UNIVERSITY OF EDUCATION WINNEBA

IMPACT OF GUIDED INQUIRY-BASED TEACHING ON ACADEMIC PERFORMANCE AND ATTITUDE OF FORM TWO BIOLOGY STUDENTS

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DECLARATION

STUDENT'S DECLARATION

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

SIGNATURE…………………………………

DATE…………………………………………

SUPERVISOR'S DECLARATION

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

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DATE: ...……………………………………………

DEDICATION

Throughout this journey, I have been inspired and supported by many people that have had a part in making this thesis possible. Glory be to God...for with him all things are possible. To my wonderful mother, Madam Kabuga Gladys Azubayam and sister, Mad. Elizabeth Agwe.

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ACRONYMS

BSAB	Biology Students Attitude towards Biology
HAPs	High Ability performing students
IBT	Inquiry-Based Teaching
LAPs	Low Ability performing students
NSES	National science and Education Standard
SHS	Senior High School
SPSS	Statistical Package for the Social Science
TLM	Teaching Learning Materials
TLA	Teacher Learner Activities
WASSCE	West Africa Senior School Certificate Examination

ABSRACT

This study examined the impact of guided inquiry –based learning on students' attitude and academic performance in biology in Tamale Senior High School, Tamale, in the Northern region of Ghana. The participants for this study were 200 senior high form two (SHS2) students offering Biology in Tamale Senior High. Quasi experimental research design involving non-equivalent groups was adopted. The selection of was based on purposive sampling technique which involved four form two classes (SHS2). Data collected using students' attitude Biology scale (BSAB) were analysed using inferential statistics. An Independent-t-test statistics was used to establish the significance of guided Inquiry-based teaching and learning on students' academic performance. Analysis was used to explain the magnitude of the Pre and post treatment on attitude and academic performance of the students. In line with the findings of this study, the teacher, students' interest and relevance of biology were identified as factors affecting students' academic performance and attitude. It was also revealed from the findings that guided inquiry based learning has a positive effect on Students' attitude and also helped identify the weakness of students and to address them to improve their academic performance. It is recommended that teachers in their classroom adopts guided inquiry-based teaching (IBT) to help build positive attitude towards biology in Tamale Senior High School.

CHAPTER ONE

INTRODUCTION

1.0 Overview

In this chapter, an explanation of the background to the study was given. The statement of problem was then discussed and the purpose of the study stated. The objectives of the study and the research questions were also stated. A discussion of the significance of the study and delimitations and limitations were also provided in this chapter. The chapter ends by presenting an organisation for the remainder of the study report.

1.1 Background to the Study

Science Education particularly Biology in the senior high school curriculum aims at helping students to appreciate nature and developed scientific approach in solving personal societal problems (Biology Curriculum, 2010). Senior high school education is a critical level in any educational system. It is also a stage in the education where students are equipped with the necessary basic skills in the various fields of study needed for advance study and training. As a transitional level to higher education, it is also important for economic development of a nation, socialisation and empowerment of the youth who are faced with massive levels of unemployment (United Nations Education Scientific and Cultural Organisation [UNESCO], 2005) Nations all over the world lay a lot of emphasis on secondary school education.

Biology is one of the science subjects taught in senior high schools in Ghana as an elective subject to be studied by General Science Students (pure science) and the Home Economics students. However, other schools replace the Biology with Chemistry for their Home Economics students. (S D A Senior High, Bantam,Kumasi)

Biology is a natural science that focuses on the study of life and activities of all living things ranging from bacteria to higher plants and animals.

The study of biology in senior high schools can furnish students with useful concepts, principles, theories, and skills that will aid learners to confront problems/challenges before and after their graduation in our rapid growing world. Inquiry-based teaching in biology may provide these opportunities for learners to involve themselves in science as opposed to learning about science. Nzewi (2018) asserted that inquiry-based teaching can be regarded as a strategy that can be used to make the work of the teacher more real to the students, contrary to the abstract or theoretical presentation of facts, principles, and concepts of subject matter. The author maintained that Inquiry-based teaching should engage students' in mind-on activity, using apposite instructional methods to achieve the lesson objectives.

There is a relationship between the method of instruction and the attainment of objectives (Baez, 2011). Among these different kinds of methodologies, inquiry method has an important place (Baez, 2011). The inquiry-based teaching approach is supported on knowledge about the learning process that has emerged from research (Bransford, Brown, & Cocking, 2017). In inquiry-based science education, children become engaged in many of the activities and thinking processes that scientists use to produce new knowledge. Science educators encourage teachers to replace traditional teacher-centred instructional practices, such as emphasis on textbooks, lectures, and scientific facts, with inquiry-oriented approaches that (a) engage student interest in science, (b) provide opportunities for students to use appropriate laboratory techniques to collect evidence, (c) require students to solve problems using logic and evidence, (d) encourage students to conduct further study to develop more elaborate explanations, and (e) emphasize the importance of writing scientific explanations on the basis of evidence (Secker,2012). Various studies by educational researchers and planners (Umar, 2011; Wood & Gentile, 2016; Azure, 2015) have found that inquiry-based approach to teaching biology, especially, ranging from the 5E to the 7E models have helped to improve the academic achievements of students tremendously. This current study seeks to find out whether inquiry-based teaching approach using the 5E model will have similar effects on the academic performance and attitude of students in biology.

1.2 Statement of the Problem

The general response and interest of students during the teaching of Biology has been on a low response on the part of many students in Tamale Senior High School. This has been a worry to the researcher as a biology teacher and other colleague teachers in the School.

The general performance of both the Science and Home Economic students has been very poor in biology over the past five years. This could be due to several factors such as poor teaching methods, number of periods per subject per teacher, calibre of students coming into the sciences in a particular year or years.(Appendix A).

Additionally, teaching periods have been upgraded from seven (7) to nine (9) hours yet current statistics still indicates poor performance in the subject biology in Tamale Senior High. Available evidence from West African Examination Council and the school analysis (WAEC, 2015- 2020) indicates student’s poor academic achievement in biology (Appendix A). Therefore, we need teaching and learning strategies that will provide us with a wide range and advanced educational potential that will help our students to enrich their understanding, develop their mental abilities, acquire science process skills and become useful and resourceful in the scientific society and the world at large.

Nzewi (2018) reported that majority of the biology teachers in senior high schools yet use the traditional lecture method to teach biology. This method of instruction has been described by educational researchers (Sandoval & Reiser, 2014) as a one-person show with a largely uninvolved learner, and often dominated by direct and unilateral instruction. According to Stofflett (2019), the traditional method of teaching makes the learner passive leaving little room for student-initiated questions, independent thought, or interaction between students. There is the need, therefore, for further research to explore other approaches of teaching biology. The literature (Umar, 2011; Wood & Gentile, 2016; Azure, 2015) points out that inquiry-based teaching approach increased the academic achievements of students tremendously compare to the traditional method of teaching. This present study seeks to find out whether inquiry-based teaching approach will have positive effects on the academic performance of form two senior high school students in biology.

1.3 Purpose of the Study

The purpose of this study was to assess the effect of inquiry-based teaching approach (IBTA) on the academic performance and attitude of form two biology students on the topic, Classification of Living things.

1.4 Objectives of the Study

The objectives of the study were to:

1. Determine the attitude of student towards Biology in Tamale Senior High School.
2. Investigate the factors that account for students' attitude towards Biology.

3. Find out the effect of inquiry-based approach on students' attitude and academic performance in Biology.

1.5 Research Questions

The following research questions guided the study:

1. What is the attitude of students' towards the teaching and learning of biology as an academic course in Tamale Senior High School?
2. What factors account for students' attitude towards Biology?
3. What is the effect of inquiry-based approach on students' attitude and performance in Biology?

1.6 Null Hypothesis

To achieve the objectives of the study, the following null hypothesis was tested at 0.05 level of significance.

H_{01}: There is no statistically significant difference in students' attitude towards biology and academic performance in Biology before and after treatment.

1.7 Significance of the Study

This study is significant for the following reasons:

- This study will bring to bear some of the attitudes that affects the performance in biology in Senior High Schools in Tamale.
- Findings from this study may inspire other biology teachers to use inquiry based teaching approach to deliver their lessons to help improve on their students' performance.

- The study will serve as a source of current literature on the topic or related areas for future researchers who would wish to investigate the same topic.

1.8 Delimitations of the Study

This study focused only on the use of inquiry-based instruction to improve the performance of form two biology students at Tamale Senior High School. In effect, findings from this research may be generalized but with caution.

The topic used was limited to the classification of living things.

1.9 Limitations of the Study

Test anxiety on the part of the students may affect their performance on the achievement tests. Absenteeism on the part some students was a challenge

1.10 Operational Definitions

5E Learning Cycle Model: A method of instructing and organizing inquiry-based learning lessons through engagement, exploration, explanation, elaboration, and evaluation (Bybee, 2014).

Inquiry-Based Learning: An educational practice and method which puts the responsibility of the learning process onto the student. This form of active learning and teaching allows students to ask questions, form solutions to problems, explore and discover content material, and reflect upon learning processes to have deeper understandings of content material (Bybee, 2014).

Traditional teaching method: An educational method of teaching where the educator provides direct instruction to students through lectures and presentations. The responsibility of learning and the flow of acquiring information and knowledge is guided by the educator.

1.11 Organisation of the Study Report

This study report has been organized into five chapters. The outline of chapter one has already been presented. Chapter two comprises the review of related literature. It begins with an overview of the chapter and then a review of related literature under various strands. Chapter three consists of the research methodology. It is divided overview of the chapter, the design of the study, population and sampling procedure, instrumentation, validity of the instruments, the reliability of the instruments, data collection, data analysis and ethical considerations. Chapter four contains results presentation and analysis of results. Chapter five covers the summary of findings, conclusion, recommendations, and suggestion for further study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

In this chapter literature related to the study is reviewed. The literature concerns the approaches to the teaching of biology. The review is meant to explore the extent to which guided inquiry approach to teaching biology could motivate learners and improve performance and attitude in the study of biology. This was followed by the examination of the factors that influence the choice of teaching method and a discussion on the use of guided-inquiry in science classrooms. Finally, the effect of inquiry-based approaches on students' performance and the limitations of inquiry-based approaches to teaching science were examined.

2.1 Conceptual Framework

The bases of this study is embedded in the constructivist cognitive theory of learning. The framework of this study is represented diagrammatically below in Figure 1

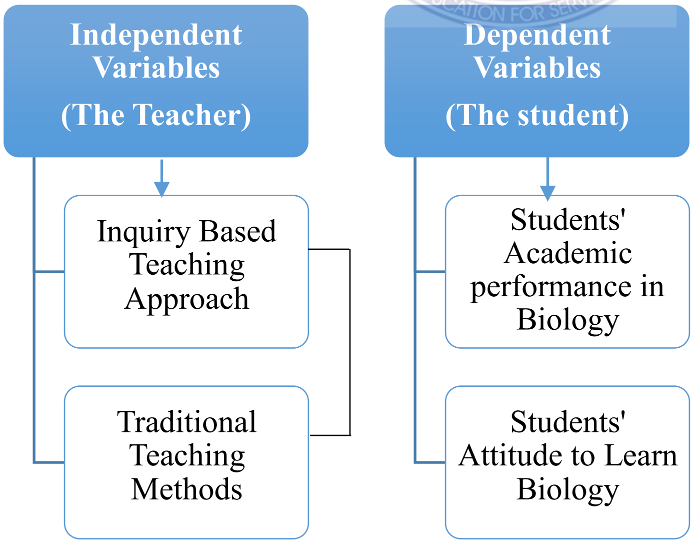

Figure 1: The Conceptual Framework showing the Interaction of the Teacher and the Learner.

The relationships between variables of the study are shown on Figure 1. In an ideal situation, the teaching approach would affect the students' achievement and motivation to learn biology. In practical situations the students' achievement and motivation to learn biology will be influenced by various factors which include, teacher training, and teachers' epistemological views on teaching, learning, and teaching resources. These are extraneous variables which need to be controlled.

Inquiry-based learning is one instructional approach to help students construct knowledge through a discovery process that supports continuous learning. Theoretically, inquiry-based learning represents constructive perspectives. It can engage students in individual and social activities such as experiments, discussions, and argumentation. Driver (2012) stated that meaningful activities can support students to make sense of scientific conceptions and the processes of scientific methods.

In this study, the design of inquiry-based learning is based on the statement of Leach and Scott (2013) that brings the personal cognitive perspective and social constructivist perspective together to support conceptual learning. They said bringing them [personal cognitive perspective and social constructivist perspective] together has important consequences for pedagogical practices and opens a range of possibilities for science education research. Primarily, it opens the possibility of relating findings about students' learning to insights about teaching, as well as explaining why internalisation is not a simple matter of transfer (p. 104).

This means that the inquiry-based learning used in this study does not only emphasised individual thinking, but also focused on how students explain their thoughts and how teachers explain scientific conceptions. These were both used to support student understanding through inquiry-based learning.

2.2 Teaching Senior High School Biology

When teaching high school biology, the educator must keep in mind how people learn and effective teaching strategies. The field of science allows for students to understand not only information, but how the information arose using experimentation (Virginia Department of Education, 2013). Currently, high school science is typically taught using the traditional lecture method. There is a call for new active learning teaching techniques, like inquiry-based learning, to be used (Shields, 2006). Biology teachers must find ways in which students are engaged in lessons that allow students to investigate and gain a positive impression of the learning experience (Stewart-Wingfield & Black, 2005). Biology is an important subject for students to understand because it teaches them how to think scientifically and appreciate nature. Instead of accepting information, science helps to teach students to question and systematically investigate problems for the truth.

The importance of science is that it allows for investigation and discovery that satisfy the human beings desire for knowledge and understanding. Science also allows for advancements in the quality of life (Virginia Department of Education, 2013). The way science is currently taught needs to be changed. Educators must be aware of what they want students to learn and then create lessons in which students will gain the right information. Biology education requires for students to not only learn facts, but to also learn how to apply, analyse, synthesize, and evaluate the information (Georgia Department of Education, 2016). The methods that are recommended are inquiry-based methods (Ebert-May et al., 2007). Superior teaching strategies are ones in which students can retain knowledge and apply what they have learned to new applications. For students to find the value in a lesson, they need to be able to relate the lesson to the real world and their future careers. Research has shown that students recognize lessons that are experimental in nature, like inquiry-based lessons, to be more useful to their future careers (Stewart-Wingfield & Black, 2005). When teaching biology, the educators' goal must be to instruct students so that they thoroughly understand the subject. This means that students are not to only learn the major biology concepts, but in order to solve problems, students must also learn to use the process of inquiry. By using inquiry-based teaching methods in biology, teachers can allow students to actively learn the major biology or science concepts by investigating for themselves (Ebert-May et al., 2007). Biology teachers must also teach so that students gain a positive experience from their lessons. Students who enjoy the way in which the lesson is presented and the way in which they are learning will gain more from the lesson and will continue to want to learn. Students who are taught using active course designs, like the inquiry method of teaching, have shown an increased enjoyment in the lesson (Stewart-Wingfield & Black, 2005).

2.3 Cognitive Development

Educators must be aware of cognitive development or the way in which people learn (Lion, 2008). A good way for educators to acknowledge different levels of cognitive development in their lessons is for them to use Bloom's Taxonomy. Bloom's taxonomy is a classification system that recognizes the process that students undergo when learning information and gives educators a tool for measuring the levels of cognitive development that they are reaching with their lessons (Love, 2009). The classification is split into six levels that range from basic knowledge gaining to higher level thinking. The lowest level is called knowledge, and describes when the student is remembering facts that they were previously learnt. The second level is comprehension, describes the students' ability to understand the significance of the material that they are being taught, where the third level is application; this is when the students can use the information that they have previously learned in an original way. The fourth level is analysis, and this is when students can separate material into ordered parts. The fifth level is synthesis, and it is when students can arrange parts into a new whole. The sixth and highest level of the taxonomy is evaluation, and it is when the students can critique the significance of the material that they had learned (Love, 2009). According to research, the traditional lecture method of teaching typically remains at the lower levels of bloom's taxonomy (Lion, 2008). This means that students are not reaching the higher levels of cognitive development by the traditional method (Lion, 2008). The inquiry-based method of teaching allows students to reach the highest levels of Bloom's taxonomy. Students reach the higher levels of cognitive development when taught with the inquiry method of teaching (Mysliwiec, Dunbar, & Shibley, 2015).

2.4 Approaches to the Teaching of Biology

There are different approaches to teaching biological science. Each type has its advantages and disadvantages. Teaching approaches, according to Ndirangu (2007) are used to impart knowledge to students; they are the means by which the teacher attempts to impart the desired learning or experience. According to Kimweri (2014), teaching method refers to the variety of ways in which a learning task is managed to facilitate the learning process. Teaching method was also defined by Osokoye (2004) as the strategy or plan that outline the approach that teachers intend to take in order to achieve the desirable objectives. This involves the way teachers organize and use teaching tools and materials to meet teaching objectives.

