UNIVERSITY OF EDUCATION, WINNEBA

EFFECT OF MULTIMODAL INSTRUCTIONAL APPROACH ON STUDENTS' ACADEMIC PERFORMANCE IN THE CONCEPT OF BIOLOGICAL CLASSIFICATION

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DECLARATION

STUDENT'S DECLARATION

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

SIGNATURE ……..

DATE ……..

SUPERVISOR'S DECLARATION

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

SUPERVISOR'S NAME: PROFESSOR ALEXANDER NII MOI PAPPOE

SIGNATURE ……

DATE……..

DEDICATION

I dedicate this work to my parents, Mr and Mrs Ayine Akotuko and siblings; Ayine Justice, Ayine Christopher and Ayine Abraham Lincoln.

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ABSTRACT

The study investigated the effect of Multimodal Instructional Approach on students' academic performance in the concept of Biological Classification at Navrongo Senior High School. The research study adopted quasi-experimental research design. The sample comprised of 100 Navrongo Senior High School form two Gold Track and Green Track science students. The students were divided into two groups and were assigned as experimental group and control group. Students from the Gold Track were assigned as experimental group and those from Green Track were also assigned as control group. Each group was made up of 25 males and 25 females. Pretest was administered to all the participants in order to be sure of their homogeneity. Treatment was administered to the experimental group using Multimodal Instructional Approach and the control group was also taught using Discussion as a teaching method. After the treatment, a posttest was administered to both groups to determine the effectiveness of the treatment. The pretest and posttest scores of the students in both groups were used for the purpose of data analysis. The results were analyzed using t-test. The results of the posttest revealed that the use of Multimodal Instructional Approach in teaching the concept of Biological Classification was effective. When the results of the two methods were compared, multimodal instructional approach was more effective than the discussion method. The posttest results of the experimental group were significantly higher than the control group. Questionnaire was also administered to students in the experimental group to determine their perceptions about multimodal instructional approach. The overall mean of the participant was 4.25 which proved that majority of the students agreed that Multimodal Instructional Approach is an effective method for teaching Biological Classification. It was therefore recommended that science teachers should adopt multimodal instructional approach in teaching practical-oriented topics like classification of living organisms. It was also recommended that science teachers should be given the opportunity to attend in-service training, workshops, seminars and conferences to update their knowledge of methods of teaching concepts in science.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter introduces readers to the background to the study which describes issues on multimodal instructional Approach. This is followed by statement of the problem, purpose of the study, objectives of the study and research questions. In addition, the chapter presents significance of the study, delimitations and limitations of the study. Definition and clarification of key concepts are also provided for readers understanding and the chapter ends with organization or structure of the thesis.

1.1 Background to the Study

The method of instruction is very essential when teachers want the academic performance of their students to be improved. For several years, the lectured method of teaching has been the most widely used instructional approach in senior high schools in Ghana. This method of instruction does not help to develop critical thinking and creativity in students because it involves only the sense of hearing and hence hinders the academic success of students. Development of instructional strategies to improve the teaching and learning of Biology at the Senior High School should be a major concern for Biology tutors in order to improve the academic performance of students. The classroom consists of students with different learning styles and they feel comfortable, learn and perform better when learning in environments that cater for their predominant learning styles (Cronin, 2009) which teachers need to take into consideration during teaching in order to meet the needs of all students in the class.

All students have different learning styles and the function of the teacher is to identify these learning styles and find instructional strategies that will match the preferred learning style in order to enhance effective teaching and learning process (Olufunminiyi, 2015).

With the introduction of Information Communication Technologies (ICTs) in the teaching and learning process, teachers can now design instructional approaches that have the capability of motivating students to learn better and improve on their academic achievement. ICTs provide opportunity for teachers to create a suitable learning environment for their students. Proper planning of teaching methods is very necessary in order to achieve the learning goals and come up with the desired learning outcomes.

The increasing use of multimedia in teaching has provided many opportunities to present multiple presentations of content (text, video, audio, images and interactive elements) to cater more effectively to the different learning styles and modal preferences of an increasing diverse student body (Sankey, Birch, & Gardiner, 2010). Multimodal learning environment allows instructional elements to be presented in a variety of presentation modes that lead learners to perceive that it is easier to learn and improve attention; thus, leading to improved performance (Moreno & Mayer, 2007). It has also observed that presenting information in a variety of modes may also encourage students to develop more versatile approach to learning (Sankey *et al*, 2010), although caution should be taken to prevent cognitive overload.

An American Educator, Edgar Dale, who was born on the 27th April, 1900 and died on the 8th March, 1985 found that people remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they hear and see, 70% of what they say and write and 90% of what they see as they do a thing (Shabiralyani, Hasan, Hamad, & Iqbal, 2015). This is an indication that instructional strategies that give room for students 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 improvement in their academic achievement. So there is no doubt that multimodal instructional approach has a greater impact on students' performance or academic achievement because it is the only method of instruction that deals with the presentation of content knowledge to students in multiple modes. Multimodal learning environments allow to present instructional media in more than one mode of presentation that provides students with a wider variety of learning styles (Suparmi, 2017). Multimodal instructional approach arouses students' interest, increases students' motivation, improves students' attention and improves students understanding of concepts (Moreno & Mayer, 2007).

Multimodal instructional approach allows students to experience learning in ways in which they are most comfortable, while challenging them to experience and learn in other ways as well (Picciano, 2009). Learners are not the same in abilities, skills, interests and styles in terms of learning (Ganapathy & Seetharam, 2016). Therefore, there is the need for Biology tutors to vary their instructional approaches in order to cater for the diverse learning needs of learners in the class. The use of multiple modes of presentation will help to bring about significant improvement in students' academic achievement.

One of the major problems facing science education in Ghana is the inability of science teachers to design pedagogical strategies that will help students understand concepts in science and also improve their performance (Bawa, 2018). Multimodal instructional approach can be effective for all students with different learning abilities as individual differences can be overcome in learning through different media (Aggarwal, 2018).

According to Ogunkula and Samuel (2011), one of the key factors in facilitating meaningful learning of biological concepts is the use of effective and efficient teaching

methods by teachers. Therefore, there is the need for biology teachers to design instructional methods that would promote better understanding of scientific concept for the improvement of students' academic performance. Multimodal instructional approach which is the integration of different stimulus modes of instructions such as realia, visual, analogy, symbols and interaction within the same text to represent scientific ideas, reasoning and findings could be effective in improving students learning (Bawa, 2018).

Multimodal presentation is used to support the verbal instructional materials (examples, printed words) and the corresponding visual instruction materials (examples, illustrations, photos, videos and animations) in the interactive instructional activity (Kuo, Yu, & Hsiao, 2013). Multimodal instructional approach involves the use of multimedia and ICT to develop dynamic resources that help to cater for diverse learning styles of students. Multimedia elements which include text, graphics, sound, video and animation help in the creation of an interactive learning environment that can help teachers' teaching and students' learning (Akinoso, 2018).

Multimodal instructional approach can be used to develop a curriculum that appeals to visual, aural, audio-visual and kinesthetic learners and overcome differences in students' performance that may result from different learning styles (Gilakjani, Ismail, & Ahmadi, 2011). Multimodal instructional approach combines text, audio, visuals, graphics and dynamic elements such animation and video. This presents learner with unique resources that can be used in a wide variety of ways to stimulate various forms of learning (John, Musa, & Waziri, 2018). With multimodal instructional approach, teachers motivate students to learn by using their different senses through audio-visual presentation of information for the student to obtain clearer and better understanding of the concept. ICT as a versatile instrument has the capability not only of engaging learners in instructional activities to increase their learning but also enable them to solve problems that they may

confront (Habibu, Al-Mamun, & Clement, 2012). Multimodal information presentation makes students feel that it is easy to learn and improve attention, thus leading to improved learning performance of lower achieving students (Chen & Fu, 2003).

1.2 Statement of the Problem

In this study the effectiveness of multimodal instructional approach on Senior High School (SHS) science students' academic performance in the concept of classification of living organisms was investigated. This topic was chosen because it is a core concept in the Biology curriculum and also considered to be a broad topic. Classification of living organisms is also considered to be a difficult topic to understand. The difficulties faced by students in classifying living organisms came up during my discussion with Biology teachers from Zamse SHS, Bolgatanga SHS, Bolgatanga Girls SHS and Zuarungo SHS in the Upper East Region of Ghana. Biology tutors from these schools complained that their students often performed poorly in classifying living organisms. Classification of living organisms is an examinable topic in the West African Senior High School Examination in Biology paper one, two and three (practical paper) yet less attention has been given to developing strategies to eliminate these difficulties, to correct misconceptions and to improve classification of living organisms' instruction in Biology.

The performance of students in Biology and particularly classification of living organisms has been generally poor (Wafula & Odhiambo, 2016). The West African Examination Council Chief Examiners' Report (WAEC, 2018) stated that a good number of candidates lost marks in biology in the West African Senior School Certificate Examination (WASSCE) in the concept of classification of living organisms.

The instructional strategies used in teaching classification of living organisms in Biology at the SHS seem not to have a positive effect on the academic performance of students on

the topic. The mode of teaching classification of living organisms in Biology in SHS whereby Biology teachers adopt only the lecture or teacher-centered method without multimodal incorporation does not help to improve the academic performance of students. Therefore, this study seeks to investigate whether there are significant differences among the effects of multimodal instructional approach and discussion web instructional approach on SHS form two science students' academic performance in classifying living organisms. Multimodal Instructional Approach (MIA) has been used by Bawa (2018) in teaching chemistry concepts in some selected colleges of education in Ghana. The author confirmed that students who were taught using MIA had a positive attitude towards the subject than those who were taught using Traditional Instructional Approach. Bicomong, Rosa, Abedes, and Dellosa (2015) also conducted a study on the use of Multimodal Instructional Approach in teaching Algebra (Measurement) of Grade 7 in Camp Vicente Lim National High School S.Y. 2014-2015. The authors confirmed that students are more active when their teachers use Multimodal instructional approach. One of the findings of the authors was that students who were taught using Multimodal Instructional Approach perform far better than students who were taught using lecture method. Based on these findings, the researcher deemed it necessary to also investigate the effect of Multimodal Instructional Approach on students' academic performance in the concept of Biological Classification.

1.3 Purpose of the Study

The purpose of this study is to determine the effect of multimodal instructional approach on Form Two science students' academic performance in the concept of Biological Classification in Navrongo Senior High School.

The researcher finds it interesting in carrying out this study because according to Lebata and Mudau (2014), the methods most Biology teachers used in teaching Biology does not produce the best result. For instance, most Biology tutors at the SHS level often use conventional method in teaching topics in Biology and classification of living organisms is not exempted. My personal experience as a Biology teacher proved that the instructional strategies used by Biology teachers to teach Biology leads to poor academic achievement of students. My experience as a science student also reminds me of how some concepts in biology were taught abstractly. Most Biology teachers teach scientific concepts in Biology without relating them to the daily life activities of the students. For instance, concepts like diffusion and osmosis were taught abstractly without practical activities. The transmission method of teaching does not help students to think critically and find solutions to problems that they may encounter. Practical activities create opportunities for students to develop experiences since they are actively engaged in the learning process, unlike the conventional teaching strategy which makes teaching abstract, thus making learners passive recipients of information from the instructor. The researcher does not blame the teachers sorely for using lecture method in teaching Biology but also the inability of the government, Ministry of Education and Ghana Education Service to provide teaching and learning materials, science laboratories and apparatus for practical activities. Based on the above observations and experiences, the researcher therefore deemed it necessary to investigate the effectiveness of Multimodal Instructional Approach as a teaching method for teaching classification of living organisms.

1.4 Objectives of the Study

The objectives of the study were to:

1. determine the difference between the pretest mean scores of students in the control group and those in the experimental group in classification of living organisms the intervention.
2. examine the difference between the posttest mean scores of the experimental and the control groups.
3. examine the difference between the pretest and posttest mean scores of male and female students in the control and experimental groups.
4. determine the difference between the pretest mean scores and the posttest mean scores of students in the experimental group.
5. investigate the perceptions of students in the experimental group about the use of multimodal instructional approach in teaching classification of living organisms.

1.5 Research Questions

The following research questions were addressed in the study:

1. What is the difference between the pretest mean scores of students in the control group and those in the experimental group in classification of living organisms before the intervention?
2. What is the difference between the posttest mean score of the control group and the experimental group?
3. What are the differences between the pretest and posttest mean scores of male and female students in the control and experimental groups?
4. What is the difference between the pretest mean score and the posttest mean score of students in the experimental group?

5. What are the perceptions of students in the experimental group about the use of multimodal instructional approach in teaching classification of living organisms?

1.6 Research Hypothesis

The following null hypotheses were tested at 0.05 level of significance:

Ho_1. There is no significant difference between the pretest mean scores of students in the control group and those in the experimental group in classification of living organisms before the intervention.

HO_2. There is no significant difference between the posttest mean score of students in the control group and those in the experimental group.

HO_3. There is no significant difference between the pretest and posttest mean scores of male and female students in the control and experimental groups.

HO_4. There is no significant difference between the pretest mean score and the posttest mean score of students in the experimental group.

1.7 Significance of the study

1. The findings of the research will serve as a reference material to science teachers in Navrongo Senior High School (NSHS).
2. Other Biology teachers in NSHS may adopt similar approach in teaching classification of living organisms and other difficult topics in science subjects.
3. Also, the study will contribute to existing body of knowledge in the concept of classification of living organisms.
4. It is also expected that science teachers in NSHS will compare the advantages of multimodal instructional approach to other instructional approaches and adopt it in teach other science subjects areas.

5. The findings will also form a basis for further research on the importance of using multimodal instructional approach to teach science students in classification of living organisms and other topic in Biology by science teachers in NSHS.

1.8 Delimitations

Delimitations are concerned with the definitions that the researchers decide to set as the boundaries or limits of their work so that the study aims and objectives do not become impossible to achieve (Theofanidis & Fountouki, 2018). The authors further argued that delimitations are in the researcher's control. These are the boundaries of the research, the scope of the research; the elements of the topic which are deliberately focused on for consideration in the research (Anthony-Krueger & Sokpe, 2015). First of all, the study was restricted to Navrongo Senior High School which is in the Kasena Nankana Municipality in the Upper East Region of Ghana. In addition, the study involved only Navrongo Senior High School form two general science students and hence the findings will not be generalized to all students in the whole Region or Country. Moreover, the study was delimited to only classification of living organisms. Furthermore, the study was delimited to only second year Track Gold and Green general science students offering Biology as one of their elective subjects.

1.9 Limitations

According to Theofanidis and Fountouki (2018), limitations of any particular study concern potential weaknesses that are usually out of the researcher's control, and are closely associated with the chosen research design, statistical model constraints and funding constraints. Limitations are conditions that the researcher has no control over and may impede the research process such that the conclusions of the research are done with

circumspection (Anthony-Krueger & Sokpe, 2015). The limitations of the study were the boundaries to which the conclusions were drawn.

There were a number of uncontrollable problems that the researcher encountered during the study. Some students were absent during the intervention and the reasons were best known to them. Also, availability of more time for the study was another problem. The researcher needed more time for the study than was given because greater part of the work was done after normal class hours which made the researcher to work under intense pressure. Travelling difficulties were also encountered during the study. The researcher had to travel from the northern part of the country specifically Upper East Region to the southern part of the country to look for certain specimen since some of the specimens are not found in the Upper East Region.

Another limitation of the study is the use of individual research strategy. With the individual strategy, the findings and recommendations may not be shared with other teachers unless the researcher decides to present the findings and recommendations at departmental or faculty meetings, making formal presentation at a conference or submit the study in a journal article or newspaper for publication. This may cost the researcher and due to financial constraints, the researcher may find it cumbersome to publish the document. Hence, the probability of other Biology or science teachers from other Senior High Schools getting access to the findings and recommendations may be difficult.

1.10 Definition and clarification of key concepts

The following concepts are defined in context and based on how they are used in this study.

Science programme: This is a programme offered at the senior high school. It consists of three main elective subjects namely: biology, chemistry and physics.

Experimental group: A group of students on whom the intervention is administered. This is a group of students taught using multimodal instructional approach. They are mainly students from Navrongo SHS.

Control group: A group of students whose performance is compared to that of the experimental group. This is a group of students taught using discussion web. They are mainly students from Navrongo SHS Track Gold.

Binomial system of nomenclature: This is a system of naming or classifying organisms in which every organism is given two-Latin names.

MIA: Multimodal Instructional Approach.

NSHS: Navrongo Senior High School.

SHS: Senior High School.

WAEC: West African Examination Council. This is an examination body responsible for conducting exams for Junior High Schools and Senior High Schools in West Africa.

WASSCE: West African Senior School Certificate Examination

Taxon: This is a taxonomic unit at a given level of classification.

SPECIES: Organisms that are similar in shape and structure and are capable of interbreeding among themselves to produce fertile offspring.

t-test: This is a statistical test use to compare two means to see if they are significantly different from each other (Urdan, 2005).

1.10 Organization of the study

The study is organized into five different chapters. The first chapter deals with the background to the study, statement of the problem, purpose of the study, objectives of the

study, the research questions, significance of the study, the delimitations and limitations that were encountered in the study and finally definition and clarification of key concepts. The second chapter highlighted review of related literature. The third chapter also dealt with research methodology. The fourth chapter highlighted presentation and analysis of the data collected. The fifth chapter discussed the finding of the study and the last chapter (chapter six) also highlighted summary of the findings, conclusions, recommendations and suggestions for future research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter discusses the literature related to the study. The chapter reviews relevant literature that provides support for the study under the following headings; theoretical framework, conceptual framework and empirical evidence.

2.1 Theoretical Framework

A theoretical framework is a framework based on an existing theory in the field of inquiry that is related and/or reflects the hypothesis of a study (Adom, Hussein, & Agyem, 2018). A theoretical framework refers to previous theory/theories, models or frameworks that are used by a researcher for his/her research study or research paper. A theoretical framework serves as bedrock upon which a research is constructed. Adom *et al*, (2018) assert that a theoretical framework guides the researcher so that he/she does not deviate from the confines of the accepted theories to make his/her contribution scholarly and academic.

The importance of educational theory cannot be underestimated as it acts as a roadmap or building plan guiding teaching and learning (Kola & Langenhoven, 2015). According to Faryadi (2015), learning is defined as the process that brings about behavioural changes to a person and teaching on the hand, denotes a process that facilitates learning. The theoretical framework that underpinned this study is hinged on constructivism and cognitive theory of multimedia learning.

2.1.1 Constructivism Theory

Constructivism is an innovative strategy in which students construct knowledge themselves through interaction with each other on the basis of previous knowledge

(Sharma & Poonam, 2016). Constructivism concept means encouraging students to use techniques such as experiments and real-world problem solving to create more knowledge and then reflect on and talk about what they are doing and how their understanding is changing (Wonkyi & Adu, 2016).

The constructivism theory of learning emphasizes that learning is an active process whereby students construct new ideas based on their previous knowledge and understanding. Effective teaching enables students to make connections of the old and the new knowledge to form new ideas (Faryadi, 2015). Constructivists assert that when learners make use of the information, ideas or concepts they receive from teachers by building up knowledge, then their thinking changed totally from acquisition of knowledge to construction of knowledge. The constructivist teaching and learning theory advocates a participatory approach in which students actively participate in the teaching and learning process (Fernando & Marikar, 2017). The primary responsibility of the teacher is to create a collaborative problem solving environment where students become active participants in their own learning (McLeod, 2019). The teacher acts as a facilitator instead of dictator during teaching and learning process. The teacher makes sure that he/she understands the students pre-existing conceptions and guides the activity to address them and build on them (Oliver, 2000). Constructivists' shares a focus on the learner-centered approach and the density of the learner's cognitive course of action for their learning and support needs and the value of providing learners with opportunities to make meaning and real dynamic contributors in the learning-teaching experience (Bhutto & Chhapra, 2013). According to the Graduate Student Instructor (GSI) teaching and learning resource Centre (Shimamura & Kiristrom, 2016); Cognitive constructivism states that knowledge is something that is actively constructed by learners based on their previous knowledge and Cognitive methods aim to help learners in assimilating new ideas or concepts to existing knowledge and

enabling them to make appropriate modification to their existing intellectual framework to accommodate the ideas and concepts.

Fundamentally, constructivist says that people construct their own knowledge and understanding of the world through experiencing things and reflecting on those experiences (Thirteen Ed Online, 2004). According to Fernando and Marikar (2017), the claims of constructivist teaching and learning theory are: a) Learning is an active experience, b) The ideas students hold about a topic or subject being taught will form part of their learning experiences and c) Learning is socially and culturally rooted.

Constructivism encourages instructors to provide each student preferred learning styles, rates of learning and personal interaction with other learners (Christie, 2005). In constructivist environment, learners need to be involved and active within a democratic classroom atmosphere while collaboration is mainly a contributing element in the learning process as well as a student centered approach (Alanazi, 2016).

