activate these skills via an engaging multimodal approach. By expanding student perceptions about learning, more learning can take place because more skills are valued. For example, if a multimodal approach is readily accepted in a classroom an increase in the use of technology would be welcomed and utilized, promoting the learning of technical skills which can lead to more learning. This idea aligns with research by Bezemer and Kress (2008) who looked at what is gained and lost with transitions through various modes. By

understanding the different affordances, each mode can offer student engagement, perceptions, and learning can be monitored while gaps in knowledge are mediated.

Although there are many benefits for multimodality in the science classroom, including a natural connection with how the subject is both taught and learned, there is a significant amount of research that suggests that this idea has implications on a more broad scale. Through understanding in many areas such as psychology, art/design, and literacy studies, multimodality is expressing its broad impact. Jewitt (2008), in his overview of multimodality as he develops an appropriate definition as well as placing it in context for implications on pedagogy, states his observations. He explains that on a more global scale people are accepting and adapting to the shift from print toward digital media. This has implications for both dissemination and presentation of information which now occurs with a more diverse and global audience. His second observation is that this perpetuates the research and idea that there are new literacies emerging. This idea stems from the changing requirements of communication, literacy, and knowledge. In a broad and global perspective, education should be assessing how these new demands and requirements in communication impact our current pedagogy. To best assess the impact of multimodality on student learning it is important to consider these topics. As teachers prepare students for the demands of the future, they will need and utilize the skill set that learning in many modes can offer.

Ultimately, student perceptions on learning may be radically different if we can infuse the needed skills for the future while teaching content knowledge. Through this approach of utilizing many modes, student engagement and interest may increase

which would promote learning and motivation for learning beyond the boundaries of content knowledge.

2.16 Theoretical Framework

The theory on which this study is premised is Sweller‟s original Cognitive Load Theory (CLT) (Sweller, 1998), and the revised version, Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2005).

2.16.1 The cognitive load theory

Cognitive Load Theory (CLT), first researched by Sweller (Sweller, 1998) in the late 1980s, is based around the idea that our working memory; the part of our mind that processes what we are currently doing, can only deal with a limited amount of information at one time. Reif‟s description of cognitive load is extremely useful. According to Reif (2010), the cognitive load involved in a task is the cognitive effort (or amount of information processing) required by a person to perform this task.

CLT identifies three different forms of cognitive load. These are

- Intrinsic cognitive load; the inherent difficulty of the material itself, which can be influenced by prior knowledge of the topic.
- Extraneous cognitive load; the load generated by the way the material is presented in a manner that does not aid learning.
- Germane cognitive load; the elements that aid information processing and contribute to the development of schemas.

CLT suggests that if the cognitive load exceeds an individual‟s processing capacity, they will struggle to complete the activity successfully. In summarising CLT, De Jong

(2010) states that cognitive load theory asserts that learning is hampered when working memory capacity is exceeded in a learning task.

Working memory should be seen as short term and finite, whereas long-term memory can be seen as infinite. The aim should be to move knowledge to long-term memory because when a student is exposed to new material, they can draw on this previous knowledge and the cognitive load is reduced. However, if subject knowledge is incomplete, the student is unable to fall back on the long-term memory and the working memory becomes overloaded, leading to working memory failures.

According to Gathercole and Alloway (2007), indications of working memory failures include:

- incomplete recall
- failing to follow instructions
- place-keeping errors
- task abandonment.

Of course, there are many other reasons for these that are not related to CLT; however, if teachers understand how this theory applies to their classroom, they can plan their lessons in a way that takes into account cognitive load.

2.16.2 Mayer's cognitive load theory of multimedia learning (CTML)

Multimedia is defined as the presentation of materials using both words and pictures and thus focused on the auditory/verbal channel and visual/pictorial channel (Mayer, 2005; 2009). Mayer (2005) presents a theory of multimedia learning in terms of an information-processing model, called cognitive theory of multimedia learning (CTML), by integrating Sweller"s cognitive load theory (Chandler & Sweller, 1991;

Sweller, 1988), Paivio‟s dual-coding theory (Clark & Paivio, 1991; Paivio, 1986), and Baddeley‟s working memory model (Baddeley, 1986).

The CTML provides empirical guidelines to promote instructional design to achieve meaningful learning (Mayer, 2009). Based on three main assumptions (dual channel, limited capacity, and active processing), seven principles (multimedia principle, spatial contiguity principle, temporal contiguity principle, coherence principle, modality principle, redundancy principle, and individual differences principle) are proposed in this theory. The modality principle suggests that as textual information, presented in an auditory mode, with concurrent visuals displayed, students have greater knowledge acquisition (Mayer, 2009). The visual information processing channel may become overloaded when students must process on-screen graphics and on-screen text at the same time. Van Someren, Reimann, Boshuizen & De Jong. (2013) suggested that the educational representations should be developed to utilize this multimodality approach to allow learners to learn by exploring and linking different modalities. Also, pieces of literature show supporting evidence that presenting information in auditory mode with concurrent visual mode leads to deeper understanding (Mayer, 2005; Mayer & Sims, 1994; Paivio *et al*., 1986). Adegoke (2010, 2011) found that learners retain more when a variety of senses are engaged in learning; and that the experience allows them to retain and recall information. Son and Simonian (2016) opined that, supplementing traditional teaching classroom with multimedia learning tools could enhance students' motivation to learn, and make them active in the learning process, thereby, improving practice. Likewise, several similar studies have reported the increased academic success of students where multimedia techniques are applied, and this success is attributed to the ability of multimedia technology to capture students‟ interest and get them engaged in the course of

learning (Ilhan & Oruç, 2016; Park *et al*., 2019; Son & Simonian, 2016). This implies that the mental representation and connections of learning materials in words and pictures enhance students' engagement via active learning (Park, Kim, Cho & Han, 2019). Hence, multimedia, in its many formats, has been found to play a crucial role in education indeed. However, care must be taken when designing multimedia instructions so as not to overload the working memory (Moussa-Inaty *et al*., 2019).

2.17 Reducing cognitive load

Intrinsic cognitive load can be reduced by breaking down the subject content, sequencing the delivery so that sub-tasks are taught individually before being explained together as a whole. The idea is to not overwhelm a student too early in the introduction of new work.

Extraneous cognitive load can be reduced by the way in which instructions are presented. Learners make sense of new material by referencing schema or mental models of pre-existing knowledge. Lack of clarity in instruction puts too high a load on the working memory, and so too much time is spent problem-solving the instructions as opposed to new schema formation. For example, lessons that use PowerPoint with excessive writing and the teacher talking at the same time, can inadvertently generate excessive cognitive load and lead to working memory failures. Chandler and Sweller (1991) write that Cognitive Load Theory suggests that effective instructional material facilitates learning by directing cognitive resources towards activities that are relevant to learning.

2.18 Introducing Ideas within a Topic

Van Merriënboer, Kirschner & Kester. (2003) recommend using simple-to-complex sequencing to try to reduce cognitive load. They advise starting with worked-out examples (where a full solution is shown, which students then have to apply to a new question), then moving into completion assignments (where a partial solution is given and they have to complete it themselves), and then moving to conventional tasks, where they are simply given the question. This acts as a form of scaffolding, which helps students to learn independently, without necessarily needing the help of their teacher for each stage. Renkl and Atkinson (2003) further investigated this fading form of scaffolding. They suggested that moving through activities sequentially could reduce intrinsic load, as learners will have already mastered some of the knowledge they need to work out a solution in an earlier skill stage. Therefore, their research recommends beginning with a model (a complete example), gradually removing completed steps, which the learner will have to complete independently, and finally leaving just the to-be-solved problem. These principles can be readily applied in the classroom by beginning with a model answer, then providing a writing frame/structure with a lot of information, followed by a writing frame/structure with less information, then finally a question that learners must complete independently without a writing frame.