The choice of a method of teaching by the teacher is dependent on several factors (Ndirangu, 2007). Among these factors may be the content to be taught, the objectives which the teacher plans to achieve, the availability of teaching and learning resources and the ability and willingness of the teacher to improvise if conventional teaching aids are not available, evaluation and follow-up activities and individual learner differences. Various studies have been conducted concerning teaching method. For example, Asikis (2010), found that qualification of teachers and students' environment do not influence students' performance but rather, teachers' method of teaching influence academic performance. Findings of this research are supported by the study conducted in the USA by Haas (2002) about teaching methods on students' Achievement. This study examined teaching methods used in science subjects at A-level. The study found that teaching method influences students' learning greatly. Another study on teaching method was carried out by Gulobia, Wokadala and Bategeka (2010) in Uganda. This study analyses the link between educational inputs; teaching methods and pupils' performance in primary schools. The findings showed that teaching and learning strategies contribute to better school performance.

Although several studies (Asikis, 2010, Gulobia et al., 2010; Haas, 2002.) support the idea that teaching method influences students' academic achievement, it is highly likely that some teaching methods can better enhance learners' academic achievement than others. Bategeka, Gulobia and Wokodola, (2010), argued that the methods of teaching espoused by biology teachers are broadly categorized in to two; teacher-centred, which are viewed to be somewhat ineffective in the impartation of knowledge, and student-centred, which are viewed as more effective in the impartation of knowledge. Below is a discussion of the two major groups and some teaching methods that can be classified under them.

2.5 Student Centred Method of Teaching

This method of teaching is student oriented. Here, the learner is vigorously engaged in the process of teaching and learning. Students can do, manipulate, ask, and experience. Bruner (1960) asserted that students need a rich supply of meaningful examples and manipulatives to help make ideas and relationships come to life. Some teaching methods that are categorized under this group are discussed below.

2.5.1 Question and answer method

Question and answer is defined as a method both for teaching and oral testing based on the type and use of questions. Questioning techniques are one of the basic and successful ways of stimulating students thinking and learning (Ndirangu, 2007). It is applicable to all teaching approaches and methods

2.5.2 Discussion method

Discussion method is an important component of any teaching or learning situation which allows students to share their ideas (Ndirangu, 2007). It can be used at the beginning of a topic to ascertain students' preconceived notion of the subject matter. It can also be presented toward the end of a subtopic by presenting the student with a new situation and asking them to explain it in terms of what they have just learned. Discussion method is a teaching and learning strategy that entails sharing and exchange of ideas, experience, and opinion (Kimweri, 2014). Strengths of discussion method are; increases the depth of learners' understanding, enhances motivation, and generates greater involvement of the learners, promotes leadership skills, develops skills of organizing and presenting ideas to others in a logical form and develops a spirit of cooperation among learners. Despite the strengths, there are also limitations of discussion method which includes; time-consuming, can be used effectively with a limited number of learners, if not well handled some extrovert learners may dominate the discussion.

2.5.3 Brainstorming

Brainstorming is a teaching technique in which every pupil's response that applies to a given topic is acceptable (MIE, 2004). The strengths of brainstorming are; promotes exploration, analysis, and problem-solving skills, develop the sense of cooperation and group cohesiveness in problem-solving, encourages the generation of creative ideas, promotes the generation of initiatives in searching solutions to problems. The limitations of brainstorming are; it is time-consuming if not planned and also need thorough preparation.

2.5.4 Peer instruction

Peer Instruction (PI) is a research-based pedagogy for teaching large introductory science courses (Fagen & Mazur, 2013). It is a method created to help make lectures more interactive and to get students intellectually engaged with what is going on. Peer instruction provides a structured environment for students to voice their idea and resolve individual misunderstandings by talking with their peer (Gok, 2012). Peer instruction (PI) is a cooperative learning technique that promotes critical thinking, problem-solving, and decision-making skills (Rao & Dicarlo, 2000). This method has the advantage of engaging the student and making the lesson more interesting to the student. It also has the tremendous importance of giving the teacher significant feedback about where the class is and what students' understanding of the subject matter.

Despite these arrays of teaching methods being advocated in literature, there is no one universally accepted method. Both learners centred and teacher centred methods of teaching are important in teaching and learning (Haas, 2002; Globa, Wakadala & Bategeka, 2010), and each is appropriate depending on the environment within which they are used. For teaching to be more effectively done, a combination of these methods should be employed since education has many different types of approach and context.

Advantages of Student-Centred Methods of Teaching

- Students are giving the opportunity to ask questions
- Students are able to interact with each other
- Students collaborate with their teachers of instructors,
- Students participate actively during the lesson.

Disadvantages of Student-Centred Methods of Teaching

- It takes a longer time for students so it difficult to achieve curriculum objectives.
- It requires a skilful teacher for the lesson

It is also difficult for teacher to manage time and students

2.6.0 Teacher-Centred Methods of Teaching

Teacher-centred method of teaching also referred to as the traditional method of teaching usually involves educator-centred instruction, dominated by "chalk and talk" teaching, lecturing, note copying by learners, factual knowledge, abstract concepts, and demonstrations (Onwu & Stoffels, 2005). In a typical teacher centred science class, the educator provides a few examples or solves a few problems on the board. In some cases, the teacher performs experimental demonstrations. Learners in such classes listen to the educator and write notes, but hardly ever ask questions or make remarks (Briscoe & Prayaga, 2004; Kang & Wallace, 2005). This mode of handling science courses may cause students not to appreciate the nature of science. For example, a report by the Organization for Economic Cooperation and Development (OECD) Global Science Forum (2006) states that most learners at high-school level are of the view that science teaching lacks a sense of community, did not reflect their experience of the world or contemporary research, involves too much repetition, did not provide a good overview of the subject, and offers little room for discussion. Other researchers (McCarthy & Anderson, 2000) have indicated that the traditional ways of teaching science usually involve little active learning, and frequently cause learners to become disengaged and unmotivated. The subsequent sections examine the literature on some of the traditional teaching approaches used in the teaching of biology.

2.6.1 Lecture method

The lecture method is a one-way communication where teacher talks to students in an autocratic way and the student have no opportunity to ask questions or offer comments during the lesson (MIE, 2004). The strengths of a lecture method are, it is useful when introducing new subject matter or presenting overview summaries to students, and it can be used for teaching groups of any size and assists the teacher to cover a lot of content in a short space of time. Despite the strengths of lecture method, it has limitations. It does not consider; individual needs, feeling or interest of students. No feedback from students is required, if not properly planned can lead to boredom, the quality of learning through lecture is poor and not permanent. Finally, the teacher spends a lot of time preparing detailed notes which are rarely learned by the student.

2.6.2 Presentation method

Presentation method of teaching involves motivating listeners to accept a new idea, alter an existing opinion or act on a given premise. The strengths of the method include mastery of the topic by the students, increases confidence among students, is a good way to learn, student search a lot of books to collect material. Nonetheless, presentation method has the following disadvantages; learners may collect erroneous data, students with low confidence level may find it difficult to engage themselves in the activity, it is time-consuming as the presenter spends a lot of time gathering relevant information.

2.6.3 Seminar method

Seminar method is structured group discussion that may follow a formal lecture or some sort of experience (Kimweri, 2014). The strengths of the seminar method are to stimulate and test learners' ability of comprehension, promote learners' ability of understanding and questioning, develop learner's sense of self – reliance, cooperation and responsibility, ability in report writing and presentation to fellow learners for the exchange of view and decision making. The limitations of seminar method are; need enough time for the leaner or presenter to plan, some learners especially those who are shy and reserved may not be able to participate effectively during discussion, some learners, particularly the vocal ones might dominate the discussion.

2.6.4 Demonstration method

The demonstration method is a practical display or exhibition of a process to express clearly the fundamental principles or actions involved (Kimweri, 2014). Teaching by demonstration is a useful tool available to the teacher and plays an important part in the teaching of skills; however, for a demonstration to be effective, it should immediately be followed by a practical session in order to reinforce procedures (Kimweri, 2014). The strength of demonstration include; learners get the actual experience of what they are learning, interesting to learners and thus promote their attention and retention. The limitations of the demonstration method are; time-consuming and expensive, needs thorough preparation, practice and rehearsal before the session, enough teaching and learning materials are required to successfully conduct a demonstration, it is more appealing when used with a group that has a limited number of learners. Other methods of teaching are role play method, case study, and field trips.

2.7.0 Factors that Influence the Choice of Teaching Method

The choice of a method of teaching may be dependent on different factors. For example, knowledge of the teacher and flexibility of the learner (MIE, 2004). In order to make an informed choice of teaching method(s) in the teaching and learning process the teacher must know; the teaching methods available, the strengths and weaknesses of each method, the purpose that each can serve and how each method can be used in practice. Other considerations in choosing a method of teaching are the number of students to be taught, age, time, and prior knowledge of the learners.

2.8.0 Definition of Inquiry-based Learning

The National Science Education Standards (NSES) defined the 'inquiry-based learning as instructional activities as well as an instructional strategy. It determined that students can learn science and understand the nature of science through engaging in a discovery process that includes meaningful inquiry-based activities. Inquiry used as instructional method encourages students to engage in activities that develope their understanding of the natural world and physical concepts in biology education. The

NSES states, "Inquiry refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (NRC, 2006, p. 23)."

The key point is that the classroom inquiry emphasises not only "the process skills of doing tasks and solving problems, but also the cognitive abilities of critical thinking and reasoning" (Bybee, 2014, p. 29). For example, 5E inquiry cycle (Bybee, 2014) employs inquiry-based activities. A range of investigative activities could be involved in each 'E', including Engagement, Exploration, Explanation, Elaboration and Evaluation. Further, the process of 5E could also be regarded as instructional strategy when teachers implement instruction. This view is like the statement by the Framework for K-12 Science Education (NRC, 2012). This emphasises that "engaging in scientific investigation requires not only skill but also knowledge" (p. 30). It proposes placing the term "inquiry" under the umbrella term "practices". The practices are further explained by the Next Generation Science Standards (Achieve, 2013) with the following aspects:

(1) Asking questions and defining the problem;

(2) Developing and using models;

(3) Planning and carrying out investigations;

(4) Analysing and interpreting data;

(5) Using mathematics and computational thinking;

(6) Constructing explanations and designing solutions;

(7) Engaging in argument from evidence and

(8) Obtaining, evaluating, and communicating information.

All eight aspects will not necessarily be used in each inquiry-based activity, but these eight are the valuable rules that support the practices of inquiry in classrooms. Furthermore, it is argued that these are important for students to understand inquiry and develop the abilities of critical thinking.

Inquiry as instructional strategy was derived from the assumption that "what students learn is greatly influenced by how they are taught" (NRC, 2006, p. 28). The assumption indicates the importance the way in which teachers taught inquiry-based curriculum. Thus, the NSES published guidelines of teaching standards in order to guide teachers' instructional design. The guidelines request that teachers understand how scientists use scientific inquiry, and that this should be modified and adapted before teachers use inquiry-based instruction in classrooms.

Further, it is recommended that teachers use various instructional strategies to support learning (Bybee, 2014; NRC, 2006, 2012). As the NSES (NRC, 2012) notes, "Although the Standards emphasize inquiry, this should not be interpreted as recommending a single approach to science teaching (p.23)". Teachers are encouraged to use different instructional strategies to develop knowledge and abilities, such as, questioning strategies, heuristic strategies, cooperative learning, group discussion, public presentations and so on.

Based on the definitions of inquiry, a practical definition of inquiry was also provided to benefit teachers' understanding and application. The NSES issued the practical definition of classroom inquiry with five essential features, as noted below:

Table 1: Essential Features of Classroom Inquiry and their Variations

1	**2**	**3**	**4**	**5**
Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in question provided by teacher, materials, or other source
Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyse	Learner given data and told how to analyse
Learner formulates explanations from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence
Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use to sharpen communication	Learner given steps and procedures for communication

**Note: From Inquiry and the National Science Education Standards: A Guide for Teaching and Learning (p. 29)*

The NSES commented that it was not necessary to include all components presented in Table 1. The more coaching and scaffoldings the teacher provided to facilitate students' learning, the less student-oriented inquiry was conducted in the classroom, where students can experience student-oriented open inquiry, student-oriented guided inquiry, and teacher-oriented guided inquiry. And it did not mean that teachers must use either the student-oriented open inquiry or the teacher-oriented guided to facilitate students' learning. Sometimes, compared with the teacher-oriented inquiry, students who engaged in the student-oriented open inquiry often could not perform better. It was advisable for teachers to understand different types of inquiry-based approaches and know when they should use which one, or a mix of the approaches.

To summarise, this study defines inquiry-based learning as a type of instructional approach with three aspects. First, it is an instructional strategy that focuses on a learning process. Second, it includes different instructional activities that can engage students in the learning process. Third, it has different types of combinations that are flexible for teachers to use in different learning situations. It aims to develop students' understanding of the nature of science and scientific conceptions, the process skills of solving problems, and cognitive abilities of critical and logical thinking through a discovery process that supports continuous learning (Windschitl, 2004).

2.8.1 Student inquiry in education

Inquiry based learning encompasses the broader vision of what education should seek to accomplish: to support the growth of healthy, engaged individuals able to contribute their communities as satisfied, productive students, citizens and lifelong learners (Barron & Darling-Hammond, 2008; Noddings, 2005). Inquiry is defined as the dynamic process of being open to wonder and puzzlements and coming to know and understand the world (Alberta Learning, 2004). According to Branch and Solowan (2003).

Inquiry-based teaching (IBL) is a student-centered approach of learning focused on the asking of questions, critical thinking, and problem solving which enables students to develop skills needed throughout their whole lives. IBT can be implemented at different levels. These levels are constructed inquiry, guided inquiry, and free inquiry (Colburn, 2000). For the action research plan that follows, the researcher will be implementing a guided-inquiry method of IBT. In a guided-inquiry, the teacher provides guidance for the construction of questions, students plan their own questions and processes, and they generate new concepts by creating connections between prior knowledge and new information (Colburn, 2000). IBT provides students with knowledge and skill development, increase intrinsic motivation, development of expertise, self-efficacy, task commitment, positive attitudes about learning, competence or expertise, and greater creativity (Saunders-Stewart, Gyles & Shore, 2012).

Inquiry, as an instructional model, focuses on the process of learning and solving problems using a hands-on approach that involves reflection and evaluation in a cyclical manner (Dewey, 1938; Spring, 2005; Van Deur, 2010). Inquiry methods of learning provide opportunities for students to focus on the process of how they learn through questioning and reflection skills (Kuhlthau et al., 2007; Littky & Grabelle, 2004; Wiggins & McTighe, 1998). Inquiry skills are aligned with methods of learning that have been referred to as problem-based learning, authentic learning experiences, investigative processes, learning through lenses, and other activities that immerse students and teachers in both the making of personal connections and well thought out choices (Harvey & Daniels, 2009; Jacobs, 2010; Kuhlthau et al., 2007; Littky & Grabelle, 2004). Inquiry based learning allows students to make determinations about problems, challenges and issues they investigate, and helps to move the students' into a more meaningful engagement and deeper learning (Buchanan, Harlan, Bruce, & Edwards, 2016).

Gaining the skills of inquiry in education is important for students and their future as citizens in a democratic society. There are four forms of inquiry that are commonly used in inquiry-based instruction. They are confirmation inquiry, structured inquiry, guided inquiry, and open inquiry (Pappas, 2014). The first level of inquiry is confirmation inquiry in which students are provided with the question and method as well as the results, which are known in advance (Tafoya, Sunal, & Knecht, 1980). The second level of inquiry learning is structured learning where the students are introduced to the experience of conducting investigations or practicing specific inquiry skills like those of collecting and analyzing data (Banchi & Bell, 2008). The third level is 'guided inquiry'. Guided inquiry is an inquiry level where the question and procedure are provided by the teacher. However, the students arrive at an explanation supported by research they have collected (Tafoya et al., 1980). The final level of inquiry learning is free inquiry. In free inquiry, students form their own questions, design their own methods of investigation, and carry out the inquiry process without guidance from the teacher (Pappas, 2014). For the current research study, the researcher is implementing the 5E Model as the guided inquiry approach to learning. The 5E Model consists of five phases: engagements, explanation, exploration, elaboration, and evaluation (Warner & Myers, 2008). The 5-E Model of inquiry is organized around relevant, authentic problems or questions. The model places heavy emphasis on collaborative learning and activity.