Tam (2000), listed four characteristics for a constructivism learning environment; i) Knowledge is shared between teachers and students. ii) The teachers' role is one of a facilitator. iii) Teachers and students share authority and iv) Learning groups consist of small heterogeneous students.

2.1.2 Pedagogical Goals of Constructivist Learning Environments

Honebein (1999) summarizes the following as the seven pedagogical goals of constructivism learning environments: a) To encourage the use of multiple modes of presentation (videos, audio and images), b) To encourage ownership and a voice in the learning process (student centered learning), c) To encourage the awareness of knowledge construction process (reflection, metacognition), d) To embed learning in a social experience (collaboration), e) To embed learning in a realistic context (authentic task), f)

To provide experience and appreciation for multiple perspective (evaluation of alternative solution) and g) To provide experience with the knowledge construction process (students determine how they will learn).

Constructivism is basically a learning theory which is based on observation and scientific study of how people learn (Olusegun, 2015). Constructivism states that learners construct their own knowledge based on previous experience. When leaners come into contact with something new, they try to connect it with their previous experience or existing knowledge, ideas or experience by modifying what they believe or hold or ignoring the new information. Constructivist theory is rooted in several aspects of Jean Piaget and Lev Vygotsky's cognitive theories and Piaget asserts that learners learn actively, create schemas, assimilate and accommodate all the form of science while Vygotsky believed that learners get social constructivism, group work and internship (Suhendi & Purwarno, 2018). Two of the key concepts within the constructivism learning theory which creates the construction of an individual new knowledge are accommodation and assimilation (Olusegun, 2015). Accommodation is the act of constructing, restricting the learner mental organization so that new information, ideas and concepts may be added whereas assimilation is the process of interpreting new information, ideas or concepts based upon existing knowledge and understanding (Alkhawaldeh, 2013). According to Sharma and Poonam (2016), assimilation is the ability to adjust new concepts, ideas and information in the existing schemas in the mind of the learner and accommodation means to change in the existing schemas to fit in new ideas. With constructivism perspective, the main responsibility of the teacher is to provide the main ideas, concepts and information for the students to make meaning from it based upon their previous knowledge and understanding. According to Singh and Yaduvanshi (2015), there are ten basic guiding principles of constructivist thinking that educators must keep in mind: a) Learning is an

active process in which the student constructs meaning, b) People learn to learn, c) Learning involves language, d) Learning is a social activity, e) Learning is contextual, f) The act of constructing meaning is mental, g) Everyone needs knowledge to learn, h) Learning is not the passive acceptance of knowledge, it takes work, i) Motivation is a major aspect of learning and j) It takes time to learn.

2.1.3 Benefits of Constructivism Theory of Teaching and Learning

Constructivism helps to develop advanced skills such as critical thinking, analysis, evaluation and creation. It promotes diverse viewpoint. Constructivism helps students to learn more on their own since it is a learner centered where students are actively engaged rather than passive learners (Singh & Yaduvanshi, 2015). It helps students to transfer their skills to real world situation. By grinding learning activities in an authentic, real–world context, constructivism stimulates and engages students (Olusegun, 2015). Constructivism teaching and learning theory helps students learn to ask meaningful questions and apply their curiosity to solve problems in their daily lives. Constructivism promotes a sense of personal agency as students have ownership of the learning and assessment (McLeod, 2019). Shermila (2011) outlined the following as benefits of constructivism teaching and learning: a) children learn more and enjoy learning more when they are actively involved, rather than passive listeners, b) Education works best when it concentrates on thinking and understanding, rather than on rote memorization. Constructivism concentrates on learning how to think and understand. c) Constructivism learning is transferable.

In constructivist classroom, students create organizing principles that they can take to other learning settings. Constructivism gives learners ownership of what they learn, since learning is based on learners' questions and exploration, and the students have a hand in designing the assessment as well. Constructivism creates new understanding via coaching, moderating and suggesting (Christie, 2005). Students in constructivist classrooms 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.

2.2.4 Differences Between Traditional Classroom and Constructivism Classroom

In a constructivism classroom, the focus is shifted from the instructor to the learner. Constructivism classroom is not a place where a knowledgeable person (an expert teacher) pours a well-organized body of knowledge to learners who are considered as empty vessels ready to be filled. In a constructivism setting, learners are encouraged to actively involved in the teaching and learning process while the instructor functions as a coach. Constructivism is a learner-centered in which the teacher acts as a motivator, coach, and a facilitator. Constructivism considered that knowledge is not a thing that can be simply given by the teacher at the front of the room to students in their desk but is rather constructed by learners through an active and mental process of development (Sharma & Poonam, 2016). Traditional classroom is focused on the teacher centeredness and students remain as passive learners. In this classroom, information, concepts or ideas are transferred from the head of the teacher to the head of the students. In traditional classroom, “talk and marker or chalk’’ method is used for spoon feeding content to the students. With traditional classroom environment, the mandate is invested in the instructor who is considered as a possessor of knowledge and his/her duty is to pour knowledge into students. Constructivism classroom provides opportunity for students to discuss among themselves, ask questions, observe and find solutions to problems by themselves. Constructivism classroom requires the active participation of the students in the teaching and learning process. The teaching method used in the traditional classroom is based on the objective view of knowledge which is grounded on the assumption that knowledge is objective, universal and complete and can be transferred from the head of the teacher to

the heads of the students while the teacher role in the constructivism classroom is shifted from the transmitter of knowledge to facilitator of knowledge construction and the role of the students changes from knowledge gainers to knowledge constructors (Singh & Yaduvanshi, 2015). In constructivism, learning is a mental process and students learn from previously built knowledge by building on that knowledge in collaboration environment and learners are provided with minimal instruction (Alanazi, 2016). In constructivism environment, the teacher guides the students through problem-solving and inquiry-based learning activities with which students put together and test their ideas, draw conclusions and inferences, group and convey their knowledge in a collaborative learning environment (Wonkyi & Adu, 2016).

The differences between Traditional classroom and Constructivism classroom are presented in a tabular form according to Thirteen Ed Online (2004):

Table 8: Summary of differences between traditional classroom and constructivism classroom

Traditional classroom	**Constructivism classroom**
Teacher's role is directive, rooted in authority.	Teachers interact with the students.
Teachers disseminate information to students.	Teachers have a dialogue with students by helping them to construct their own knowledge.
Students work individually.	Students work in groups.
Knowledge is inert.	Knowledge is dynamic/changes with experience.

Assessment is through testing /correct answers. Focus on product.	Assessment includes student's works, observations and point of view as well as tests, process is as important as product.
Strict adherence to curriculum.	Pursuit of students question and interest is valued.
Learning is based on repetition.	Learning is interactive, building on what the students already know.
Materials are primarily textbooks and workbooks.	Materials include primary sources of materials and manipulative skills

Source: Thirteen Ed Online (2004)

2.1.5 Implications of Constructivism Theory for Teaching and Learning

The constructivism theory of teaching and learning argued that learning is an active process where the learner actively participates in the learning process and the instructor serves as a facilitator instead of a dictator. Constructivism requires a teacher to act as facilitator whose main duty is to help students become active participants in their learning and make meaningful connection between prior knowledge and the process involved in learning (Olusegun, 2015). The constructivist believes that students construct their own understanding of the world through experience by asking questions and through inquiry.

The implications of constructivism theory for teaching and learning are outlined according to Cohen, Manion and Morrison (2004) as follows: (i) Science teachers should act as facilitators and guides of learning; (ii) Science teachers should encourage students to establish criteria on which their work is assessed, (iii) Science teachers should encourage student's discovery learning in the science class as it helps to create creativity in the students, (iv) Science teachers should encourage their students to always engage in a discussion with their peers in the class and (v) Science teachers should place more

emphasis on experimentation rather than rote learning. There is also the need for Science teachers to place great emphasis on problem solving rather than memorization. Instruction should be built around students' interest by science teachers. Science teachers should encourage collaborative and co-operative learning rather than individual learning in the science class. Science teachers should engage students in experience that contradicts with their previous knowledge and encourage discussion among students in the class.

2.1.6 Conclusion of Constructivism Theory

From the constructivism point of view, the major duty of the teacher is to create a suitable or problem solving environment for students to construct their own knowledge and find solutions to problems that they may encounter. In this environment, the teacher acts as a facilitator and encourages students to play an active role in the teaching and learning process and also accepts the autonomy of the learners. This theory asserts that students are not empty vessels ready to be filled but will always try to make meaning of any information they receive and construct their own knowledge and understanding from the information based on their previous experience. In the constructivism classroom setting, the teacher discusses with the students by helping them to construct their own knowledge unlike the traditional classroom setting where the teacher disseminates information to the students. In Constructivism classroom settings, teachers design instructions that enable students to learn best by finding and generating their own knowledge. Students play an active role in producing knowledge and teachers encourage students to broaden their own understanding and explain their own perspectives so that they can be responsible for what they do (Suhendi & Purwarno, 2018). In a constructivism classroom setting, teachers treat students with equal, kind and considerate attitude and supply students learning which will help them communicate with teachers and respond to teachers' praises and criticisms and hence improves the relationship between teachers and students (Jia, 2010).

2.2 Cognitive Theory of Multimedia Learning (CTML)

Another theory that underpinned this study is the cognitive theory of multimedia learning proposed by Richard E. Mayer in 2007 and other cognitive researchers such as Sorden, Sweller, Clark, Baddeley, Paivio and Moreno. The cognitive researchers assert that multimedia learning supports the way the human brain retains information. According to Mayer (2010), multimedia is defined as the presentation of materials using words and pictures. The cognitive theory of multimedia learning is centered on the idea that learners attempt to build meaningful connections between words and pictures and that students learn more deeply than they could have with words or pictures alone (Mayer, 2009). According to Mayer (2010), words include spoken and written text and pictures include images, charts, diagrams, animations, videos, photos and illustrations. Consequently, the use of both words and pictures allows the brain to process more information in the working memory.

The cognitive theory of multimedia learning has been presented by researchers which are based on three assumptions suggested by cognitive science researchers about the nature of human learning thus the channel assumption, the limited capacity assumption and the active learning assumption (Simhachalam, 2016). The dual channel assumption states that the human brain process separate information systems for verbal and visual representations. For instance, illustration, images, diagrams, animation are processed in the pictorial channel and spoken words are also processed in the auditory or verbal channel. The limited capacity assumption is based on the cognitive load theory and it states that each subsystem of the working memory has a limited capacity. The active processing assumption suggests that people construct knowledge in meaningful ways when they pay attention to the relevant material, organize it into a coherent mental structure and integrate it with their prior knowledge (Mayer, 2010).

The cognitive theory of multimedia learning accepts a model that includes three components; sensory memory, working memory and long term memory. The sensory memory is defined as the cognitive structure that permits learners to receive new information, working memory is a cognitive structure in which learners consciously process information and long term memory is also defined as the cognitive structure that stores our knowledge base (Sweller, 2005). Mayer (2005a) states that the sensory memory has a visual sensory memory that briefly holds pictures and printed text as visual images and auditory memory briefly holds spoken words or sounds as auditory images.

The working memory attends to or selects information from the sensory memory for processing and integration. Sensory memory holds an exact sensory copy of what was presented in less than 0.25 of a second while the working memory holds a processed version of what was presented for less than 30 seconds and can process only a few pieces of materials at a given time (Mayer, 2010). Finally, the long term memory holds information for an indefinite period of time. The information can also be retrieved from the long term memory by the working memory whenever the information is needed. There are five forms of representation of words and pictures that occur as information is processed by the memory and each form represents a particular stage of processing in the three memory store models of multimedia learning (Mayer, 2005a). The first form of representation is the words and pictures. Words enter the cognitive system or model through the ears and pictures enter through the eyes. In the cognitive process of selecting words, the learner pay attention to some of the words, yielding the construction of some words sounds in the working memory and in the cognitive process of selecting images; the learner pays attention to some aspects of the pictures, yielding the construction of some images in working memory (Mayer, 2002). With the cognitive process of organizing words, the learner mentally arranges the selected words into a coherent mental

representation in working memory called verbal model or component and with the cognitive process of organizing images, the learner mentally arranges the selected images into a coherent mental representation in working memory called pictorial model (Morena & Mayer, 2007). In the cognitive process of integrating, the learner mentally connects the verbal and pictorial models as well as appropriate knowledge from the long term memory (Mayer, 2002). In multimedia learning, active processing of information requires five cognitive processes; selecting words, selecting images, organizing words, organizing images and integrating verbal model, pictorial model and prior knowledge.

Based on the multimedia learning model in Figure 2, the arrows represent the steps or processes involved in the cognitive theory of multimedia learning: selecting relevant words, selecting relevant images, organizing selected words, organizing selected images, and integrating verbal and visual representation as well as prior knowledge.

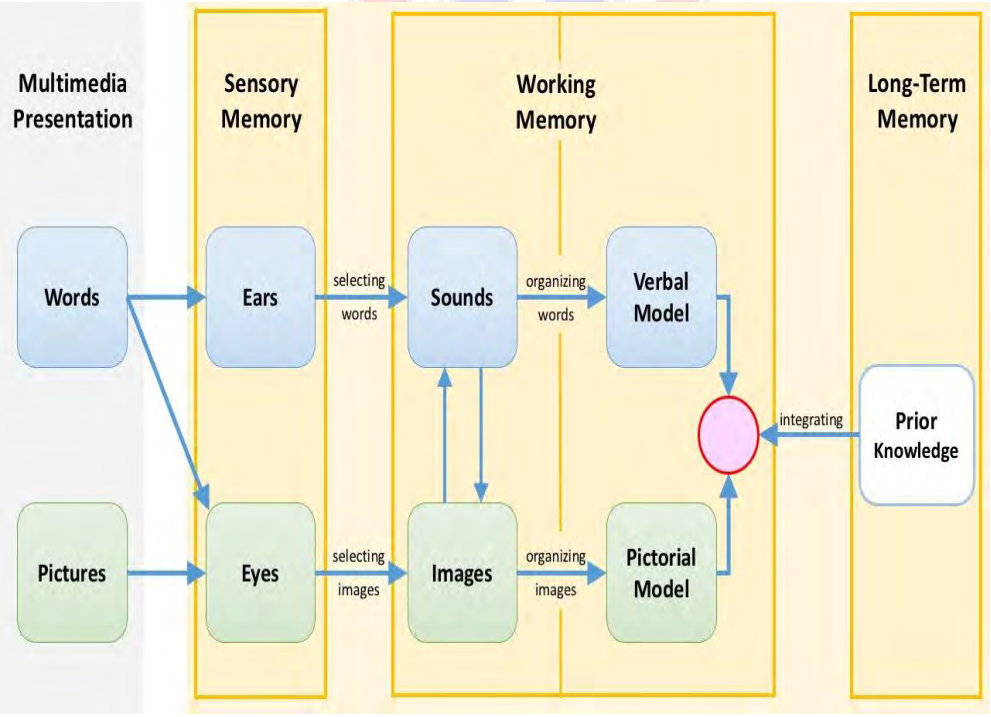

Figure 1: Visual Representation of the Cognitive Theory of Multimedia Learning (Source: Mayer 2010)

2.2.1 Research Based Principles for Instructional Design of Multimedia Lessons

The multimedia principle is a theory studied by Richard Mayer which states that words and pictures are more conducive to learning than words or pictures alone. The theory is based on the idea that learners learn better when they are engaged in relevant cognitive processing such as attending to the relevant material in the lesson, mentally organizing the materials in the lesson, mentally organizing the material into a coherent cognitive representation and mentally integrating the material with the existing knowledge, idea or experience.

Gilakjani (2011) identified eight most important principles of multimedia learning and what research says about how they contribute to learning:

A). Words and Pictures are better than Words Alone. People learn better from words and pictures than from words alone (Mayer, 2005b). Words include written and spoken text, and pictures include static graphic images, animation and video (Gilakjani *et al*., 2011). The use of both words and pictures helps the brain to process more information in the working memory (Sweller, 2005). Narration and video is much more effective than narration and text (Mayer, 2005b). Similarly, narration and video appear to be more effective than narration, video and text alone (Gilakjani, 2011)). Narration and text rely on the same channel to process information (Gilakjani *et al*., 2011).

B). Multimedia learning is more effective when learner attention is focused, not split.

Multimedia applications are more effective when learner's attention is not divided. Split attention occurs when the learner is forced to attend to information that is far apart, such as when content is visually far on the screen or if it is presented at separate points in time (Gilakjani, 2011). When related content is presented together in time visually, learning is more effective (Mayer, 2005b). When related content is not presented together, learner

attention is divided and the brain has more work to do to integrate the separate source of information (Gilakjani, 2011). Words and pictures presented simultaneously are more effective than when presented sequentially (Mayer & Simm, 1994).

C). The presentation of Multimedia content should exclude extraneous and redundant information. Multimedia learning is more effective when it includes only content that is relevant and aligned to the instructional objectives (Mayer, 2003). Kalyuga, Chandler and Sweller (1999) found that students learn more when extraneous and redundant information was not included in a multimedia presentation. Learning is most effective when irrelevant information is eliminated because of the brain's limited information processing resources (Gilakjani, 2011).

D). Multimedia learning is more effective when it is interactive and under the control of the learner. Students do not learn at the same pace. Research tells us that when learners are able to manage the pace of the presentation they learn more (Gilakjani *et al.,* 2011). Multimedia presentations are more effective when the learner has the ability to interact with the presentation, by slowing it down or by starting and stopping it (Gilakjani, 2011). This pacing can also be achieved by breaking the presentation into segments; shorter segments that allow users to select segments at their own pace work better than longer segments that offer less control (Mayer, 2003).

E). Multimedia learning is more effective when learner knowledge structures are activated prior to exposure to multimedia content. Learning from multimedia presentation is enhanced when the structures for organizing the information are activated (Pollock, Chandler & Sweller, 2002). Activation can be accomplished by allowing students to preview the content through demonstrations, discussions, directed recall and written descriptions (Gilakjani *et al.,* 2011). These preview activities should be directed at

activating prior knowledge (Kalyuga, 2005), signaling what is important and showing the content is organized. Activating knowledge helps provide a structure from long term memory to understand and organize the new information from working memory (Gilakjani, 2011).

F. Multimedia instruction that includes Animation can improve learning. When used effectively, animated content can improve learning. Animation appears to be most effective when presenting concepts or information that students may have difficulty envisioning (Gilakjani, 2011). Animation is more effective when students have the ability to start and stop the animation and view it at their own pace or are able to manipulate various facets of the animation (Gilakjani *et al*., 2011). Animation is more effective if it is accompanied by narration, which makes use of both the auditory and visual channels (Mayer & Chandler, 2001).

G. Multimedia learning is more effective when the learner is engaged with the presentation. Multimedia is most effective when the content and format actively engaged the learner (Gilakjani *et al.,* 2011). Active engagement helps the student construct and organize information into meaningful schema (Mayer, 2005b). Multimedia that is more personalized engages learners more than multimedia that are less personalized (Mayer, 2005b). Presentations that have a more conventional tone tend to be more engaging than those that have a more formal tone (Gilakjani *et al.,* 2011). Learners tend to find presentations that use a familiar voice with a familiar accent more engaging than those that use a less familiar voice and accent (Mayer, Sobko & Mautone, 2003).

H. Multimedia learning is most effective when the learner can apply their newly acquired knowledge and receive feedback. Multimedia is most effective when students are provided with opportunities to apply what they have learned following exposure (Mayer, 2003).

This reinforces and strengthens the newly acquired knowledge (Gilakjani, 2011). Students should be provided with opportunities to integrate what they have learned with their everyday life (Gilakjani *et al.,* 2011). Feedback is an essential aspect of the learning process. It is important to provide learners with clear feedback about their progress on an ongoing basis (Gee, 2005). Feedback helps keep students informed about their progress. Providing feedback can reinforce what has been learned and can also correct any misconception (Gee, 2005).

Mayer (2009) also identified twelve principles of multimedia instructional design principles: (a) Coherence principle: People learn from multimedia that exclude rather than includes extraneous materials, (b) Signaling principle: People learn better from multimedia lessons that highlight the important essential material by using a heading, outline and pointer words such as first, second, third etc., (c) Redundancy principle: People learn better from graphics, narration and printed text, (d) Spatial contiguity principle: People learn better when corresponding words and pictures are placed near each other on the same page or screen, (e) Temporal contiguity principle: People learn better when corresponding pictures and words are presented at the same time rather than in succession, (f) Segmenting principle: People learn better when the lesson is broken into the learner controlled segments, (g) Pre-training principle: People learn better and more deeply from a multimedia message when they receive pre-training in names and characteristics of key concepts, (h) Modality principle: People learn better from graphics and narration than from graphics and printed text, (i) Multimedia principle: People learn better from words and pictures than from words or pictures alone, (j) Personalization principle: People learn better from multimedia presentations which are in conversational and polite style, (k) Voice principle: People learn better when the words in a multimedia are spoken by a friendly human voice rather than a machine and (l) Image principle: People learn more

deeply from a multimedia presentation when the speaker's image is on the screen rather than not on the screen.