2.19 Presenting Information to Minimize Cognitive Load

Chandler and Sweller (1991) found evidence of the split-attention effect. This occurs when different sources of information discussing the same topic are separated by time or space, such as a diagram with a key that corresponds to separate text next to it. When information is presented in this way, it is left to the learner to attempt to amalgamate it, which generates extraneous cognitive load. Therefore, it is

recommended that if one of the sources adds nothing new, it should be eliminated. However, if it is essential to include both sources, they should ideally be physically integrated (e.g. texts and diagrams combined). This way, extraneous cognitive load is reduced and working memory capacity can be used for intrinsic and germane cognitive load instead.

2.20 Definitions of Anatomy and Physiology

The term "anatomy" was derived from two ancient Greek words; "ana" meaning "up" and "tomia" meaning "cutting". Put together, anatomy would literally mean "cutting up". Modern day anatomy is the study of structures that make up the body and how those structures relate with each other. Human anatomy is subdivided into macroscopic (or gross) and microscopic anatomy. Macroscopic anatomy describes structures, organs, muscles, and bones, which are visible to the unaided eye. In order to establish a certain order, they are divided topographically and systematically. Microscopic human anatomy is the study of "tissues", that is histology or the study of cells, that is cytology. In contrast to macroscopic anatomy, you require – as the name suggests - an optical magnification in order to evaluate microscopic (e.g., cellular) structures. Embryology needs to be considered as part of human anatomy as well. It is the study of the development of the human body beginning from fertilization of the ovum until birth.

Much like anatomy, physiology is concerned with the principal organ systems, such as the musculoskeletal and nervous systems. The word "physiology" is derived from a Greek word for study of nature. It is the study of how the body and its parts work or function. However, when studying physiology, you will be looking at the functions of cells and organs within their biological systems, rather than their structures. You

could study physiology on a broad level, such as the physiology of mammals, during which you would study the manner in which organs function in the body of a mammal as a whole. You might also study with a narrower focus, such as the physiology of the cardiovascular system. For example, during this course, you might take a look at how the heart performs its particular function. Hence, Anatomy and physiology are studied together to give students a full appreciation and understanding of the human body.

Human anatomy has a very old and vast history; it is about 2000-year-old scientific discipline (Olofin, 2006). Historically seen since the first dissection of the human body in the third century B.C. in the old Egypt there has been no rapid development - at least not in the beginning. Some of the most intelligent people the world has ever seen had been part of this history. The overall history of human anatomy can be divided into the following periods:

2.21 Anatomy and Physiology in Senior High Biology

Human anatomy and physiology in senior high school Biology is perceived as a difficult concept by many senior high school biology students for reasons including but not limited to lack of motivation, inclusion of higher course contents and poor presentation of contents by some biology teachers (Lieu, Gutierrez & Shaffer, 2018). In Ghanaian senior high schools, students reading biology also study mammalian anatomy and physiology. This is catered for by their biology teaching syllabus. It is captured under four sections in year two. In the biology syllabus, mammalian anatomy and physiology have the following topics under it: Dissection of small mammals (neck, chest and abdomen), nutrition, transport system, respiratory system, excretory system, movement, reproductive system and control and coordination.

For the purpose of this study, transport and movement will be used. This is because the sample for this study have already been taught entirely, mammalian anatomy and physiology as spelt out in the syllabus hence this will form a good basis for a pre-assessment.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter presents the research design, population of the study, sample and sampling technique, research instruments, validity of the main instruments, reliability of the main instruments, treatment, data collection procedure, data analyses technique, expected results and ethical issues.

3.1 Research Design

The quasi-experimental design was adopted for this study. Quasi-experimental design has the pre and post-test design as well as the post-test only design. The pre and post-test design of the Quasi experimental is a design used to test the effectiveness of a method or a program (Stratton,2019). Quasi-experimental design works with two groups of students or participants. One group is known as the control group with the other as the experimental group. The two groups are all given the pre-test to answer.

After, only the experimental group is taken through the treatment. After the treatment, the two groups are both given the post-test questions to answer. They are given the post-test to find out whether the treatment given was effective or not. In experimental research, the Quasi-experimental design generates results faster than the other types of experimental design. It is also less expensive to conduct. It again goes an extra mile to avoid internal validity threat that may come out or show up. Quasi experiment design further avoid the threat of internal validity that may arise when participants in non-blinded experiments change their behaviour in response to the experimental assignment such as compensatory or resentful demoralization.

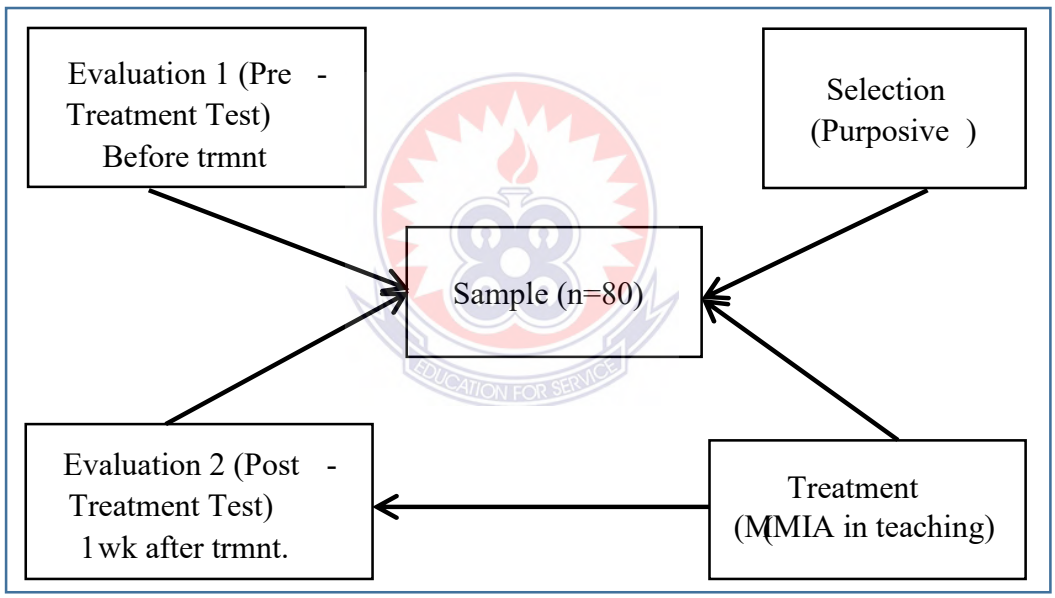

Figure 2**: **Diagrammatic form of the Research Approach

3.2 Population of the Study

A research population is generally a large collection of individuals or objects that is the main focus of scientific query. It is for the benefit of the population that researches are done (Clifford, Michal & John, 2007). For any study, the target population is all the members of a group defined by the researcher‟s specific interest in order for him

or her to answer research questions. The target population of the study included all the Senior High Schools within the New Juaben South Municipality.

3.3 Research Sample and Sampling Techniques

The sample of the study is the group of subjects in the study. Clifford et al. (2007), noted that for a study, the size of the sample selected for the study is immaterial and depends solely on the research objective. A total of eighty (80) SHS 2 green track science students were used for the study. The sample was drawn from Koforidua Senior High Technical School (KSTS) and Oti Boateng Senior High School (OBOSS) both in the same Municipality. Out of the eighty research sample, forty were taken from each school. Those from KSTS formed the control group and it was made up of twenty-eight (28) males and twelve (12) females. Those from OBOSS formed the experimental group which comprised of eighteen (18) males and twenty two (22) females.

The two schools were randomly selected to take part in the study. Forty students were purposively selected from each school to make up for the sample of the study. Purposive sampling also known as judgmental, selective or subjective sampling is a type of non-probability sampling technique where the units that are investigated are based on the judgement of the researcher (Clifford et al.2007). Purposive sampling was most suitable because it allowed the researcher to appropriately exclude students who do not have the previous knowledge the researcher based the research on.

3.4 Research Instruments

The research instruments used in the study for data collection were two tests and a Likert scale questionnaire. They were the pre-treatment and post-treatment tests. The tests were used to collect quantitative data from both the control and experimental

groups. A fifteen (15) itemized questionnaire was used to collect data from the experimental group on their perceptions or opinions towards the use of Multimodal Instructional Approaches (MMIA) as a teaching strategy for teaching mammalian anatomy and physiology (transport and movement).

