UNIVERSITY OF EDUCATION, WINNEBA

SENIOR HIGH SCHOOL BIOLOGY TEACHER'S KNOWLEDGE AND CLASSROOM PRACTICES OF INQUIRY BASED APPROACH: A STUDY OF SELECTED TEACHERS

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DECLARATION

STUDENT'S DECLARATION

I, **EDWARD ANSAH**, declare that this thesis with the exception of quotations and references contained in publish works which all have been duly acknowledged, is entirely my own original work, and it has not been presented, either in part or in whole for another degree elsewhere.

SIGNATURE…………………………….

DATE: ………………………………….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this thesis was supervised in accordance with the laid down procedures of supervision of thesis at University of Education, Winneba.

NAME OF SUPERVISOR: **DR. JAMES AZURE**

SIGNATGURE …………………………………

DATE: ………………………………………..

DEDICATION

I dedicate this work to my wife and my parents who had been a great source of inspiration to me during the period of this work.

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I am grateful to the Almighty God for his protection guidance and wisdom through this research work. Special thanks go to my supervisor Dr. James Azure for his guidance throughout all the stages of this work. I am also indebted to my family for their prayers and support throughout this study and all the biology teachers in Sekondi Takoradi Metropolis who participated in the completion of questionnaires and availed themselves for classroom observations. May God bless you all.

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ABSTRACT

The study investigated senior high school biology teacher's knowledge and classroom practices of inquiry-based approach on some selected teachers in the Sekondi Takoradi Metropolis. The study employed descriptive survey design with qualitative approaches to collect data. The sample consisted of 10 senior high schools selected using convenience sampling and 30 senior high school biology teachers selected using simple random sampling. Instruments used for the study were questionnaire and classroom observation chart. Questionnaire was used to collect data on teachers' knowledge on inquiry approach and difficulties they encounter in the classroom practice of inquiry-based approach. questionnaire was made up of A and B. Section A was made of 8 closed ended questions aimed at finding out about participants' background data and the methods they employ in their teaching and facilities available in participants' school. Section B on the other hand consisted of 5-point Likert scale questions ranked on a scale of 1-5 with1 being strongly disagree and 5 being strongly agree aimed at finding out participants' knowledge of inquiry-based approach. The classroom observation chart originally developed by Lawson, Devito, and Nordland was adopted and slightly modified for the purpose of this study. The final observation schedule consisted of sections A and B. Section A consisted of items to collect background information of the teacher being observed. Section B consisted of items grouped into three categories to collect information on the contexts used during instruction. The first category described the materials and activities used during the lesson. The second category described teachers' behaviour such as self-confidence, handling classroom interruptions, and playing the role of an investigator. The fourth category described teachers' questioning techniques, teachers' acceptance of students' opinion, and the allocation of time for students' responses. The Classroom observation chart was used to collect data on the extent to which teachers utilize their knowledge of inquiry in the classroom. Data was analysed using simple tables, frequencies, and percentages. The study established that most teachers agree that inquiry approach is one of the best methods of teaching biology in the senior high schools. The study also revealed that most teachers were taught inquiry-based approach to teaching in their teacher training programme. However, many refuse to implement the inquiry strategy in their classroom practice due to challenges such as large class size, lack of equipment, too many classes taught by teachers and some existing school policies. The findings suggest that implementation of traditional instruction persists in the selected senior high schools, despite the emphasis of current curricula rationale for all students to be actively engaged in inquiry investigations.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter looks at background of the study, statement of the problem, objectives of the study, research questions and significance of the study, delimitations, limitations and organization of the study.

1.1 Background of the Study

According to Fensham (2008) study after study since year 2000 has made it clear that there is an alarming crisis in relation to students' interest in science, either as a possible future career, or as an intrinsic interest that will continue after school. One factor which has contributed to low interest in science by students is the method adopted for teaching and learning science. He listed some views of students which contribute directly to low interest in science: (i) Science teaching is predominantly transmissive, (ii) The content of school science has an abstractness that makes it irrelevant, (iii) Learning science is relatively difficult, for both successful and unsuccessful students.

This unfortunate development on the part of students towards science has sparked the search for and development of alternative methods of science teaching and learning which can stimulate students' interest and guarantee an educational system that offers equal opportunities for all students. Science education as a field of study is therefore in dire need of methods with qualities such as lesson clarity, promotion of self-activity, promotion of self-development, stimulation of interest and curiosity and relying on the psychological process of teaching and learning to recommend to science teachers. The methods should encourage science teaching and learning that is better than it is now. Many students today are learning science in a passive way in classrooms where information is organised and presented to them by their teacher (Moyer, Hackett & Everett, 2007). They noted that often, the teacher pays little attention to what students already know about science.

Biology, the study of living things, is a branch of science that helps learners to have insight on natural and environmental concepts, principles, theories, and laws. In the teaching and learning of biology, it is very important to involve the learners in the teaching process so as to sustain their interest, develop an awareness of their environment and to have meaningful and relevant knowledge in biology necessary for successful living in a scientific and technologically advancing world.