The twelve principles are grouped into a framework based on the three types of cognitive load (Mayer. 2009). These are: Reducing extraneous processing (coherence, signaling, redundancy, spatial contiguity and temporal contiguity principles), imaging essential processing (segmenting, pre-training, and modality principles) and fostering generative processing (multimedia, personalization, voice and image principles). Cognitive overload occurs when the processing demands of the learning task are greater than the processing system capacity of the human processing system (Dickson, 2019). In every learning situation, there are three main types of cognitive demands on the learner's cognitive system. These include; extraneous processing, essential processing and generative processing (Mayer, 2010). Mayer (2010) explained these demands as follows:

Extraneous processing: This is a cognitive processing that does not support the learner objective and is caused by poor instructional design (Mayer, 2010). According to Dickson (2019), extraneous processing refers to cognitive processes that are not required for making sense of the presented material, but occur due to the design of the learning task. For instance, extraneous processing may occur when a text describing a specimen is on one page and the corresponding illustration of the specimen is on another page so that the student has to waste precious cognitive processing resources by looking back and forth between the words and the illustration (Mayer, 2010). Extraneous processing must be reduced since it does not contribute to learning and is caused by poor instructional design (Shamin, 2018). This can be achieved by eliminating extraneous material (coherence principle), highlighting essential material (signaling principle), not adding written material to spoken words (Redundancy principle) and placing printed words near corresponding images (Mayer, 2005a).

Essential cognitive processing: This process describes the cognitive processing required to mentally represent the essential material from a lesson in working memory mainly through the cognitive processes of selecting and minimal amount of organizing (Mayer, 2010). Dickson (2019) asserts that essential processing refers to the cognitive process that allows a mental representation to be held in working memory for a period of time. According to Shamin (2018), essential processing must not be reduced but managed in a manner that does not overload the cognitive capacity. This can be achieved by providing prior necessary knowledge (pre-training), allowing the learners to divide the lesson into segments (segmenting) and presenting words orally (modality) (Mayer, 2010).

Generative processing: This is a cognitive processing aimed at making sense of the presented material that is mainly the cognitive processes of integrating and organizing and driven by the learner's motivation to understand the material (Mayer, 2010). Even when learners have the cognitive capacity, they may not involve in active learning when they are not motivated to learn (Mayer, 2005a). This can be achieved by presenting words and images (multimedia), presenting words as normal conversation (personalization), and using voice from human rather than machine (voice principle) (Mayer, 2010). Therefore, instructors need to generate cognitive processing in order for their students to engage fully in the learning process.

2.2.2 Conclusion

The cognitive theory of multimedia learning has progressed for more than two decades and has several implications in the teaching and learning process. It is learner-centered and hence making it relevant to the instructional process. This theory proved that there are two main channels that learners use to process information in the brain. These channels are auditory/verbal channel and visual channel. The visual channel process pictures that we

see and the auditory channel also process words that we hear. The combination of these two enables learners to learn better and more in-depth. Information also stays in the learners' memory for long when the information is presented in both auditory and pictorial manner.

Also, when the information presented to students is over loaded with text and pictures, it can cause cognitive overload since the human memory has a limited capacity. Teachers' presentations will be more effective to their students if they have limited number of text, clear and simple pictures or diagrams and clear spoken narration. The cognitive theory of multimedia learning is based on three assumptions; the dual channel assumption, the limited capacity assumption and the active process assumption.

2.3 Conceptual Framework

Conceptual framework has been variously described. According to Camp (2001), conceptual framework is a structure which the researcher believes can best explain the natural progression of the phenomenon to be studied. A conceptual framework is the researcher's understanding of how the variables of the study connect with each other (Regoniel, 2015). According to Adom *et al* (2018), conceptual framework is the researcher's explanations of how the problem will be explored. Figure 3 depicts the conceptual framework or model for the current study. Multimodal instructional approaches make use of different modes of representation (words, pictures, diagrams, images, photos, animations and videos) which help to improve students' academic performance. According to Bicommong *et al*, (2015), multimodal instructional is an attempt to translate these modes of representation into a systematic and practical technique for teaching. This strategy will stress linkages among different modes of representation thus deepening students understanding which will definitely influence the academic

performance of students positively. Discussion method is a variety of open forums for open-ended, collaborative exchange of ideas among a teacher and students or among students for the purpose of further thinking, learning, understanding and problem solving (Wilkinson, 2009). Discussion web is a method of instruction in which students are put into groups and questions are posed to them by a teacher for them to discuss within their groups and respond to the questions. According to Alkhawaldeh (2013), discussion web involves students working in groups and sharing their ideas to reach a consensus and one group is paired with another group to compare their views and come up with a final conclusion. The teacher plays a facilitative role in discussion web method of instruction by asking questions and proving scientifically correct explanation of the concepts.

In terms of the variables that are used in this study, the independent variables are two different methods of instructions, which is Multimodal Instructional Approach and discussion web. The output that was measured reflects the students' academic performance, the said output is being influenced by the implementation of either Multimodal Instructional Approach or discussion web. The differences between the scores of the pretest and posttest served as a guide in determining whether learning had occurred or not. Figure 3 depicts the conceptual model of the study.

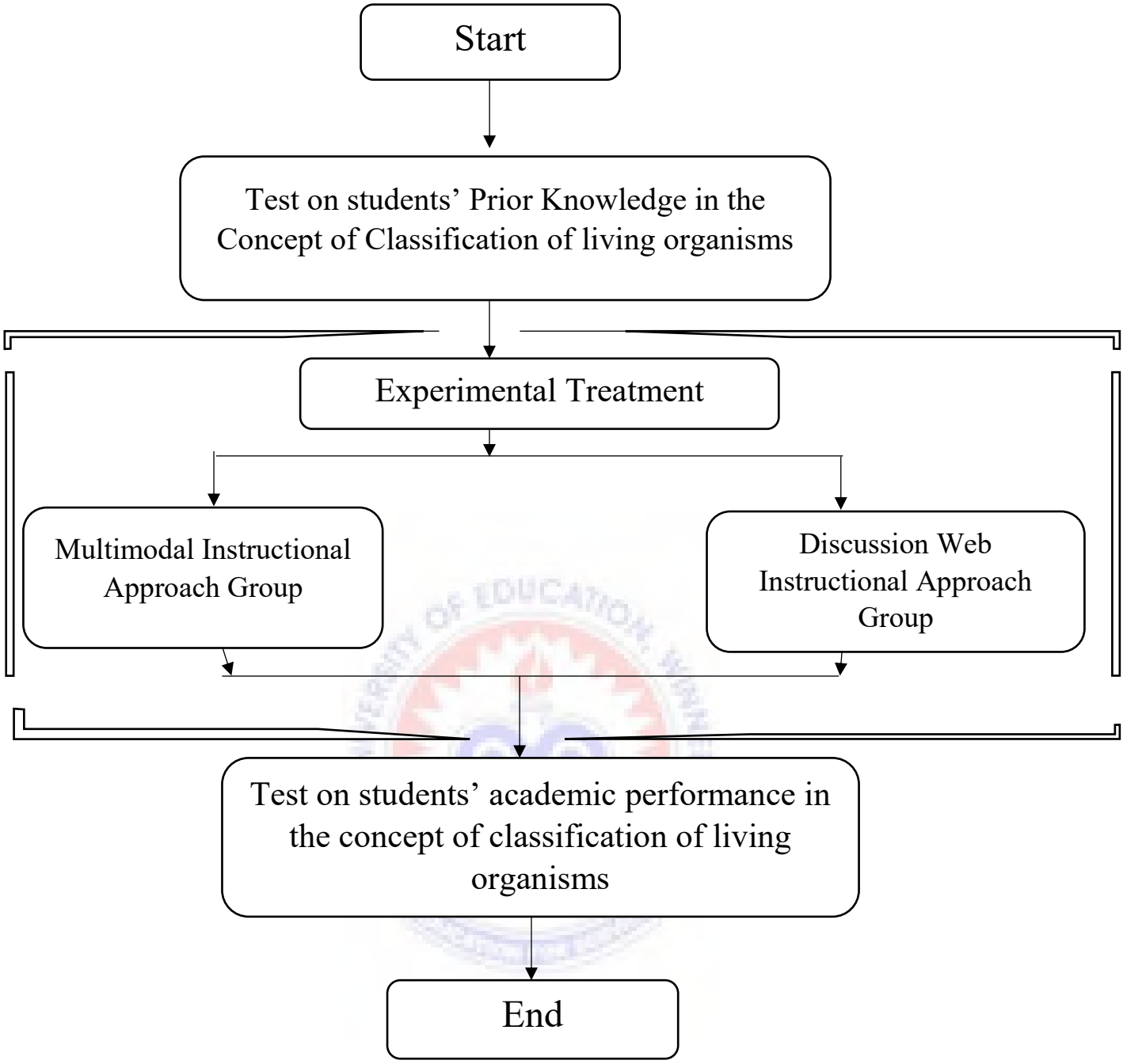

Figure 2: Conceptual Model of the Study

(Source: Adapted From Ayittey, 2015)

2.4 Related Empirical Studies

Empirical evidence deals with the aspects that the researcher brings into light which is similar or related to his/her area of study. It could be related study or an exact previous study. The empirical evidence of the study is presented under the following sub-headings:

difficulties faced by students in learning Biology, instructional methods used in teaching science, learning styles, multimodal instructional approach, importance of multimodal instructional approach, concept of multimedia, historical background of Biological Classification and finally importance of Biological Classification.

2.4.1 Difficulties Faced by Students in Learning Biology

Biology as a branch of science has interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observation (Ong'amo, Ondigi, & Omariba, 2017). The study of biological learning difficulties has been studied by many researchers across the world (Buah & Akuffo, 2017). The study conducted by Çimer (2012) reported that there were five main topics that have been perceived as most difficult to learn by XI Grade Biology Students in the Rize District of Turkey. Those topics were materials cycles, Endocrine system, Aerobic respiration, Cell division as well as Genes and Chromosomes. The study conducted by Tekkaya, Ozcan and Sungur (2001), informed that High School students in Turkey perceived Hormones, Genes and Chromosomes, Mitosis and Meiosis, Nervous system and Genetics as topics that are difficult to learn.

Moreover, the Respiratory system and Circulatory system in humans are also reported as the topics that are considered as the most difficult to learn by Junior High School Students in Techiman North District, Ghana (Buah & Akuffo, 2017). Etobro and Fabinu (2017) who research on topics that Senior Secondary Students had difficulties in learning in Lagos States, Nigeria also reported that students often have difficulties studying five major topics in Biology. These topics are Nutrients cycling in nature, Ecological management, Conservation of natural resources, Pest and Disease in plants and Reproductive system in plants. Fauzi and Mitalistiani (2018) who did a study on High School Biology topics that are perceived to be difficult by undergraduate students reported that students often face

difficulties learning the following topics: Genetics, Metabolism, Cell division, Immune system, Coordination system and Biological Classification.

According to Hadiprayitno, Muhlis and Kusmiyati (2019), Biological classification, Genetics, Evolution, Biotechnology, Nervous System and Endocrine System are also reported as the topics in Biology that students find difficult to learn in State High Schools in Lombok Island, Indonesia. According to Ozcan, Ozgur, Kat and Elgun (2013), the topics that Secondary School students have difficulty learning are classification of living organisms, Respiration, Photosynthesis, Mitosis and Meiosis, Reproduction, Cell cycle, DNA and RNA replication.

Various causes are reported to be the reasons why many students have difficulty in learning Biology. Based on Tekkaya *et al.* (2001), the source of biological learning difficulties were terminologies, textbooks, teachers teaching methods, curriculum and abstract nature of the subject. Etobro and Fabinu (2017) also reported that teaching methods, students' attitude, lack of learning resources along with students learning habits were the cause of difficulty students experienced in learning some topics in Biology. Çimmer (2012) outlined five main reasons why students find it difficult learning Biology. Those reasons were the nature of the topics, the teachers teaching styles, ways of learning and students' learning habit, negative feeling and students' attitude on some Biology topics and lack of learning resources. Hadiprayitno *et al*. (2017) reported that the factors that caused High School students in Lombok to experienced difficulties in learning Biology are that the material taught is abstract, relies on memorized power, uses of Latin language, lack of practical activities, some topics are not related to everyday life, the teacher's teaching style is monotonous, the level of discussion is less in-depth and finally the academic atmosphere is less supportive for learning. Fauzi and Mitalistian (2018) further reported that students learning difficulties in Biology are caused by the abstract

nature of certain topics, the numerous terminologies used in the subject, some biological events cannot be seen with the naked eye and lack of practical activities. Ozcan *et al*. (2013) reported that the main reasons for the difficulties in learning these topics are: broad nature of the topics, teachers teaching strategies, lack of practical activities, lack of students' interest in Biology, topics not related to their daily lives, Latin expression, topics required memorization, lack of materials, topics are too complicated and detailed and certain topics being new to students. According to Etobro and Fabino (2017) students attributed their sources of difficulties in learning Biology to abstractness, complexity, misconception of topics, poor attitude of teachers to teaching, lack of practical activities and poor students study habit.

2.4.2 Related Studies on Multimodal Instructional Approach

According to Sankey, Birch and Gardiner (2010), the use of multimedia in conjunctions with hypermedia have been used in many learning environments to cater for the different learning styles of students. Students feel comfortable and eventually perform better when learning in environments that caters for their learning styles (Chen & Fu, 2003). It has also been proven that presenting materials in a variety of modes also encourage students to develop a more dynamic approach to learning (Bicomong *et al*., 2015). According to Akinoso (2018), multimodal learning environments allow instructional materials to be presented to learners in multiple modes (visual, aural and written). Also, elements presented to learners in multiple modes may lead learners to think it is easier to learn and improve their attention, leading to academic success of average students (Chen & Fu, 2003). Morena and Mayer (2007) assert that students learn more deeply from words and pictures than from words or pictures alone. Bicomong *et al*. (2015) conducted a study on the effect of multimodal approaches and found that students performed far better when exposed to multimodal approaches than students taught using conventional method. MIA

enables learners to think more effectively, develop problem solving skills and decision making (Satyaprakasha & Behera, 2014). Research has indicated that MIA improves learning and retention of concepts in Biology presented to students (Satyaprakasha & Sudhanshu, 2014). Bawa (2018) found that MIA helps learners to develop positive attitude towards learning of science. According to Picciano (2009), MIA allows students to experience learning in ways in which they are more comfortable and also challenge them to learn in various ways as well. Satyaprasha and Behera (2014) found that MIA significantly improves students' academic success with respect to knowledge, comprehension and application of scientific skills in Biology. Satyaprasha and Sudhanshu (2014) conducted a study on the effect of MIA on students' academic achievement in Biology and found that both male and female students performed significantly higher when taught using MIA. Thomas and Israel (2014) found that multimodal instructional approach helps students to visualize abstract concepts, develop scientific skills and enhance their understanding of scientific processes. According to Aggarwal (2018) multimodal instructional approach is effective for all students with different learning abilities. Kuo *et al.* (2013) conducted a study on the effect of multimodal presentation and found that the method saves more time during instruction than the conventional method. Bawa (2018) conducted a study on the effect of multimodal instructional approach on students' learning of Chemistry concepts in some selected Colleges of Education in Ghana and found that students who were taught using MIA performed far better than those taught using conventional method. Aggarwal and Dutt (2014) conducted a study on the effectiveness of multimedia presentation in acquisition of Biological concepts and found that students taught through this method achieved significantly higher in acquisition of biological concepts than those taught through the traditional method. Kareen (2018) conducted a study on the use of multimedia in teaching Biology and its impact on

students' learning outcomes and found that lessons presented through multimedia presentations are more effective and better understood by learners. Fadel (2008) established that, students engaged in learning that incorporates multimodal designs, performed better than their counterparts who learn using conventional approach of single modes.

2.4.3 Methods of Teaching /Instruction in Biology

Methods of teaching/ instruction are strategies, means and approaches that a teacher adopts in order to execute the function of teaching. Teaching methods according to Burden and Byrd (2010) 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). The author 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 then, it has to be in relation with the students' characteristics and the type of learning it is supposed to bring about. For an instructor to select a particular teaching strategy, he/she must take into account both the student and the subject matter to be taught. The strategies or approaches used for teaching science are generally grouped into teacher-centered teaching method and learner-centered teaching method. In Teacher-centered approach to teaching, the teacher takes full control of the class. The students are considered as empty vessels ready to receive information from the instructor. Therefore, it is considered as a teaching method where the teacher is actively involved in teaching whiles the learners receive information from the teacher. Teacher-centered teaching method is often seen as a traditional form of teaching with the students receiving information directly from the teacher through lectures. According to Abubakar and Arshad

(2015), traditional method of teaching is a method of instruction where teachers dominate the whole 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. Learners remain passive throughout the class and take the ideas, information or concepts which are provided to them by the instructor. With this method, the principal duty of the teacher is to pass knowledge and information directly to students. The teacher centered method has been criticized for lack of effective interactive approach and poor academic performance of students in science education (Kola & Langenhoven, 2015). Traditional method of instruction does not allow students to express themselves, ask questions and direct their own ways of learning and thinking. According to Alaagib, Musa and Saeed (2019), the main critique of the lecture method is the passive delivery of information or knowledge by the teacher and the students have insufficient exposure to the content which encourages superficial learning. Teacher-centered method of teaching does not enhance critical thinking and collaborative problem solving since "chew and pour" is the order of the day (Wonkyi & Adu, 2016).

In student centered strategy of teaching, the teacher and the students play an equal active role in the teaching and learning process. The teacher's primary role is to guide, coach and facilitate students' learning and overall comprehension of the material and to measure students learning through formal and informal assessment including group project and students' participation in the class. With the learner-centered approach, teaching and learning are connected, that is students learning is continuously measured through the period of instruction.

Methods used by teachers in presenting scientific information, principles or skills to students include; lecture method, discovery method, demonstration method, project

method, peer instruction method, laboratory method, concept mapping method, field trip method and enquiry method and each of the methods specifies the various activities that need to be carried out by both the teacher and the students in order to attain the outlined objectives of the lesson. Modern theories of learning and trends in education emphasizes teaching methods which are learner-centered as opposed to those that are teacher-centered (Azure, 2018).

2.4.3.1 Lecture Method. The lecture method is the most popular and traditional method of instruction used by instructors in presenting scientific knowledge, information, ideas, concepts, principles, laws and theories to students in large numbers or groups. It is a one way channel of communication in which the teacher talks and the students listen. The lecture method is also known as transmission method. The transmission view implies that the pupil's role in the learning process is largely passive and that a student mind is a tabula rasa – a blank slate onto which knowledge can be written (Ajaja, 2013). The lecture method bases itself upon the transmission teaching model, that is knowledge is an object that can be transferred from the teacher to the learner (Marmah, 2014). In the lecture method, the principle function of this pedagogy is the presentation of ideas and information meaningfully and effectively such that clear, stable and unambiguous meaning emerges and is retained over a long period of time as organized body of knowledge (Olubu, 2015). This method of instruction has both advantages and disadvantages. The benefit of lecture method is that, it saves the time and energy of the teacher, as the teacher can say one thing to all students in the class at the same time (Umar, Dauda, & Mutah, 2016). It also allows for easy handling of large class size where the students- teacher ratio is very high. According to Ajaja (2013), the main advantage of the lecture method is that it helps the teacher to cover more content materials within a short period of time. On the

other hand, it renders students' passive which does not help them to develop critical thinking skills and creative ability in the learner (Alaagib *et al*., 2019).

2.4.3.2 Discussion Method. Discussion is a process whereby two or more people express, clarify and pool their knowledge, experiences, opinions and feelings (Radman, Khalil, Jumani, Ajmal, Malik, & Sharif, 2011). Discussion method of instruction provides opportunity for dialogue between teacher and students and students to students. This approach is centered on shared conversations and exchange of ideas or information in class. Discussion method is a variety of open forums for open-ended, collaborative exchange of ideas among a teacher and students or among students for the purpose of further thinking, learning, problem solving and understanding (Wilkinson, 2009). Discussion method is an active teaching technique because it enables students to explore issues of interest, opinions and ideas (Hackathorn, Solomon, Blankmeyer, Tennial, & Garczynski, 2011). The student is the owner of his/her own knowledge in this method of teaching. The role of the teacher in this method of teaching is to facilitate the learning process and act as a catalyst to tilt the learners mind into thinking and reflecting on the topic or concept. The discussion method of teaching does not consider the learner to be an empty vessel prepared to receive information from the teacher but the learner has knowledge which may be wrong or correct about a given concept and the main duty of the teacher is to help polish the learner's prior knowledge. In the discussion method, teachers often initiate a topic by asking a question on the topic or concept and students respond to the question with an answer and the teacher evaluates the responses of the students to the question and provides feedback. According to Rahaman *et al*. (2011) the discussion class is intended to be a free give and take between teacher and students and among students on the current topic of concern in the subject.