The pre-treatment and post-treatment tests were made to be equivalent in terms of difficulty but contained different items.

3.5 Validity of the Main Instrument

Validity refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration (Bybee, 2014). There are various types of validity, which include construct validity, content validity, criterion-related validity, and face validity (Gall & Borg, 2007). Of these, content validity, defined as the degree to which a measure covers the range of meanings included in a concept (Bybee, 2014), was considered relevant. To determine the content validity of the research instruments, three biology teachers together with the researcher"s supervisor were made to review the items were retrieved to assess whether:

- Only the concepts relevant to the study were examined
- The instruments were suitable for use by senior high school learners.
- There were no factual errors.
- The items covered the entire concepts taught sufficiently and proportionally.

The teachers were selected on the basis of their expertise and experience in the teaching of biology. Imputes from the assessors were used to revise the items before administering.

3.6 Reliability of the Main Instrument

A pilot study was conducted to test the reliability of the data collection instruments. The purposes of the pilot study were to:

- collect data for further review and improvement of the instruments
- determine the approximate effective duration for each instrument

collect data for determining the reliability of the instruments

Second year science students at Ghana Secondary School, Koforidua were used for pilot testing the test instruments. It was done on two separate occasions. The time gap between the two administrations of the instruments was two weeks. The duration of two weeks was thought sufficiently long for the participant not to remember their previous responses (in the first administration of the instruments). Data from the first and second administrations of the instruments were used to compute the reliability of the instruments. The test-retest reliability method was used to determine the reliability of the test items, whereas the interrater reliability technique was used to determine the reliability of the questionnaire item. A reliability co-efficient close to one (i.e., above 0.5) signified a high reliability of the instruments while a low reliability co-efficient (i.e., below 0.5) suggested a low instrument reliability. According to Bybee (2014), reliability is a measure of whether a particular technique or instrument applied repeatedly to the same object yields the same result each time.

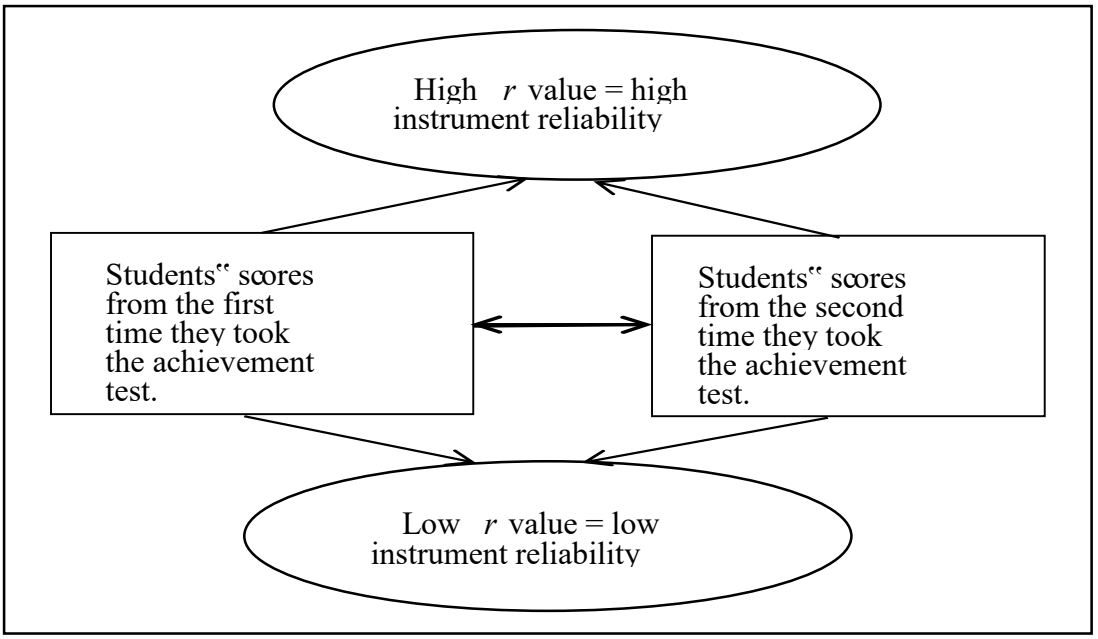

Figure 3 *: Instrument Reliability (Researcher made)*

3.7 Treatment

A pre-test was conducted for all eighty (80) students. The test was marked and scored and recorded, followed by the treatment. A treatment was carried out for a period of four weeks with each week having four sessions. The duration for each session was an hour. During this period, participants (experimental group) of the study were taught the concept of mammalian anatomy and physiology (transport and movement) using MMIA whilst the control group were taught using the lecture method on the same topics as the experimental group. For the purposes of convenience, some lessons were conducted outside of the usual contact hours.

The eighty (80) students were drawn from KSHTS and OBOSS with forty (40) from each school. Students from KSHTS formed the control group while those from OBOSS formed the experimental group. Students used for this study were taken from SHS two green track.

Those in the experimental group were taught using computer assisted animations, charts and models. The control group were taught using the lecture method. The treatment took four weeks. The first two weeks was used in treating transport as a topic with the remaining two weeks used to treat movement. Separate lesson plan for the teaching of both groups were prepared and used. The researcher groomed a biology teacher at the control group school to teach the selected topics using the lecture method using the prepared lesson plan given. The individual lesson plan can be found at the appendix F-G.

After the four weeks of treatment, both groups were given the post-test questions to answer. The post-test questions of only the experimental group had the questionnaire attached for them to respond as well. After, the scripts were collected and scored to generate data for the posttest and the questionnaire as well.

3.8 Data Collection Procedure

Prior to the treatment, a pre-treatment test was administered to the participants of the study to assess their performance in the relevant concepts. The outcome of this test was collected and stored. For four weeks, the participants were given instruction in biology on the relevant concepts using MMIA. After the treatment, a post-treatment test together with the Likert scaled type of questionnaire was administered to the participants. The questionnaire was for only those in the experimental group. The scores obtained by the students on the post-treatment test were also be recorded and stored.

3.9 Data Analysis Technique

Microsoft Excel was adopted to analyze the data collected. Where necessary, measure of central tendency (i.e., mean) was used to analyze the data. The data were organized into frequencies and percentages and presented using frequency tables.

The sources of data, methods of data collection and how data collected was analysed are summarized in the matrix Table 2.

Table 2 **Source of Data Collection Technique and Analysis**

Research Questions	Sources of Data	Data Collection Technique	Data Analyses Technique
1. What is the effect of MMIA on students‟ cognitive achievement (performance) in the selected biology topics before the treatment?	Students	Pre-Treatment Tests	Frequency counts

2. What are the relative differences in the performance of the control and experimental groups after the treatment?	Students	Post Treatment Test	Frequency count
3. What are students‟ perceptions on the selected biology topics and the use of MMIA?	Students	Questionnaire	Frequency/Percentage counts

3.10 Expected Results

This study was expected to establish the impact of multimodal teaching approach (MMIA) on the performance of senior high school students in biology.

3.11 Ethical Issues

The researcher ensured that prospective participants were made aware of the purpose of the study and their rights as a participant. Following that, prospective participants were assured of the confidentiality of data collected. Also, permission was sought from the school authorities before the commencement of the study.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Overview

The purpose of this chapter is to present data from the study in order to determine the effect of multimodal instructional approach on the performance of students in Oti Boateng Senior High School. It also lays emphasis on discussion of data findings.

4.1 Discussions of Research Questions

In the quest to provide a clear guide to this study, the researcher formulated the following research questions were formulated:

1. What is student‟s cognitive achievement (performance) in the selected biology concepts before the treatment?
2. What are the relative differences in the performance of the control and experimental groups after the treatment?
3. What are the students‟ perceptions on the use of MMIA in teaching the biology concepts?

The results obtained from the study are presented here in this chapter according to the research questions posed.