Students are cognitively engaged in sense making, developing evidence-based explanations, and communicating their ideas. The teacher plays a key role in facilitating the learning process and may provide content knowledge on a just-in-time basis (HmeloSilver, Duncan, & Chinn, 2007). In guided inquiry, the teacher acts as a facilitator and provides scaffolding of the content whenever needed to ensure the correct flow of knowledge for students in the inquiry process. Scaffolding makes the learning more attainable for students by changing complex and difficult tasks in ways that make these tasks accessible, manageable, and within student's zone of proximal development (Rogoff, 1990; Vygotsky, 1978). With the teacher scaffolding the inquiry process, the students can engage in sense making, managing their investigations and problem-solving processes, and articulate on their thinking and reflect on their learning (Quintana, C., et al., 2004). While rote memorization is an important skill to master, inquiry is a skill that will take you into the 21st century and allows students to seek answers and find resolutions (Cox, 2009).

A study has found out that students in the 5E model instructed classes were more eager to share their own experiences and knowledge in relation to the content. Students were actively engaged in the lessons and activities and worked well with peers to accomplish assigned tasks. The students in the 5E model approach of instruction were more motivated to continue working and seek more depth in the content than those students in the traditionally taught class. Work returned and student dialogue that occurred in the 5E model class was far greater and more accurately detailed than that of the traditionally instructed classes. The response from the implementation from the 5E model of inquiry-based instruction had a positive impact on the attitudes and academic performance of students. The research found that student interest was increased which helped to develop mastery of concepts and an improvement in recall of knowledge. In a similar study, the constructivist approach to instruction was more effective in increasing the academic achievement of students when compared to students that received traditional instruction. Students in the inquiry-based instruction classes outperformed their traditionally taught peers with an average of 40% growth from the pre-assessment to the post-assessment. The researchers believe this growth occurred due to the nature of constructivism and inquiry-based learning as a vehicle to "encourage 50 students to discover or construct information by themselves" (Witt & Ulmer, 2010, p. 279 interests and questions" (Selwyn, 2014, p. 268). Some challenges do arise when trying to implement a constructivist approach to learning. Inquiry-based instruction and learning is affected by influences that can be overcome with the right guidance and support.

Challenges can be a lack of resources or multiple perspectives, not enough time to plan and properly implement inquiry lessons and assessments, the ease of direct instruction over inquiry instruction, limiting classroom disruptions, and the attitudes of teachers and students in the inquiry process. Inquiry-based learning cannot thrive on access to the textbook alone. (Selwyn, 2014). To assist in inquiry-learning, teachers must create useful inquiry questions that "are broad enough to offer depth and complexity and narrow enough to be meaningful and graspable" (Selwyn, 2014, p. 269). Good questioning grants teachers the opportunity to connect concepts and provide students with the necessary content needed to perform at high levels of mastery (Mathis, 2015). To build high-levels of mastery in the inquiry approach to learning, students must be given the opportunities to teach and learn from each other (Pahomov, 2014).

Collaboration is vital to the success of inquiry and most schools are not designed for inquiry with their desks facing forward in rows. But with collaboration, students can openly communicate with each other creating potential challenges to inquiry instruction. Disruptions in the learning environment happen even in the inquiry process. Some of the disruptions in this approach to learning are pressure to conform to majority opinion, domination of the group by one student, and members of the group not completing their share of the work (Burke, 2011). Teachers can overcome these challenges by using peer evaluations, grading students both individually and as a group, assigning specific roles to the students, creating team contracts with roles, rules, and expectations for the task, assisting groups in appropriate communication, giving feedback to groups as they are working, and giving inquiry time to occur (Barkley, n. d. Pahomov, 2014).

Another challenge is the impact of teacher and student attitudes on the inquiry process. Teachers that have never taught with a constructivist approach believe they have never opened to the learning theory due to "rigid curriculums, unsupportive administrators, and inadequate preservice and in-service educational experiences" (Brooks & Brooks, 2001, p. 101). Students, on the other hand, have more frequently been exposed to more teacher-centred instruction and have little to no experience in inquiry (Pahomov, 2014). To combat negative attitudes about inquiry for teachers and students, Brooks and Brooks (2001) offer these actions to bring about instructional change to inquiry learning. Brooks and Brooks (2001) assert that teachers need in-service programmes that revolve around constructivist approaches in pre-service education along with continued education and that resources and educational spending should be dedicated to teacher professional development. Student attitudes can be shifted toward inquiry when the content holds meaning to their lived experiences and the learning environment is "caring and fosters individual growth and isn't based on measuring one student against another" (Pahomov, 2014, p. 25).

2.9 Inquiry Teaching Methods

Four methods appear to be used most often, and while all four of these methods tend to overlap in some respects, there are distinctions among them are guided inquiry, field trip, Projects, group work.

2.9.1 Experimental projects

One way for students to understand how scientists think and work, and to acquire the skills and knowledge to think and act scientifically is for them to engage in long-term experimental projects. In one study, an instructor replaced the ecology and environmental science unit with a five-week long class project (Petersen, 2000), during which students conducted an experiment and analysed their results statistically. Students in these classes were required to perform all the tasks faced by contemporary scientists, including balancing a fictitious budget, and applying for collection permits. The subjects consisted of honours (corticated holders) students and regular students. Both groups showed development and improvement in interdisciplinary skills related to science, and a greater understanding of scientific papers and data interpretation. Interestingly, the honours students gained more understanding and appreciation for science than did regular students.

Other experimental projects include semester-long projects of original research. In one study, the instructor assembled a research team consisting of high school students, college undergraduates (one non-major), and a graduate student engaged in an original research project (Oates, 2002). This mix of students was used as an example of how students from different backgrounds, educational levels, and interests can all learn from one another. There were no formal labs that showed the students how to use pipettes, or colorimetric spectrophotometry, instead techniques were taught and used in context (Oates, 2002).

Having students engage in research allows the student to be more actively involved in their own learning and discovery. They also learn in context, which provides students a better mental framework in which to incorporate new knowledge (Seago, 2002). When engaged in open-ended research, the students also gain ownership of their learning (Grant & Vatnick, 2008). Once students engage in protracted research, they begin to learn how science is done, and thus gain an appreciation for science. Students also get an opportunity to practice thinking biologically and scientifically, which is what one must do while conducting research (Seago, 2002).

2.9.2 Problem-based learning

In problem–based learning (PBL) the instructor presents students with a problem, query, or puzzle that the learner wants to solve (Allen & Duch, 2008). What are presented to students are complex, real world problems that motivate students to identify and research concepts and principles they need to know to solve the problem. PBL was started in medical schools where students solved real patient problems using case studies (Herreid, 2013). This model was subsequently modified and applied in science courses (Herreid, 2013). The process of problem–based instruction (Boud & Feletti, 2011) is as follows:

A) Students are presented with a problem, and working in permanent groups, organise their ideas and previous knowledge related to the problem. The problem could be a case study, research paper, or videotape. Within their groups, the students attempt to define the broad nature of the problem. Problems are generally started with a brief introductory lecture (Allen & Duch, 2008). Then each group is presented with the first part of a problem. Groups are then asked to start identifying the broad nature of the problem and the major factors or issues involved.

B) During an initial brainstorming session groups organize their thoughts about the problem and critically analyse their initial ideas and solutions to the problem. Throughout these steps, members within the group recognize issues and concepts that they do not understand; these "learning issues" are recorded. In their discussion, students pose questions about aspects of the problem that they do not understand. In this, students start to define what they know and, more importantly, what they know. Learning issues are recorded by the group and help generate and direct discussion.

C) The group will reach a point where no further progress can be made until the group learns more about specific topics. Learning issues are prioritized, and the most effective ways of researching the learning issues are discussed. The first session ends and students are expected to return to the groups having investigated their learning issues. Before groups leave, learning issues are ranked in order of importance. Students then decide which questions the whole group, will follow up, and which issues can be assigned to individuals. Individuals who are assigned issues are expected to teach the rest of the group later. A discussion with the instructor outlines what resources are needed to research the learning issues and where they can be found.

D) The second session begins with group members communicating what they have learned. The learning issues can then be revisited from a perspective of deeper understanding, integrating new knowledge into the context of the problem. While students discuss in groups, they continue to define new learning issues as they progress through the problem. During any of the above activities, the problem–solving process can temporarily be interrupted by short lectures, discussions, or group assignments to help clarify concepts. Once the instructor is satisfied that the student groups have arrived at a conclusion, the solution to the initial problem can be summarized in a wrap-up discussion. Students are also encouraged to summarize their knowledge and connect new concepts to old ones. For complex problems, additional stages may be added that require a more in–depth analysis, and the cycle of activities described above continues.

The PBL process fosters the ability to identify information that is needed for a application, where and how to seek information, how to organize information into a meaningful conceptual framework, and how to communicate that information to others (Allen & Duch, 2008). Students also begin to recognize that knowledge transcends artificial boundaries because problem–based instruction highlights interconnections among disciplines and the integration of concepts (Allen & Duch, 2008).

2.9.3 The learning cycle method

The learning cycle approach to teaching consists of three to five phases. In the three-phase model, the first phase is the Exploration Phase, where students generally interact with each other to solve a problem or complete a task (Allard & Barman, 2004). The problem is open-ended to allow students to be creative yet directed in their problem solving. In other words, the problem does not have just one answer or one way of arriving at the answer. However, the instructor can narrow the field of possibilities. This phase also allows students to share ideas about something that is familiar to them, and try to relate the problem to different concepts (Beisenherz et al., 2011). For example, to begin a unit on cells, students may investigate the differences between plant and animal cells by observing different specimens with a microscope, then draw and discuss observed differences (Allard & Barman, 2004).

During the second phase, concept introduction, students are introduced to the main concepts of the lesson, and any pertinent vocabulary. Here, students report findings accumulated during the exploration phase. The instructor then uses the information provided by the students as a springboard to discussions, for example: on the differences between plant and animal cells (Allard & Barman, 2004).

The final phase of the learning cycle is concept application. During this phase, students study additional examples of the main concepts. This may lead to a new task where students are asked to apply concepts they have learned to new situations. For instance, identifying unknown cell specimens (Allard & Barman, 2004). In an example in plant nutrition (Lee, 2003), the instructor started the lesson with the open-ended question, “What do plants need to live?” After a period of open discussion, the instructor started to guide students to think about the raw materials necessary for plant growth. The exploration phase could then begin with students setting up a host of experiments to determine what nutrients that may be necessary for plants to live and grow. Students were expected to collect data for several weeks. After the experimental phase was complete, the instructor introduced reading assignments on nutrient effects on root and shoot growth. Applications from this point could vary widely from chemical testing in soils, to the use of different types of fertilizers (Lee, 2003).

In the 5E model, two more phases have been added to the learning cycle (Llewellyn, 2002). In the 5E model, the first phase is Engagement. Here the teacher sets the stage for the lesson, explains the objectives, and focuses the students' attention. During the Engagement phase the instructor can also assess prior knowledge, and have students share their experiences, in true constructivist fashion (Llewellyn, 2002).

The second phase is the Exploration phase. Here students raise questions and develop hypotheses to test. The instructor is not directly involved with the students, while they gather evidence and data and share with other groups.

The third phase, Explanation, is more instructor-directed. Here the students are guided through data-processing techniques, and how their data relate to scientific concepts. The instructor may introduce more details and vocabulary to provide a common language for discussion of their results (Llewellyn, 2002).

The fourth phase is the Elaboration or Extension phase. The instructor reinforces concepts by applying gathered evidence and data to new and real-world situations. This places the new knowledge within the students' conceptual framework.

The final phase of the 5E method is the Evaluation phase. During this phase the instructor and the students summarize the relationships among the variables in the experiment. In addition, the instructor poses questions to the students to get them to make judgments and analyse their own work (Llewellyn, 2002). The instructor can make comparisons between knowledge shared in the Engagement stage and new knowledge acquired throughout the lesson. This evaluation then may lead to another Engagement.

The most noticeable difference between the learning cycle and traditional teaching methods is that in the learning cycle the laboratory, or exploratory, experiences come first. In traditional lecture/lab situations, the labs are performed after the teacher has discussed the topic and the laboratory is purely for verification and reinforcement. In these traditional exercise students are rarely engaged mentally (Colburn & Clough, 2007), rather they are performing steps in a cookbook with a predetermined outcome.

2.9.4 Scientific inquiry method

The NSES (NRC, 2006) describes inquiry as follows:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as, an understanding of how scientists study the natural world. Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyse, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations (p. 23).

The American Association for the Advancement of Science, AAAS (2013) defines scientific inquiry similarly:

Scientific inquiry is not easily described apart from the context of investigations. There simply is no fixed set of steps that scientist always follow, no one path that leads them unerringly to scientific knowledge. There are, however, certain features of science that give it a distinctive character as a mode of inquiry. Although those features are especially characteristic of the work of professional scientists, everyone can exercise them in thinking scientifically about many matters of interest in everyday life (p. 4).

Scientific inquiry learning can also be viewed as a cycle (Llewellyn, 2002):

1) Inquisition: The lesson starts with a question to be investigated.

2) Acquisition: Students brainstorm possible solutions to the problem.

3) Supposition: Students select which solution to test.

4) Implementation: Students design and carry out an experiment.

5) Summation: Upon collecting evidence, students draw conclusions.

6) Exhibition: Students communicate their findings to other students.

During the exhibition phase, students may discover more questions to be answered, and thus start back at the inquisition phase.

One difference from the learning cycle is that during the learning cycle, the second step is devoted to learning the terminology and the main concepts. This is absent in the scientific inquiry method and could be done before, during, or after the inquiry process. The scientific inquiry method more closely models the scientific method and that which scientists do every day (Windschitl & Buttemer, 2010), than does the learning cycle. The scientific inquiry method develops science process skills; this is an intellectual ability (Basaga et al., 2004). These process skills, once learned, can then be used to formulate responses to questions, justify points of view, interpret data, and explain events and procedures (Basaga et al., 2004). The scientific inquiry method is more flexible than the learning cycle, and is more representative of how scientists engage in problem solving. While some instructors may use the structured steps, as outlined above, others may wish to leave the process more flexible.

To be sure, the differences between the four outlined methods are subtle, yet may be outlined as follows: The experimental projects method involves more long-term projects that may have research teams and even fictitious budgets. Problem-based learning generally employs case studies. The learning cycle is a structured method that may give inexperienced students a better idea of the process of science. Finally, the scientific inquiry method is somewhere in between these methods. It allows for the flexibility of short and long-term projects, it may follow defined steps, or allow students the freedom to jump around within the process, and it may start off with a case study.

2.9.5 Inquiry-based learning method

The inquiry-based learning method is a teaching technique in which teachers allow students to learn through discovery. Inquiry based learning demands that students are actively participating in their own learning (Education Broadcasting Corporation, 2004). Research shows that active teaching methods, like inquiry, are found in the opinion of most students to be more useful (Stewart-Wingfield et al., 2005). Inquiry based methods allow for students to interact with their surroundings, ask questions, and draw conclusions by thinking critically and logically (National Science Teachers Association, 2004). Inquiry based learning especially lends itself to teaching science courses because of its investigative nature.

Science courses require students to learn the scientific method and perform scientific inquiries. Inquiry based learning builds on the required scientific curriculum and elevates the cognitive development of students to the highest levels of bloom's taxonomy (Mysliwiec, 2015; Shields, 2006). The National Science Teachers Association posted a position on scientific inquiry, which said, "understanding science content is significantly enhanced when ideas are anchored to inquiry experiences" (p. 1). The association also recommended that all educators need to make inquiry based learning the focus of their science classes (National Science Teachers Association, 2004). According to both the Georgia and Virginia State Standards for Biology, students are required to obtain higher levels of cognitive development by not only observing and recalling information, but also by analysing and evaluating (Georgia Department of Education, 2016; Virginia Department of Education, 2013). Inquiry based methods allow for higher levels of cognitive development to be reached by students (Mysliwiec, 2015).

2.10 Guided Inquiry in Science Classrooms

There is no doubt that further research is needed to understand how different types of instructional approaches can be implemented in science classrooms (Bunterm et al., 2014). While research seems to agree on the effectiveness of both open and guided inquiry-learning approaches, the more appropriate type of teaching and learning remains controversial (Sadeh & Zion, 2009). Proponents of open-inquiry learning, a type of learner-centred approach that allows the learner to take charge of his/her own learning process, claim that it enhances the student's levels of inquiry and their logical thinking skills (Berg, Bergendahl, Lundberg, & Tibell, 2003; Germann, Haskins, & Auls, 1996). By contrast, those who are in favour of a guided inquiry-approach laud the efficiency of this method in preventing a waste of time and in reducing student frustrations at unexpected results (Trautmann, MaKinster, & Avery, 2004).