According to the Malawi Institute of Education (Fernando & Marikar, 2017), the following are some of the occasions in which the discussion method can be employed: when checking what has been learnt after a field or an educational trip; when exploring the opinions, knowledge and experiences of students; and when giving students practice in forming, expressing and evaluating opinions. According to Fernando and Marikar (2017), the institute also gave the following guidelines to employing the discussion method; (i) The topic chosen for study should be interesting and relative to the students' level of learning, which can ensure maximum student participation during the discussion; (ii) The discussion should be structured by means of a series of questions; (iii) The teacher should clarify important terms before the discussion in order to help students understand the topic under discussion better; (iv) The teacher must ensure that only one student speaks at a time during the discussion; (v) The teacher must follow up on interesting points raised by the students in order to assist them to understand the major points of the topic under discussion; (vi) The teacher must ensure that the discussion adheres to its objectives and takes place within the given amount of time; and (vii) The teacher must write down the main points on the white board.

This method of teaching has its advantages and disadvantages. The advantage of discussion method is that it helps to develop a positive interpersonal relationship between the students and their teacher. It encourages learners to think and construct their own knowledge which enables them to build confidence in themselves. The discussion method gives students the opportunity to express their opinions, and ideas, hear those of their peers and the teacher (Fernando & Marikar, 2017). It also leads to deeper level of learning because in order to build on each other idea, the students must first listen and understand the contributions of other students in order to respond or add to it (Hadjioannous, 2007). Proper discussion would assist learners to reach a critically informed understanding of the

topic, self-awareness and capacity for self-critique, appreciation of diversity and informed action (Applebee, Langer, Nystrand, & Gamoran, 2003). Discussion method of teaching encourages active participation on the part of students in the class. Discussion method of teaching may assist in fostering intellectual growth, individual expression and character development (Abdulbaki, Suhaimi, Alsaqqaf, & Jawad, 2018). The discussion method provides opportunities for learners to exchange thoughts and views. The disadvantage of this method of teaching is that it consumes a lot of time and hence coverage of syllabus will not be easy for the teacher. Discussion method of teaching is not also suitable for all topics since there are topics that students may not have any prior knowledge.

2.4.3.3 Demonstration Method. Demonstration method is an instructional strategy in which a teacher demonstrates an activity with explanations where necessary and students or learners watch (Olufunminiyi, 2015). Demonstration strategy is a method of teaching concepts, principles of real things by combining explanation with handling or manipulation of real things, materials and equipment (Akinbobola & Ikidite, 2011). Demonstration method is used for explaining how to use an apparatus or equipment, how to carry out an experiment, how to solve a mathematical problem or how to do something in a particular way while the learners observe. According to Umar *et al* (2016), demonstration method utilizes several senses; students can see, hear and possibly experience an actual event which stimulates interest and reinforces learning. With demonstration method, the teacher teaches students how to do or make something in a step by step manner whiles the students observe carefully. Demonstrations are useful for facilitating and developing learning since they promote students interest in the lessons and provide teachers with greater variety of pedagogical tools (Basheer, Hugerat, Kortam, & Hofstein, 2017). The purpose of teaching using the demonstration method is to show process, occurrence of an event according to the teaching materials, how they are attained

and the ease to be understood by the students in teaching and learning process (Ramadhan & Surya, 2017). This method of instruction has both advantages and disadvantages. Some of the advantages are; it enables the instructor to show students the correct usage of equipment in order to avoid accidents and breakages (Azure, 2018). It helps students to learn how to secure accurate results and measurement. It also helps the teacher to handle activities that may be dangerous to students. Demonstration based teaching strategy promotes hand on exposure to students and makes learners active (Giridharan & Raju, 2016). On the other hand, this method of teaching involves only the sense of hearing and sight. It also offers little opportunity for learners to observe, touch and record events since the time available is limited (Kola & Langenhoven, 2015).

2.4.3.4 Discovery Method/Inquiry Method. Discovery method of instruction involves presenting students with information in the form which require the students to discern relationships within the information and to structure and make sense of the information and relationship (Ajaja, 2013). The discovery method engages students in many activities and thinking processes that scientists use to produce knowledge (Abdi, 2014). Inquiry model is a method used in the learning process so that students can have the ability to ask questions, examine and investigate problems in a systematic, critical, logical and analytical manner so that they can formulate their own conclusions (Andrini, 2016). According to Olufuminiyi (2015), inquiry-based teaching is a pedagogical strategy that gives opportunity to students to explore academic content by questioning, investigating and finding solutions to questions. The main objective of inquiry learning is helping students to develop intellectually disciplined and thinking skills by providing questions and getting answers on the basis of curiosity (Andrini, 2016).This method of teaching allows students to investigate a problem in a systematic and a critical manner and find solution to the problem. Martin-Hansen (2002) has outlined four distinct forms of inquiry-

based instruction which include: open inquiry, guided inquiry, coupled inquiry and structured inquiry. Open inquiry is also referred to as full inquiry and most closely resembles actual scientific practice. It is a student-centered approach where the student directs the questions, experiment and communication of the result (Rizzo & Taylor, 2016). This type of inquiry allows students to ask questions and find solutions to the questions. Guided inquiry is more of a balanced approach of teacher and student direction through the investigation cycle with the teacher more directly addressing the development of inquiry skills (Rizzo & Taylor, 2016). In the guided type of inquiry, the students explore and the teacher guides (Vlassi & Karaliota, 2013). Coupled inquiry is the combination of guided-inquiry through the cycle of guided inquiry, open inquiry, resolution and assessment (Martin-Hansen, 2002). Lastly, structured inquiry is often referred to as directed inquiry and is perceived as less engaging/students-oriented and thus less effective (Martin-Hansen, 2002). According to Abdi (2014), the guided type of inquiry is used to teach specific concepts, facts or skills and leads the way to open inquiry where students formulate their own problems to investigate.

This method of teaching has several advantages and disadvantages. Inquiry method helps students to build their own knowledge which guides them to become problem solvers. Inquiry method of teaching helps students to gain self-confidence in scientific and research abilities (Gormally, Brichman, Haller, & Norris, 2009). It also encourages critical, analytical and logical thinking. The understanding that students develop through inquiry is deep and lasts longer than any pre-packed knowledge delivered by teachers to students (Wonkyi & Adu, 2016). The disadvantage of this method of instruction is that it consumes much time and involves a lot of money. For a large class, effective supervision by the teacher may be very difficult.

2.4.3.5 Laboratory Method. Laboratory method of teaching is an activity-based method for individual or a group of students targeted at 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 of conclusion. In the laboratory, students work individually or in small groups on a question, problem or hypothesis (Hamidu, Ibrahim & Mohammed, 2014). With laboratory method of teaching, students learn in a real world environment, function as a team member and discuss the planning of experiments and share ideas about the analysis and interpretation of the results (Krivickas & Krivickas, 2007). Laboratory method enables students to translate what they have read in their textbooks into realities, thereby enhancing their understanding of the learnt concept (Hamidu, Ibrahim & Mohammed, 2014). This method of teaching has its advantages and disadvantages. The advantages are; it provides opportunity for students to develop manipulative skills. It enable students to become familiar with the scientific process of observing, classifying, inferring, measuring, interpretation of data, hypothesizing and drawing of conclusion (Azure, 2018). It helps students to learn how to use laboratory tools and equipment. It also enables students to develop experimental skills. It helps students to work in team, communicate effectively and be responsible for their own results (Krivickas & Krivickas, 2007).The disadvantage of this method of teaching is that it is very expensive and hence cannot take place in all schools. In schools where laboratories are not available, it will be very tedious for science teachers to adopt this method of teaching. It will also be difficult for science teachers to adopt this method of teaching in schools where the class sizes are very large.

2.4.3.6 Project method/Project-Based learning. Project-based learning involves assignments that call for students to produce something such as a process or a product design, a computer code, stimulation or the design of an experiment and the analysis and

interpretation of the data obtained (Muriithi, Odundo, Origa, & Gatumu, 2013). According to Copon and Kuhn (2004), project-based learning pedagogy is an instructional technique that transforms learning from 'teacher telling' to 'students doing' in which students are provided tasks based on challenging questions or problems that involves the students problem-solving, decision-making, meaning-making, investigative skills and reflection, that includes teacher facilitation and not direction. Project teaching is a plan, an idea, an activity directed to change the form of something, to develop it and to complete it (Zhylkybay, Magzhan, Suinzhanova, Balaubekov, & Adiyeva, 2014). Project method of instruction enables learners to acquire knowledge and skills to solve real problem through investigation. This method of instruction is leaner centred because the learner has control over the planning, refining, presenting, summarising report, collecting data and analysing the data. The actual work is normally done by the learner with the supervision of the teacher. According to Muriithi *et al*. (2013), when project method is used, students arrive at an understanding of concepts by themselves and the responsibility of learning rests with the learners. Projects-based learning technique has been successfully used in developed countries to improve students' academic achievement and prepare them for life outside the classroom (Wafula & Odhiambo, 2016). It makes students to be responsible for their learning process as they learn privately with very little assistance from the teacher (Abubakar & Arshad, 2015). Project method helps to foster unity and cooperation among students. It aids in discovery because in the process of finding solution to the problem, new ideas could be revealed (Azure, 2018). It also enhances creativity and critical thinking among students. According to Thomas (2000), project-based learning has the following advantages that make it stands out among other pedagogies; it engages learners, it boosts cooperative learning skills, it improves academic performance of students, and it helps to develop high order thinking skills and builds positive relationship between students and

teachers. On the other hand, this method of teaching is very expensive and also consumes a lot of time. Lazy students may not also participate fully in situation where the method involves students in groups.

2.4.3.7 Concept Mapping. A concept map is a diagram showing relationships among concepts (Joel & Kamji, 2016). This method of teaching is a structured process focused on a topic or construct of interest involving input from one or more participants that produces an interpretable pictorial view of their ideas and concept and how they are interrelated. This method serves as a tool to help learners organize their cognitive frameworks into more powerful integrated pattern (Udeani & Okafor, 2012). This method of teaching helps students to describe their ideas about a topic in a pictorial form. Concept mapping also helps students to make meaningful connection between the main ideas and other information. It enables students to actively construct a conceptual framework to which new ideas and knowledge are added, related and defined thereby improving on their learning capability and strategy (Akeju, Rotimi, & Kenni, 2012). The authors further asserted that concept mapping offers a technique for revealing students cognitive structure and involves the following systematic steps: identifying the major components of the concepts, arranging the concepts components in hierarchical order, linking the components with linking phrase and making cross links with directed lines.

2.4.3.8 Field Trip or Excursion. Educational field trip is a progressive method of teaching and learning by which students go through the necessary learning experiences under the direction, leadership or guidance of the teacher (Shakil, Faizi, & Hafeez, 2011). Field trip is an activity-based method of teaching which offers opportunity for learners to get first-hand information on people, places and things 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 field trips which create authentic learning opportunities for students regardless of the content area. Excursion method of teaching provides an opportunity for learners to visit different places across the world for their educational enhancement (Astalin & Chauchan, 2018). Field trip helps teachers to clarify, establish, co-relate accurate concepts and enable him/her to make learning more concrete, effective, vivid and meaningful (Shakil et al, 2011). According to Behrendt and Franklin (2014), field trip may be planned for the following purposes: to provide first- hand experience; to stimulate interest and motivation in science; to add relevance to learning and relationship and to strengthen observation skills of students.

Field trip learning method is crucial to train students to think critically and also how they should work together to investigate and find data and information based on the discussed problem (Taneo, 2017). Field trip method of teaching allows students to learn through participation and observation in the learning process (Estawul *et al*., 2016).

According to Namale and Buku (2011), the main purpose of field trip is to provide students with accurate first-hand information in their original situation or natural environment.

Field trip is very important because it makes the work of the teacher easier and effective. It also increases student-student and student –teacher social interaction which supports cooperative learning strategy (Astalin & Chauchan, 2018). Field trip also serves as recreation to pupils after being in the classroom for a long time (Namale & Duku, 2011). The disadvantage of this method of instruction is that it is very expensive. It also wastes much time if it is not properly planned with specific learning objectives. It is sometimes difficult for the teacher to control the students when the class size is very large.

2.4.3 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 goal (Namale & Buku, 2011). A learning style is a student's consistent way of responding to and using stimuli in the context of learning (Namale & Buku, 2011). A learning style could also be explained as strategies or methods used by learners to process and retain information. According to Soundariya, Deepika and Kalaiselvan (2017), learning style refers to the learner's way to perceive, process and retain the information, in terms of their sensory modality. When teachers know the learning styles of their students, it enables them to use instructional strategies that will help their students learn better.

2.4.4.1 Classification of Learning Styles

According to Awla (2014), learning styles can be categorized into three main types; cognitive, personality (psychology) and sensory. Sensory learning styles are divided into four. These are auditory/verbal, visual, tactile/kinesthetic and audio-visual.

Auditory learners. They are group of students who learn through listening. They learn best from lectures, discussion, talking to others and listening to others (Namale & Buku, 2011). According to Fatt (2000), auditory learners would prefer lectures, discussions, seminars and tapes. Auditory learners are also known as verbal learners. They learn best by hearing, explanation and discussion (Olufunminiyi, 2015). These learners gain information through aural channels such as verbal discussion and listening to others' speech (Awla, 2014). Verbal learners will learn more easily if they get a learning environment in which the learning content is verbally oriented and provide more opportunity for listening (Sethi, Lomte, & Shinde, 2017). When taking a test, auditory learners would do their best when they are giving oral examination (Fatt, 2000).

Visual learners. These categories of learners learn by seeing. These learners need to see the teacher's facial expression and body language (Namale & Buku, 2011). Visual learners get more information from visual images (schematics, graphs, diagrams, pictures and demonstration) (Olufunminiyi, 2015). Visual learners prefer to think in picture and obtain the information through visual means such as diagrams and videos (Awla, 2014). According to Fatt (2000) visual students would rather learn by watching movies, film strips, pictures and graphs which help integrate the subject. Visual learners will learn better if they get a learning environment in which the learning contents are visually presented (Sethi, Lomte, & Shinde, 2017). When taking a test, a visual learner would do better on the test if the test had visual diagrams (Fatt, 2000).

Kinesthetic/Tactile learners. They are learners who learn through experiencing or hand-on approach. They learn by touching and moving objects and taking them apart and putting them together. Individuals who are considered kinesthetic learners prefer to learn by doing (Fatt, 2000). These persons learn best through hands-on approach, actively exploring the physical world around them (Namale & Buku, 2011). By giving a test with task-oriented questions, a kinesthetic learner would have better results (Fatt, 2000).

Audio-Visual learners. This category of learners learn by seeing and listening at the same time. Learners with this learning style learn best by watching the instructor and listening to what he/she says. They learn best by watching videos. Audio-visual learners also learn best when teachers use demonstration method of teaching. Audio-verbal learners will learn better if they get a learning environment in which the learning contents are presented verbally and visually (Sethi, Lomte, & Shinde, 2017).

Sensing-Intuitive. This learning style deals with how information is perceived. Sensing learners tend to do well in learning facts and to follow well establishes approaches and

procedures when solving problems (Ifenthaler & Lehmann, 2012). These learners prefer information that arises from the senses (Awla, 2014). The learning styles of those who prefer sensing are oriented towards procedures, facts and are practical (Olufunminiyi, 2015). Intuitive learner prefers information that originates from their imagination, reflection and internal memory (Awla, 2014). Intuitive learners are innovative, creative, independent, conceptual and oriented towards theories and meaning but dislike repetition (Olufunminiyi, 2015). Intuitive learners can better grasp new concepts, work usually faster and have less difficulty with abstract concepts and mathematical expression (Ifenthaler & Lehmann, 2012).

Sequential-Global learners. This category of learning style deals with how information is understood. Sequential learners gain understanding in an orderly manner and go through stepwise path in finding solutions to the problems (Olufunminiyi, 2015). Sequential learners tend to understand better by learning in logical linear steps where each step is a logical sequence of the previous step (Ifenthaler & Lehmann, 2012). Global learners concentrate on the big picture and follow their instincts or guess the main idea of the text (Awla, 2014).

Active-Reflective learners. This category of learning style deals with the way information is processed. Active learners enjoy working in groups or participating in discussion. They learn best through participation, working in groups, trying things out and require body movement and action for optimal results (Olufunminiyi, 2015). According to Awla (2014), active learners enjoy doing tasks and discussing them with others. Reflective learners are learners who prefer working alone. They understand and remember information by reflecting on it. Reflective learners understand lesson best by thinking about it quietly and prefer working alone. According to Ifenthaler and Lehmann (2012), the motor of active

learners is ‘‘let try and see how it works’’ while reflective learners pursue the principle of ‘’let us think carefully about it’’

2.4.4.2 Importance of Identifying and Understanding Learning Styles

The identification and understanding of learning styles play a pivotal role in teaching and learning processes. The identification of the learning styles is beneficial to both the teacher and the student. When students identify their learning styles, they will be able to include it in their learning process which makes it easy for them to absorb, process and retain information. Another benefit of identifying learning styles of students is that it assists learners to solve problems more effectively (Awla, 2014). When teachers identify and understand the learning styles of their students, it will help them adopt instructional strategies that will help their students learn best. Identifying the various dimensions of learning styles provides educators with a greater awareness of the unique characteristics of learners (Moussa, 2014). The author further asserted that educators can use this awareness to maximize students’ learning and support effective education by developing teaching methods that incorporate various learning styles. Learning style identification provides an overview of the course instructors to deliver course materials by using approaches that suit students learning styles (Ariffin, Solemon, Din, & Anwar, 2014). Identifying students learning styles enables teachers to organize their instructions according to their students’ individual needs (Bhat, 2014). The advantage of students identifying their own learning styles is that it will help them to become effective problem solvers (Kazu, 2009). Through the familiarity with learning styles, teachers and educational planners can conform planning and educational methods to the learning styles of the learners (Kalantari, Tahan, & Taraghi, 2016). In other words, understanding the learning styles of students enable teachers to match their teaching strategy with the learning styles of their students which helps learners to understand the lesson better. It is very essential for students to know their

learning styles and teachers to know the learning styles of their students in order to facilitate effective teaching and learning. This will also lead to significant improvement in their academic achievement.

2.4.4 Multimodal instructional Approach as a Teaching Strategy

Multimodal instructional approach is a teaching strategy in which students learn material through a number of different sensory modalities. For example, a teacher may create a lesson in which students learn through auditory and visual method or visual and tactile method. Multimodal instructional approach involves the use of multiple modalities in the teaching and learning process. According to Marchetti and Cullen (2016), multimodal approaches are modes which are visual, audio, text, speech and movement channels used in a classical classroom situation. Multimodal instructions include elements such as images, videos, charts, diagrams, animations, audio and simulations in the teaching process.

Multimodal instructions involve the use of multimedia and ICT to develop dynamic course resources that appeal to different sensory modes and a variety of learning styles (Birch & Gardiner, 2005). With this new flexibility, major concepts within the course material may now be presented in variety of modes for example, in both aural and visual form (Birch & Sankey, 2008). According to Moreno and Mayer (2003), multimodal learning environments use different modes to represent content knowledge for instance verbal and non-verbal where the non-verbal mode is the pictorial mode including diagrams, charts, animations and stimulations. These different representations are used to cater for the different sensory modes of learners. This mode of instruction enables teachers to present content knowledge to students in more than one mode which helps the teacher to get adequate attention of the students. Each mode contributes to meaning construction; an image on the board to get a visual backdrop, manipulation of the object to locate the

discussion in the physical setting, action to make clear the dynamic nature of the concept and the image on the textbook to do a stable summary (Gilakjani, 2011). With the help of images, charts, videos, pictures, animations and diagrams, students are able to understand abstract concept better. In multimodal learning environment, students are presented content knowledge with a verbal representation and one or more corresponding visual representation (Kuo *et al*., 2015).

Multimodal instructional approach helps to cater for the diverse learning needs of students in the class (Moreno & Mayer, 2007). The classroom environment has diverse students' population with a wide variety of learning needs or styles. There are students who learn best through auditory/verbal, visual, read/write or tactile/kinesthetic (Namale & Buku, 2011). Others also learn through a combination of two or three of these modes. Such students learn through auditory and visual methods or visual and tactile methods. These learners are considered as multimodal learners and hence multimodal instructional approach will help these learners in the class to achieve academic success. Also, multimodal presentation creates a suitable learning environment for learners to learn more after class (Bao, 2017).