4.2 Research Question 1

What is student's cognitive achievement (performance) in the selected biology topics before the treatment?

In answering this research question, a pre-treatment test was administered to the students in order to determine their performance before the implementation of the treatment activity. The result from the pre-treatment test is summarized in Table 3 and 4.

Table 3: *Performance of Control Students in Pre-treatment Test*

Marks(x)	**Number of Students (f)**	**F(x)**
1	9	9
2	6	12
3	12	36
4	5	20
5	3	15
6	1	6
7	3	21
8	1	8
9	0	0
10	0	0
TOTAL	**∑f = 40**	**∑f(x) = 127**

Mean = $\frac{\sum f(x)}{\sum f} = \frac{127}{40} =$ **3.175**

Table 4:*Performance of Experimental Students in Pre-treatment Test*

Marks(x)	**Number of Students (f)**	**F(x)**
1	11	11
2	4	8
3	8	24
4	9	36
5	3	15
6	1	6
7	3	21
8	1	8
9	0	0
10	0	0
TOTAL	**∑f = 40**	**∑f(x) = 129**

Mean = $\frac{\sum f(x)}{\sum f} = \frac{129}{40} =$ **3.225**

Table 3 and 4 show some statistical tendencies of the pre-test between the experimental and the control groups. The mean value of 3.175 and 3.225 of the control and experimental groups respectively indicates that a lot of the students' scores were centred around 3. Therefore, the mean score of the test results confirms the low knowledge students had in mammalian anatomy and physiology before the use of the treatment in teaching.

It is evident from the results gathered for the pre-treatment tests that students in both groups, thus the control and experimental groups performed poorly during the instructional process. This might have been affected by the mode of teaching used by the teacher in explaining the concept to them. Modes and media are independent of and interdependent with each other, meaning that although media and modes are different from each other, the media used affected the ways in which we could realise meaning through various modes. For instance, the mode of communicating content is affected differently by the affordances and limitations of the medium of the whiteboard versus the medium of the screen (Kress, 2003). The notion of the teacher as a single, solitary voice communicating to his or her learners through the finished product of the whiteboard has been transformed as communications media have opened up the possibilities for textual production to be non-linear, hyper textual, continuously revisable, and interactive. To wit, the mode of instruction affects students participation, understanding and overall application of the concept taught. Students in general have various learning styles hence using a single approach to teaching a particular concept may be a disadvantage to many who do not go by the teacher‟s style of instruction.

4.3 Research Question 2

What are the relative differences in the performance of the control and experimental groups after the treatment?

In order to answer this research question, a post-treatment test was administered to assess the effectiveness of the treatment activities. A test consisting of 10 items was administered to the students and scored. Learners who scored five (5) were considered to score a pass mark. Those who scored below 5 were considered to score below the pass mark and finally, those who had above five (5) were considered to score above a pass mark. The mean score and the standard deviation were calculated for each group and the values were used in the analyses of the results. The results from the post-intervention test are presented in Table 5 and 6.

Table 5 : Post-treatment Test Scores of Control Group

Marks(x)	**Number of Students(f)**	**f(x)**
1	0	0
2	0	0
3	1	3
4	6	24
5	14	70
6	11	66
7	4	28
8	3	24
9	0	0
10	1	10
	∑f=40	**∑f(x)= 225**

Mean = $\frac{\sum f(x)}{\sum f} = \frac{225}{40} =$ **5.625**

Table 6 *Post-treatment Test Scores of Experimental Group*

Marks(x)	**Number of Students(f)**	**f(x)**
1	0	0
2	0	0
3	0	0
4	1	4
5	7	35
6	7	42
7	12	84
8	4	32
9	4	36
10	5	50
	∑f=40	**∑f(x)= 283**

Mean $= \frac{\sum f(x)}{\sum f} = \frac{283}{40} =$ **7.075**

Data from the post intervention test scores indicates an appreciable increase in the performance of students after the treatment. The control and the experimental groups had a cumulative mean score of 5.625 and 7.075 respectively. The mean score of both groups although increased, that of the experimental group doubled after the treatment. Multimodal instructional approach has proven to enhance participation, improve understanding and performance of students. This was manifested during the post treatment exercises as students were able to answer questions well, use the right terminologies and contribute to the lesson in class. This had a positive effect on their understanding as well as enhancing their performance than before.

Mayer (2009) argues that student‟s learning becomes more meaningful when an array of interactive tools and resources are deployed rather than using text alone. Moreover, the visual representation of content is vital for communicating subject matter and improving students‟ understanding. Studies have shown that collaboration can enhance the quality of the learning process, hence the importance of achieving specific learning outcomes combining multimedia content with collaborative learning may lead to engaging, interactive and powerful multimedia learning environments (Dillenbourg, 1999). Students working collaboratively in groups have the opportunity to share their thoughts and prior knowledge. Collaborative dialogue supports learning by clarifying thinking and consolidating ideas (Hmelo-Silver, 2002). Multimodal collaborative learning promotes the idea of creating a learning community with a shared purpose of making sense of scientific ideas and practices (Harris & Rooks, 2010). As teaching becomes an increasingly screen-based activity, the ways in which we teach necessarily make more fluid and transitory the role we occupy as teachers. This change in the role of the teacher and thus in the way in which meaning can be communicated through text, was facilitated by technological advancement that allowed for a shift from the static medium of the page and whiteboard to the more fluid medium of the screen.

4.4 Research Question 3

What are the students' perception of MMIA on the selected biology concepts?

Table 7 : Responses of Students to the Questionnaire Items

Premise	SA (Strongly	A (Agree)	UN (Unde	D (Dis	SD (Strongly

	Agree)		cided)	Agree)	Disagree)
	Freq (%)	Freq(%)	Freq(%)	Freq(%)	Freq (%)
MMIA help me to apply what I learnt to life	17(42.5)	18(45)	3 (7.5)	2 (5.0)	0 (0.0)
I am satisfied with this method of instruction.	19(47.5)	21(52.5)	0(0.0)	0 (0.0)	0 (0.0)
MMIA made the lesson learner-centred	24 (60.0)	15(37.5)	1(2.5)	0(0.0)	0(0.0)
MMIA motivated me on the topics	18(45.0)	19(47.5)	0 (0.0)	2 (5.0)	1(2.5)
MMIA made the lesson meaningful	11(27.5)	26(65.0)	0(0.0)	3(7.5)	0(0.0)
I recommend MMIA to other science teachers.	15(37.5)	22(55.0)	3 (7.5)	0 (0.0)	0 (0.0)
My performance was improved by MMIA.	17(42.5)	23(57.5)	00 (0.0)	0(0.0)	0(0.0)
MMIA enhances my critical thinking skills.	15(37.5)	23(57.5)	1(2.5)	1(2.5)	0 (0.0)
MMIA increased my interest in mammalian anatomy and physiology	17(42.5)	19(47.5)	2(5.0)	1(2.5)	1(2.5)
MMIA helped me to understand the topics better	19(47.5)	20(50.0)	1(2.5)	0(0.0)	0(0.0)
MMIA helped me to cater for my learning needs	20(50.0)	18(45.0)	1(2.5)	1(2.5)	0(0.0)
MMIA helped me to retain more information	13(32.5)	16(40.0)	10(25.0)	0(0.0)	1(2.5)
MMIA made lesson visual for me	15(37.5)	25(62.5)	0(0.0)	0(0.0)	0(0.0)
MMIA helped me to concentrate on the lesson	15(37.5)	25(62.5)	0(0.0)	0(0.0)	0(0.0)

MMIA made the lesson practical	17(42.5)	23(57.5)	0(0.0)	0(0.0)	0(0.0)

Thirty five (35) students asserted that MMIA help them to apply what they learn in class in real life. Two students disagreed to the statement while three were indecisive of the statement. On the issue of the satisfaction of MMIA as an instructional approach, all the students (40) agreed that they were satisfied with this instructional approach as it brings both the abstract and the real objects to cognition to enhance better understanding of concepts.