Although there is an extensive empirical literature comparing inquiry approaches against non-inquiry-based approaches, there are only a few studies that focused on studying the effectiveness of the guided inquiry-based approach in the biology classroom (Blanchard et al., 2010). Blanchard et al. (2010) found that the guided inquiry-approach is more effective than the open-inquiry approach in enhancing both the science process skills and the content-knowledge of students. In their study, Blanchard et al. (2010) compared the pre, post, and delayed post-tests results of high and middle school students who were taught using either open-inquiry or guided-inquiry approaches.The results generally indicated that students, who were taught using the guided-inquiry approach and particularly in high school, produced better results and stronger growth in their understanding than did the students in the open-inquiry group. The guided inquiry approach also showed its efficacy in other developing countries such as Thailand. Bunterm et al. (2014) studied the effects of guided-inquiry versus other traditional methods on 239 secondary school students in three schools in Thailand. The measures in this study were science process skills, content knowledge, and scientific attitudes. Although the results showed variations between the three schools in the scientific attitudes and content knowledge, there were greater improvements for students in the guided-inquiry condition in both science content knowledge and science process skills Granger (2010) investigated the effect of the guided-inquiry approach on science process skills and scientific problem-solving. The research reported that the use of a guided-inquiry approach improved the learning of science process skills.

Additionally, Roth and Choudhary (1993) examined the development of biology process skills in the context of guided inquiry laboratory sections. The approach of the study was qualitative. The results showed that students developed higher order process skills. Students learned to (a) identify and define pertinent variables (b) interpret, transform, and analyse data (c) plan and design an experiment (d) formulate a hypothesis.

Guided inquiry may be used in the biology classroom to enhance the academic achievements of students in concepts like classification. The concept of classification provides a challenge for high school teachers because it requires students' dealing with abstract reasoning. Research indicate that classification is a complex concept and is thus difficult for the students to master (Dawkins et al., 2008). This difficulty can be associated with different factors. Among them may be the abstract nature of classification.

In the traditional modes of instruction, however, classification is taught using the chalk and talk method. Smith et al. (2017) indicated that in such traditional model, the students are rarely encouraged to interact with each other or to reason about the phenomena, which often leads to a lack of conceptual understanding and scientific explanations of classification. Teachers' pedagogical practices are an effective tool for enhancing the quality of students' explanations of science phenomena (Osborne, Erduran, & Simon, 2004). In a guided-inquiry classroom, the teacher's role is essential in supporting the students' constructions of evidence-based, scientific explanations (Duschl & Osborne, 2002; McNeill & Krajcik, 2008). Studies indicate that students' understanding of abstract concepts such as classification, can be enhanced when they engaged in inquiry-based learning experiences (Austin, 2005).

During the inquiry phases, the learners' roles should be distinguished from the teachers' roles and, thus, more opportunities for students should be provided for them to reason about evidence, to modify their ideas in the light of this evidence and to develop 'bigger' ideas from 'smaller' ones. Bybee (2014) identified the teacher's role as a guide for students' learning in the five phases of guided inquiry. The engage phase which is the beginning of teaching provides opportunities for teachers to elicit students' prior knowledge, which in turn can be used to review and resolve inconsistent views in the second phase (explore). The teacher's role in the explore phase is to listen, observe, and guide students as they clarify their understanding. In the explain phase, the teacher establishes linkages and relationships between students' prior knowledge and new learning experiences leading them to construct an evidence-based explanation. Students in the elaborate phase are challenged with a new situation to apply the learned concept and encouraged to interact with each other and with other resources. Finally, in the evaluate phase, the teacher should involve students in experiences that are understandable and consistent with those of prior phases and congruent with the explanations (Bybee, 2014). In so doing, teachers learn about students' conceptual understanding and can provide effective teaching, creating more opportunities for student-oriented learning.

2.11 Effect of Inquiry Approaches on Students' Interest in Learning Biology

Inquiry based learning encompasses the broader vision of what education should seek to accomplish; to support the growth of healthy, engaged individuals able to contribute to their communities as satisfied, productive students, citizens, and lifelong learners (Barron & Darling-Hammond, 2008; Noddings, 2005). These levels are constructed inquiry, guided inquiry, and free inquiry (Colburn, 2000). For the quasi experiment that follows, the researcher will be implementing a guided-inquiry method of IBL. In a guided-inquiry IBL model, the teacher provides guidance for the construction of questions, students plan their own questions and processes, and they generate new concepts by creating connections between prior knowledge and new information (Colburn, 2000). IBL provides students with knowledge and skill development, increased intrinsic motivation, development of expertise, self-efficacy, task commitment, positive attitudes about learning, competence or expertise, and greater creativity (Saunders-Stewart, Gyles, & Shore, 2012). Inquiry, as an instructional model, focuses on the process of learning and solving problems using a hands-on approach that involves reflection and evaluation in a cyclical manner (Dewey, 2013; Spring, 2014; Van Deur, 2010). Inquiry methods of learning provide opportunities for students to focus on the process of how they learn through questioning and reflection skills (Kuhlthau et al., 2007; Littky & Grabelle, 2004; Wiggins & McTighe, 1998). Inquiry skills are aligned with methods of learning that have been referred to as problem-based learning, authentic learning experiences, investigative processes, learning through lenses, and other activities that immerse students and teachers in both the making of personal connections and well thought out choices (Harvey & Daniels, 2009; Jacobs, 2010; Kuhlthau et al., 2007; Littky & Grabelle, 2004). Inquiry based learning allows students to make determinations about problems, challenges, and issues they investigate, and helps to move the student into a more meaningful engagement and deeper learning (Buchanan, Harlan, Bruce, & Edwards, 2016).

Gaining the skills of inquiry in education is important for students and their future as citizens in a democratic society. However, educational reforms are putting teachers into a state of standardized testing that focuses more on the standards taught than the skills students need to thrive in Senior High School society. A consequence of these government educational policies is that students enter biology classes without subject knowledge and without any skills or experiences in Biology (Selwyn, 2014). Students come to these classes trained to follow the teacher's direction and learn the content standards for the benefit of a good performance on the state-mandated testing. These tests narrow the possibilities of the curriculum and limit the ability of the teacher to address the inquiry needs of the students (Au, 2013). Content control focuses on the idea of "teaching to the test." Within this level of control, the teacher focuses more on teacher-centred instruction where students are less likely to engage in inquiry learning or critical analyses (Au, 2013). As Ross (2000) points out, "the dominant pattern of classroom biology pedagogy is characterized by text-oriented, whole group, teacher-centred instruction, with an emphasis on memorization of factual information" (p. 47). Standardized test measures are geared at finding out how well students will perform on achievement measures rather than focusing on whose knowledge, language, and points of view are most worth learning (Sleeter & Stillman, 2013). Biology teachers are more inclined to narrow the content to match the tests, adopt more teacher-centred instruction, and resort to fast paced lectures to cover the content in a timely manner (Smith, 2006; Vogler, 2005; van Hover & Heinecke, 2005).

Eisner (2013) believes the function of school should focus on enabling students to do better in life and not just to do well in school. In order to seek this opportunity for all students, educators must demand more than rote memorization of facts for students and the biology content. A school that limits the curriculum to teaching to the test is assisting in undermining the opportunity for students to be curious and interested in engaging and challenging ideas (Eisner, 2013).

For when students are engaged and challenged, thinking is being promoted (Eisner, 2013). Teaching biology allow teachers to open the minds of students and allow the student to see the connections in nature. When students walk into a classroom they come with different viewpoints and pathways about nature that make their own experiences unique. Biology can foster those characteristics that make us different and use them to make us more aware of the beauty and diversity in nature. For students to engage in effective inquiry, the teacher must provide a classroom that rests upon positive connections between the teacher and the student, positive relationships between peers, ample time for students to speak with one another, and a classroom that fosters empathy (Cooper & Murphy, 2016). Creating an atmosphere for open-dialogue can help to build bridges between different people from different social backgrounds. This is becoming increasingly important as our society continues to become more diversified (Zúñiga, 2013).

2.12 Theoretical Framework

The theoretical framework that guided this study was based on Bybee's 5E learning cycle model which is an approach model (Llewellyn, 2002). The 5 E learning cycle model sequences learning experiences so that students could construct their understanding of a concept during the teaching and learning process (Bybee, 2014). The model leads students through five phases of learning that are easily described using words that begin with the letter E: Engagement, Exploration, Explanation, `Elaboration and Evaluation as presented in the figure below.

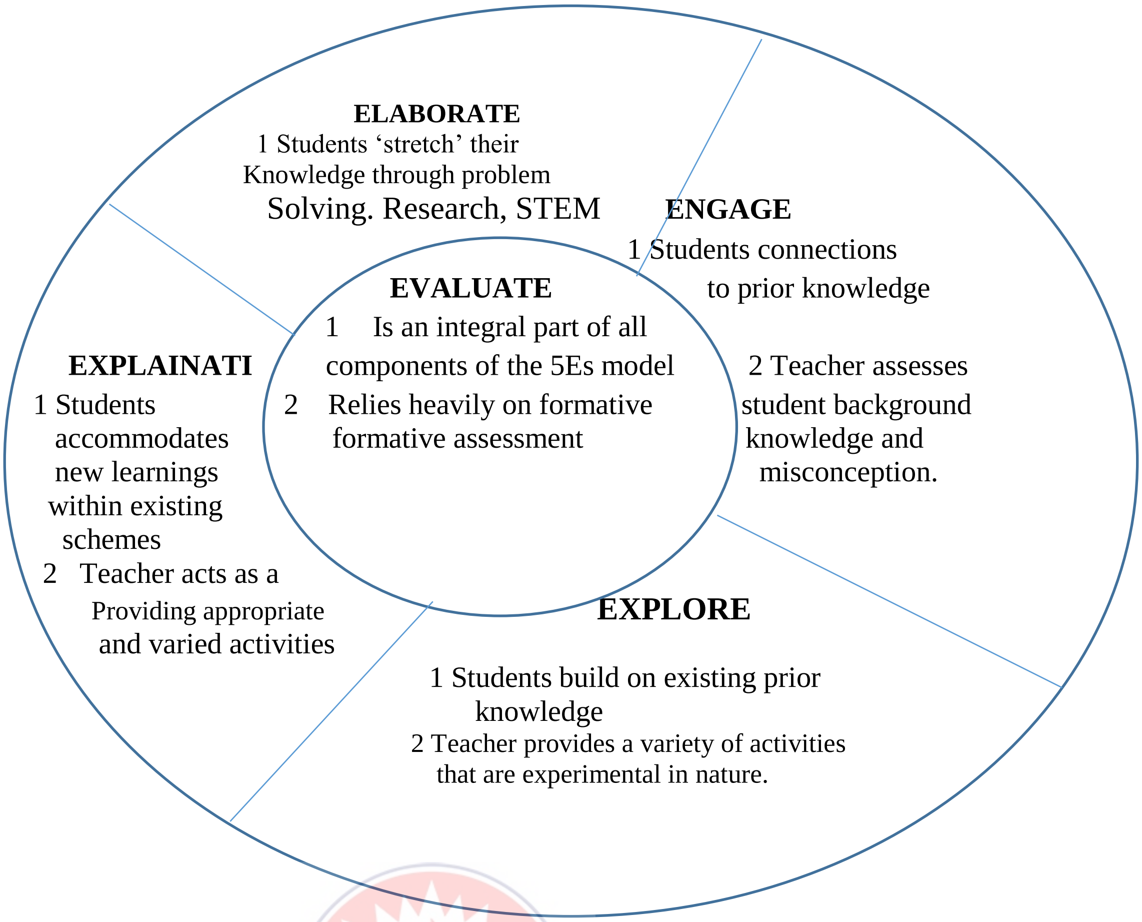

Figure 2: Bybees's 5E Learning Cycle Model: (Bybee, 2014)

In the engagement phase the teacher captures students' interest and makes them curious about the topic and concepts to be learnt. This phase provides an opportunity for the teacher to find out what students already know or think they know about the topic and concepts to be developed (Bybee, 2014). In the exploration phase students interact with materials and ideas through classroom and small group discussions (Llewellyn, 2002). This helps the students to acquire a common set of experiences so that they can compare results and ideas with their classmates. In the explanation phase students are provided an opportunity to connect their prior experiences with current learning and to make conceptual sense of the main ideas. This phase also provides the opportunity for the introduction of formal language, scientific terms and content information that might make students' prior experiences easier to describe. In the elaboration phase students are provided with the opportunity to apply introduced concepts to new experiences (Llewellyn, 2002). This phase helps students to make conceptual connections between new and prior experiences, connect ideas and deepen their understanding of concepts and processes. In the evaluation phase that is centrally placed in the model and takes place virtually in every phase of the 5E learning cycle model provides a summative assessment of what students know (Bybee, 2014).

Jones' Music Model of Academic Motivation was also applied in this study. The Music Model of Academic Motivation consists of psychological components that have been derived from research and considered to be critical to student engagement during content presentation (Jones, 2009). This model integrates aspects of existing motivation constructs that are important for secondary school biology teachers to consider in classroom settings. IBT approach combined with Bybee's 5E Learning Cycle model may provide students with a wider range of learning experiences within the concepts in biology. This may lead to deeper conceptual understanding and skills development which may enhance students' academic performance and attitude in biology.

2.13 The Effectiveness of Inquiry-Based Learning

A significant number of research studies have proved that IBL has a positive effect on students' learning in science education, especially when compared with traditional laboratory instruction that seems minimally effective in meeting educational goals (Bybee, 2014; Duschl & Osborne, 2002). "In general, research shows that inquiry teaching produces positive results" (McCarthy & Anderson, 2000, p. 4); and "there is substantial empirical and theoretical evidence that inquiry-based instruction is a starting point for personal construction of meaning and can lead to higher achievement of all students" (Von Secker, 2002, p. 151).

In order to investigate the effectiveness of inquiry-based learning, Shymansky (1983) conducted a large-scale analysis of existing research studies. Shymansky systematically analysed 105 experimental studies within 27 inquiry-based curricula, and found that students with inquiry-based instruction had higher achievement test scores compared with the students taught with traditional instruction. Analysis of the 2018 National Education Longitudinal Study (Kenya, 2012) data showed that 7642 10 students' who used inquiry-based instructional activities performed better than those without the same activities (Von Secker 2002). Similarly, the study of Brunkhorst (1992) found that the mean score of 280 students who participated in inquiry-based curricula outperformed 87% of the scores in the national sample.

Further, Mattheis (1988) found that inquiry-based science instruction supported students' performance in graphing and data-interpretation skills. Von Secker (2002) found a significant positive effect on students' conceptual understanding when students who had inquiry-based instruction were measured by achievement tests in science. And Gerber (2001) found that inquiry-based instruction also effectively improved students' reasoning ability. The use of inquiry-based instruction is striking in that the grade 9s gained more than the grade 10s on the same science test, because the grade 9s engaged in inquiry-based activities, while the grade 10 students did not participate in the activities (Kelly, 2006; Rickles et al., 2005).

2.14 Limitations to Inquiry-Based Learning Approach

Despite the general assumption that inquiry-based learning leads to effective conceptual understanding, its effects are challenged by practical implementation. The TIMSS 1999 Video Study (NCES, 2006) reported that less than 15 hours out of 88 were used for grade 8 science lessons with inquiry-based teaching. Almost 60 hours were spent developing instructional content, such as students' learning about facts, the definition of physical concepts through memorising, and repeating procedural experiments. The same situation was also reported by the National Research Council, which stated that the inquiry-based instruction in science laboratories in the US was conducted without clear learning goals: "teachers and laboratory manuals often emphasize the procedures to be followed, leaving students uncertain about what they are supposed to learn" (Singer, 2005, p. 133).

Why inquiry-based instruction is strongly advocated but seldom taking place in real-life classrooms? Studies have identified some problems that teachers encounter in practicing inquiry-based instruction (Jones et al., 2009), such as lack of knowledge of the scientific inquiry, incompetent instructional management, inexperienced pedagogical content, teachers' uncertain beliefs, lack of time and professional supports, risky experiments, inability to track the inquiry process, expensive experimental equipment, and so on.

Additionally, studies comparing the effects of inquiry-based learning to more traditional instructions found unstable evidences in its favour. As Metz (2004) explains, "simply engaging students in 'inquiry' is insufficient to bring about these desired changes" (p. 220). Furtak (2012) argue the inconsistent performances were because of disagreements among researchers about the features of inquiry-based instruction. Again, more studies noted that inquiry-based learning, when it has appropriate scaffolds, can help student learn concepts (Kirschner, 2006; Mayer, 2004).

Another challenge is the impact of teacher and student attitudes on the inquiry process. Teachers that have never taught with a constructivist approach believe they have never opened to the learning theory due to "rigid curriculums, unsupportive administrators, and inadequate preservice and in-service educational experiences" (Brooks & Brooks, 2001, p. 101). Students, on the other hand, have more frequently been exposed to more teacher-centred instruction and have little to no experience in inquiry (Pahomov, 2014). To combat negative attitudes about inquiry for teachers and students, Brooks and Brooks (2001) offer these actions to bring about instructional change to inquiry learning. Brooks and Brooks (2001) assert that teachers need in-service programs that revolve around constructivist approaches in preservice education along with continued education and that resources and educational spending should be dedicated to teacher professional development. Student attitudes can be shifted toward inquiry when the content holds meaning to their lived experiences and the learning environment is "caring and fosters individual growth and based on measuring one student against another" (Pahomov, 2014, p. 25).