According to the Ministry of Education (2010, p. ii) the following are the general aims of the Senior High School (SHS) Biology syllabus:

1. Appreciate the diversity of living things.
2. Understand the structure and functions of living things.
3. Develop scientific approach to solving personal and societal (environmental, economic and health) problems.
4. Develop practical skills required to work with scientific equipment, biological materials and living things.
5. Collect, analyse and interpret biological data; and also, present data graphically.
6. Be aware of the existence of interrelationships between biology and other scientific disciplines.
7. Sustain their interest in studying biology
8. Appreciate and understand the interrelationships between organisms and themselves and with the environment.
9. Recognize the value of biology to society and use it responsibly.

10. Develop a sense of curiosity, creativity and critical mind.

11. Provide a foundation for those who will develop a career in biological sciences.

With these aims in mind the content of the syllabus has been designed in such a way as to provide students with basic knowledge in biology for them to understand themselves and other organisms, which enable them make very informed choices as they interact with nature. Hence, the introduction of biology to senior high school students is a crucial step towards grooming Senior High School students for a successful career. It is, therefore, important that schools should have trained and qualified biology teachers with adequate knowledge on and practice pragmatic teaching methods that will make their students more of active learners than passive learners. Unfortunately, this is far from the case as there are limited number of trained and qualified teachers to take up this task.

Akowuah, Patrick and Kyei (2018), in their study in Ghana concluded that one of the factors contributing to poor performance of students in senior high school is poor methods of teaching. Dedicated, knowledgeable and resourceful science teachers are therefore needed to lay good foundation of science these students. Unfortunately, despite the government's drive to draw more students to science, especially at the second cycle levels, more students keep running away from it. O'Connor (2000) identified the use of inappropriate teaching methods as one of the factors that contribute to the low participation and performance of students in science. The teaching methods used are not practical enough and that teachers make little effort to relate the concepts learnt and the examples/illustrations used to real life, especially within the context of the students' own lives and environment. This has a negative effect on students' interest and motivation to study science.

It is against this background that the researcher sought to investigate senior high school biology teachers' knowledge and classroom practices of inquiry – based strategies in selected senior high schools in Sekondi-Takoradi Metropolis.

1.2 Statement of the Problem

There are various teaching methods that can be used by teachers to enhance students understanding of scientific concepts and make teaching more pragmatic. Baafi (2020), in a study conducted in senior high schools in Ghana observed that many teachers in Ghana exhibit ineffective teaching strategies due to lack of structured teacher professional development. The study further established that strategies which increase learner engagement as well as those which increase learning during lesson delivery were largely inadequate.

This phenomenon is a great source of worry for students, parents, teachers and educational planners. Additionally, this trend raises a lot of questions and eyebrows as to whether biology teachers' have adequate knowledge on students' centered teaching strategy and its subsequent practices in the classroom to enhance academic achievements.

Inquiry is one of the methods of instruction that has become a popular teaching strategy in education due to its unique realistic, problem-based method of instruction (Phipps, Osborne, Dyer, & Ball, 2008). A study conducted by Mensah-Wonkyi and Adu (2016), Annan, Adarkwah, Abaka-Yawson, Sarpong and Santiago (2019), on the effect of inquiry based teaching approach in senior high school (SHS) students' conceptual understanding of concepts in science, recommended among others that inquiry-based teaching approach should be integrated into classroom teaching and learning since the inquiry method proved to enhance students' ability to be innovative and to think outside the box. Despite this strong track record, many teachers avoid implementing inquiry-based strategy in their classrooms because of its complexity and intensity during the instructional process (Puntambekar, Stylianou, & Goldstein, 2007). Additional reasons explaining why teachers are hesitant to utilise this teaching method relates to their lack of training and experience with constructivist style teaching (Llewellyn, 2002). This study therefore aims at investigating the knowledge of biology teachers on inquiry based- strategy and its use in the biology classroom in selected Senior High Schools in the Western Region.

1.3 Purpose of the Study

The purpose of the study was to investigate the knowledge of biology teachers in inquiry – based learning method and their practices in the classroom in senior high schools in the Sekondi-Takoradi Metropolis.

1.4 Research Objectives

The study was to:

1. determine SHS biology teachers' knowledge on the types of inquiry-based approach to teaching.
2. determine how biology teachers' utilise the types of inquiry –based approach to teaching.
3. ascertain the difficulties biology teachers' encounter in the classroom practice of inquiry-based teaching and learning approaches.

1.5 Research Questions

The study addressed the following research questions:

1. What are teachers' knowledge about inquiry method of instruction?
2. To what extent does the teachers utilize inquiry base strategy in their classroom practice?
3. What are the difficulties biology teachers' encounter in the classroom practice of inquiry-based learning?