Again, majority of the students (39) agreed that some concepts in biology is best taught using the MMIA and this made the lesson more learner-centered than the traditional teacher-centered approach of lesson delivery whereas one student was uncertain. Thirty-seven students agreed to the statement that MMIA motivated them to learn the concept very well and this boosted their understanding of the concept and overall performance in the subject with three students disagreeing. Again, majority of the students agreed that MMIA used during the lesson made the concept more meaningful. Three students however, disagreed that MMIA made the lesson more meaningful as asserted by 37 students during the study.

Also, 37 students recommended the use of MMIA to other science teachers to boost their understanding of concepts especially abstract ones during biology lessons while the remaining three (3) were uncertain. All the students (40) agreed to the fact that their performance had improved since the introduction of MMIA in the classroom and therefore are very certain that their performance in Biology will also improve if MMIA is continuously used as an instructional approach.

With respect to the enhancement of critical thinking skills of students, 38 students agreed that MMIA has enhanced their critical thinking skills, while one student was indecisive of this statement and one student disagreed to it. In addition to this, 36 students agreed to the statement that the use MMIA increased their interest in the study of mammalian anatomy and physiology while two students disagreed the remaining two were uncertain. Thirty-nine students stated that MMIA helped them to understand the concepts better and also made lessons practical for them whereas one student was uncertain.

Majority of the students (38) agreed that MMIA helps to cater for their learning needs, one was uncertain with the other person disagreeing. Again, 29 said it helped them retain more information with 10 being uncertain and one disagreeing. All 40 students asserted that MMIA made lessons more visual for them and also helped them to concentrate during instructional delivery and made it practical too.

In the new unfamiliar environment of high school education, first year students are exposed to a totally new scenario of teaching/learning process. They develop problems like difficulty in studying and understanding new topics (especially Anatomy), problems related to adjusting and adapting to the school, teaching and learning environments. As a result, learning becomes very unpleasant task leading to frustration, corroding of the morale and loss of self-confidence of the students.

Teachers who are also familiar with anatomy and physiology of the mammal are able to help students to improve their knowledge, attitude and skills in the concept. They teach students how to encounter and deal the nature of the concepts in biology. Using MMIA to introduce students to the concept of mammalian anatomy and physiology enable them to visualise and get a better understanding of the concept as posited by

Graham (2006). In his study, Graham postulated that students who are introduced to abstract concepts like anatomy and physiology have difficulty in comprehension since they are not familiar with the concepts and its content but when such concepts are introduced with different approaches such as the MMIA, they are able to visualise the concept which aid in better comprehension and therefore are able to apply what they learn in class. The role of the teacher in the concept of anatomy is to facilitate the learning process. It is important to use multiple techniques in order to reach as many different types of learners as possible.

On the issue of learner-centeredness and students motivation to learn, Aziz *et al*. (2002) observed that when learners are involved in the planning of the lesson as well as using multiple instructional techniques, they become satisfied and take ownership of the lesson. This will instil learning as students are always motivated to take up new task and learn from them. Again, majority of the students asserted that the MMIA used by the researcher enhanced their understanding and critical thinking skills. Studies have shown that collaboration can enhance the quality of the learning process, hence the importance of achieving specific learning outcomes combining multimedia content with collaborative learning may lead to engaging, interactive and powerful multimedia learning environments (Dillenbourg, 1999). Students working collaboratively in groups have the opportunity to share their thoughts and prior knowledge. Collaborative dialogue supports learning by clarifying thinking and consolidating ideas (Hmelo-Silver, 2002). Multimodal collaborative learning promotes the idea of creating a learning community with a shared purpose of making sense of scientific ideas and practices (Harris & Rooks, 2010) and this helps students to understand their concepts they are taught, cater for their learning needs and help them to retain much information. This has been asserted by studies such as Miller and

McVee (2013) which stipulate that teachers, although still reluctant in using technology in pedagogically driven ways, have slowly started to integrate new educational teaching and learning practices including but not limited to learning games, collaborative editing and online media manipulation. These activities help to improve the critical thinking skills of students as well as enhancing their understanding of concepts taught.

The multimodal approach significantly affected students engagement, perceptions, and learning because they were presented with many opportunities to resonate the content with students. As Jewitt (2008) explains; meanings are made, distributed, interpreted, and remade. Therefore, much more than just presenting information in multiple ways, but requiring students to seek out learning through these many modes provide opportunities for students to use their skills and tap their interests while interacting with the content. If teachers can achieve this broad approach on information gathering and activation, student perceptions about learning are likely to expand. If educators can alter how students become engaged with content knowledge or challenge their perception of what is acceptable knowledge beyond simply a correct answer, then students may be exposed to the complete process of learning, enhancing a variety of skills that are valued beyond the pages of a text or the walls of the classroom.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter contains summary of the finding, conclusions, recommendations and suggestions offered to improve upon the teaching and learning of biology.

5.1 Summary of Findings

RQ1. What is the effect of MMIA on students" cognitive achievement in the selected biology topics before the treatment?

The data collected had the control group mean to be 3.175 and the experimental group mean to be 3.225 out of 10 respectively.

This indicated that students in both groups scored a little above 3 which is below average of 5. It goes to confirm that, students had a low knowledge in mammalian anatomy and physiology before the treatment in teaching.

RQ2. What are the relative differences in the performance of the control and experimental groups after the treatment?

From the data collected, the control group mean was 5.625 and the experimental group mean was 7.075 out of 10 respectively.

The mean score of both groups increased above an average of 5 after the treatment was given with the score of the experimental group higher than the control group.

RQ3. What are the students‟ perception of MMIA on the selected biology topics?

From the data collected, 94% of the experimental group agreed to all questions in the questionnaire which showed that students had a high positive perception towards MMIA. 4% were undecided whereas the remaining 2% disagreed.

5.2 Conclusions

The study investigated the effect of multimodal instructional approaches on students‟ performance in selected topics in biology (Mammalian anatomy and physiology).

The following conclusions were made or drawn on the analysis and findings of the study. MMIA was effective in teaching the concept of mammalian anatomy and physiology. This was based on the fact that students who were exposed to MMIA performed better than those who were taught using the lecture method.

The claim that the control and the experimental groups will perform equally well after the treatment was not true as the performance of the experimental group was better than that of the control group after the treatment. The cognitive achievement of students before the treatment was nothing that can be compared to the achievement after the treatment using MMIA. Last but not the least, the perception of students on the use of MMIA before the treatment was minimal as compared to that of the post-treatment perception. This is because of the student-centered nature of the instructional approach.

5.3 Recommendations

Based on the findings, there is an urgent need for biology teachers to adopt instructional approaches that place students (learners) at the center of the teaching and learning process and again to improve their critical thinking skills. Science teachers

should shift from the traditional mode of instruction to the one that caters for the diverse needs of students in the classroom based on their different learning styles.

Based on the finding of the study, the following recommendations are put forward by the researcher:

i. Biology teachers in various schools should be encouraged to teach biology lessons using MMIA to improve their academic performance.

ii. Workshops, seminars and conferences should be organized to train teachers to adopt and use current and efficient instructional approaches such as the use of computer-assisted animations, models, charts, etc. to improve academic performance or achievements of students.

iii. Specimens of various kinds in addition to teaching-learning materials must be made available to biology teachers so that they make their lessons as practical as possible so that it enhances learning and retention of what has been learned on the part of students.

5.4 Suggestions for Further Study

Further research should investigate the effect of the multimodal instructional approach in other subject areas at the senior high school to generate empirical evidence with greater generalization. The study was limited to Koforidua Senior High Technical School (KSHTS) and Oti Boateng Senior High School (OBOSS) in the New Juaben South Municipality in the Eastern Region of the country but further studies should consider large number of schools and students in the different regions of Ghana.

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APPENDICES

APPENDIX A

QUESTIONNAIRE FOR STUDENTS IN THE EXPERIMENTAL GROUP

This questionnaire was designed to evaluate your perceptions on the impact of multimodal instructional approaches on the performance of selected senior high school students on selected topics in biology (Mammalian Anatomy and Physiology)

Please respond to each of the items to the best of your knowledge.