2.15 Empirical Framework

Research has shown implementation of IBT, is more effective than traditional learning, TM, for increasing student achievement (Baker & Robinson, 2018). Saunders-Stewart, Gyles, and Shore (2012) discovered and established 23 learning aspects and outcomes through IBT and showed recall and retention of knowledge were more predominant with IBT strategies. Abdi (2014) conducted a study in a fifth-grade primary school in Kermanshah, Iran and found that students who were instructed using IBT had higher academic achievement than students in a TM classroom. Throughout the study, a control group of 20 female students and an experimental group of 20 female students were compared. While the control group was given a lesson through traditional teaching strategies such as direct instruction, the experimental group received a lesson through inquiry-based instruction. Abdi

(2014) began the study by giving both groups an academic achievement pre-test. The test contained 30 multiple-choice questions to assess student achievement. Both groups were taught a lesson on three units on the fifth-grade content including topics of the nervous system, human diseases, and environment (Abdi, 2014). Both groups were given a lesson presented by the same instructor and classroom observations were conducted to ensure the implementation of the treatments. Students within the experimental group were given lessons and activities designed around a learning model called the 5E Learning Cycle Model., and evaluation and is centered on cognitive psychology and practices in science education (Bybee & Landes, 1990, as cited in Abdi, 2014).

The control group was given the lesson through direct instruction, lecture, and discussion in order to present the concepts. After the lesson, a post-test identical to the pre-test was given to the students. Based on the results, the mean score from the pre-test to post-test for the experimental group increased by 4.15 points. In contrast, the mean score from the pre-test to post-test for the control group only increased by 3.4 points (Abdi, 2014). Abdi concluded that there was a significant relationship between IBL and student achievement in biology, and those students exposed to IBL had a deeper understanding of the material and could further interpret the information. Through implementation of IBT, students interact with the relationships of scientific material, obtaining long-term knowledge and retention. Science knowledge and information should be transmitted through active and critical thinking of the learner (Cakir, 2008). Abdi (2014) discussed how IBT can be implemented to increase student achievement as well as longer term retention and application of interpretation.

IBT allows learners to construct and develop long-term ideas and knowledge through scientific experiences and skills (Schmid & Bogner, 2015). Schmid and Bogner (2015) conducted a study in Bayreuth, Germany with 138 ninth graders from 10 classes and four schools to examine the effects of inquiry-based science education on learning outcomes and long-term knowledge. They hypothesized that students who participated in a structured inquiry-based science unit would have a significant increase to their content knowledge. Their theory was developed around the idea of exposure to IBL and its connection of long-term knowledge retention. With IBT, students could activate prior knowledge, build upon newly gained information, and retain content knowledge based upon relevant and personal connections (Abdi, 2014).

Schmid and Bogner (2015) also hypothesized students learning and experiencing through IBT would develop a deeper understanding and long-term retention of the content material in both student genders. Throughout the study, Schmid and Bogner (2015) presented a topic on air and sonic waves to both an experimental and control group. Both groups were instructed by the same instructor to ensure teaching style was consistent. The control group consisted of 64 students from three classes and they did not take part in IBT. The experimental group consisted of 74 students from seven classes and were exposed to IBT for long-term knowledge retention. The experimental group was given four questionnaires which were completed over the course of a 14-week schedule. The questionnaires included a diagnostic test which was presented two weeks prior to the unit lesson, a post-test which was presented directly after the lesson, and a second and third post-test which were given at the six- and 12-weeks mark after the lesson. The unit consisted of three sequential lessons at 45 minutes each, all relating to the topics of how humans hear and the definition of sound (Schmid & Bogner, 2015). In the experimental group, students conducted inquiry-based projects in small groups. Each group member was given a role that was switched between the four members of the group. The roles included reading text out loud, collecting correct experimental equipment from areas, conducting the experiment, and writing the group's analysis and conclusions.

Schmid and Bogner (2015) explained that the teacher was only a guide to lead students to a solution when issues were raised, and students' only source of information was the inquiry lesson (Schmid & Bogner, 2015). The results showed through the diagnostic test that there was a mean score of 5.9 and rose significantly on the post-test given directly after the inquiry lesson to a mean score of 12.00. The second post-test given six-weeks after the lesson had mean score of 9.9, showing a slight decrease. The post-test given at 12 weeks after the inquiry lesson had a mean score of 9.8 showing a slight decrease from the six weeks post-test (Schmid & Bogner, 2015). These results strongly support the hypothesis IBT promotes formation of long-term retention and recall of knowledge. The control group did not practice content knowledge skills through the repeated completion of the content knowledge tests and there were no significant impacts on their knowledge scores of the four assessments (Schmid & Bogner, 2015).

2.16 Summary

The literature showed that several pieces of research were conducted on this topic up to date. However, results of existing studies surprisingly show no reliable empirical evidence supporting the link between inquiry-based teaching and student achievement in biology, as the existing studies have produced mixed findings with some suggesting a positive relationship and others suggesting no relationship in various subject areas and various levels of education. Therefore, a conclusion cannot yet be drawn as to whether inquiry-based Teaching positively influence students' biology achievement at all levels. Further research is, therefore, needed to make conclusive judgement about the link between inquiry-based learning and students' achievement in biology.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Overview

This chapter presents a discussion of the research procedure that was followed in the study. It includes the research design, study sample and sampling procedures, development, and validation of research instruments. It also examined the reliability of the instruments and data analysis procedures. The pre (experimental group) - and post (the control group) treatment findings, as well as the implementation procedure, are also discussed.

3.2 Research Design

This study adopted a quasi-experimental design involving Non-Equivalent Control Group design. Basically the design is structured as pre-test and post-test comparison groups. This is because there was non-random assignment of students to the groups. According to Bybee (2014), a quasi-experimental design involves the use of an existing control group that is like the experimental group but is not created by a random assignment of subjects to groups.

The methodological shortcomings of quasi-experimental design were acknowledged in the study. These include the difficulty of controlling extraneous variables, complications of comparing non-equivalent groups resulting from non-random assignment of participants to the control and experimental groups (Gall & Borg, 2007). Consequently, several measures were taken, as attempts to minimize the effect of variations in the selected group. First, pre-tests were administered to participating students in order to compare their competencies on Classification of living things before the treatment. Again, Senior High School classes exist as intact groups and school authorities do not normally allow the classes to be dismantled and reconstituted for research process (Shadish, Cook & Campbell, 2002). Quasi-experimental researches are used in the evaluation of teaching interventions because it is not practical to justify assignment (Randolp, 2018).

A predominantly quantitative research approach was necessary for the study because it was consistent with the nature of the main research questions. A quantitative research approach also provided the advantage of being able to measure and compare the performance of many learners in the form two (SHS2) Biology classes, and still be able to present the findings in a concise but efficient manner (Gall & Borg, 2007). Moreover, a quasi-experimental design was used because unlike the true experiment, the participants of this study were not randomly assigned to groups in order that normal class schedules are not distracted.

3.3.0 Population

The target population of this study comprised all senior high school students in Tamale Senior high school, at the time of the study in the Northern region. The accessible population, however, comprised all form two Biology students within the school. The school has a population of 3592 students, 2020/2021 Academic year. The school runs seven different programs, General Arts (AG), General Science (GSC), Agriculture Science (AG), Business (BS), Visual Arts (VA), Home Economics (HE) and Technical (TC). The accessibly population for the study consisted of 573 Biology students distributed among form two biology classes. There are twenty two Biology classes in the school. The large number of classes is due to current educational reforms at the SHS. The school runs the double track system, where we have Gold and Green tracks for the form three and form two students and single track for the form ones(SHS1), But for the current study in based on the green track system.

There are four professional Biology teachers in the school with other teachers with biology background teaching the subject Biology in the school.

The school lacks professional trained Biology teachers as well as science teachers in general due to the introduction of the double track system and the free educational policy which was established 2017 in the country. This has led to increase number of students in the school and classes.

3.2.1. Sample and Sampling Procedure

A sample of 200 (106 male, 94 females) hundred students who study Biology as one of their elective was purposely selected for the study. Purposive sampling technique was used to select the participants because it deals with conscious selection of people with a set of attributes that have effect on the issue of interest and ensure comprehensive representativeness (Stringer, 1996; O' Lery, 1990). This goes to indicate that a particular sampling unit to be selected for the sample depends on the subjective, or judgement of the researcher. Notwithstanding the subjectivity of this sampling procedure, the actual structure remains the same (Depoy, Gitlin, 2011), as noted by Patton (2002), 'The logic and power of purposeful sampling lie in selecting information-rich cases for the study. Information-rich case are those from which one can learn a great deal of central importance to the purpose of the inquiry.''(p.230).

Several reasons might have been accounted for choice for the sample, but there are three main reasons that accounted for the choice of SHS Two (SHS2) students for the study. Firstly, the SHS 1, students had just begin the secondary school system, coupled with the fact that, we are still on the introductory topics to senior high school biology of which the topic under study ''Classification of Living things'' is only taught in SHS 2. Secondly, the SHS3, are about existing , and for that matter preparing seriously for their final West Africa Secondary School Certificate (WASSCE), Again, the school authorities would not approved such group for the study. Thirdly, The topic 'Classification of Living things' is one of the first semester topics to be taught in the biology syllabus which is expected to be covered by any biology student in the second year for that matter, the SHS 2 students were the cohort of students more likely to give appropriate or fair responses on the attitude instrument. Again, the topic classification is the topic provides the basic understanding for students' into other topics such 'Introduction to lower organisms', Interaction in nature 1&2' among other topics.

3.2.2. Instrumentation

The main instruments used in this study include a closed-ended questionnaire and a set of pre- and post-assessment questions test items on the topic ' Diversity of Living things in biology' (Appendix B). The Biology attitudinal questionnaire to assess students' attitude towards biology'.

3.3.0 Questionnaire

A biology attitude questionnaire [BAQ] (Appendix A) was developed by the researcher based on extensive literature review on areas related to students' attitude towards biology. These areas include; students attitude towards science, students attitude towards biology. At this stage, a pool of twelve items was generated/ designed using the content of the areas reviewed as a guide. The items consisted of both negative and positive statements to avoid students' answers being skewed towards one side responses option. The questionnaire was based on five Likert type scale (5= ‘strongly agree’ and 1 =strongly disagree). Each option was weighted. Positive items were scored ‘Strongly agree’ =5; ‘Agree’=4; ‘Nuetral’ =3; ‘Disagree’=4 ‘Strongly disagree’ =1. This was to ensure that a numbered responses on Likert scale would represent a positive attitude.

Reviewers and analysts were informed about the goal of the study and the purpose of the instrument, and were asked to individually check each items relationship with the goal of the instrument, content and clarity redundancy and any other related issue that might result in refining the item or the instrument as a whole. All analysts’ suggestions and comments were collected, examined and considered. This resulted in changing, deleting and adding few items to the existing instrument. A good number were considered appropriate. Two items were dropped and other two slightly revised, the experts considered them not appropriate. By the end of this phase, a refined draft of the instrument was designed with 12 items. Some of these items were ‘I study biology with a feeling of hesitation’ (item 5) and ‘knowing biology will earn me a living’ (item 12). The final designed instrument contained two parts, the first part seeking information on the students’ demographic characteristics such as gender, age and class. The second part, Biology Students Attitude towards Biology (BSAB) scale assessed Biology students’ attitude towards biology. The instrument consisted of 12 Likert type items related to students’ interest, relevance and teacher instructional methods in biology.

A Likert scale is commonly used when you are measuring characteristics of people such as attitude, feelings, opinions etc. A Likert- type combines scores of several items, each of which records how positively or negatively a person feels about a statement (Likert item). The negative and positive responses are balanced around a neutral point (research methods Lecture notes (UEW), 2017).

3.4 Test

A two teacher made test were developed and administered at the intervention stage. The test consisted thirty (30) multiple choice questions. These were constructed by the researcher and the questions drawn from the topic taught on 'Diversity of living things'. The five kingdoms and the hierarchy of classification, phyla of kingdom Protoctista, Fungi and Animalia, Classes and Orders of Kingdom Animalia , for both pre-test and post-test. Questions were drawn from the following topics; Phylums of the kingdom, Protoctistae (eg, euglenophyta), Fungi (eg, Ascomycota) Animalia (Arthropoda). Each test had thirty (30) multiple choice objective questions compulsory to all. The content of the test items were validated based on the specified instructional objectives in the biology curriculum for SHS in Ghana (CRDD, 2010).

The pre and posttests scripts were scored out of thirty (30) marks each. The scores were used to categorize the students into various learning ability groups as Low, Average and High achievers. Those who scored below fifteen (15) out of thirty (30) were the Low achievers, while the average and the high achievers were those who scored 20 average, and above 25 to twenty five out of thirty (30) marks respectively. The post-test was administered to the students after the intervention. Time allocated for both tests was 30 minutes. Each correct response attracted a maximum of one (1) mark (Appendix E).

3.5 Pilot test

In this study, the student attitude instrument was piloted on 60 SHS 2 science students of Ghana Senior High School, Tamale to establish the internal consistency and reliability of the questionnaire. Ghana Senior High School, Tamale was chosen for the pilot test because it runs similar programmes. Again, students' demographic characteristics were similar because they were of the same year group. Also, the SHS 2 students in this school had been taught the same topics in biology subject curriculum for the semester.

Participants were assured of confidentiality of any information given, and the instrument was responded anonymously with no identification information. Students were given sometime within the instructional hours to provide their responses after which all questionnaires were retrieved with the assistance of other science teachers in the school.

3.6 Validity of the Instruments

According to Mouton (2001), validity refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration. There are various types of validity, which include construct validity, content validity, criterion-related validity, and face validity (Gall & Borg, 2007). Of these, content validity, defined as the degree to which a measure covers the range of meanings included in a concept (Mouton, 2011), was considered relevant to this study. To determine the content validity of the research instruments, the researcher's supervisor together with three other biology teachers were made to review the items to assess whether:

- Only relevant concepts were included,
- The instruments were suitable for use by high school learners

All three assessors agreed that the materials met the stated requirements. However, some `assessors commented on the length of certain narratives and suggested the inclusion of certain concepts and the removal of others. They also recommended the removal of certain phrases and terms considered difficult for the students understanding. Comments from the assessors were used to revise the instruments. The construct validity of the questionnaire was established by employing the confirmatory factor analysis. The first step involved extraction of factors through principal component analysis with varimax rotation. This resulted in the generation of two (2) components with Eigen values exceeding one (Table two). According to Osman, Linn & Subahan (2006), the Eigen values represents a measure that attaches to the factors and indicates the amount of variance in the pool of original variables that the factor explain. Each construct or factor is retained if its Eigen valve was more than 1.

The next step involved factor rotation. In the study, the varimx rotation method was used because of its' advantage in producing factors that are free and independent of one another (Blakenship & Moore, 1977). In constructing of factors, a scree plot was used to determine the number of components to be extracted. The scree test (Cattell, 1966) is also based on eigenvalues but uses their relatives rather than absolute values as a criterion. Cattell suggest that the right number of factors" can be determine by looking at the drop in amount of information (and thus in eigenvalue magnitude) across successive factors. Ideally, the progression of factors will have a point at which the information drops off suddenly, with an abrupt transition from vertical to horizontal and a clear elbow (Appendix E) in the plot, the drop was indicated on the first component.

Table 2: Descriptive statistics, factor loading and item-Total Correlation of BAQ Scale

Factor	Item	MS	SD	Item-total correlation	Cronbach Alpha-item-deleted
F1	1	3.27	3.28	.60	.854
	3	2.98	1.50	.87	.843
	4	2.15	1.47	.87	.842
	10	3.57	6.905	.92	.842
	12	2.43	1.62	.89	.842
F2	5	2.33	2.83	.92	.840
	7	3.95	1.21	.85	.844
	11	3.12	1.63	.91	.840
				.87	.842
F3	2	3.43	1.37	.91	.842
	6	2.60	1.48	.91	.841
	8	3.20	1.30		
	9	2.00	1.29		

Factor 1= Interest or confidence of students (I), F 2= The teacher (T), Factor3= The relevance biology (R).

Table 3: Percentage of the overall variance of the two factors extracted

Factor	Total variance	Percentage (%) total variance
1	9.461	72.780
2	1.017	7.821
Percentage of overall variance		80.601

The percentage overall variance was high at 80.601.The total variance at 80.601 was good according to Fraser, McRobie and Giddings (1993). Given that individual means were used as the unit of analysis. Table 2 shows that factor loading on the first component ranged from .59 and to .92. This component interpreted as the extent to which biology students learn biology effectively with interest and confidence. The second principal component, Factor 2, had factor loading ranging between .64 to.89. This was interpreted as the extent to which Biology students learn biology effectively through the teacher as an instructor. The total average means of the scales were 2.88 and 3.13 respectively.