Multimodal instructional approach makes teaching easier and faster for teachers. This instructional approach enables teachers to expose their students to a variety of diagrams, charts, graphs, videos, audio and animations which involve more of their senses. Therefore, abstract concepts are normally explained to students with the aid of illustration, diagrams, images, video and charts for easy understanding. Hence the energy of both the teacher as well as the students can be saved. With multimodal instructional approach, contents are retained in the mind of students for a long period of time since abstract concepts in the students' mind can be made clearer with an illustration. It encourages

learner-centered method of teaching (Birch, 2006). MIA allows students to actively involved in the teaching and learning process (Moreno & Mayer, 2007). With this mode of instruction, students hear, see, touch and manipulate the object or material being presented to them while the instructor play a facilitative role. It also enables the instructor to get the attention of the students during the instructional process. When teachers present information to students which meet their learning needs, it motivates them to pay attention to the teacher. When concepts are presented to students using multimodal instructional approach; visual, auditory, tactile/kinesthetic learners learn and the attention of the students will be captured by the teacher during teaching process (Moreno & Mayer, 2007).

2.4.5 Concept of Multimedia

Multimedia instructional system refers to the use of appropriate and carefully selected varieties of learning experiences which are presented to the learner through selected teaching strategies which reinforce and strengthen one another so that the learner will achieve predetermined and desired behavioural objectives (Satyaprakasha & Sudhanshu, 2014). Multimedia is a combination of text, graphics, sound, animation, audio and video (Babikar, 2015). Text, graphics and images are three static elements whereas audio, animation and video are moving objects or dynamic objects within a multimedia application (Mukherjee, 2018). Instructional activities that include multimedia help to cater for diverse learning styles of students. Multimedia can be used to present a more inclusive curriculum that appeal to visual, aural and tactile learners and overcome differences in students' performance that may result from different learning styles (Gilakjani *et al*., 2011) The application of multimedia devices to classroom teaching helps enlarge the amount of classroom information, enrich teaching content, enhance interactivity between teacher and student, increase teachers competence and as a result help teachers' achieve their goal (Li & Kang, 2014). As teaching of science subjects

include abstract things and concepts, the teaching/learning process can be better supported via multimedia enhanced material (Koseoglu & Efendioglu, 2015). Multimedia teaching offers alternative form of pedagogy and innovation that speed up the teaching process of classroom instruction, step up teaching efficacy and consequently promote the effectiveness of classroom instruction (Li & Kang, 2014)

2.4.5.1 Importance of Multimedia in Teaching and Learning

"Verbalism is a disease in our teaching and learning situation and multimedia act as an antidote to the disease of verbalism'' (Satyaprakasha & Sudhanshu, 2014 pp.42). Multimedia help students to visualize unseen phenomena, develop scientific language, improve understanding of the scientific process and contribute to the development of scientific thinking (Thomas & Israel, 2014). Multimedia presentations have immense potential of motivating learners by gaining their attention, increasing their perceptions, enhancing their comprehension skills as their uses allow educators to present more information, more examples, illustrations and problems for students to solve (Aggarwal & Dutt, 2014). Multimedia aided teaching moves us towards the constructivist approach of learning in which students play an active role (Akinoso, 2018). Multimedia approach can be effective for all students with different learning abilities as individual differences can be overcome in learning through different media (Aggarwal, 2018). The benefit of multimedia is that it takes advantage of the brain ability to make connections between the verbal and visual representations of content leading to deeper understanding which in turn supports the transfer of learning to other situations (Chioran, 2016). This is very necessary as teachers bear the responsibility of training students for a future where higher level of thinking, problem solving and collaborative skills are needed. Multimedia instructions expose students to a variety of graphics, pictures and animation which draw students' attention more and involve more of their sense organs (John, Musa, & Waziri,

2018). It also facilitates the conceptual understanding of biological and other scientific concepts leading to greater achievement (Aggarwal & Dutt, 2014). Multimedia promotes interactivity between instructors and learners, encouraging and enhancing student's engagement in the learning process (Li & Kang, 2014). Multimedia helps students to develop positive attitude towards science subjects, thus improving the academic achievement of students (Kareen, 2018). It also boosts students' comprehension of difficult topics and raises their interest level (Simhachalam, 2016). The benefits derived from the use of multimedia resources is not limited to the ease of the teacher's work alone especially to support constructive concept development , but help students in such a way that make them relate their knowledge in real life situations (Akinoso, 2018). Multimedia can improve learning and retention of material presented during teaching and learning (Kapri, 2017). The use of multimedia increases student success and motivation while positively affecting students' attitudes towards lessons (Ilhan & Oruç, 2016). It also helps students' to develop positive attitude towards learning, thus improving the academic performance of students (Kareem, 2018).

2.4.6 Introduction to Biological Classification of Living Organisms

Classification is the sorting of living things or organisms into groups on the bases of characteristics they have in common (Provencal, 2007). Biologists estimate that there are between 30 and 50 million species, of which approximately 1,500,000 species have been identified and named (Asabere-Ameyaw & Haruna, 2007). Each organism has numerous names as there are many local languages. To avoid confusion among scientists of one organism having different names, scientists categorize living organisms into groups and assigns scientific names to them and these names are accepted by scientists all over the world (Asabere-Ameyaw & Haruna, 2007).

2.4.7 Historical Background of Biological Classification

Many strategies have been used to classify living organisms. The idea of classification was first introduced by Aristotle (384-322BC), the Greek philosopher and naturalist (Asabere-Ameyaw & Haruna, 2007). Aristotle is the first taxonomist to classify living organisms. He classified animals based on the presence or absence of red blood. Aristotle also classified plants based on their appearance and size. He further classified plants into trees, herbs and shrubs. Aristotle's system of classifying living organisms lasted for 2,000 years. His system of classification was replaced by Carolus Linnaeus (1707-1778) because there was no natural relationship among the organisms. Carolus Linnaeus's system of classification is considered as the modern method or system of biological classification. This system classifies organisms based on the similarities in their structures and external characteristics or features. Carolus Linnaeus is the ''father of Taxonomy'' who classified all living organisms (plants and animals) into the largest groups called kingdoms. All plants and animals were put into kingdom Plantae and kingdom Animalia respectively. Carolus Linnaeus adopted a system of naming living organisms (plants and animals) called binomial system of nomenclature where each species is given a two-word Latin name which is accepted by scientists all over the world. The first name is the genus or generic name and the second name is the species or specific name (Johnson & Losos, 2010).

2.4.8 Importance of Biological Classification of Living Organisms

Classification helps biologists to trace the evolutionary trends in different groups of organisms and to put organisms into a systematic manner for easy identification and study (Provencal, 2007). It enables taxonomists to know the exact position of organisms. Classification enables Biologists to understand diversity better. It helps in the

identification of different kinds of living organisms and this allows taxonomists to learn about plants and animals, their similarities, characteristics and differences. Classification of living organisms is very important since it allows Biologists to identify, group and properly name living organisms by using a standardized system called binomial system of nomenclature (Anapkor, 2010). Biological classification helps scientists to predict the characteristics that a particular organism might have based on the observation of other organisms within the same group or category. Biological classification enables scientists to have much knowledge about living organisms (plants and animals) (Johnson & Losos, 2010). Such knowledge could be used to biologically or chemically control certain diseases and pests (Provencal, 2007). Classification also helps to avoid confusion among scientists or Biologists all over the world (Asabere-Ameyaw & Haruna, 2007). With biological classification of living organisms, every organism is given a two word Latin name that is a generic name and a species name with the generic name starting with a capital letter and the species name also starting with a small letter and such names are universally accepted by scientists all over the world.

2.5 Summary of Reviewed Literature

The importance of classification of living organisms cannot be underestimated as far as biology is concerned. Classification enables Biologists to understand diversity better. It helps them to learn much about plants and animals. Classification of living organisms is a core concept in the biology curriculum and it is the only topic that is normally examined in biology paper one, two and three in the West Africa Senior School Certificate Examination (WASSCE). Therefore, effective understanding of the topic is necessary in order to attain the best from this study. In view of this, the literature of this study was divided into three areas, components or frameworks; theoretical framework, conceptual framework and empirical framework.

The theoretical framework highlighted theories of teaching and learning of science in general and classification of living organisms in particular. The researcher identified two theories thus constructivism and cognitive theory of multimedia learning. Constructivism is basically concerned with learning in which students construct their own knowledge based on previous experience and understanding. With this theory, the teacher acts as facilitator, coach or guide by providing a problem solving environment for students to construct their own knowledge and find solution to the problem that they encounter. The cognitive theory of multimedia learning asserts that people learn better from words and pictures than from words or pictures alone. This theory is centered on the idea that learners build meaningful connections between words and pictures and that they learn more deeply than they could have with either words or pictures alone.

The literature also highlighted a conceptual framework for the study. The literature also highlighted the difficulties faced by students in learning Biology. The literature further highlighted the methods used in teaching science subjects and classification of living organisms in biology in particular. It was observed that the methods used in teaching science include discussion method, demonstration method, project based method, inquiry method, laboratory method, field trip method and concept mapping.

The literature discussed learning styles of students, classification of learning styles and importance or advantages of identifying learning styles of students. The literature also looked at multimodal instructional approach as a teaching method and its importance in teaching and learning. Concept of multimedia and its advantages in teaching and learning was also observed. The literature of the study finally highlighted introduction to biological classification of living organisms, historical background of classification of living organisms and importance of classification of living organisms.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter presents the research design, study area, population of the study, sampling technique, sample size and research instruments. The methodology also includes test items, questionnaire, validity of the instruments, pilot testing, reliability of the instruments, data collection procedure, intervention and the mode of data analysis and ethical issues.

3.1 Research Design

Quasi-experimental design was adopted for the study. Quasi-Experimental Design is used in education to test the effectiveness of a method or program (Bradley, 2018). In quasi-experimental design, two groups or classes are selected, a pretest is given to the two groups and then treatment or intervention is given to the experimental group. Finally, a posttest is conducted to determine the effectiveness of the treatment. Quasi-experimental design was used in this study because it has much stronger external validity since they do not require individuals to volunteer to participate and reflect real-life practice (Tugwell, Knottnerus, McGowan, & Andrea, 2017). Quasi-experimental designs generate results faster and at lower costs than true–experimental designs. Quasi experimental designs further avoid the threats 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 (Barnighausen, Geldsetzer, Tugwell, & Lavis, 2017).

3.2 Study Area

The study was conducted at Navrongo Senior High School in the Kassena Nankana Municipality in the Upper East Region of Ghana. Kasena Nankana Municipality is one of the 260 Metropolitan, Municipal and District Assemblies (MMDAs) in Ghana and form part of the fifteen Municipalities and Districts in the Upper East Region. Kassena Nankana Municipality lies within the Guinea Savannah ecological zone. The administrative capital of the Municipality is Navrongo. The Municipality shares boundaries with Bongo and Bolgatanga to the east, west Mamprusi Municipality to the south, to the west with Bulsa South District, Kassena Nankana West District and Bulsa North District. Finally, the Municipality shares boundaries with Burkina Faso to the north. The population of the Municipality according to the 2010 population and housing census stands at 109,994 with 53,676 males and 56,268 females (www. Ghanadistricts.com).

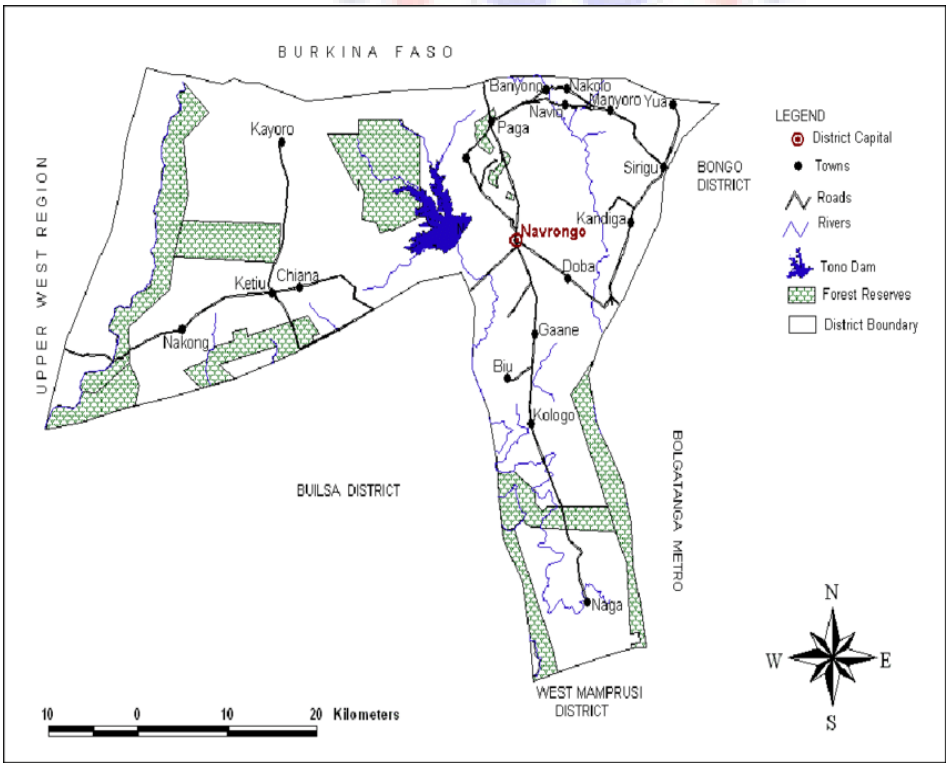

Figure 3: Map of Kassena Nankana Municipality

(Source: https:// www. Ghanadistricts.com)

3.3 Population

The population for the study included all Form Two Gold Track science students and Form Two Green Track science students of Navrongo Senior High School in the Kassena Nankana Municipality in the Upper East Region of Ghana.

The school was chosen for the study due to the accessibility of the school to the researcher, the willingness of the school's head, departmental head to accommodate the researcher and the willingness of Biology tutors to cooperate with the researcher in the study. The researcher is a Biology teacher at Navrongo Senior High School and hence getting access to the students was easy. Gold Track and Green Track were chosen for the study because students from both tracks share similar characteristics.

Gold Track was also chosen because the researcher teaches Track Gold and hence getting access to the students will not be a big issue. Green Track was also chosen due to accessibility and familiarity of the students to the researcher. In both groups, form two students were chosen because in the Teaching syllabus for Biology in SHS in Ghana, classification of living organisms is treated in the second year.

3.4 Sampling Technique

The entire Form Two science student's body cannot be used for the study due to financial constraints and hence there was the need for the researcher to sample portion of the students to represent the entire population for the study. Sampling is the process of selecting a number of individuals for a study in such a manner that the individuals represent the larger group from which they were chosen. Purposive sampling technique was adopted for this study**.** Purposive sampling is a non-probability sample which is selected on the basis or assumption that with good judgment, one can handpick elements

of cases in a population and develop samples which are satisfactory in relation to ones needs. Purposive sampling also called judgmental sampling is the deliberate choice of subjects due to the qualities that they possess (Tongco, 2007). With this method of sampling, decisions concerning the individuals to be included in the study are taken by the researcher hence it helps in eliminating individuals who are not suitable for the study. Purposive sampling consumes less time and it is also less expensive.

3.5 Sample Size

Participants for the study included, Fifty Form Two Gold Track science students of Navrongo Senior High School consisting of twenty-five males and twenty-five females. This served as the experimental group.

Another Fifty Form Two Green Track science students of Navrongo Senior High School consisting of twenty-five males and twenty-five females. This also served as the control group.

Both males and females were also equal in this study in order to create gender equity and equality in the classrooms. Gender equity denotes fairness in the distribution of resources and access to opportunities whereas gender equality denotes women having the same opportunities as men.

3.6 Research instruments

The instruments used in the study for data collection were two test instruments of comparable standard which were used to collect quantitative data from both the experimental and control groups. A questionnaire was also used to collect qualitative data from the experimental group on their perceptions towards the use of Multimodal Instructional Approach (MIA) as an instructional strategy in teaching Classification of

Living Organisms. The test instruments were dubbed Students' Knowledge in Classification of Living Organisms Concept Test (SKCLOCT) and Students' Academic Performance in Classification of Living Organisms Concept Test (SAPCLOCT). The SKCLOCT and SAPCLOCT were used as pretest and posttest respectively in this study **(**Appendix B and Appendix C).

3.7 Test items

The pretest and posttest items of the study were covered in classification of living organisms' concepts based on the Biology syllabus for Senior High School Form Two.

Pretest: Students Knowledge in Classification of Living Organisms Concept Test (SKCLOCT). It was made up of forty items in two sections, A and B. All the test items were lifted from WAEC Biology questions from 1993 to 2015. Section A was made up of thirty multiple choice questions. Each item had one correct answer and three distractors which reflected students' misconceptions in classification of living organisms. Section B was made up of ten essay questions. Students were required to answer all questions in both sections. Both sections were marked over sixty marks which were made up of thirty marks for section A and thirty marks for section B. The time allotted for the students to respond to the pretest was one hour.

Posttest: Students' Academic Performance in Classification of Living Organisms Concept Test (SAPCLOCT). Posttest was administered to both groups after the treatment. The posttest items were also in two sections, A and B. These test items were also past questions from WAEC Biology paper from 1993 to 2017. Section A was made up of thirty multiple choice test questions and section B comprised of ten essay questions. Each item of the multiple choice test had one correct answer and three distractors which reflected students' misconceptions in classification of living organisms. Sections A and B were

marked over sixty marks which was made up of thirty marks for section A and thirty marks for section B. The posttest was administered after the intervention. The time allotted for students to respond to the posttest was one hour.

3.8 Questionnaire

Questionnaire is a data collection tool for collecting and recording information about a particular issue of interest (Wong *et al*., 2012). A questionnaire is a predetermined set of questions used by a researcher to gather data. According to Anthony-Krueger and Sokpe (2015), questionnaire consists of a list of questions referred to as items which relate to the aims, objectives and the research questions or hypotheses of the research.

A self-developed questionnaire was used to determine the perceptions of students in the experimental group towards the use of MIA as an instructional method for teaching classification of living organisms after the intervention. The questionnaire for the students comprised of fifteen items using the Likert scale format. The options included Strongly Agreed (SA), Agree (A), Uncertain (UC), Disagree (DA) and Strongly Disagree (SD). The respondents were asked to tick the appropriate option that applied to their case.

3.9 Validity of the Instruments

Validity expresses the degree to which a measurement instrument measures what it purports to measure (Bolarwin, 2015). According to Kimberlin and Winterstein (2008), validity is the extent to which the interpretations of the results of a test are warranted, which depends on a particular problem the results are intended to solve. There are several forms of validity which include face validity, construct validity, content validity and criterion validity (Eshun & Effrim, 2014). These validity tests can be grouped into two main categories, namely; internal and external validity. Internal validity refers to how accurately the measures obtained from the research was actually quantifying what it was designed to measure whereas external validity refers to how accurately the measures

obtained from the study sample described the reference population from which the study sample was drawn (Wong, Ong, & Kuek, 2012).

To ensure the face and content validity of the instruments, the instruments for data collection were given to my supervisor and one science educationist in the Department of Science Education of the University of Education, Winneba to help establish their validity. The instruments were also validated by two experienced Senior High School Biology teachers who are examiners of Biology for WAEC for critique and suggestions which were used to modify the instruments.

3.10 Pilot testing

The test items were pre-tested at Zamse Senior High Technical School in the Upper East Region of Ghana. The school was selected because it shares similar characteristics with the Senior High School selected for the study. Students from Zamse Senior High School also offer Biology as one of their science elective subjects hence Biology is a compulsory subject for science students in this school. The pilot study helped the researcher to restructure the instruments to help elicit the correct responses from the students. This school was also chosen due to its accessibility to the researcher.

3.11 Reliability of the Instruments

Bolarwin (2015) defines reliability as the extent to which a questionnaire, test, observation or any measurement and procedure produces the same results on repeated trials. According to Wong *et al*. (2012), reliability is the degree to which results obtained by a measurement and a procedure can be replicated. For instance, a test or scale is said to be reliable if it produces the same results on different occasions under similar conditions. A reliability test was conducted by using test- retest reliability coefficient and Cronbach's alpha coefficient. The Cronbach alpha coefficient of the instrument on perceptions of the experimental

group towards the use of multimodal instructional approach in teaching classification of living organisms was found to be 0.70. The test-retest reliability coefficient of the instruments on Students' Knowledge Classification of Living Organisms Concept Test (SKCLOCT) and Students' Academic Performance in Classification of Living Organisms Concept Test (SAPCLOCT) were found to be 0.73 and 0.78 respectively. These were then compared with the tabulated coefficient of reliability which according to Taber (2018), a test item instrument with a Cronbach alpha of 0.70 or greater is widely considered desirable. The school and students used for establishing the reliability of the instruments did not take part in the main study.