Your truthful responses will be greatly appreciated. Your Reponses will be kept confidential and will not affect our examination results. It will be used purposely for research.

1. Background information

   Pleases tick [√] in the appropriate spaces provided below

   Gender Male [ ] Female[ ]

   Age 14-16 [ ] 17-19 [ ] 20-22[ ]

2. Student‟s perceptions about the use of MMIA as a teaching method for teaching mammalian anatomy and physiology.

   INSTRUCTIONS; please read the following statements and indicate how much you agree or disagree with each of the statements by ticking the appropriate option provided in a scale form below;

Strongly agree (SA) =5, Agree (A)= 4, Uncertain (UC) = 3, disagree (DA)=2, Strongly disagree (SD)=1

S/N	ITEM	SA	A	UC	DA	SD
1.	MMIA helped me to apply what I learnt to life					
2.	I am satisfied with this method of instruction					
3.	MMIA made the lesson learner-centered					
4.	MMIA motivated me on the topics					
5.	MMIA made the lesson meaningful					
6.	I recommend MMIA to other science teachers					
7.	My performance was improved by MMIA					
8.	MMIA enhanced my critical thinking skills					
9.	MMIA increased my interest in mammalian anatomy and physiology.					
10.	MMIA helped me to understand the topics better					
11.	MMIA catered for my learning needs					
12.	MMIA helped me to retain more information					
13.	MMIA made the lesson visual for me.					
14.	MMIA helped me to concentrate on the lesson					
15.	MMIA made the lesson practical					

APPENDIX B

PRETEST DATA COLLECTION INSTRUMENT

These questions seek to find out your basic knowledge about mammalian anatomy and physiology.

Please respond to each item to the best of your knowledge. Your truthful response to each of the items will be greatly appreciated. Your response will be kept confidential and will not affect your examination results. It will be used purposely for a research.

Please fill or **tick [√]** in the appropriate space provided below

Participant number: [ ]

Gender: Male [ ] Female [ ]

Age: 14-16 [ ] 17-19 [ ] 20 – 22 [ ]

INSTRUCTIONS: answer all questions

1. Define the term skeleton name the types and give an example each of each of the types.

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2. Give three functions of the mammalian skeleton.

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3. Outline three points that describes the pectoral girdle in mammals.

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4. Name the skeletal tissues found in mammals.

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5. Describe the bone of the lower arm of a human using two statements/sentences

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6. List three functions of blood.

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7. List three constituents of the lymph in humans.

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8. Name the cellular components of the human blood.

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9. State three substances in the body that requires water medium for transportation

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10. Explain the term diastole.

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APPENDIX C

MARKING SCHEMES OF PRE-TEST

1. Skeleton is hard part of an animals which form the framework of body. [2mks]

Type of skeleton	**Example**
endoskeleton	Goat/man
Exoskeleton	Ant /crab /millipede/spider

[1/2*4] =2mks

2. Maintains shape and form the rigid framework of the organism

   - Red blood cells are manufactured in the marrow of the bone
   - Provides surfaces of attachment of muscles
   - Provides a series of levers for movement of the body and its part.
   - Protects delicate internal organs
   - Aids in breathing mechanism
   - Supports internal organs as well as the total body weight of the organism

[any 3 x 1] = 3mks

3. Each half consist of a scapula blade, coracoid and clavicle bone

- The scapula is triangular in shape fused with the coracoid.

- The scapula has a cavity called glenoid cavity, into which fits the head of the humerus.

-One end of the clavicle articulates with the scapula, which the other end is joined by ligaments to the sternum.

[Any 3 x 1] = 3mks

4. Skeletal tissues found in mammals are

   i) Bone ii) cartilage [1x2] = 2mks

5. It consists of radius and ulna, with the ulna longer and bigger than the radius with a depression called the sigmoid notch near its anterior or proximal end.

   - Beyond the sigmoid notch is the olecranon process which forms below the elbow.
   - Lying beside the ulna on the inner surface is a narrower bone slightly shorter than the ulna called the radius.

   [any 3 x 1] = 3mks

6. Functions of blood are;

   - Transport of soluble end products of digestion from small intestines to tissues to be stored and used

   Transport hormones from ductless glands to target tissues or the whole body.

   - Prevents excessive blood loss through clotting by platelets
   - Transports carbon dioxide as hydrogen carbonate from tissues to lungs and oxygen from lungs to tissues.
   - Protects against diseases through antibodies and phagocytic white blood cells that engulf and digest disease causing bacteria.
   - Regulates pH, temperature and water content of cells.

- Transport excretory matter from tissues to excretory organs.

[any 3 x 1] = 3mks

7. Cellular components of human blood are;

- Red blood cells or erythrocytes.
- White blood cells or leucocytes.
- Platelets or thrombocytes.

[1 x 3] = 3mks

8. Constituents of lymph in humans:

- Dissolved mineral salts
- Nutrients/fatty acids/glycerol/amino acids.
- White blood cells
- Oxygen
- Carbon dioxide
- Hormones
- Water
- Waster/nitrogenous waste/urea

[any 3 x 1] = 3mks

9. Substances that require water medium for transport;

- Hormones
- Digested food substances / nutrients.
- Excretory products / urea.
- Oxygen.

- Carbon dioxide.
- Mineral salts.
- Anti-bodies.
- Enzymes

[Any 3 x 1] = 3mks

10. Diastole is the phase of the heart beat that occur between two contractions of the heart during which the heart muscles relax and ventricles fill up with blood.

3mks

TOTAL MARKS = 30MKS.

APPENDIX D

POST-TEST DATA COLLECTION INSTRUMENT

These questions seek to find out your basic knowledge about mammalian anatomy and physiology.

Please respond to each item to the best of your knowledge. Your truthful response to each of the items will be greatly appreciated. Your response will be kept confidential and will not affect your examination results. It will be used purposely for a research.

Please fill or **tick [√]** in the appropriate space provided below

Participant number: [ ]

Gender: Male [ ] Female [ ]

Age: 14-16 [ ] 17-19 [ ] 20 – 22 [ ]

INSTRUCTIONS: answer all questions

1. Explain the term diastole.

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2. State three substances in the body that requires water medium for transportation

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3. Name the cellular components of the human blood.

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4. List three constituents of the lymph in humans.

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5. List three functions of blood.

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6. Describe the bone of the lower arm of a human using two statements/sentences.

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7. Name the skeletal tissues found in mammals.

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8. Outline three points that describes the pectoral girdle in mammals.

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9. Give three functions of the mammalian skeleton.

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10. Define the term skeleton name the types and give an example each of each of the types.

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APPENDIX E

MARKING SCHEME FOR POST TEST

1. Diastole is the phase of the heart beat that occur between two contractions of the heart during which the heart muscles relax and ventricles fill up with blood.

3mks

2. Substances that require water medium for transport;

- Hormones
- Digested food substances / nutrients.
- Excretory products / urea.
- Oxygen.
- Carbon dioxide.
- Mineral salts.
- Anti-bodies.
- Enzymes

[Any 3 x 1] = 3mks

3. Constituents of lymph in humans:

- Dissolved mineral salts
- Nutrients/fatty acids/glycerol/amino acids.
- White blood cells
- Oxygen

- Carbon dioxide
- Hormones
- Water
- Waster/nitrogenous waste/urea

[Any 3 x 1] = 3mks

4. Cellular components of human blood are;

- Red blood cells or erythrocytes.
- White blood cells or leucocytes.
- Platelets or thrombocytes.

[1 x 3] = 3mks

5. Functions of blood are;

- Transport of soluble end products of digestion from small intestines to tissues to be stored and used

Transport hormones from ductless glands to target tissues or the whole body.

- Prevents excessive blood loss through clotting by platelets
- Transports carbon dioxide as hydrogen carbonate from tissues to lungs and oxygen from lungs to tissues.
- Protects against diseases through antibodies and phagocytic white blood cells that engulf and digest disease causing bacteria.
- Regulates pH, temperature and water content of cells.
- Transport excretory matter from tissues to excretory organs.