3.7 Validity of the test

Validity refers to whether a test does truthfully what it is constructed to do (Taale & Ngman-Wara, 2003). In addition, validity of a test is dependent upon the use of the test. A test is valid if the results are appropriate and useful for making decision and judgement about an aspect of the students' achievement (Gronlund & Linn, 1990). The face validity of the test items were validated by three experienced teachers who had taught biology in the school for eight years for the study. They analyse the test items to ensure that they fall within the content of the topic taught. Content validity of the test items were examined by the researcher based on the cognitive level of the students and the instructional objectives stated in the biology curriculum for Senior High Schools in Ghana (MOESS, 2010) and the course content used in the intervention. To Taale and Ngman-wara (2003), content validity is most appropriately considered in connection with achievement testing. An achievement test has content validity if it represent faithfully the objectives of govern instructional sequence and reflects the emphasis accorded the stated objectives as the instruction was carried out. In other words, it is the degree or the extent to which the test items adequately cover the subject matter or the part of the curriculum covered during instruction.

3.8 Reliability of BAQ instrument

Depoy and Glitin (2011) define reliability as the degree of consistency with which an instrument measures an attribute. To Joppe (2000), reliability refers to the extent to which results are consistent overtime and if the results of a study can produce under the same methodology, then the research instrument is considered to be reliable. Data from the pilot test was used to determine the reliability of the research questionnaire. Item analysis at this point was carried out to identify items whose removal would enhance the internal consistency (i.e correlation between a certain item and the rest of the items excluding that item). Items meeting any of the following criteria were deleted: correlation coefficient between any item and the total score less than 0.30 and if internal consistency (Cronbach α) of the whole scale was high after deleting the item. This led to the deletion of one item (5) of the 13 items resulting in a Cronbach alpha reliability coefficient of .988 (Appendix J).

Table 4: Reliability Coefficient of the BAQ

No .of Items	Alpha Coefficient	KMO	Bartlett's Test
12	.988	.916	155

The Bartlett's Test was significant at P< 0.05. According to Leach, Barrette and Morgan (2005) alpha value of 0.70 and above shows reasonable internal consistency and that the alpha values between 0.60 and 0.69 indicate minimally adequate reliability. They however added a lower alpha value may be due to handful of items in a scale .According to Ary, Jacobs and Razavieh (2002) if results are used to make decisions about a group or for research purposes, reliability coefficient of 0.05 to 0.60 are accepted. The instrument was therefore accepted as reliable based on the purpose and objectives of this study, thus, the final BAQ has 12 items.

3.9.0 Test Reliability

This refer to consistency with which a test measures whatever it measures from one measurement to another, over and over again, over times. Also, Reliability concerns the degree to which an experiment, test, or any measuring procedure yields the same results on repeated trials (Patton, 2002). The researcher administered an initial test followed by a second one within the intervening time to the participants. The test-retest with alternate forms method was used to determine the reliability. In this method, the reliability of either one of the alternate forms and this is known as the coefficient of stability and equivalence. Hence, s strong correlation coefficient between the two tests was at 0.91 (Appendix E).

3.10 Intervention

The intervention stage is divided into three phases, pre- intervention, intervention and post- intervention. The main intervention process involved the use of guided inquiry instruction and learning model (Fig.2) to teach a major biological topic, 'Classification of living things', characteristics of the various kingdoms (Prokaryotae/Monera, Protoctista, Fungi, Plantae and Animalia), orders and classes of the kingdoms Protoctista and Animalia. The model of guided inquiry-based learning that was implemented is the 5E Model developed by Biological Sciences Curriculum Study (BSCS).

The researcher implemented this model (Appendix F) through group investigation for a period of six week. A plan of activities for six (6) weeks instructional during the intervention stage is outlined in Appendix G.

The unit of instruction or the content to be learned covered one major topic with its sub-topics of instruction and begin after administration of the pre-test. The first topic of instruction was Classification of living things. The second sub- topic of instruction was on the characteristics of the kingdom Animalia, and class 'Insecta' and lasted approximately six weeks. Both time frames shifted a bit as the school year started and lessons had to be tailored to meet the goals of the content. Traditionally, the first part of the topic was the easiest for the students because the content has been studied in last semester.

The implementation of the intervention started in the first week of the study period.

In implementing the inquiry based instructional module, students were put into groups, this was to get every students actively engage and participatory in lessons. Grouping is one of the essential method in teaching and learning to helps motivate, encourage active learning, and develop key critical-thinking, communication and decision-making skill for that matter inquiry based instruction. Six intact different classes were used as the sampled population for the study. Students' number in classes differ. Classes with less than fifty students in a class six (6) groups were formed and the same number of groups was also formed in those classes with more than fifty students.

In every class, students were made to line up in gender mode, girl first, boy second until the last student in the class in that order. Followed by numbering into groups (1, 2, 3, 4, 5 and 6), all students with the Number-One, formed group one (1), Number-Two another group (group two) and continued until the last group (Number-6) formed. Based on researcher experience of the students' academic strength, the researcher had to reassign some students to different groups. Students were asked to select and assign the roles of recorder or secretary, assistant facilitator and spokesperson of the group. They were provided with writing pads, text books, models, chart, preserved insects, fishes and crustaceans. Objectives of every lesson was clearly stated as showed in Table 5 to them by the researcher to guide participants in their findings. All groups were assigned the same task and within each group, members decide how information is to be presented in class to their colleagues during class presentation of group work. The researcher allocated 15 minutes each to every group to do presentation. The next stage was explanation of the tasks, the researcher defined clearly the assignments, taught the required content or learning indicators. Each week task was outlined to students in the classroom after weekly group presentation. This was done until the fifth week, and the sixth week, the second and final assessment was done on the students.

During the first week, the researcher introduced the lesson topic, then from there. Students' were asked to move into their various groups and each group leader picking a task card. All groups were tasked on the topic characteristics of the kingdom Animalia' using the 5E model learning style. Engagement stage (the first stage of the model) of inquiry, the researcher tried to elicit prior knowledge from the students by providing a "hook" that stimulates curiosity in the content without providing an explanation. The "hook" for the study was, "what are the structural differences among members of the pictures in the chat? The researcher assisted students in making sense of the question and guided inquiry. They worked with a Chart containing picture of different animals for information collection throughout the lesson. The Chart (Appendix E) guides students to identify what they already know about the guiding question, what they want to find out about the question, and what they learned regarding the question posed by the teacher. Each student in the groups receiving guided inquiry-based instruction completed the first chart during the engage stage of inquiry.

The next phase of the 5E Model was exploration. In the exploration phase, the researcher moved into the groups' one after the other to make observations and clarification for students, and also to ensure that every students get involved in the lessons in groups of six to apply process skills, Students were to compare what they had written on their individual Charts from the engagement stage of inquiry. Questions posed by the students were to relate to the overarching "hook" were explored during this phase of inquiry. Students at this stage were tasks to find information and draw conclusions for themselves prior to any formal explanation of terms, definitions, or concepts that were explained by the researcher. Students recorded all information that relates to the guiding question of the lesson on an inquiry chart (Appendix C).

Also, students' working and collaborating to investigate the guiding question used a variety of resources provided by the researcher .The resources for the investigation included, models, web resources (computer lab), resources available at the school laboratory (preserved specimen) and library, and/or the course textbook. After exploration of resources, students entered the explain stage of the 5E Model. At this stage, students' were provided the opportunity to communicate what they had learned in groups so far and figure out what it meant in relation to the guided question at the third activity stage of the lessons (lesson plan). The initial phase of this stage, the researcher only play her facilitator role. The researcher allow the students to share their own explanations and ideas before explanation and followed by clarification from the researcher. As the phase evolves, it became more researcher directed. After the students' sharing their findings within the inquiry learning experience, the researcher pointed out and explained all misconceptions or incorrect conclusions some groups came out with and guide students back to the explore phase to gather additional information and move into the elaboration stage .

Elaboration stage. Here, students were to apply their understandings of the guided question, and carrying further observations and investigations to find out close structural relationships of the specimen or organisms provided into the next rank of classification using the new skills to deepening their understanding. During this phase of the research, the researcher again instructed the students to group the organisms' based on similarities that helps them to conduct additional investigations into the guided question while making connections to prior knowledge and researched knowledge. The Chats that were used were the same during this stage of inquiry. The chats allowed students to distinguish between organisms with simple body plan and those with complex body plan. The final stage of the 5E Model is evaluate. During this stage, the researcher and the students determine how much learning and understanding has taken place through oral responses for student to evaluate their own work through group presentations. The researcher observed and made informal assessment to conclude each lesson. This schedule was adopted and used each week of the study. A summative evaluation of student growth was conducted using a teacher-made post-test comprised of 30 multiple choice questions that target concepts of 'classification of living things'. The data obtained from the post-test was used to determine if the implementation of guided IBL was beneficial to the academic performance and attitude of students in biology.

The second week of the study was on the sub topic, Phyla of the kingdom Animalia. The same guiding instructions were employed during each lessons, students' were to continue with the same instructions to come out with organisms or members in the kingdom with same body plan. Presentation of findings were made at the second lesson in the week.

Week three, the sub topic was orders of kingdom Animalia'. Concept of this topic was explained to students at the introduction stage of the lesson. Pictures of animals and preserved animal specimen were also provided to students' to enable them carryout their further investigations. Groups presentations were made in the second week as explained in the first week.

The fourth week, the topic for the previous week was to be continued. This was done due to greater detailed differences and similarities that exist within organisms in the kingdom as you go down the taxa in Linnaeus system of classification of living things. The week ended with group presentations.

Fifth week activities were on classes (class, insecta, crustacean and Arachnida) of kingdom Animalia. Here, students were to employ the same instructions as in the previous week. Students' presentation in this week was on drawing and label any organism of their choice. Drawing was the assignment at this stage because, it forms part of their final practical paper at WASSCE and subject scheme for the semester. Further explanations were made on the n taxa for student understanding. All other groups' presentations were collected.

Sixth week, All groups presentations were evaluated orally alongside writing post – test and questionnaire administration, the whole period of study ended in this week.

3.11 Data Collection Procedure

The researcher used a sample lesson plan and subject scheme of work for the period of study. The researcher obtained an introductory letter from Graduate School, University of Education, and Winneba, which was used to secure a research permit from the headmaster of the school to carry out the study. Before the researcher introduced the pre-test and questionnaire items, the samples classes were briefed on the purpose of the investigation. The date for the questionnaire and tests to be conducted was communicated to the students. Before the questionnaire administration, students were assured of the confidentiality of any information provided on the questionnaire.

Again, the researcher added, the essence of the research was also to help identify their weaknesses and determine the appropriate instructional approaches which could benefit them. The researcher again used the quantitative research approach to collect data before and after treatment. The researcher sought the assistance of other science teachers in the school to administer and retrieved the pre-test and post-test scripts and the questionnaire. The questionnaire and the tests was administered during biology lessons to facilitate easy and prompt retrieval since some of the students were day-students and also to pave way for other subject's lessons. The completed questionnaire were collected after students indicated that they had responded to all. The same procedure was employed during the pre-test and post-test of data collection during the study. Scores of the students on both tests were collated and analysed using appropriate statistical methods. Next was the implementation of the IBTL model.

3.11.1 Post intervention

The procedure employed during the intervention stage for administering the BAQ was repeated using the same set of items to determine whether changes had occurred with regards to the students' attitude towards biology after the intervention. A post-test was also conducted using equivalent form of the pre-test to determine the impact of

Inquiry-based teaching and learning on students' academic performance in biology. To ensure reliability, both forms of test were administered in the respondents' classroom under the researcher's supervision with assistance of other biology teacher. An equivalent form of the pre-test was used for post-test to avoid the effect of pre-test sensitization. According to Aryl et al, (2002), pre-test sensitization is a major treat to the validity of the test when very same test is repeated rather than parallel forms. Students were assured that the exercise would not influence their continuous assessment or semester grade score, and they are not obliged to write their names or any identification number. The completed answer sheets were marked and scores recorded for analysis.

3.12 Data Analysis

Table 5: Data analysis plan for the BAQ

Positive attitude			Negative attitude	
General Positive Attitude		**Neutral**	**General Negative Attitude**	
5	4	3	2	1
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

From the mean values <3.0 indicates negative attitude, mean values at 2.5 -3.0 represents neutral and mean values >3.0 represents positive attitudes towards biology.

The BSAB data from both pre and post interventions was analysed using Statistical Package for Social Science (SPSS) version 26.0 for windows. The data of the BSAB instrument were coded and keyed into SPSS for the statistical analysis. Descriptive statistics function of the SPSS was used to determine mean scores, standard deviations and responses also converted into percentages on the Biology students' scores from the BAQ of answer Research Question 1. This was followed by descriptive statistics analyses based on the subscales: students' interest, the teacher and relevance of biology to students to answer Research Question 2. The same descriptive statistics function of software was again used to determine mean scores, standard deviations and percentages on Biology students' scores from post-test and administered BAQ together with paired t-test statistical method at p-value =0.05 level of significance using scores of the pre and post- test to answer Research Question 3.

3.13 Ethical Issues

According to Mertler (2014), "making sure that action research adheres to ethical standards is a primary responsibility of the educator-researcher" (p. 106). All research undertaken in situations which involve people interacting with each other will have an ethical dimension; educational research is no exception and the ethical issues are often complex (Stutchbury & Fox, 2009). As Mills writes (2014), "the roles of ethics in any teaching endeavour ought to be considered in terms of how each of us treats the individuals with whom we interact at our school setting: students, parents, volunteers, administrators, and teaching colleagues" (p. 31).

Dana and Yendol-Hoppey (2014) encourage educators to "embrace working through the ethical dimensions of your work by engaging in a "self-interrogation." This interrogation, of sorts, is posing on-going questions that need to be continually revisited as you teach and inquire into your teaching practices" (p. 155). The researcher continually ask for assistance of the students' class monitors. The researcher will be collecting data from assessment pieces throughout the period of study. The school authorities requires that all students' and their parents or guardian information remain confidential and free from any identifying markers. In accordance with district policy, the research. Permission was sought from the authorities of

Tamale SHS. Also, the researcher ensured that prospective participants were made aware of the purpose of the study and their rights as participants. Data collected was treated confidentially and was used for the purposes of the research only.

CHAPTER FOUR

RESULTS

4.0 Overview

The purpose of the study was to investigate the impact of inquiry- based teaching on students' academic performance and attitude towards biology using inquiry based instructional and learning approach. The chapter of this study is to convey the results of the study. The data collected will be used to address the research questions, the respondents 'demographic, follow with pre- and post-intervention. Results of the BAQ to answer Research Questions 1 and 2 respectively. Then impact of guided Inquiry based instruction and learning on students' academic performance, research question 3.

4.1 Demographic Characteristics of Respondents

The table below shows data on the background of students' for the study.

Table 6: Gender distribution of Students

Gender	**Frequency count**	**Percentage frequency**
Male	106	53
Female	94	47
Total	**200**	**100**

Table 6.0 shows that 53% (106) of the sample are male students and 47% (94) are female students' studying biology. The slim margin could be due to increase education and reduce bias against women in the current global of women involvement in science related courses.

Table 7: Age Groups of Students for the Study

Ages of students (years)	Frequency count	Percentage frequency (%)
13-15	84	42
16-18	102	51
19-21	11	5.5
Above 21	3	1.5
Total	**200**	**100**

Research Question 1

What are the attitudes of biology students' towards the teaching and learning biology as an academic course?

The research question sought to determine the attitude of students towards biology. Data was collected using a questionnaire before the treatment was introduced. This was to find out the prior attitude of the respondents towards Biology. The descriptive statistics function of SPSS software was used to analyse the data into mean scores and standard deviations, in table 7. The responses were also organized into frequency counts and converted into percentages as indicated in appendix E. The respondents mean scores ranges between 2.00 to3.95

Table 8: Means and standard deviations of respondents before Treatment

Sub-scale	I /No	Item	Mean	SD
Sub-scale interest	1	I am not the type who do well in biology	3.28	1.62
	3	Biology is a boring subject	2.98	1.50
	4	I don't think I could do advance biology	2.15	1.47
	10	Biology is the least loved subject among My subjects	3.57	1.90
	12	I will like to attend biology class in all my school grade	3.21	1.59
Average mean			**2.32**	**1.47**
The Teacher	7	The teacher seems to be the only correct approach to solving biology problems	2.33	1.18
	8	Getting a teacher to take me seriously in in biology is a problem in biology is a problem	3.95	1.69
	6	My teacher has encouraged me in my progress in biology	3.25	1.62
Average mean			**3.13**	**1.49**
Relevance of biology				
	2	The things I learn in biology are so useful our daily lives	2.70	1.48
	9	The subject biology has little relation to What I experience in the real world	2.00	1.29
	11	Attending biology made me understand the surrounding world. How the natural world works	2.64	1.51
	5	Knowing biology will earn me a living	2.60	1.47
		Average mean	2.72	1.51
			2. 99	**1.51**

From the Likert scale analysis, the negatively worded items 1, 2 and 3 were reversed coded to ensure that high mean score represented positive or favourable attitude beliefs. Again, with the 5-point Likert-type scale coding a score of 3.0 reflects a neutral/uncertainty in response and score of 1 or 2 represent high or low levels of attitude respectively. Hence results from Table 8 indicates that students had neutral stand towards the teacher with his/her instruction methods with average mean scores accordingly (MS=3.13, SD=1.49) and had a weak negative attitude towards their interest to Biology (MS=3.22,SD=1.47) However, the relevance to Biology was observed to be a strong negative attitude (MS=2.99,SD=1.51).