3.12 Data collection procedure

The researcher applied for an introductory letter which was used to seek permission from the headmistress, head of department for science and Biology teachers of the school to undertake the study. Pretest was then conducted on the experimental group and the control group. Classification of living organisms was then introduced using multimodal instructional approach and discussion web instructional approach for the experimental group and the control group respectively within four weeks and posttest was then administered to both groups after the intervention or treatment. A questionnaire was also administered to the experimental group to determine the perception of the students towards the use of multimodal instructional Approach as a teaching method for teaching classification of living organisms. This was done after the intervention.

3.13 Treatment

The study was carried out in the first semester of 2019/2020 academic year. It took four sessions per week for four weeks for each of the groups. A total of one hundred students from both tracks were assigned as experimental group and control group. Gold Track

students were assigned as experimental group and were instructed using Multimodal Instructional Approach. Green Track students were also assigned as control group and were instructed using Discussion Web Instructional approach. Both groups were taught by the same teacher (researcher) and received identical syllabus-teaching content. Students in both groups were exposed to the same content for the same duration. The duration for each lesson was sixty minutes for four periods per week for four weeks.

The students in the control group were instructed using discussion web method of teaching (discussion method). The topic "Biological Classification'' was divided into five main subtopics which included; Kingdom Animalia, Kingdom Plantae, Kingdom Protoctista, Kingdom Fungi and Kingdom Prokaryotae. The students in the control group were divided into ten groups and each group was made up of five students. The duration for the instructions was four weeks.

For the first week, the various groups were assigned to read on the subtopic Kingdom Animalia. During class hours, questions were raised under the subtopic Kingdom Animalia and students were required to discuss within their groups and provide the answers and each group was then combined with another group for them to compare their answers and share their ideas to reach a consensus. When each group of ten students has reached its final conclusions, a representative from each group was then selected by the group members to present their final answers to the entire student body in the class. Each possible answer provided by the various groups was then discussed with the help of the instructor. The teacher emphasized the misconceptions held by students in the concept classification of living organisms based on the answers provided by the various groups and provided scientific explanations that corrected their misconceptions of the concept biological classification.

For week two, the various groups were assigned to read under the subtopic; Kingdom Plantae. During instructions time, class test was given for the various groups to respond concerning characteristics of Kingdom Plantae and classes of division Angiospermophyta. Each group of five students discussed among themselves within the group and responded to the questions. The class test was then marked by the researcher and corrections were made. The teacher then further discussed divisions of Kingdom Plantae with the students in each group. Characteristics of the various Classes of Angiospermophyta; Class Monocotyledonaea and Class Dicotyledonaea were discussed with the help of specimen that belongs to each class.

During the third week, the various groups were tasked to study under Kingdom Protoctista. During the instructions, questions were raised under characteristics of Kingdom Protoctista and the various Phyla of the Kingdom Protoctista. The students discussed among themselves within their groups and provided the answers. Each group was combined with another group for them to compare their answers and share their views to reach a final conclusion. Each group was given four minutes to discuss their answers given that best supports the group's conclusion. A speaker for each group was selected by the group members to report their conclusions that they had reached after the group discussion. In this way, the whole class was involved in the discussion while reaching a consensus. The researcher then emphasized the misconceptions held by students by asking questions and mentioning the scientifically correct explanations of the concepts.

Finally, Kingdom Fungi and Kingdom Prokaryotae were treated in the fourth week. The teacher discussed with students general characteristics of Kingdom Fungi and characteristics of Phylum Ascomycota, Phylum Basidiomycota and phylum Zygomycota.

The teacher also discussed with the students' general characteristics of Kingdom Prokaryotae.

Students in the experimental group were taught using Multimodal Instructional Approach. The duration of the lesson for each group of the experimental group was one hour for four times per week. The students were taught using MIA which involves the use of images, diagrams, real specimen, videos, animation and illustrations. The students were divided into groups and each group was made up of five students due to limited number of certain specimen.

During the first week, the teacher introduced to students the history of biological classification, importance of biological classification and various kingdoms of biological classification. During instruction on the kingdoms of biological classification specifically Kingdom Plantae, Kingdom Animalia and Kingdom Fungi, each group was given specimen that belong to each of the kingdoms for students to observe and state their characteristics. For Kingdom Prokaryotae/Monera and Kingdom Protoctista, the teacher used images, diagrams, animation of organisms that belong to those kingdoms for students to observe. Included in the images and diagrams of specimen were written words of the Kingdoms, Phyla/Divisions, Class, Order, Family, Genus and Species of the specimen. Videos of Kingdom Animalia and Kingdom Plantae were also shown for students to observe. During these sessions, the teacher discussed with the students the general characteristics of the Kingdoms of Biological Classification.

Kingdom Plantae was taught in the second week. The teacher discussed characteristics of division Bryophyta, Filicinophyta, Coniferophyta, Lycopodophyta, Cycadophyta and Angiospermophyta with the students. The two main Classes of Angiospermophyta (Class Monocotyledoneae and Class Dicotyledoneae) were also discussed with the aid of

specimen such as maize, rice, grass, banana, pepper, orange and mango which belong to the various classes.

Kingdom Animalia was treated in the third week. The teacher discussed with the students the various phyla such as Cnidarian, Platyhelminthes, Nematoda, Annelida, Mollusca, Arthropoda, Echinodermata and Chordata. For Classes in the Phylum Chordata which include Class Chondrichthyes, Class Osteichthyes, Class Amphibia, Class Reptilia, Class Aves and Class Mammalia, the teacher provided specimen that belong to the various Classes for each group to observe and state the characteristics of the various classes. The habitats and adaptive features of the organisms were also discussed. Classes under the phylum Arthropoda which comprises Class Crustacea, Class Chilopoda, Class Diplopoda, Class Insecta and Class Arachnida which is considered as the largest phylum in the kingdom Animalia were also discussed with the students in each group with the help of specimens provided to them by the teacher (researcher). The researcher asked them to observe the specimen such as cockroaches, weevils, grasshoppers, tilapia and toad and state their habitats and adaptive features. Each group was given answer sheet to respond to the questions. Their answers were then marked by the researcher and corrections were made by giving the correct habitats and adaptive features of the specimens.

Kingdom Fungi and protoctista were treated in the fourth week. Characteristics of Phyla Ascomycota, Basidiomycota and Zygomycota were discussed with the help of real specimen and pictures of specimen under each Phylum. Characteristics of Phyla of Kingdom Protoctista: Ciliophora, Zoomastigina, Apicomplexa, Rhizopoda, Euglenophyta, Chlorophyta, Rhodophyta and Phaeophyta were also discussed among the students with the help of the researcher (teacher).

Figure 4 shows the mode of instruction used in the experimental group

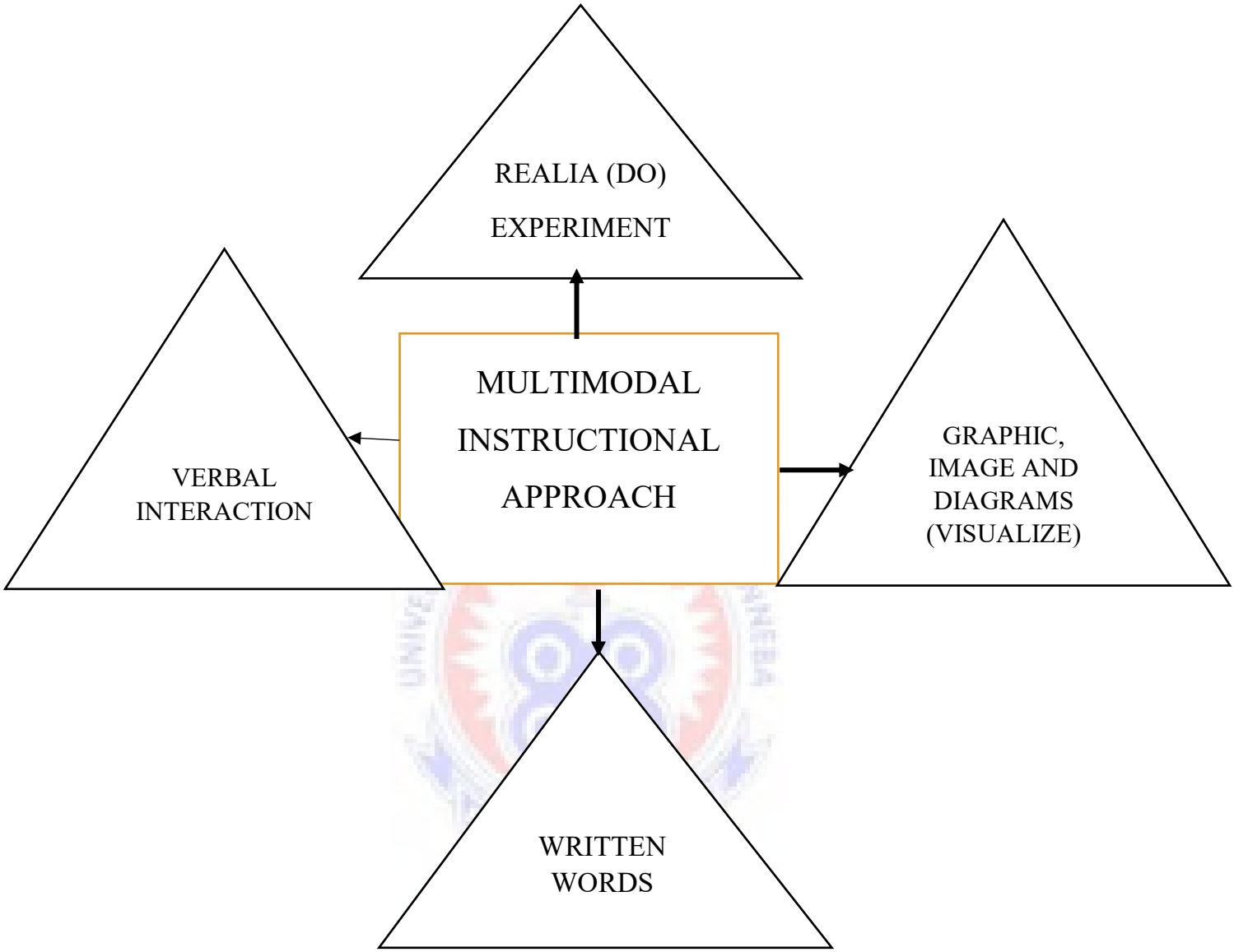

Figure 4: Multimodal Instructional Approach Model

3.14 Data Analysis

The data collected were analyzed using descriptive and inferential statistics. The data were converted into frequency and percentages. This descriptive statistical approach was used in the analysis of the qualitative part of the data specifically perception of students in the experimental group towards the use of MIA in teaching classification of living organisms.

The pretest and posttest scores of the students were analyzed statistically using t-test. A t-test is an inferential statistical procedure for determining the probability level of rejecting or accepting the null hypothesis. According to Al-Achi (2019), t-test also known as student's t-test is used to compare group means for a particular variable. T-test is divided into two, namely; paired and unpaired t-test. According to Gerald (2018), there are three types of t-tests and these are: independent sample t-test, dependent sample t-test and one sample t-test. Gerald (2018) further defined these types of t-test as: One sample t-test compares the mean of a sample to a predetermined value. Dependent (related, within subject or paired) sample test-test compares the means of two conditions in which the same or closely matched participants participated in the study. Independent (unrelated or unpaired) sample t-test compares the means of two groups of participants. The t-test was used to compare the achievement of students in the experiment group and those in the control group. Independent sample t-test was also used to compare the performance of both the male and the female students. Independent sample t-test was used to compare samples means in order to determine whether the population means are significantly different. The t-test was used to compare the achievement of students in the experiment group and those in the control group. Independent sample t-test was also used to compare the performance of both the male and the female students in the experimental group and the control group. Inferences were drawn from the statistically analyzed results in relation to the research questions and to test the null hypotheses. The details of the data analysis are presented in chapter four. The data collected were on the assumptions that;

i. The tests were conducted under standard conditions.

ii. The participants sincerely answered the questions in the instruments.

iii. There was no interaction between students in the experimental group and those in the control group.

iv. The researcher was not biased during the treatment.

3.15 Ethical Issues

Ethics refer to the standards and codes of research that the study has to put in place (Robson, 2002). Ethical issues that were considered in this study were the permission to collect data, confidentiality and the protection of the participants.

3.16 Confidentiality

The participants were assured that all the information obtained would be treated as confidential. That is, data was only used specifically for the stated purposes and no other person had access to the collected data. The names of students were not needed on the pretest, posttest and questionnaire and respondents were informed before they responded to the test items. This was done to avoid biased responses from the participants. The learning atmosphere in the school was not also disturbed during the data collection process and the data that was collected through pretest, posttest and questionnaire were kept confidential and made available to only persons who had direct interest in the study.

3.17 Anonymity

The researcher ensured that there was no way a participant from the information provided could be traced. This was done by not including names and addresses of participants.

CHAPTER FOUR

RESULTS/FINDINGS

4.0 Overview

The purpose of the study is to investigate the effect of Multimodal instructional approach on students' academic performance in the concept of classification of living organisms. This chapter deals with discussion of the data and presentation of the results and findings of the study. The data collected from the students' scores were analyzed using descriptive statistics of mean, standard deviation and inferential statistic of t-test. The results of the study are organized in relation to the research questions and null hypotheses.

4.1 Results

Two comparison groups from two different Tracks (SHS Gold Track and Green Track) which were as similar as possible were selected for the study to make fair comparison between the control and the experimental group. Control group is a group of students whose performance is compared to those of the experimental group. This is a group of students taught using discussion web. They are mainly students from Navrongo SHS Green Track. Experimental group is a group of students on whom the intervention is administered. This is a group of students taught using multimodal instructional approach. They are mainly student from Navrongo SHS Gold Track.

The data collected from the students' scores were analyzed using descriptive statistics that is, mean and standard deviation and inferential statistics, that is, independent student t-test. Independent-sample t-test statistic was used to test the null hypotheses at significant level of 0.05. The independent-sample t-test was used because the population variance was not known and it has interval scale of measurement and involved two groups in the study. Independent sample t-test compares the means of two groups of participants (Gerald,

2018). In addition, a questionnaire data was also collected from students' in the experimental group on their perceptions about the use of Multimodal Instructional Approach in teaching classification of living organisms. The results of the study are presented below:

Biodata of participants

The students who participated in study are shown below in Table 2.

Table 9: Biographical Data of Participants

Age		**Track**		**Gender**	
15 – 17	18 – 20+	Gold	Green	Male	Female
79	21	50	50	50	50

From Table 2, the total number of students who participated in this study was one hundred. Fifty were Gold Track students and Green Track students were also fifty. The male students were fifty and the female students were also fifty. Seventy-nine students had their ages range from 15 to 17 years and twenty one students had their ages range from 18 and above. For Gold Track, forty one students had their ages range from 15 to 17 and nine students also had their ages range from 18 and above. Also, for Green Track, thirty eight students had their ages range from 15 to 17 and twelve students had their ages range from 18 and above.

Research Question 1: What is the difference between the pretest mean score of student in the control group and those in the experimental group?

Table 10: t-test summary of pretest means score of students' in the control and experimental groups

GROUP	N	Mean	SD	df	t-value	p-value	Remarks
CONTROL	50	30	3.82	98	0.29	0.57	Not Significant
EXPERIMENTAL	50	30.2	3.23				

Source: Field data, 2020 Significant level = 0.05 df=degree of freedom

Table 3 is a summary of the pretest mean scores of students in the control and experimental groups. From Table 3, the pretest mean score of students in the control group was similar to that of the experimental group. Thus, the mean score of the control was 30 with a standard deviation of 3.82 whilst that of the experimental group was 30.2 with a standard deviation of 3.23. The difference between the means was 0.20. To see if there was any significant difference between the mean scores, a hypothesis was used.

Analysis of Research Hypothesis One:

Research hypothesis 1: There is no significant difference between the pretest mean scores of students in the control group and those in the experimental group.

From Table 3, the t-value, (t = 0.29), p value (p = 0.57, p>0.05). Since p> 0.05, it means that there was no statistically significant difference between the pretest means score of students in the control group and those in the experimental group. In the light of this, the null hypothesis was accepted. This indicated that the two groups selected for the study were homogenous since there was no difference in their academic performance.

Research Question 2. What is the difference between the posttest mean scores of the control group and the experimental group?

Table 11: t-test summary of posttest means score students in the control and experimental groups

GROUP	N	Mean	SD	df	t-value	P-value	Remarks
CONTROL	50	41.06	4.45	98	13.46	0.000	Significant
EXPERIMENTAL	50	51.56	3.68				

Source: Field data, 2020 Significant level = 0.05 df= degree of freedom

Table 4 is a summary of the posttest results of the students in the control group and those in the experimental group. From Table 4, the posttest mean score of students in the control group was 41.06 with a standard deviation of 4.45 while the posttest mean scores of students in the experimental group was 51.56 with a standard deviation of 3.68. The mean difference between students in the experimental group and those in the control group was 10.5 which indicated that the performance of students in the experimental group was far better than their counterparts in the control group. To see if there was any significant difference between the mean scores, a hypothesis was used.

Analysis of Research Hypothesis Two:

Research Hypothesis 2: There is no significant difference between the posttest mean score of students in the control group and those in the experimental group.

From Table 4, the t- value, ($t = 13.46$), p-value ($p = 0.000$, $p<0.05$). The p-value was less than 0.05. This showed that the mean score of students in the experimental group differed significantly from those in the control group. The null hypothesis was rejected and the alternative hypothesis was accepted. Therefore, there was a significant difference between the posttest mean scores of students in the control group and those in the experimental

group. By implication, the students that were taught using MIA outperformed the students that were taught using discussion web as a teaching method. This is an indication that the treatment given to the students in the experimental group was effective and responsible for the difference in the performance in favour of the experimental group.

Research Question 3. What are the differences between the pretest and posttest mean scores of male and female students in the control and experimental groups?

*Table 12*a: t-test summary of the pretest of male and female students' in the experimental group

Gender	N	Mean	SD	df	t-value	p-value	Remarks
MALE	25	30	3.25	48	0.43	0.66	Not Significant
FEMAL	25	30.4	3.27				

Source: Field data, 2020 Significant level = 0.05 df = degree of freedom

Table 5a is a summary of the results of the pretest of male and female students in the experimental group. From Table 5a, the pretest mean score of the male students in the experimental group was 30 with a standard deviation of 3.25 while the female students in the same group had a mean of 30.4 with a standard deviation of 3.27. The difference between the means was 0.40, an insignificant figure. To see if there was any significant difference between the mean scores, a hypothesis was used.

Analysis of Research Hypothesis 3a:

Research Hypothesis 3a: There is no significant difference between the pretest mean score of the male and female students in the experimental group.

From Table 5a, the t-value, (t = 43), p-value (p = 0.66, p>0.05). The p-value was greater than 0.05. In the light of this result, the null hypothesis was retained. The result of the test suggested that there was no statistically significant difference between the pretest means

score of male and female students in the experimental group. This indicated that both male and female students in the experimental group were similar in academic performance since there was no significant difference in their academic performance.

Table 5b: t-test summary of the posttest of male and female students' in the experimental group

GENDER	N	Mean	SD	df	t-value.	P-value	Remarks
MALE	25	51.84	3.69	48	0.55	0.54	Not Significant
FEMALE	25	51. 24	3.72				

Source: Field data, 2020 Significant level = 0.05 df= degree of freedom

Table 5b is a t-test summary of the results of the posttest of male and female students in the experimental group. From Table 5b, the posttest mean score of the male students in the experimental group was 51.84 with a standard deviation of 3.69 while the female students in the experimental group had a mean of 51.24 with a deviation of 3.72. The mean difference between the two groups was 0.60. The difference was not much. To see if there was any significant difference between the mean scores, a hypothesis was used.

Analysis of Research Hypothesis 3b:

Hypothesis 3b. There is no significant difference between the posttest mean scores of the male and female students in the experimental group.

From Table 5b, the t-value, ($t = 0.55$), p-value ($p = 0.54$, $p>0.05$). This indicated that there was no significant differences between the posttest mean scores of the male and the female students in the experimental group. In the light of this, the null hypothesis was retained. Therefore, sex is not a major issue in learning and understanding concepts in biological

classification when taught using MIA. This indicated that the use of MIA in teaching Biological classification is effective to both male and female students since the performance of the male and female students were similar.