[Any 3 x 1] = 3mks

6. It consists of radius and ulna, with the ulna longer and bigger than the radius with a depression called the sigmoid notch near its anterior or proximal end.

   - Beyond the sigmoid notch is the olecranon process which forms below the elbow.
   - Lying beside the ulna on the inner surface is a narrower bone slightly shorter than the ulna called the radius.

   [any 3 x 1] = 3mks

7. Skeletal tissues found in mammals are

   i) bone ii) cartilage

   [1x2]= 2mks

8. Each half consist of a scapula blade, coracoid and clavicle bone

   - The scapula is triangular in shape fused with the coracoid.
   - The scapula has a cavity called glenoid cavity, into which fits the head of the humerus.
   -One end of the clavicle articulates with the scapula, which the other end is joined by ligaments to the sternum.

   [any 3 x 1] = 3mks

9. Maintains shape and form the rigid framework of the organism

   - Red blood cells are manufactured in the marrow of the bone
   - Provides surfaces of attachment of muscles
   - Provides a series of levers for movement of the body and its part.
   - Protects delicate internal organs

- Aids in breathing mechanism
- Supports internal organs as well as the total body weight of the organism

[any 3 x 1] = 3mks

10. Skeleton is hard part of an animals which form the framework of body. [2mks]

Type of skeleton	**Example**
endoskeleton	Goat/man
Exoskeleton	Ants/ crab /millipede/spider

[1/2 x 4] =2mks

APPENDIX F
LESSON NOTES FOR CONTROL GROUP
CLASS: SHS2

WK	DURATION / TOPIC/ SUBBTOPIC	OBJECTIVES/ TLM	TEACHER-LEARNER ACTIVITY	CORE POINTS	REMARKS
1	**DAY** Tuesday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Transport	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Explain the concept transport and its need. ii) Describe the structure of the mammalian heart. **TLM** Charts	Teacher introduces the lesson by asking students questions on transport to review their RPK. Teacher takes students through the concept of transport and its need. With the aid of chart of the mammalian heart, the takes students through the structure and its parts.	The heart is divided into four chambers: the two upper chambers called right and left atria and the two lower chambers called right and left ventricles. A septum separates the right from the left side of the heart. The atria receive blood whilst the ventricles pump blood from the heart.	1) Give the functions of the following: i)Right and left ventricles. ii)right and left atria. 2) Draw and label the mammalian heart.
	DAY Thursday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Transport	**OBJECTIVES** By the end of the lesson, the student should be able to: i)explain the mechanism of heart excitation and contractions ii)describe the structure of blood vessels. **TLM** Chart on blood vessels.	Teacher reviews students RPK though questioning. Teacher takes students through the mechanism of heart excitation and contraction. Teacher uses the chart on blood vessels to take students through the structure of blood vessels.	Heart beat is initiated by the Sino-atrial node (SAN) and it consist of two stages. They are systole and diastole. The blood vessels are veins, atries and capillaries.	Compare the structure of an artery, vein and capillaries

WK	DURATION / TOPIC/ SUBBTOPIC	OBJECTIVES/ TLM	TEACHER-LEARNER ACTIVITY	CORE POINTS	REMARKS
2	**DAY** Tuesday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Transport	**OBJECTIVES** By the end of the lesson, the student should be able to: i)describe the composition of blood. ii)state the functions of blood. iii)describe circulation of blood of a mammal. **TLM** A chart of the circulatory system	Teacher ask questions to review students RPK. Teacher takes students through the composition of blood. Teacher takes students through functions of blood. Teacher takes students through circulation of blood using the chart.	Composition of blood: -plasma -blood cells -platelets. Functions of blood -blood clotting. -Production of antibodies. -Phagocytosis -Transport of materials.	Draw and label the circulatory system of a mammals?
	DAY Thursday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Transport	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Explain the formation of lymph. ii) Outline the functions of Lymph iii) Describe heart diseases, causes and functions	Teacher takes students through the formation of lymph. Teacher takes students through the functions of lymph. Teacher takes students through heart diseases, causes and control.	Lymph is the excess tissue fluid in the lymph vessels. **Functions** -Production of lymphocytes. -Excretory product removal. **Heart diseases** -thrombosis -hypertension -stroke etc.	1) What is a lymph? 2) How is a lymph formed? 3) Outline two functions of a lymph. 4) State any two heart diseases.

WWK	DURATION/ TOPIC/ SUBBTOPIC	OBJECTIVE/ TLM	TEACHER-LEARNER ACTIVITY	CORE POINTS	REMARKS
3	**DAY** Tuesday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Movement	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Explain the concept of skeleton and its types. ii) Describe the general plan of the skeleton. **TLM** Snail crab fish.	Teacher ask questions to review students RPK. Teacher takes students through the concept of skeleton and its types using the TLMs available. Teacher takes students through the general plan of the skeleton.	Skeleton is the supporting structural framework for locomotion. **Types:** -exoskeleton -endoskeleton -hydrostatic **Divisions:** -axial -appendicular. **Appendicular** is made up of limbs and limb girdles. **Axial** is made up of vertebral column, skull, ribs and sternum.	1)Explain the term skeleton. 2)Name the types of skeletons and give an example each. 3)Name the bones that make up appendicular skeleton.
	DAY Thursday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Movement	**OBJECTIVES** By the end of the lesson, the student should be able to describe the various constituents of the axial skeleton. **TLM** Various bones of the vertebral column.	Teacher ask questions to review students RPK. Teacher continues the lesson by using the TLMs to take students through the constituents of the axial skeleton.	The axial skeleton is made up of the skull, vertebral column, ribs and the sternum. The bones of the vertebral column are: -cervical -thoracic -lumber -sacral -caudal.	1)Draw and label a generalized vertebra. 2)Name the constituent of the axial skeleton.

WK	DURATION/ TOPIC/ SUBBTOPIC	OBJECTIVES/ TLM	TEACHER-LEARNER ACTIVITY	CORE POINTS	REMARKS
4	**DAY** Tuesday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Movement	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Describe the structure of the skeletal tissues. ii) Identify the different vertebrae in the vertebral column. iii) Outline the functions of the mammalian skeleton. **TLM** Pictures of bones of the vertebral column.	Teacher ask questions to review students RPK. Teacher takes students through the structure of the skeletal tissues. Teacher with the aid of the TLMs, take students through the various vertebrae of the vertebral column. Teacher outlines the functions of the skeleton.	**Cervical** -Transverse process are flattened. - has a canal through which nerves and blood vessels passes. - found in the neck. **Thoracic** - has large centrum. - has a neural canal. **Lumbar** - has large thick centrum. - neural spine projects outward	1) Describe the structure of a bone and a cartilage. 2) State two functions of the skeleton. 3) Describe the structure of a bone and a cartilage.
	DAY: Thursday **DURATION:** 2hrs **TOPIC**: Mammalian Anatomy and Physiology. **SUBTOPIC:** Movement	**OBJECTIVES** By the end of the lesson, the student should be able to: i)define joints and identify the different types. ii)identify the types of muscles. iii)describe how muscles bring about movement. **TLM**: Chart on the skeletal system	Teacher ask questions to review students RPK. Teacher takes students through joints and muscles and their types. Students brainstorm on the functions of the vertebral column. Teacher discuses how muscles bring about movement with students.	A joint is a place where two or more bones meet In the body. **Types:** -moveable -slightly moveable -immoveable Muscle tissues are tissues made of cells that can contract and relax to produce movement. **Types:** -smooth -cardiac -skeletal.	1) Describe how muscles bring about movement 2) Explain the following: -joint -muscles