However, the highest mean scores were found for the on some items focused on the interest and the teacher and instruction in biology. Especially items ‘‘getting a teacher to take me seriously in Biology is a problem’’ (MS=3.95 SD=1.69), and Biology is the least loved subjects among my subjects’’ (MS=3.57 SD=1.90) had mean scores above 3.0 thus indicating positive attitudes. In contrast, few items ‘I don’t think I could do advance biology and knowing biology is not relevant in my life’ (MS: 2.15, SD: 1.47) revealing a negative attitude. This gives an indication that many of the students do not actually see the relevance or importance of the subject biology to their life here and after.

Research Question 2: What factors accounts for students’ attitude towards Biology?

This research question sought to identify the factors responsibly for the students’ poor attitude towards biology. These are represented in Table 9

Table 9: Factors accounting for students' poor attitude and performance towards biology (response before treatment)

Factor	Statement	Frequencies and % frequency					MS	SD
		SD	D	N	A	SA	MS	SD
Student interest	1. I am not the type who do well in biology	89 (44.5%)	58 (29%)	5 (2.5%)	29 (15.5))	19 (9.5%)	3.28	1.62
	3. Biology is a boring subject	39 (19.5%)	30 (15%)	27 (13.5%)	64 (32%)	40 (20%)	2.98	1.50
	4. I don't think I could do advance biology	39 (19.5%)	38 (19%)	27 (13.5%)	47 (23.5%)	49 (24.5%)	3.14	1.47
	10. biology is the least loved subject among my subjects	51 (25.5%)	49 (24.5%)	5 (2.5%)	49 (24.5%)	46 (23%)	3.57	1.90
	12. I will like to attend biology class in all my school grades	98 (48%)	76 (38%)	0 (0.0%)	22 (11%)	9 4.9(48%)	3.21	1.49
	Average mean score						**3.22**	**1.47**
Teacher	7. teacher seems to be the only correct approach to solving biology problems	73 (36.5%)	64 (3.2%)	0 (0.0%)	32 (16%)	21 (10.5%)	3.4	1.43
	8. getting a teacher to take me seriously in biology is a problem	71 (35.5%)	43 (21.5%)	16 (8.0%)	32 (16%)	38 (21.5%)	3.39	1.54
	6. My teacher has encourage me in my progress in biology	83 (14.5%	76 (38%)	5 (2.5%)	49 (24.5%)	46 (23%)	2.73	1.39
	Average mean						**3:18**	**1.49**
Relevance of biology	2. the things I learn in biology are so useful in our daily lives	32 (16%)	38 (19%)	0 (0%)	83 (41.5%)	47 (23.5%)	3.27	1.53
	11. Attending biology class made me understand the surrounding world	64 (32%)	55 (27%)	2 (1%)	31 (15.5%)	43 (21.5%)	2.64	1.51
	12. Knowing biology is will earn me a living	57 (28.5%)	62 (31%)	24 (12%)	38 (19%)	19 (9.5%)	2.84	1.55
	9. the subject biology has little relation to what I experience in the real world	44 (22%)	32 (16%)	9 (4.5%)	62 (31%)	53 (25.5%)	3.29	1.57
	Overall average						**2.41**	**1.23**

Factor 1= students interest (SI) Factor 2 = the Teacher=(T) Factor 3= relevance of biology (R)

The data in Table 9 indicate that students had negative attitude towards Biology, this can also be inferred from table 8, which indicate that students' had interest as a factor with average mean score of 3.22 and the teacher and his or her methods of instruction, with a mean score of 3.18, whiles relevance to biology had a mean score of 2.01. In the table, it also shows the individual mean scores and standard deviations but cumulative of stands, ie Agree or disagree. On the disagree stand,(SA&D) 86% (174) of the students' disagreed that they will like to attend biology class in all my school grades had MS=3.21,SD=1.49.

However, there was no neutral response to this item 0 % (0.00). 73.5% (145) students' disagreed that, they do not do well in biology, and 25% (48) agree whiles 2.5% (5) of the students remained neutral. Interestingly, 52 %(104) students agreed that biology is a boring subject, 34.5% (69) students disagree to this item and 13. 5 %(27) did not react to this item. On the item, 'I don't think I could do advance biology', 48% (106) students' agreed, 50% (100) disagree and 2.5% (5) students do not react to the item. 47.5% (95) students agreed that biology is the least love subject among all other subjects.50% (100) students' disagree and 2.5% (5) students remained neutral. This statistics revealed that students have average interest in biology as one of their subjects. Most students, 68% (68) students' disagree that the teacher seems to be the only correct approach to biology problems, 26.5% (53) disagree to this while no students reacted to the item. 35% (70) students agreed that getting a teacher to take me seriously in biology is a problem, 57% (114) students' disagree and 8% (16) students' remained neutral. On the item; my teacher has encouraged me in my progress in biology', 47.5% (95) students agree, whiles 79.5%

(159) disagree and 2.5% (5) remained neutral. This indicates that the teacher is actually the main problem even though some items shows positive attitudes.

On the relevance of biology to students', 65% (130) students' showed positive attitude to learn in biology in their daily lives whiles 35% (70) showed positive attitude. 56.5% (115) students showed positive attitude to the item' biology has little relation to what I experienced in the real world', 38% (76) exhibited negatively. Learning biology change my ideas about how the natural world works, 37% (74) students agreed to this whiles 59.5% (119) disagreed indicating negative attitude, 28.5% (57) students agreed that knowing biology will earn them a living, 59.5% (119) disagreed and 12% (24) remained neutral. In all, students showed positive attitude to this factor, though some of the students responded negatively. From observations of the students' responses and the mean scores and standard deviations of items, It reveals that the teacher and his or her instructional approach is the major factor negative even though negative attitude were also exhibited on students interest to biology.

Research question 3: What is the impact of inquiry based teaching and learning approach on students' academic performance and attitude towards biology after the treatment.

Table 10: Results of the t –test on form two biology students' pre and post mean and standard deviations scores (independent t-test)

Variable	Group	N	Mean	SD	df	t-value	p-value
Pre-test	E1	200	13.35	3.194	199	24.177	0.19
Post-test	C2	200	20.65	14.756			

To determine whether there was statistically significant difference in the academic performance and attitude of students in biology when they were taught with the guided inquiry based learning. Research question 3 was formulated into null hypothesis.

Ho: There is no significant difference in form two biology students' academic performance and attitude' before and after the treatment.

Both pre-test (Experimental group) and post-test (Control Group) were scored over 30 marks with 15 marks as pass mark. The average mean score of the pre-test was 13.35 (SD= 3.194) whilst that of the post-test was 20.65(SD=14.756), yielding a mean difference of 7.30. The t-test analysis was found to be statistically significant at 0.05 level (t (199) = 24.177;p=0.00), indicating that the difference between the average mean score of pre and post was statistically significant (Table 10).

The result is in favour of the pre- test. Hence the treatment was positive, indicating that inquiry based approach of teaching could significantly improve students' academic performance and attitude towards biology.

The students had positive attitude towards the inquiry-based teaching. This can be inferred from the mean scores and standard deviation from the post intervention BAQ results (Appendix L). The average means score of the factors ranged from 2.98 to 4.57. It was therefore concluded that the use of guided Inquiry base approach to teach topics in biology showed a significant difference in the form two biology students' academic performance and attitude in Tamale senior high school, Tamale, northern region. Hence the hypothesis was rejected since there was statistically significant difference between the pre and post- tests. This can be inferred from the data analysis plan for this study (table 4).

The second part of the question was to determine the weather the implementation of the intervention has positive effect on students' attitude towards biology. Table 11 below indicates the means and standard deviations of respondents after intervention. It reveals that the mean score ranges between 2.27 to 4.54 and standard deviations 56 to1.63. These ranges indicates a positive change, hence an improvement in respondents attitude towards biology. Almost all means score were above 4.0, especially on the teacher factor, i.e 'getting a teacher to take me seriously in biology is a problem had a mean value of 4.54, 'biology is a boring subject 4.22'. These were all score in the reverse order. The overall mean score of the respondents of the experimental group was 4.10 (positive response) compared to the control average mean score of 2.41 (strong negative). This comparison indicates that a positive attitude has developed after treatment. The differences between the control and experimental group suggest a significant development of positive attitude towards biology.

Table 11: Means and Standard Deviations of Responses after Treatment

Sub-scale	I /No	Item	Mean	SD
Sub-scale interest	1	I am not the type who do well in biology	4.37	.63
	3	Biology is a boring subject	4.22	.93
	4	I will like to attend biology class in all my school grades	4.11	1.09
	12	I don't think I could do advance biology	4.51	.56
	10	Biology is the least loved subject among My subjects	3.85	1.21
Average mean			**4.21**	**0.88**
The Teacher	7	The teacher seems to be the only correct approach to solving biology problems	4.42	.64
	8	Getting a teacher to take me seriously in in biology is a problem in biology is a problem	4.54	.66
	6	My teacher has encouraged me in my progress in biology	4.43	.71
Average mean			**4.46**	**0.67**
Relevance of biology	2	The things I learn in biology are so useful our daily lives	2.29	1.51
	12	The subject biology has little relation to What I experience in the real world	3.92	1.60
	9	Learning biology change my ideas about How the natural world works	4.37	.63
	10	Knowing biology will earn me a living	4.52	.97
	11	Knowing biology made me understand better the natural world	3.12	1.63
	Average score		**3.644**	**1.27**
Over all mean score			**4.10**	**0.94**

CHAPTER FIVE

DISCUSSIONS

5.0 Overview

This chapter discusses the results in line with the research questions under the following headings. Biology students of Tamale SHS attitude and academic performance towards biology, factors accounting for the negative attitude and the impact of IBL on students' attitude and academic performance in biology. The study aimed at improving students' academic performance and attitude towards biology through the use of IBL strategy in the school. The study also sought to identify the possible factors for students' attitude towards biology in Tamale SHS in the Northern Region.

A questionnaire was employed to seek feedback on students' attitude towards Biology, teachers and their influence, relevance of Biology to the students and level of students' interest in Biology. Descriptive statistics were used to analyse the data showing the means standard deviations, percentages and inferential statistics, t-test statistics to establish the impact of guided IBL on the students' academic performance in biology and their attitudes towards biology.

5.1 Students Attitude towards Biology

Table 11 indicates that students exhibited overall positive attitudes towards Biology both after the use of IBL (MS = 3.95; SD = 1.21) and after (MS = 4.10; SD = 0.94) using the IBT approach intervention. The results further indicated that the teacher factor initially influenced students to exhibit uncertainty in their attitudes (MS = 3.32; SD = 1.22) toward Biology but after IBL, the student made a decision with a mean score (MS=4.46; SD=0.67). Again, teachers behaved as if the 'teacher' was the only correct approach to solving Biology problems. However, all these views did change after the IBT intervention (MS = 4.57; SD = 0.99). Nonetheless, under both the pre-IBT approach and the post-IBL approach conditions, students exhibited moderate positive attitudes towards biology due to their high interest in studying Biology and acknowledging the relevance of biology in their lives. According to Muellerleile (2005), attitude is a way of looking at things. In the work of Uitto, Juuti, Lavonen & Meisalo, (2006), they found out that information about students' interest may help teachers to devise strategies to enhance students' interest in Biology.

5.2 Factors Accounting for Students' Attitudes towards Biology

The results of Table 8.0 outlined some factors that indicated that students had high positive attitudes. The factors include:

- Subject Matter: students do not regard Biology as the least loved subject/lesson among the subjects they study and that Biology is not boring to learn.
- Internal locus of control: students do not see teachers as one correct approach to solving biology problems nor do they think that the inability to get teachers to take them seriously in biology should affect their attitudes towards Biology.
- Personal interest: Students feel at ease in attending lesson/learning biology.

  Also, some moderate attitudes towards biology were exhibited by some students (Table 8). These were as follows:

  - Mode of knowledge acquisition: Students acknowledge moderately that biology is not primarily concerned with learning of known facts but rather involves investigating the unknown (MS_1 = 3.62, MS_2 = 3.62).
- Lack of World view and daily life application of subject: students regarded learning Biology as a subject that had minimal relation to what they experience in real world (MS_1 = 3.48, SD_1= 1.37) and that Biology did not adequately change

their ideas about how the Natural world Again, some form two biology students exhibited negative attitudes (Table 8) towards biology as a result of the following factors:

- Immediate use except for career: Students initially regarded the things they learnt in biology as not so useful in their lives, knowing it biology could earn them a living Nonetheless, these attitudinal views changed positively after the IBT intervention respectively.
- Teacher factor: That teachers do little to encouraged students in their progress in learning biology (MS_1 = 3.11, SD_1 = 1.54). This could result from poor teachers-students rapport, poor pedagogical and content knowledge approaches to the subject.

The factors identified in this study strongly affected form two biology students' attitude toward biology are common and similar to what is in the related literature. However, the order of the influence or importance of these factors is different. Again, a growing body of research (Woolnough, 1994) suggests that good teaching and an overall teacher quality are the critical determinants of students' attitudes to science and science achievement.

5.3 The Impact of the guided inquiry based teaching approach on students' attitudes towards biology and academic performance

The results indicate that students initial had moderate positive attitude towards biology (MS_1 = 3.14; SD_1 = 1.47), which was improved upon/ changed (MS_2 = 4.22, SD_2 =0.88) after guided inquiry-based teaching approached. However, the difference in pre and post IBT intervention mean score values was statistically significant (Table.9). According to the independent t-tests analysis of samples scores [t (12) = -

24.177, p= 0.00]. Therefore, the inquiry-based learning approach had changed the overall mean scores of students' attitudes towards Biology.

This can also be inferred from table 9 results which showed that before the inquiry-based teaching approach was introduced, 71.7% (43) of students had performance scores in the teacher-made test below 50% (30 marks). Hence majority of students exhibited traits of low ability performing students (LAPS) group. Nonetheless, after the IBT intervention the results showed that 53.3% of students had performance scores categorizes as HAPS group and 36.7% had performance score in the average ability performing students groups.

Interestingly, Table 9 indicated a pre-IBT test 1 students' performance mean score of 40.4% (SD = 17.6%) which had improved upon in test 2 (66.5%; SD = 14.6%), after IBL was used. The difference of mean scores of 26.1% was shown to be statistically significant [t (59) = 15.585, p= 0.00]. Hence, the IBL approach has had positive impact on changing students' content knowledge performance ability.

The above impact of guide IBT approach on attitudes and knowledge acquisition is not surprising as students had exhibited some level of good attitudes towards biology before the intervention was introduced. Again, the structure and organization of the IBL and learning technique employed by the researcher enabled students to learn through group works. They had several personal encouragement to compete within groups for scores and became motivated as they worked in the groups (Johnson, Johnson, & Holubec, 1993). The results as have been observed relates to findings of Weinberg's (1995), that, the relationship between learner's attitude and achievement is fundamentally linked in science. And that attitudes, goals and interest were identified as key factors for students to understand, learn and succeed academically.

Further, Erdemir and Bakirci (2009) stated that some attitudes are based on the people own experience, knowledge and skills and some are gained from other sources. However, the attitude does not stay the same. It changes in the couple of time and gradually. These qualities that IBT employ enable teachers creatively facilitate all lessons to create the required environment to foster learning leading to a change in the individual.

CHAPTER SIX

SUMMARY, CONCLUSION, RECOMMENDATION AND SUGGESTIONS

6.0 Overview

In this chapter, a summary of the major findings of the research, the implications and conclusions are presented, recommendations and suggestions for further research on the study. The study was conducted to investigate the impact IBL on form two biology students 'academic performance and attitudes towards Biology in Tamale SHS.

6.1 Summary of Findings of the Study

This part focuses on the summary of the major findings of the study. It looks at the summary of the students' attitudes towards Biology before and after the guided IBT approach in relation to teachers' influences, relevance of Biology to students and students' internal locust of interest in biology. Finally, the significance of IBL approach on students' academic performance and attitudes towards Biology was considered.