Table 5c: t-test summary of the pretest of male and female students' in the control group

Gender	N	Mean	SD	df	t-value	p-value	Remarks
MALE	25	30.2	4.49	48	0.73	0.49	Not Significant
FEMALE	25	29.8	3. 09				

Source: Field data, 2020 Significant level = 0.05 df= degree of freedom

Table 5c is a t-test summary of the results of the pretest of male and female students in the control group. From Table 5c, the pretest mean score of male students in the control group was 30.2 with a standard deviation of 4.49 while the pretest mean score of female students in the control group was 29.8 with a standard deviation of 3.09. The mean difference between the two groups was 0.40. The difference was not much. . To see if there was any significant difference between the mean scores, a hypothesis was used.

Analysis of Research Hypothesis 3c:

Research Hypothesis 3c: There is no significant difference between the pretest mean score of the male and female students in the control group.

Also, from Table 5c, the t-value, ($t = 0.73$ and p-value, ($p = 0.49$, $p>0.05$). In the light of this result, it was hard to reject the null hypothesis. The results of the pretest proved that there was no statistically significant difference between the pretest means score of the male and female students in the control group.

Table 5d: t-test summary of the posttest of male and female students' in the control group

GENDER	N	Mean	SD	df	t-value	p-value	Remarks
MALE	25	40.88	5.24	48	0.62	0.74	Not Significant
FEMALE	25	41.24	3.09				

Source: Field data, 2020 Significant level = 0.05 df= degree of freedom

Table 5d is a t-test summary of the results of the posttest of male and female students in the control group. From Table 5d, the posttest mean score of the male students in the control group was 40.88 with a standard deviation 5.24 while the female students in the control group had a mean of 41.24 with a standard deviation of 3.09. The mean difference between the two groups was 0.36. The difference was insignificant. To see if there was any significant difference between the mean scores, a hypothesis was used.

Analysis of Research Hypothesis 3d:

Research Hypothesis 3d: There is no significant difference between the posttest mean score of the male and female students in the control group.

Also, from Table 5d, the t-value, ($t = 0.62$), p-value ($p = 0.74$, $p>0.05$). In the light of this, the null hypothesis was accepted. The result of the posttest of the male and female students in the control group proved that there was no statistically significant difference between the posttest means score of the male and female students. Therefore, sex is not a major issue in learning and understanding concepts in biological classification when taught using discussion web method. By implication, the use of discussion web approach in teaching Biological classification is not peculiar to a particular sex since the performance of the students were similar.

Research Question 4. What is the difference between the pretest mean score and the posttest mean score of students in the experimental group?

Table 13: t-test summary of the pretest and posttest scores of students in the experimental group

TEST	N	Mean	SD	df	t-value	p-value	Remarks
Pretest	50	30.2	3.23	49	33.18	0.000	Significant
Posttest	50	51.56	3.68				

Source: Field data, 2020 Significant level = 0.05 df= degree of freedom

Table 6 is a t-test summary of the results of the pretest and posttest scores of students in the control and experimental groups. From Table 6, the pretest mean score of students in the experimental group was 30.2 with a standard deviation of 3.23 while the posttest mean scores of the same students was 51.56 with a standard deviation of 3.68. The difference between the mean scores was 21.36. The posttest mean scores of the students in the experimental group were higher than their pretest mean score. . To see if there was any significant difference between the mean scores, a hypothesis was used.

Analysis of Research Hypothesis Four:

Research Hypothesis 4. There is no significant difference between the pretest mean score and the posttest mean score of students in the experimental group.

From Table 6, the t-value, (t= 33.18), p-value, (p=0.000, p< 0.05). Since the p-value was less than 0.05, the null hypothesis was rejected and the alternate hypothesis was accepted. This is an indication that the treatment given to the experimental group was effective and responsible for the differences in performance of the students in the pretest and posttest.

Analysis of Research Question Five:

Research Question 5: What are the perceptions of students in the experimental group about the use of MIA in teaching classification of living organisms?

To answer the fifth research question regarding students' perceptions of MIA, percentage, mean and standard deviation were calculated from the responses of the students. The students indicated their level of agreement with each questionnaire item on a scale that ranged from 5=Strongly Agree (SA), 4= Agree (A), 3= Uncertain (UC), 2= Disagree (DA) to 1= Strongly Disagree (SD)

Table 14: The Perception of the Students' in the experimental group about MIA

		RESPONSE						
S/N	ITEM	SA	A	UC	DA	SD	MEAN	S.D
1	MIA made the lesson visual for me.	20 (40%)	30 (60%)	0 (0%)	0 (0%)	0 (0%)	4.4	.49
2	MIA helped me retain more information.	14 (28%)	25 (50%)	10 (20%)	1 (2%)	0 (0%)	4.04	.75
3	MIA catered for my learning needs.	18 (36%)	29 (58%)	1 (2%)	2 (4%)	0 (0%)	4.22	.70
4	MIA made the lesson practical.	20 (40%)	30 (60%)	0 (0%)	0 (0%)	0 (0%)	4.4	.63
5	MIA helped me concentrate on the lesson.	15 (30%)	33 (66%)	0 (0%)	2 (4%)	0 (0%)	4.22	.57
6	MIA helped me understand the topic better.	19 (38%)	29 (58%)	1 (2%)	0 (0%)	1 (2%)	4.3	.70
7	MIA increased my interest in biological classification.	27 (54%)	19 (38%)	2 (4%)	1 (2%)	1 (2%)	4.4	.83
8	MIA enhanced my critical thinking skills.	15 (30%)	20 (40%)	11 (22%)	2 (4%)	2 (4%)	3.98	1.03
9	MIA helped me improve my performance.	18 (36%)	30 (60%)	0 (0%)	0 (0%)	2 (4%)	4.24	.82
10	I recommend MIA to other science teachers.	20 (40%)	25 (50%)	3 (6%)	1 (2%)	1 (2%)	4.24	.82
11	MIA made the lesson meaningful.	15 (30%)	30 (60%)	5 (10%)	0 (0%)	0 (0%)	4.2	.61
12	MIA made the lesson learner-centered.	13 (26%)	30 (60%)	2 (4%)	3 (6%)	2 (4%)	3.98	.96
13	MIA motivated me on the topic.	15 (30%)	30 (60%)	4 (8%)	0 (0%)	1 (2%)	4.16	.80
14	I am satisfied with this method of instruction.	20 (40%)	25 (50%)	3 (6%)	1 (2%)	1 (2%)	4.24	.82
15	MIA helped me apply in real life situation the entire topic I had learned.	13 (26%)	35 (70%)	2 (4%)	0 (0%)	0 (0%)	4.22	.51
Overall mean							**4.25**	**.73**

According to Table 7, the generality of the responses showed a high level of agreement. For the statement "MIA made the lesson visual for me" (M=4.4, SD=0.59), 40% of the students responded strongly agree, 60% responded agree, 0% responded uncertain, 0% responded disagree and 0% responded strongly disagree. "MIA helped me retain more information (M=4.04, SD=0.75), 28% responded strongly agree, 50% responded agree, 20% uncertain, 2% disagree and 0% responded strongly disagree. "MIA catered for my learning needs" (M=4.22, SD=0.70), 36% responded strongly agree, 58% responded agree, 2% responded uncertain, 4% responded disagree and 0% responded strongly disagree. "MIA made the lesson practical" (M=4.4, SD=0.63), 40% responded strongly agree, 60% responded agree and 0% responded uncertain, disagree and strongly disagree. "MIA helped me concentrate on the lesson" (M=4.22, SD=0.57), 30% responded strongly agree, 66% responded agree, 0% responded uncertain, 4% responded disagree and 0% strongly disagree. "MIA helped me understand the topic better" (M=4.3, SD=0.70), 38% responded strongly agree, 58% responded agree, 2% were uncertain, 0% responded disagree and 2% strongly disagreed. "MIA increased my interest in biological classification" (M = 4.4, SD = 070), 54% responded strongly agree, 38% responded agree, 4% were uncertain, 2% disagreed, and finally, 2% responded strongly disagree. "MIA enhanced my critical thinking skills" (M=3.98, SD=1.03), 30% responded strongly agree, 40% responded agree, 22% were uncertain, 6% disagreed and 4% strongly disagreed. "MIA helped me improve my performance" (M=4.24, SD=0.82), 36% responded strongly agree, 60% agreed, 0% uncertain, 0% disagreed and 4% strongly agreed. "I recommend MIA to other science teachers" (M=4.24, SD= 0.82), 40% responded strongly agree, 50% agreed, 6% responded uncertain, 2% disagreed and 2% responded strongly disagree. "MIA made the lesson meaningful" (M= 4.20, SD= 0.61), 30% responded strongly agree, 60% responded agree, 10% responded uncertain, 0% responded disagree and strongly disagree.

"MIA made the lesson learner-centered" (M=3.98, SD=0.95), 26% responded strongly agree, 60% responded agree, 4% were uncertain, 6% disagreed and 4% strongly disagreed. "MIA motivated me on the topic" (M= 4.16, SD= 0.74), 30% responded strongly agree, 60% responded agree, 8% responded uncertain, 0% disagreed and 2% strongly disagreed. "I am satisfied with this method of instruction" (M=4.24, SD= 0.82), 40% strongly agreed, 50% agreed, 6% were uncertain, 2% disagreed and 2% strongly disagreed. "MIA helped me apply in real situation the entire topic I had learned" (M=4.22, SD=0.51), 26 % responded strongly agree, 70% responded agree, 4% were uncertain, 0% disagreed and strongly disagreed. The mean level ranged from 3.98 to 4.40 and the standard deviation ranged from 0.49 to 1.03. The overall mean constraints is M= 4.25, SD=0.73. The overall mean in table 5 indicates that the students found MIA as an effective instructional method that helped them learn.

CHAPTER FIVE

DISCUSSION OF RESULTS

5.0 Overview

This chapter deals with the discussion of the results and findings from the study. The chapter is organized based on the research questions and null hypotheses.

5.1. Discussion of Results

The purpose of the study was to find out the effect of MIA on students' academic performance in the concept of classification of living organisms.

There was no statistically significant difference between the pretest mean scores of the students in the control group and those in the experimental group. This implies that the sample was drawn from a student population that is similar in academic achievement before the treatment. Similar finding was made by Azhar, Niwaz and Khan (2017), who researched on scientific application of audio visual aids in teaching science in Government Model High School Vehari, in Punjab and revealed that there was no significant difference in achieved scores of control and experimental groups of students in the pretest.

Another finding of the study is that there was a significant difference between the posttest mean scores of students in the experimental group and those in the control group. This is an indication that students who were taught concepts of biological classification using MIA, performed better in classifying living organisms than those who were taught using discussion web as an instructional method. Students in the experimental group performed better than their counterparts in the control group because participants in the experimental group interest, participation, motivation and concentration level was very high due to the treatment. This finding agrees with previous studies by Bawa (2018), who found out that students exposed to MIA performed better than those exposed to conventional teaching

method in learning chemistry concepts. This finding also agrees with Kuo *et al*. (2018) who found out that those students who were exposed to multimodal presentation performed better than those who were exposed to blackboard/marker board presentation. This finding further agrees with Bicomong *et al*. (2015), who investigated the use of multimodal approach in teaching algebra (Measurement) and found out that students who were exposed to MIA performed better than those exposed to conventional method of teaching. This study is also in agreement with Thomas and Israel (2014), on the effectiveness of animation and multimedia teaching on students' performance in science subjects and showed that the performance of students in the multimedia teaching group was far better than the performance of the students in the conventional teaching group. Similar finding was made by Aggarwal and Dutt (2014), who researched on the effectiveness of multimedia teaching and showed that students who were taught with multimedia presentation were found to perform significantly better that those taught with the lecture method.

Another finding of this study is that there was no significant difference between the pretest mean scores of the male and the female students' in the experimental group. This shows that both male and female students' in the experimental group were similar in academic achievement before the treatment.

Also, there was no significant difference between the pretest means score of the male and female students in the control. This is an indication that both male and female students in the control group were similar in academic success before they were taught using the discussion method of instruction.

Also, there was no significant difference between the posttest means score of male and female students in the control group. This proved that the effect of discussion method of

instruction on students' ability to classify living organisms was equal for male and female students in the control group.

A further finding of the study is that there was no significant difference between the posttest means score of the male and the female students exposed to multimodal instructional approach. This means that MIA influenced both male and female students' ability to classify living organisms equally. This implies that the use of MIA in classifying living organisms is not influenced by gender. This may be due to the advantages that MIA presents to students irrespective of gender. MIA helps in boosting students' understanding of difficult topics and also raises their interest level (Simhachalam, 2016). This study further agreed with Akinoso (2018) on effect of the use of multimedia on students' performance in Secondary Mathematics revealed that there was no significant difference between the mean achievement of male and female students taught using Multimedia. This finding is also in agreement with Thomas and Israel (2018), who studied the effectiveness of animation and multimedia teaching on students' performance in science and found that there was no significant difference in the performance of male and female students taught using animation and multimedia. This finding further corroborates the findings of Satyaprakasha and Sudhanshu (2014) on effect of multimedia teaching on students' achievement in Biology where it was found out that both male and female students' academic achievement was equal when they were taught using multimedia teaching method.

This finding did not agree with that of Olutola (2017) who conducted a study on school and gender as predictors of students' performance in WASSCE multiple choice test in Biology and found that female performed significantly better than male students. This finding also disagreed with Aggarwal and Dutt (2014) who found that male students

performed better than female students in acquisition of Biological concepts using multimedia presentation.

Finally, students in the experimental group perceived that MIA was an effective method that helped them to learn and improve on their academic performance in Biological classification. Participants in the experimental group had an affirmative perception about the use of Multimodal Instructional Approach in teaching Biological classification. Majority of the participants exposed to Multimodal instructional approach have the same opinion. They have an Agree perception with an average mean of 4.25. This proved that participants in the experimental group perceived MIA to be an effective instructional method for teaching classification of living organisms. This result agrees with the results of other studies that investigated students' perceptions about multimodal approach. Bicomong *et al.* (2015) who researched on the use of Multimodal Approach in teaching Algebra (Measurement) of Grade 7 in Camp Vicente Lim National High School and found that students who were exposed to multimodal approach strongly agreed that multimodal approach helped them to improve their academic performance. The result also agreed with Bawa (2015) who found that the use of MIA engages students in an active translation across modes of representation which address their learning differences and make them able to interpret and construct the concept according to the scientific principles.

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

6.0 Overview

This final chapter gives an overview of the study and research findings. It also highlights the summary, conclusions and recommendations of the study and presents suggestions necessary for policy formulation and for future research.

6.1 Summary

The purpose of the study was to investigate the effect of multimodal instructional approach on students' academic performance in the concept of classification of living organisms. It was an experimental research guided by quasi-experimental design with action research approach. One hundred general science students offering Biology as one of their elective subjects from Navrongo SHS Gold Track and Green Track were selected for this study and were divided into two groups. Students from the Gold Track were treated as experimental group while those from the Green Track were treated as control group. The experimental group students were taught using MIA and those from the control group were also taught using discussion web method. The instruments used for this study was pretest, posttest and questionnaire in a Likert scale format. The pretest was made up of 40 items and the posttest was also made up of 40 items. The Likert scale questionnaire was made up of made of 15 items for the experimental group students only.

6.2. Major findings

The following major findings were drawn from the study:

I. Difference in Performance between the Pretest mean scores of Students in the Control Group and those in the Experimental Groups

There was no significant difference in academic performance of the pretest scores of students in both control and experimental groups. This implies that the students were drawn from a students' population that had similar if not the same characteristics.

II. Difference in Performance of Students in the Experimental Group and Those in the Control Group

The performance of students in the experimental group was significantly higher than those in the control group on the posttest, indicating that those who were exposed to MIA performed significantly far better than their counterparts who were taught using discussion web method of instruction. This proves that MIA had a positive effect on students' academic performance in the concept, classification of living organisms.

III. Difference in Performance between Male and Female Students in the Experimental and Control Groups

Gender proved redundant in the acquisition of knowledge in the concept classification of living organisms. There was no significant difference in academic performance between male and female students exposed to MIA. This means that MIA enhanced the academic performance of both male and female equally. This is an indication that MIA is not influenced by gender.

Also, there was no significant difference in the academic performance of male and female students in the control group who were taught using discussion web method of instruction.

IV. Difference in performance between the Pretest and Posttest mean scores of Students in the Control and Experimental Groups

The posttest scores of students in the experimental group were significantly higher than their pretest scores. This is an indication that the intervention or treatment given to the experimental group students was effective and responsible for the differences in performance of students' pretest and posttest scores.

v. Perceptions of Students in the Experimental Group about Multimodal Instructional Approach (MIA)

The generality of the responses of the students in the experimental group showed a high level of agreement. The students exposed to multimodal instructional approach have a strongly agreed perception with an average mean of 4.25 in the use of Multimodal instructional approach in teaching classification of living organisms. This proves that the students found MIA to be an effective method that helped them to learn.

6.3. Conclusions

The study investigated the effect of MIA on students' academic performance in the concept classification of living organisms. The following conclusions were drawn on the basis of statistical analyses and the findings of the study. The study found that MIA was effective in teaching the concept, classification of living organisms since the students who were exposed to MIA performed significantly far better than their counterparts who were taught using discussion web. It is also established that MIA was more effective in enhancing the academic performance of both male and female students in biological classification. The claim that a significant difference occurs between male and female students in acquisition of biological concepts may not be true as the performance of male and female students in the experimental group was similar. This study portrayed that MIA

being a learner-centered approach, changed students' attitude positively towards biological classification that contributed towards improved academic performance.

The findings also provide empirical evidence for concluding that multimodal instructional approach facilitates higher level of learning and understanding of the concept, Biological Classification that lead to improved academic performance.

6.4. Recommendations

Based on the findings, there is an urgent need for Biology teachers to adopt instructional methods that place students at the center of the lesson and also improves the critical thinking skills of the students. Science teachers should shift from the traditional mode of instruction to one that caters for the diverse learning needs of students in the classroom since learners have different learning styles.

Based on the findings of this study the following recommendations are put forward by the researcher:

i. Biology teachers in NSHS should be encouraged to teach Biological Classification using MIA in order to improve the academic performance of both male and female students.
ii. PTA and NABIA should organize workshops, seminars and conferences for science teachers on the need to adopt current instructional strategies in order to improve the academic performance of students.
iii. The allocated fund for practical activities in NSHS should be increased in order to enable Biology tutors purchase specimens that may not be available in the school lab or environment.

iv. School authority should invite educational technologists, instructional materials technicians and computer experts to help science teachers of NSHS on how to incorporate ICT in teaching science subjects.

6.5. Suggestions for Future Research

Further research should investigate the effect of multimodal instructional approach in other subject areas from the basic level to Senior High School level in order to generate empirical evidence with greater generalization.

The study was limited to only Navrongo SHS in the Kasena Nankana Municipality of the Upper East Region. The same research could be carry out in other Senior High Schools in the Municipality, Region and the country at large.

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APPENDICES

APPENDIX A

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DSE/M.1/VOL.2/

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TO WHOM IT MAY CONCERN

Dear Sir/Madam,

INTRODUCTORY LETTER

The bearer of this letter, **Ezekiel Akotuko Ayimbila** with Index Number ***8180130009,*** is an M.Phil. student of the Department of Science Education in the above University.

He is conducting a research on "***Effect of Multimodal Instructional Approach on Students Academic Performance in the concept of Classification of Living Organisms***" for his studies. We would be grateful if you could assist him collect data for his research.

Counting on your usual co-operation.

Thank you.

Yours faithfully,

PROF. VICTOR ANTWI, PhD
Head of Department

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APPENDIX B

PRETEST DATA COLLECTING INSTRUMENT

These questions seek to find out your basic knowledge about classification of living organisms. 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 [ ]

Track of Participant: Gold Track [ ] Green Track [ ]

Age: 15-17 [ ] 18-20+ [ ]

SECTION A

MULTPLE CHOICE QUESTIONS

INSTRUCTIONS: ANSWER ALL QUESTIONS. EACH QUESTION IS FOLLOWED BY OPTIONS A – D. SELECT FROM AMONG THE OPTIONS THE ONE THAT BEST ANSWERED THE QUESTION.

1. Amoeba belongs to the phylum
   A. Chlorophyta
   B. Ciliophora .
   C. Oomycota.
   D. Rhizopoda.

2. The scientific name of an organism is derived from

   A. Class and Species.

   B. Family and Species.

   C. Genus and Species.

   D. Order and Species.

3. Which of the following characteristics is observed by arachnids only?

   A. Chitinous exoskeleton.

   B. Four pairs of walking legs.

   C. Jointed appendages.

   D. Segmented body.

4. Dove, snail, fish and monkey are placed in the kingdom Animalia because they

   A. are vertebrates.

   B. are heterotrophic.

   C. have different habitats.

   D. can move.

5. Bacteria are placed in the kingdom Prokaryotae because they

   A. have cell walls made of chitin.

   B. Possess mitochondria.

   C. are diseases causing organisms?

   D. lack nuclear membrane.

6. A plant that bears sori on the lower surface of leaf-like structure belong to the phylum
   A. Angiospermaphyta.
   B. Bryophyta.
   C. Filicinophyta.
   D. Lycopodophyta.
7. The main objective in the classification of organisms is
   A. for easy identification and communication.
   B. to demonstrate the diversity of living organisms.
   C. to ensure that each organism is named accurately.
   D. to establish an evolutionary trend.
8. All fungi are
   A. heterotrophic.
   B. pathogenic.
   C. saprophytic.
   D. symbiotic.
9. Which of the following cells or structures are associated with asexual reproduction in fungi?
   A. Ascospores.
   B. Basidiospores.
   C. Conidiospores.
   D. Zygospores.
10. Sporangia on upright hyphae that produces asexual spores are characteristics of
   A. Ascomycetes.
   B. Basidiomycetes.