APPENDIX G

LESSON NOTES FOR EXPERIMENTAL GROUP

CLASS: SHS2

WK	DURATION/ TOPIC/ SUBBTOPIC	OBJECTIVES/ TLM	TEACHER-LEARNER ACTIVITY	CORE POINTS	REMARKS
1	**DAY** Tuesday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Transport	**OBJECTIVES** By the end of the lesson, the student should be able to: i)explain the concept „transport" and it"s need. ii)describe the structure of the mammalian heart. **TLM** Charts Computer assisted animation	Teacher introduces the lesson by reviewing students" previous knowledge by asking them questions. Teacher begins the lesson by projecting a computer animation of the transport system and how materials are transported and discuss it with the students. A chart of the structure of the mammalian heart was presented to the students for discussion. The discussion will include the parts of the heart and their functions. The lesson will be concluded by asking students questions on the topic of the day.	*Transport in mammals:* -surface area/ volume ratio -substances have to move greater distances *structure of the heart:* The heart is divided into four main chambers, the 2 upper chambers are called the left and right atria and the lower chambers are called the left and right ventricles. A septum separates the right from the left sides of the heart. The atria receive blood into the heart whilst the ventricle pumps blood from the heart.	1) Give one reason why transport in mammals is necessary. 2) give the functions of the following: -right and left ventricles - right and left atria 3) draw and label the mammalian heart

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1	**DAY** Thursday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Transport	**OBJECTIVES** By the end of the lesson, the student should be able to: i)explain the mechanism of the heart (excitation and contraction). ii)describe the structure of the blood vessels. **TLM** Charts Computer assisted animation	Teacher introduces the lesson by asking students to describe the structure of the heart. The lesson continued with the teacher leading the discussion on the mechanism of the heart excitation and contraction using the computer assisted animation [SAN and AVN] The lesson continues with a discussion on the structure of the blood vessels using the computer assisted animation as well as their functions. The lesson will be concluded by asking students questions on the topic of the day.	The heart beat is initiated by the Sino-atrial node [SAN] and it consist of two stages: - The diastole the heart muscles relax to enable blood to fill the heart. - The systole The contraction of the heart muscles to force blood out of the heart. The blood vessels are veins, arteries and capillaries. Functions of the blood vessel -veins Carry blood under low pressure to the heart -arteries Carry blood under high pressure from the heart to all parts of the body. -capillaries	Compare the structure of an artery, vein and capillary.

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2	**DAY** Tuesday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Transport	**OBJECTIVES** By the end of the lesson, the student should be able to: i) describe the composition of blood. ii) state the functions of blood. iii)describe circulation of blood in a mammal. **TLM** Charts Computer assisted animation; a dissected guinea pig	Teacher reviews students R.P.K by asking questions on mechanism of heart beat and structure of blood vessels. Lesson continues with teacher leading a discussion on the composition of blood as well as functions of blood. Students will be made to examine the circulatory system of a dissected guinea pig and describe it. The computer assisted animations will be used to explain how blood circulates in mammals as well as single and double circulation. The lesson will be concluded by asking students questions on the topic of the day.	Composition of blood: -plasma -corpuscles Platelets Functions of blood: - regulation of body temperature - transport of metabolic substances - transport of food nutrients	Draw and label the circulatory system of a mammal.

WK	DURATION/ TOPIC/ SUBBTOPIC	OBJECTIVES/ TLM	TEACHER-LEARNER ACTIVITY	CORE POINTS	REMARKS
2	**DAY** Thursday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Transport	**OBJECTIVES** By the end of the lesson, the student should be able to: i) Explain the formation of lymph ii) outline the functions of lymph iii) heart diseases, causes and effects.	Teacher reviews students R.P.K by asking students to describe the mammalian circulatory system. Lesson continues with teacher leading a discussion on what a lymph is and how it is formed in the body of humans. Teacher ask students to name some diseases of the heart, then lead them in a discussion of the causes, symptoms and prevention of the named heart diseases. The lesson will be concluded by asking students questions on the topic of the day.	Lymph is the excess tissue fluid in the lymph vessels. Functions -production of lymphocytes which are released into the blood. -it removes excretory products from the cells and transport them for excretion. -Helps absorb and transport fat Heart disease; -varicose veins -thrombosis - hypertension -stroke	1) What is a lymph. 2) how is a lymph formed 3) outline two functions of lymph 4) list two diseases of the mammalian heart.

WK	DURATION/ TOPIC /SUBBTOPIC	OBJECTIVES/ TLM	TEACHER-LEARNER ACTIVITY	CORE POINTS	REMARKS
3	**DAY** Tuesday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Movement	**OBJECTIVES** By the end of the lesson, the student should be able to: i) explain the concept skeleton and mention the types of skeletons ii) describe the general plan of the mammalian skeleton. **TLM** Snail Crab Fish Computer assisted animations	Teacher introduces the lesson by reviewing the R.P.K of students on the skeleton. Lesson continues with the teacher leading the discussion on the types of skeletons. Students will be given the snail, crab and fish to determine their type of skeleton. Teacher uses the computer assisted animation of the skeleton to aid the discussion of the general plan of the mammalian skeleton. Teacher discusses the appendicular skeleton with students with the aid of charts. The lesson will be concluded by asking students questions on the topic of the day.	Skeleton is the supporting structural framework for locomotion. Types of skeletons -exoskeleton Endoskeleton Hydrostatic Divisions of skeleton Axial Appendicular Appendicular skeleton. It is made up of the limbs and limb girdles.	Explain the term skeleton Name the types of skeletons and give an example each. Name the bones that make up the appendicular skeleton.

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3	**DAY** Thursday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Movement	**OBJECTIVES** By the end of the lesson, the student should be able to: i) describe the various constituents of the axial skeleton **TLM** Model of the skull, bones of the vertebral column.	Teacher ask questions to review students R.P.K. Teacher continues the lesson by taking students through the axial skeleton by allowing students to examine models of the axial skeleton. Students be made to examine the model of the skull as well as the various bones of the vertebral column. The students are taken through the parts of the generalized vertebral column.	The axial skeleton is made up of the skull, vertebral column, ribs and the sternum. The bones of the vertebral column are; -cervical [neck region] -Thoracic [chest region] -lumbar [abdomen] -sacral [hip region] Caudal [tail]	Draw and label a generalized vertebra. Name the constituent of the axial skeleton.

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4	**DAY** Tuesday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Movement	**OBJECTIVES** By the end of the lesson, the student should be able to: i) describe the structure of the skeletal tissues. ii) identify the different vertebrae in the vertebral column. iii) outline the functions of the mammalian skeleton. **TLM** Slides of the compact tissue Computer assisted animation of types of vertebral column bones.	Teacher reviews students R.P.K. through questioning. Teacher guides students to observe the T/S of bone on the slides using the microscope and discusses with them. Students observe the different vertebrate and describe them separately. Teacher discusses the functions of the mammalian skeleton with students. Students will observe computer assisted animation of a cartilage	Vertebrae of the vertebral column -cervical transverse process is flattened. Has a canal through which blood vessels and nerves in the neck passes. Found in the neck. -thoracic Has a large centrum Has a long neural canal Has a long neural spine Found in the chest. - Lumbar Found in the abdomen Has large thick centrum Has large thick neural spine Neural spine projects outwards and upwards.	Describe the structure of a bone and a cartilage State two functions of the mammalian skeleton

WK	DURATION/ TOPIC /SUBBTOPIC	OBJECTIVES/ TLM	TEACHER-LEARNER ACTIVITY	CORE POINTS	REMARKS
4	**DAY** Thursday **DURATION** 2hrs **TOPIC** Mammalian Anatomy and Physiology. **SUBTOPIC** Movement	**OBJECTIVES** By the end of the lesson, the student should be able to: i) define joint and identify the types of joints. ii) identify the types of muscles iii) describe how muscles bring about movement. **TLM** Chart on the skeletal system.	Teacher ask questions to review students R.P.K. Teacher allows students to brainstorm on the functions of the vertebral column. Teacher discusses with students‟ what joints and muscles are and their various types. Teacher discusses with students how muscles bring about movement.	A joint is a place where two or more bones meet in the body. Types - movable - slightly movable - immovable muscle tissue is a tissue made of cells that can contract and relax to produce movement. Types -smooth - cardiac - skeletal	Describe how muscles bring about movement Explain the following - joints - muscles