6.2 Findings of the Study

The findings are that:

i. Biology students' of Tamale SHS had (moderate) positive attitudes towards biology. However, the level of attitude towards biology increased after the Inquiry-Based Teaching intervention was introduced, the change in students' attitudes was statistically significant.

ii. Guided Inquiry-Based Teaching approach had a greater impact on students' content knowledge ability performance/achievement. The level of change in content knowledge test score after Inquiry-Based Teaching approach tremendous as compared to the traditional teaching approach.

iii. The factors that promoted positive attitudes in the students were the love for subject matter (biology), student's internal locus of control and personal interest in biology.

iv. The factors that students were uncertain or sure of their impact on the attitudes towards biology was seen in the mode by which biological knowledge was acquired and the opinion that biology is useful in their daily life application.

v. Factor(s) that produced positive student's attitudes towards biology was the teacher and his/her teaching approach, interest in biology and inability to avail themselves to encourage students to learn biology.

6.3 Conclusion

The purpose of the study was to investigate the impact guided of Inquiry-Based Teaching (IBT) approach on form two biology students' academic performance and attitude towards biology. The results showed that the form two (SHS 2) Biology students' in Tamale Senior High School have positive attitudes toward biology. However, relevance of biology' factor influences should be improved so that students will see the relevance of the subject in their lives and do not detest biology.

To conclude findings from the study have revealed that guided Inquiry teaching has tremendous effect on academic performance and attitude of students of Tamale senior high school towards biology over the use of the traditional methods of teaching.

Factors that accounts for poor students' academic performance and attitude towards biology are, the Teacher(T), Students interest(S.I) and Relevance of biology to students'(R).

6.4 Recommendation

Based on the findings of the study, the following recommendation were made;

1. It is recommended that guided inquiry-based teaching (IBT) be adopted by biology teachers in their classroom practices to improve academic performance and positive attitude towards biology in Tamale Senior High School.
2. Teachers should be oriented using in service training on the use of guided inquiry-based teaching (IBT).
3. Using Inquiry based teaching, the biology content should relate to students' daily life experiences for them to relate to the relevance of biology.

6.5 Suggestions

The generalization of the present study is limited based on some constraints under which the investigation was conducted. With these constraints, the following areas are suggested for further studies: a replication with a bigger sample size and in other subjects' areas.

The subject Biology is an interesting subject in the SHS system therefore teachers should adopt appropriate methodologies to help improve students' attitude and performance in Biology (Biology curriculum, 2010)

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APPENDICES

APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

Biology Students' Performance in Biology from 2016 -2020 Academic Years in Tamale SHS

Year	Number of students	Percentage (%) pass	Remarks
2017	443	44	Below average with regards to the total number who took the exam.
2018	452	42	A slight drop in performance.ie below average'
2019	538	51	Due to the introduction of the 4-year SHS system from the 3-years.
2020	587	50	Average performance compare the previous years.

Source: Records from Tamale Senior High School, Tamale -N/R.

APPENDIX B

TEACHER MADE PRE AND POST INQUIRY-BASED LEARNING INTERVENTION

Test 1 / Test 2

TEST ONE (1) GENDER : CLASS: DATE:

INSTRUCTION:

Do not write your name on this paper.

Answer all questions by circling the best suit answer to the questions below.

1. Which of the following Naturalists is the father of classification? A. Carl Linn B. John Ray C. Aristotle D. Carolus Linnaeus
2. Mesosomes are found in … A. Protists B. Bacteria C. Protozoa D. Fungi
3. Biodiversity is defined as……… A. Study of living things B. Variations in forms of life C. Classification of living things D. Living and non-living things in habitat
4. In binomial system of naming organism, the second name is called …. A. Generic name B. Common name C. Scientific name D. Specific name
5. Which of the following groups contain the unicellular eukaryotes? A. Protozoa B. Fungi C. Insects D. Bacteria
6. Autotrophic eukaryotes are …………….. A. Photosynthetic bacteria and plants B. Algae and plants C. Plants D. Photosynthetic bacteria, alae and plants.
7. Similarities is best among members in. **A**. Kingdom **B**. Phylum **C**. Species **D**. Genus.
8. Which of the following ranks in classification will have the least resemblance among organisms? **A**. Class **B.** Species **C**. Phylum D. Family.

9. Bugs belong to the Order… A. Isoptera B. Hymenoptera C. Lepidoptera C. Hemiptera
10. Sucking mouth parts is possessed by…… A. Lepidoptera B. Isoptera C. Odonata D. Hymenoptera
11. Which of the following pairs of organisms are photosynthetic? A. Amoeba and Moss B. Laminaria and Rhizopus C. Euglena and Mucor D. Spirogyra and euglena.
12. One common similarity between Oomycota and Fungi is the possession of.. A. Hypha B. Chitanous cell wall C. Gametangia D. Ascospore
13. Unicellular Fungi are called…. A. Yeast cells B. moulds C. hyphae D. spores
14. Phylum Basidiomycota lacks A. membrane-bound organelles B. chlorophyll C. rhizoids D. sporangiosphores
15. A protest with flagella belongs to the phylum A. Apicomplexa B. Chiliophora C.Rhizopoda D. Zoomastigina
16. A dichotomous key is used to…….. A. classify organisms B. name organism C. locate Organisms D. Identify Organisms
17. Which of the following is not common in ALL adult chordates? A. Pharyngeal slit B. Dorsal nerve chord C. Notochord D. Tail
18. The female gametangium, characteristics of bryophytes, ferns, and many conifers is called? A. Oogonium B. oospore C. gametangia D. archegonuim
19. Which of the following groups of organisms possesses nervous system? A. Cnidaria B. Porifera C. Nematoda D.Platyhelminthes
20. In which of the following groups is Malpighian tubule found? A. Annelids B. Crustaceans C. Platyhelminthes D. insects

21. Radial symmetry is observed in the following EXCEPT A. Sea urchin B. Obelia C.Brittle star D. Octopus
22. The germ theory of diseases was stated by A. Anto Van Leeuwenhoek B. Rudolph Virchow C. Robert Hook D. Robert Koch
23. To which kingdom do arthropods belongs? A. Prokaryotea B. Animalia C. Plantae D. Protoctista
24. The organisms below belongs to different phylum's because.. A. Both do not fly B. Both have the same body shape B both have different body plan D. Both feed on insects

25. The following are examples of bacteria EXCEPT…. A. salmonella B. clostridium C. anabaena D. mucor
26. Which of the following is NOT a form of bacteria?.. A. spherical B. Spirilla C. Vibrio D. Bacilli
27. The scientist who classified plants and animals based on the presence and absence of red blood cells is.. A. Aristotle B. John Ray C. Carolus Linnaeus D. Robert Koch
28. One economic important of protozoan is A. They release carbon dioxide for photosynthesis during their respiratory activities B. Control the spread of diseases C. Are used in bread making D. In diagnosis of diseases

29. The main objective of classification of organisms was …… A.to establish the evolutionary trend B. for easy identification C. to demonstrate the diversity of organisms D. to ensure that each organism is name properly
30. Viruses can sometimes be regarded as living organisms because.. A. causes diseases in planta and animals B. exist in variety of shapes C. reproducers D. has nucleus

APPENDIX C

Teacher Made Pre and Post- Inquiry-Based Intervention

Test 1/ Test 2

University of Education of Winneba, Faculty of Science Education, Winneba.

Determination of SHS two biology students on Tamale Senior High School, Tamale.

Test 1 & 2 Marking scheme

Objectives Test only (30 marks)

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

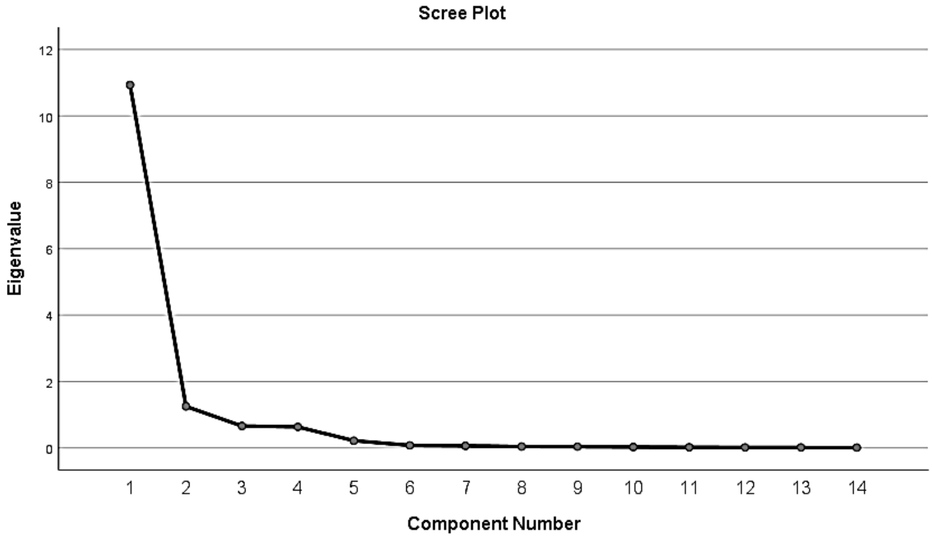
APPENDIX D

SAMPLE BSAB – (Questionnaire)

NO.	ITEM/STATEMENT	SD	D	N	A	SA
1	Biology is a boring subject.					
2	I am not the type who do well in biology.					
3	I discuss with friends' things I learn in biology.					
4	I will like to attend biology classes in all my school grades.					
5	I study biology with a feeling of hesitation.					
6	My teachers have encourage me to learn biology.					
7	The teacher is seeming to be the only correct approach to solving biology problem.					
8	Getting a teacher to take me seriously in biology is a problem.					
9	Attending biology class made me. Understanding better the surrounding world.					
10	Knowing biology is not relevant to my life.					
11	I see biology course as a course I will really use in daily life as an adult.					
12	I don't think I could do advance biology.					

APPENDIX E

Scree Plot



APPENDIX F

Structure design of Inquiry Based Teaching Module

Student Role	Teacher Role
ENGAGEMENT	
Shows interest in the topic	- Create interest
- Ask questions such as ‘why did this happened?’, ‘what else can I found’?	- Generate curiosity - Elicit responses that uncover what the students know about the topic
- **EXPLORATION**	
- Form new predictions and hypothesis - Test predictions	- Encourage students to work together without direct instruction
- Record observations and ideas - Ask related questions	- Observe and listen to the students as they interact ask questions to redirect - Ask probing questions to redirect the students’ investigations
EXPLANATION	
- Listen critically to others	- Ac t as a consultant for students

explanations	
- Explain own answers or possible solutions to others	- Create a 'Need to Know' setting
- Questions ' others explanations	
- Listen to and try to comprehend Explanations that the teacher offers	- Encourage students to explain concepts and definitions in their own words
- Refers to previous activities	- Ask for clarification and justifications from students
- Use recorded observations	
- Assesses own understanding.	- Formally clarify definitions , explanations and new labels when needed
	- Use students previous experiences as the basis for explaining concepts
ELABORATION	
- Applies new labels, definitions, explanations in new but in similar situations	- Assess students growing understanding
- Uses previous information to ask questions, propose solutions and make decisions and design experiments	- Expect students to use formal labels, definitions and explanations provided previously
- Draw reasonable conclusions	- Encourage the students to apply or extend the concepts and skills

from evidence - Records observations and explanations - Check for understanding among peers	in new situations. - Remind students of alternate explanations - Refer the student to existing data and evidence ask ‘what do you already know’?
EVALUATION - Demonstrate understanding or knowledge of the concept or skill - Students to evaluate their own progress and knowledge - Answers open-ended questions by using observations, evidence and previously accepted explanations - Ask relater questions that would encourage future investigations	- Observe the students as they apply new concepts and skills. - Assesses students’ knowledge and skills - Look for evidence that the students have change their thinking and behavior - Allows students to assess their own learning and group –process skills. - Ask open- ended questions such as ‘What evidence do you have’ ,’ What do you think about x’?, How will you explain X’?

APPENDIX G

Activities to be carry out during the intervention stage for a period of six weeks

Week	Topic	Obj./TLM	TLA	Evaluation
1	Diversity of living things	Importance of classification of living things	Discuss the importance of classifications	Pre-test and Group presentation of characteristics of kingdom Prokayortae, Protoctista, Fungi, Plantae and Animalia
2	Phyla of the kingdoms protoctista and fungi	List the major phyla of the kingdoms protoctista and fungi TLMs Charts on living things -Models of living things Relia of living things (Cockroach)	Student to examine mucor groom on bread and kenkey, visit a stagnant water to observe various forms of algae	Report on visit to gutters puddles and bathrooms.

		Text books Biology for SHS, puddles in the school.		
3	Division and classes of kingdom plantae	Outline major divisions of kingdom plantae	Discuss various sample of plants/ Outline their structural differences	Report in a form of presentation in structural differences of members of the divisions of plantae
4	Phyla and classes of kingdom Animalia	Identify and describe the characteristics of major phyla and classes of kingdom Animalia. TLMs Preserve cockroach, lizard, snail and crab	Examine and make a label diagram of at least one organism of the major phyla and class	Presentation of Drawings

5	Phyla, Classes and Order of Kingdom Animalia	Identify and describe the characteristics of the class and orders of Kingdom Animalia. TLMS Preserve cockroach, lizard, snail and crab	Make observation of sample of organism and note their structure differences, group the various organisms into their various taxa	Presentation on the observation made
6	Post test	All Questions	Written test for 30 minutes	Class test two

APPENDIX H

SAMPLE LESSON PLAN

TAMALE SENIOR HIGH SCHOOL

LESSON ONE : ONE (1)

TOPIC: Diversity of Living things

SUBTOPIC: Classification of living things 2

RPK : Students' have been introduced to the topic (classification one) in the last semester

OBJECTIVES : By the end of the lesson, the learner will be able to;

1. State at least three structural differences between organisms of the five kingdoms of classification.
2. Group organisms into theirs various phyla
3. State at least four organisms of the class insecta and Arachnida

DURATION : 120 minutes

CLASS : SC 2A,B, D & HE2A

REFERENCES: Teaching syllabus of senior high school biology (SHS 1-3) PP

Biology for senior high text book (SHS 1-3) PP

REMARKS: Lesson was taught successfully because the set objectives were achieved.

TLM	Content/ Time	Teacher activities	Learner activities	Major ideas/core points
	Introduction: Begin lesson 10minutes	Teacher introduce Lesson by reviewing learners RPK using questions and answers -State two characteristics of the vaarious kingdoms of classification Teacher goes round the	Student respond individually from each group.	Animalia: have pre anal tail Planta: Are photosynthetic Fungi: Lack chlorophyll Prokaryortae: lack nuclear membrane Protoctista: have nuclear membrane

Prevseved Toads, crabs, cockroaches, lizards. Chats.	DEVELOPMENT Step 1 Grouping of organisms 45 mins Development Step 2 30 minutes Development Step 3 30 minutes Evaluation 5minutes	groups to observe that each group has the desired TLM. Teacher continue to observe groups work Teacher listen to groups presentation and make clarifications on certain misconceptions Teacher gives out weekly reading assignment to students	Learners to follow instructions on cards and group the specimen provided to them Group leaders to lead their groups to present their findings Students to read on Phyla of Kingdom Fungi.	

APPENDIX J

Factor loading

Statement / item	Component	
	1	**2**
3 Biology boring	.867	.443
2 Knowing biology is not relevant to my life	.854	.493
3. Attending biology class made me understand better the surrounding better the surrounding world	.837	.502
4. I will like to attend biology class in all my school grade	.836	.525
5. biology is the least subjects among my subject	.834	.490
6. I discus with friends things I learn in biology	.811	.514
7. getting a teacher to touch me seriously in biology is a problem	.792	-
8. I don't think I could do advance biology	.782	.550
9. I am not the type who do well in biology	.755	-
10. my teacher have encourage me to learn biology	.659	.641
11. The teacher seeming to be early correct approach to solving biology problems	-	.917
12. I see biology	.153	.838

Factor 1= Interest or confidence of students (I), F 2= The teacher (T), Factor3= The relevance biology (R)

APPENDIX K

Percentage of the overall variance of the two factors extracted

Factor	Total variance	percentage (%) total variance
1	9.461	72.780
2	1.017	7.821
Percentage of overall variance		80.601

APPENDIX L

Means scores and Standard deviations of the three factors before and after treatment. 20

Sub-scales on students attitudes towards biology	Pre - IBT M S (SD)	Post - IBT M S (SD)
F1- Interest of students (Items 1, 3, 10, 12)	3.22 (1.47)	4.21 (0.88)
F3- Relevance of biology in daily lives (Items 2, 4, 6, 8, 9)	2.72 (1.51)	3.64 (1.27)
F2- The teacher (Items:5, 7,11)	3.13(1.49)	4.46 (0.67)
Overall mean score	3.02 (1.49)	4.10 (0.94)