C. Club fungi.

D. Zygomycetes.

11. Jelly fish and sea anemones both belong to phylum

A. Annelida.

B. Arthropoda.

C. Cnidaria.

D. Platehelminthes.

12. Which one of the following features distinguishes crustaceans from other arthropods?

A. Hard exoskeleton.

B. Jointed legs.

C. Two pairs of antennae.

D. Segmented.

13. To which one of the following groups do mosses belong?

A. Angiosperms.

B. Bryophytes.

C. Conifers.

D. Ferns.

14. A protoctist with flagella belongs to the phylum

A. Apicomplexa.

B. Ciliophora.

C. Rhizopoda.

D. Zoomastigina.

15. Which of the following structure is not associated with sexual reproduction in fungi?

    A. Gametangia.

    B. Progametangia

    C. Sporangiosphore.

    D. Zygospore.

16. Which of the following represent the main phyla of the kingdom fungi?

    A. Ascomycota, Basidiomycota and Zygomycota .

    B. Ascomycota, Bryophyta and Zygomycota.

    C. Ascomycota, Phaeophyta and Zygomycota.

    D. Basidiomycota, Bryophyta and Zygomycota.

17. The lowest rank in taxa among the classification of living organisms below is

    A. Class.

    B. Family.

    C. Genus.

    D. Order.

18. Monocotyledonae and Dicotyledonae belong to the division

    A. Angiospermophyta.

    B. Cycadophyta

    C. Filicinophyta.

    D. Lycodophyta.

19. Algae belong to the kingdom

    A. Fungi.

    B. Plantae.

    C. Prokaryotae.

D. Protoctista.

20. Which of the following arthropods possesses two pairs of antennae?

A. Butterfly.

B. Cotton stainner.

C. Crayfish.

D. Spider.

21. Yeast belongs to the phylum

A. Ascomycota.

B. Basidiomycota.

C. Oomycota.

D. Zygomycota.

22. Organisms whose endoskeleton is made of cartilage and lack operculum belong to the class

A. Aves.

B. Chondrichthyes.

C. Osteichthyes.

D. Reptilia.

23. Tilapia and herring belong to the class

A. Amphibians.

B. Chondrichthyes.

C. Osteichthyes.

D. Reptilia.

24. Living organisms that live in both terrestrial and arboreal habitats belong to the class

A. Amphibian.

B. Aves.

C. Chondrichthyes.

D. Mammalia.

25. A Protoctist among the following organisms is

A. Bacterium.

B. Hydra.

C. Mushroom.

D. Paramecium.

26. The binomial system of classification was developed by

A. Aristotle.

B. Darwin.

C. Linnaeus.

D. Mendel.

27. Organisms with their nuclear diffused in the cytoplasm belong to the kingdom

A. Animalia.

B. Fungi.

C. Plantae.

D. Prokaryotae.

28. A numbered key is used to

A. classify organisms.

B. identify organisms.

C. locate organisms.

D. name organisms.

29. Birds and fishes belong to the kingdom

A. Animalia.

B. Fungi.

C. Plantae.

D. Protoctistae.

30. The idea of classification of living organisms was first attributed by

A. Aristotle.

B. Darwin.

C. Linnaeus.

D. Mendel.

SECTION B

INSTRUCTION: ANSWER ALL QUESTIONS IN THIS SECTION

31. Briefly explain classification in Biology. **(3marks)**

32. State three reasons for classifying organisms. **(3marks)**

33. What is binomial nomenclature? **(3marks)**

34. State five kingdoms in the classification of living organisms. **(2½marks)**

35. List the seven ranks into which Taxonomists classify living organisms in the correct order starting from the largest. **(3½ marks)**

36. State three differences between Chondrichthyes and Osteichthyes. **(3marks)**

37. State three adaptive features of a bony fish. **(3marks)**

38. Mentions three general characteristics of organisms under the class Aves. **(3marks)**

39. Mention three classes under the phylum Arthropoda. **(3marks)**

40. State three structural features that distinguish Amphibians from Reptiles. **(3marks)**

APPENDIX C

POSTTEST DATA COLLECTING INSTRUMENT

These questions seek to find out your understanding in classification of living organisms. 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 of Participant: Male [ ] Female [ ]

Track of Participant: Gold Track [ ] Green Track [ ]

Age: 15-17 [ ] 18-20+ [ ]

SECTION A

MULTPLE CHOICE QUESTIONS

INSTRUCTION: ANSWER ALL QUESTIONS. EACH QUESTION IS FOLLOWED BY OPTIONS A – D. SELECT FROM AMONG THE OPTIONS THE ONE THAT BEST ANSWERED THE QUESTION.

1. Which of the following characteristics is not true for all insects? They have
   A. a pair of antennae.
   B. a pair of wing.
   C. three pairs of legs.
   D. jointed appendages.
2. The class Hepaticae and the class Musci belong to the major division
   A. Bryophyta.
   B. Chlorophyta.

C. Filicinophyta.

D. Lycopodophyta.

3. A large number of organisms with broad general features in common belong to the group known as

A. Class.

B. Genus.

C. Kingdom.

D. Species.

4. Which of the following characteristics is observed in Arachnids only?

A. Chitinous exoskeleton.

B. Four pairs of walking legs.

C. Jointed appendages.

D. Segmented bodies.

5. Organisms in the kingdom prokaryotae lack

A. cell wall.

B. chloroplast in their cells.

C. genetic materials.

D. nucleus bounded by a membrane.

6. All the members of the kingdom Plantae do not possess

A. cell wall.

B. chitinous exoskeleton.

C. chlorophyll.

D. multicelluar body.

7. The Basidiomycota lack

A. chlorophyll.

B. membrane bound organelles.

C. rhizoids.

D. sporangiospore.

8. A dichotomous key is used to

A. classify organisms.

B. identify organisms.

C. locate organisms.

D. name organisms.

9. Hyphal wall of fungi is composed of
   A. cellulose.
   B. chitin.
   C. lignin.
   D. mucilage.
10. Algae belongs to the kingdom
   A. Fungi.
   B. plantae.
   C. prokaryotae.
   D. protoctista.

Use the taxa listed below to answer question 11 to 13

I. Class II. Species III. Family IV. Genus

11. The correct sequence of ranking the taxa is
   A. I, II, III and IV.
   B. I, II, IV and III.
   C. I, III, II and IV.
   D. I, III, IV and II.
12. In the Binomial system of nomenclature, the taxa used are
   A. IV and II.
   B. II and III.
   C. II and IV.
   D. III and IV.
13. The taxon, *order*, comes in between
   A. I and III.
   B. II and III.
   C. II and IV.
   D. III and IV.
14. Which of the following group of organisms are not autotrophs?
   A. Chlorophytes.
   B. Fungi.
   C. Mosses.
   D. Protoctists.

15. The term acoelomate refers to an organisms with
    A. body cavity.
    B. three body layers.
    C. no body cavity.
    D. two body cavity.
16. Which of the following groups of organisms are unicellular?
    A. Coelenterates.
    B. Mollusca.
    C. Platyhelminthes.
    D. Protozoans.
17. Which of the following is a living organism?
    A. Mitochondrion.
    B. Muscle.
    C. Nucleus.
    D. Yeast.

    Use the following phyla to answer question 18 to 19

    I. Rhizopoda II. Oomycota III. Ciliophora IV. Chlorophyta

18. Amoeba belong to the phylum
    A. I.
    B. II.
    C. III.
    D. IV.
19. Which of the following pairs of phyla are more closely related?
    A. I and II.
    B. I and III.
    C. I and IV.
    D. II and III.
20. Cold-blooded vertebrates that spend part of their life cycle in water and part on land but return to water to reproduce belong to the class
    A. Aves
    B. Amphibian.
    C. Mammalia.
    D. Reptilia.

21. Members of the kingdom prokaryotae can be distinguished from other organisms by the
    A. Absence of nuclear membrane.
    B. Mode of nutrition.
    C. Possession of flagellum.
    D. variety of shape.
22. For the scientific name *Anoma muricata, muricata* is derived from the
    A. Class.
    B. Family.
    C. Genus.
    D. Species.
23. The cockroach and the butterfly are placed in the same class because both of them have
    A. exoskeleton.
    B. jointed appendages.
    C. segmented bodies.
    D. three body divisions.
24. A plant that bears sori on the lower surface of leaf-like structures belongs to the division
    A. Angiospermophyta.
    B. Bryophyta.
    C. Filicinophyta.
    D. Lycopodophyta.
25. The presence of mesogloea and cnidoblasts are features of
    A. annelids.
    B. coelenterates.
    C. flatworms.
    D. roundworms.
26. The fine thread-like structures that constitute the vegetative body of fungi are called
    A. hyphae.
    B. mycelia.
    C. rhizoids.
    D. stolons.

27. The smallest taxon among the following is
    A. Class.
    B. Genus.
    C. Order.
    D. Species.
28. A protoctist with flagellum belongs to the phylum
    A. Apicomplexa.
    B. Ciliophora.
    C. Rhizopoda.
    D. Zoomastigina.
29. The main difference between plants and animals is in their
    A. colour.
    B. growth.
    C. movement.
    D. nutrition.
30. Fossil records are important in classification because
    A. the hard parts of the organisms fossilize.
    B. they give the shape of the organisms.
    C. they can be dated to give appropriate time of evolution of traits.
    D. they are embedded in rocks.

SECTION B

INSTRUCTION: ANSWER ALL QUESTIONS IN THIS SECTION

31. List three characteristic features of Insects. **(3marks)**

32. With a named example, state the two main classes of fishes. **(3marks)**

33. State three characteristic features of Reptiles. **(3arks)**

34. What is taxonomy? **(3marks)**

35. State three general characteristics of the kingdom Fungi. **(3marks)**

36. In a tabular form, state three differences between Aves and Reptiles. **(3marks)**

37. Name two scientists who contributed to the development of biological classification. **(3marks)**

38. State two characteristics of each of these classes

    I. Osteichthyes **(2marks)**

    II. Mammalia **(2marks)**

39. In a tabular form, outline three differences between two named classes of Bryophyte. **(3marks)**

40. State three phyla of the kingdom Fungi. **(3marks)**

APPENDIX D

MARKING SCHEME FOR PRETEST ITEMS

1	**D**
2	**C**
3	**B**
4	**B**
5	**D**
6	**C**
7	**A**
8	**C**
9	**D**
10	**A**
11	**C**
12	**C**
13	**B**
14	**D**
15	**C**
16	**A**
17	**C**
18	**A**
19	**D**
20	**C**
21	**D**
22	**B**
23	**C**
24	**B**
25	**D**
26	**C**
27	**D**
28	**B**
29	**A**
30	**A**

TOTAL = 30marks

31. Biological classification is the sorting out of living things into groups according to their common characteristics. **[3marks]**

32. Reasons for classifying living organisms.

- For easy identification of similar living organisms.
- For easy study/research.
- For easy communication among scientists.
- To trace geographical distribution of living organisms.
- To show the relationships between different categories of living organisms.

[Any 3x1=3marks]

33. Binomial nomenclature is a system of naming an organism using two-word Latin name. The first name is genus/generic and the second name is specific /species**. [3marks]**

34. Kingdoms of biological classification.

- Kingdom Animalia.
- Kingdom Plantae.
- Kingdom Protoctista.
- Kingdom Prokaryotae.
- Kingdom Fungi.

[5x½ = 2½marks]

35. **Taxa or ranks in biological classification**

Kingdom →Phylum/Division → Class → Order→ Family →Genus →Species

[Correct order 7x½=3½marks]

36. Differences between Chondrichthyes and Osteichthyes.

Chondrichthyes	**Osteichthyes**
Month is ventral	Mouth is terminal
Heterocercal tail	Homocercal tail
Swim bladder absent	Swim bladder
Skeleton made up of cartilage	Skeleton made up of bones
Absence of operculum	Presence of operculum
Pectoral fins are lateral	Pectoral fins are ventral

[Any 3 correctly paired x1=3marks]

37. Adaptive features of a bony fish

- Lateral line for sensitivity.
- Eyes for vision or sight.
- Gills for respiration in water.
- Scales protects the body against mechanical injury.
- Streamlined body for easy movement through water.
- Operculum protects the gills.

[Any 3x1=3marks]

38. Characteristics of Aves

- Horny scales on the legs.
- Fore limbs modified to forming wings.
- Horny beak present but no teeth.
- Skin is covered with feathers for protection, warm and flight.

[Any 3x1=3marks]

39. Classes of phylum Arthropoda

- Class Crustacean.
- Class Insecta.
- Class Diplopoda.
- Class Chilopoda.
- Class Arachnida.

[Any 3x1=3marks]

40. Distinguishing features of Amphibians from Reptiles.

- Skin is moist.
- Webbed hind limb digits.
- Jaw does not contain teeth.

[3x1=3marks]

SECTION A = 30marks

SECTION B = 30marks

TOTAL = 60marks

APPENDIX E

MARKING SCHEME FOR POSTTEST

1	**B**
2	**A**
3	**C**
4	**B**
5	**D**
6	**B**
7	**A**
8	**B**
9	**B**
10	**D**
11	**D**
12	**A**
13	**A**
14	**B**
15	**C**
16	**D**
17	**D**
18	**A**
19	**B**
20	**A**
21	**A**
22	**D**
23	**D**
24	**C**
25	**B**
26	**B**
27	**D**
28	**D**
29	**D**
30	**C**

TOTAL = 30marks

31. Characteristics features of Insects.

- They have a pair of compound eyes.
- Three body divisions namely head, thorax and abdomen.
- Three pairs of thoracic legs.
- A pair of antennae.
- Possess wings for flight.
- Breathe through spiracles or trachea.
- Thorax made up of prothorax, mesothorax and metathorax.

[Any 3x1= 3marks]

32. The two main classes of fishes with one example for each class

- Chondrichthyes **[1mark]** example; shark , ray **[any 1x ½]**
- Osteichthyes **[1mark]** example; tilapia, herring **[any1x ½]**

33. Characteristic features of Reptiles.

- Have homodont dentition.
- Skin is covered with dry, horny epidermal scales.
- Have two pairs of limbs with claws except snakes.
- Absence of external ears.
- They lay cleidoic eggs, capable of full development on land.

[Any 3x1=3marks]

34. Taxonomy is a branch of biology that deals with the principle of classification based on structural, generic or cellular organisms.

35. Characteristics of the kingdom Fungi.

- Have cell wall made chitin.
- They have no true roots, stems or leaves.
- They lack chlorophyll.
- They are eukaryotic i.e. they have a definite nucleus.
- Their vegetative body is made up of mycelium of hyphae.

[Any 3x1=3marks]

36. Difference between Aves and Reptiles

AVES	REPTILES
Presence of beak	Absence of beak
Teeth absent	Teeth present
Wings present	Wings absent
Feathers present	Feathers absent
Homoeothermic	Poikilothermic

[Any 3 correctly paired x1=3marks]

37. Scientists who contributed to the development of biological classification.

- Aristotle **[1mark]**
- Carolus Linnaeus **[1mark]**

38. I. Characteristics of Osteichthyes.

- Have terminal mouth.
- Have homocercal tail.
- Have gills covered by an operculum.
- Have homodont dentition.
- Their endoskeleton is made of entirely bones

[Any 2x1=2marks]

II. Characteristics of Mammals.

- Skin covered with hair/fur.
- Possess sweat glands.
- Have external ear called pinna.
- Have heterodont dentition.
- Presence of well-developed brain.

[Any 2x1=2marks]

39. Names of the classes of Bryophyte

- Musci [**½mark]**
- Hepaticae **[½mark]**

Difference between Class Hepaticae and Class Musci

HEPATICAE	**MUSCI**
Presence of unicellular rhizoids	Presence of multicellular rhizoids
Spores develop into gametophyte	Spores develop into protonema
Have a flattened and branched gametophyte	Have an upright gametophyte
Gametophyte stage is dominant	Sporophyte stage is dominant

[Any 3 correctly paired x1=3marks]

40. Phyla of the kingdom Fungi.

- Ascomycota.
- Basidiomycota.
- Zygomycota.

[3x1=3marks]

SECTION A=30marks

SECTION B=30marks

TOTAL = 60marks

APPENDIX F

QUESTIONNAIRE FOR STUDENTS IN THE EXPERIMENTAL GROUP

This questionnaire was designed to evaluate your perceptions on the effectiveness of Multimodal Instructional Approach on the teaching of Biological classification. Please response to each of the items to the best of your knowledge. Your truthful responses will be greatly appreciated. Your response will be kept confidential and will not affect your examination results. It will be used purposely for research.

I. Background Information

Please tick [ ] in the appropriate spaces provided below.

Gender Male [ ] Female [ ]

Age 15- 17 [ ] 18-20+ [ ]

II. Students Perceptions about the use of MIA as a teaching method for teaching classification of living organisms.

INSTRCTIONS; Please read the following statement and indicate how much your agree or disagree with the statement by ticking the appropriate option please use the scale below;

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

S/N	ITEM	SA	A	UC	DA	SD
1	MIA made the lesson visual for me.					
2	MIA helped me retain more information.					
3	MIA catered for my learning needs.					
4	MIA made the lesson practical.					
5	MIA helped me concentrate on the lesson.					
6	MIA helped me understand the topic better.					
7	MIA increased my interest in biological classification.					
8	MIA enhanced my critical thinking skills.					
9	MIA helped me improves my performance.					
10	I recommend MIA to other science teachers.					
11	MIA made the lesson meaningful.					
12	MIA made the lesson learner-centered.					
13	MIA motivated me on the topic.					
14	I am satisfied with this method of instruction.					
15	MIA helped me to apply in real life situation the entire topic I had learned.					

APPENDIX G

COLLECTED DATA OF CONTROL AND EXPERIMENTAL GROUPS

STATISTICAL DATA

CONTROL GROUP				EXPERIMENTAL GROUP			
Student	Gender	Pretest	Posttest	Student	Gender	Pretest	Posttest
1	Male	25	37	1	Female	31	54
2	Female	28	40	2	Male	32	56
3	Female	30	48	3	Female	30	49
4	Female	27	38	4	Male	31	53
5	Female	25	38	5	Female	40	57
6	Female	28	41	6	Male	30	48
7	Female	30	40	7	Female	30	54
8	Male	27	43	8	Male	27	46
9	Male	30	39	9	Female	28	48
10	Male	24	41	10	Male	40	56
11	Female	33	47	11	Female	25	42
12	Male	32	43	12	Male	28	44
13	Male	40	49	13	Female	32	56
14	Male	34	41	14	Male	31	52
15	Male	35	50	15	Female	29	47
16	Male	37	48	16	Male	32	49
17	Male	31	41	17	Female	31	52
18	Male	29	41	18	Male	31	54
19	Male	34	45	19	Female	28	50
20	Female	29	39	20	Male	28	54
21	Male	28	37	21	Female	28	46
22	Female	31	39	22	Male	31	54
23	Male	37	43	23	Female	31	56
24	Female	31	44	24	Male	27	52
25	Male	20	28	25	Female	32	47
26	Male	30	42	26	Male	30	56
27	Female	23	35	27	Female	39	53
28	Male	29	36	28	Male	33	51
29	Female	28	36	29	Female	29	49
30	Male	27	34	30	Male	32	50
31	Male	25	34	31	Female	32	54
32	Male	31	44	32	Male	21	58
33	Female	32	44	33	Female	29	54
34	Male	33	46	34	Male	30	54
35	Female	30	41	35	Female	30	51
36	Female	31	43	36	Male	28	49
37	Female	36	45	37	Female	29	49
38	Female	29	40	38	Male	29	53
39	Female	30	42	39	Female	33	54

40	Male	28	40	40	Male	31	54
41	Female	24	41	41	Female	28	56
42	Female	35	43	42	Male	31	52
43	Female	30	40	43	Female	28	49
44	Female	24	40	44	Male	29	56
45	Female	32	42	45	Female	29	49
46	Female	30	41	46	Male	27	51
47	Female	29	44	47	Female	31	52
48	Male	30	43	48	Male	29	44
49	Male	29	34	49	Female	28	53
50	Male	30	42	50	Male	32	51