1.6 Significance of the Study

The findings of this study would be useful to biology teachers and other subject teachers in Western Region of Ghana. Secondly the heads of second cycle institutions, would be informed on the need to impress upon their teachers to use teaching strategy that promotes participatory learning to augment students understanding of abstract concept.

1.7 Delimitations of the Study

There are a total of 35 Senior High Schools' in the Western Region of Ghana at the time of the study. This study confined itself to only 10 schools and 30 biology teachers. The study also focussed only on biology teachers' knowledge of inquiry-Based Approach.

1.8 Limitation of the Study

Study of this nature should cover a large number of schools, however, due to time and financial constraints, the researcher limited the study to 10 out of the 35 Senior High Schools in Western region. Since the sample size is small the findings could not be applied to all Senior High Schools in the region.

1.9 Organisation of the Research Report

This thesis is organized into five chapters. The first chapter is the introduction which contains the background to the study, problem statement of the study, the purpose of the study, the research questions and the significance of the study. The limitation and delimitation of the study of this study have also been captured in chapter one.

Chapter two contains the review of literature related to the study while chapter three provides the details of the methodology that was used for this study. Chapter three also describes the various areas of the study such as the research design, sample and sampling technique, data collection procedures and the data analysis procedures.

In the fourth chapter, there is a presentation of the gathered data, analysis of the gathered data and a discussion of the results. The last chapter which is chapter five covers a summary of the research findings, conclusion, recommendations and suggestions for further studies.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

The review of the related literature in this chapter involved the discussion of materials related to various aspects of this study. This chapter embodies the review of literature related to the topic documented by some writers, authorities, and researchers. The literature was reviewed under these themes: conceptual framework, concept of inquiry, forms of inquiry- based learning in science education, inquiry base science education, characteristics of inquiry–based learning, role of the teacher in inquiry–based learning, effectiveness of inquiry learning, relationship between inquiry and students' achievements and teachers' knowledge on inquiry-based learning.

2.1 Theoretical Framework

Theoretical framework on which this study is based is John Dewey's theory of inquiry learning. The theory propose that students need to be actively involved in their learning by inquiring into problems and situations that concern them, all the while guided by a teacher who adapts to a role of facilitator or guide. Dewey posits that it isn't just the student who learns, but rather the experience of students and teachers together that yields extra value for both. According to Janse (2019) The John Dewey theory recommends an interdisciplinary curriculum, or a curriculum that focuses on connecting multiple subjects where students can freely walk in and out of classrooms. In this way, they pursue their own interests, and build their own method for acquiring and applying specific knowledge. In this setting, the teacher has a facilitating role. According to John Dewey, the teacher should observe the student's interests, follow the directions, and help them develop problem-solving skills.

It is a common practice to see the teacher stand in front of a group of students and provided information all day long. The students' task is to absorb the information and test this in the form of an exam or other written test. John Dewey's ideal describes an entirely different function of the teacher. According to Dewey, the teacher should only provide background information and have the students work together in groups on the concept. This should start conversation and discussion, and give rise to valuable collaboration.

As a former science teacher, Dewey advocated the use of inquiry in the classroom as opposed to students being instructed about conclusive facts where the thinking had been done for them and any indeterminate situation already being settled (Deters, 2006). As one of the key leaders of the progressive movement in education, Dewey encouraged teachers to use inquiry as the primary teaching strategy in their science classrooms. Modelled on the scientific method, Dewey advocated that the process of inquiry involves sensing perplexing situations, clarifying the problem, formulating a tentative hypothesis, testing the hypothesis, revising with rigorous tests, and acting on the solution (Barrow, 2006). Dewey was critical of transmission-based pedagogies that emphasised acquiring facts at the expense of fostering modes of thinking and attitudes of the mind related to the ways scientific knowledge is created. As Dewey's thinking on education evolved, he broadened the scope of topics and subjects in which to engage students with inquiry. Dewey (1938) encouraged students to formulate problems related to their own experiences and augment their emerging understandings with their personal knowledge. Dewey believed that the teacher should not simply stand in front of the class and transmit information to be passively absorbed by students. Instead, students must be actively involved in the learning process and given a degree of control over what they are learning. The teacher's role should be that of a coordinator and a guide. It is important to emphasize that this process did not involve anything-goes, free-for-all exploration; it was to be guided by empirical approaches to knowledge creation. From a curricular perspective, Dewey, like Socrates, believed that active inquiry should be used not only to gain knowledge and particular dispositions, but also to learn how to live. Dewey (1944) felt that the purpose of education was to help students realize their full potential, to strengthen democracy, and to promote the common good.

Thus, according to this theory of learning, effective teaching must offer experiences that:

1. Build on what students already know so they can make connections to their existing knowledge structures
2. Encourage students to become active, self-directed learners provide authentic learning opportunities
3. Involve students working together in small groups (i.e. in collaborative or cooperative learning). Rather than being the "sage on the stage" in a transmission mode of teaching, in inquiry-based approach teachers should act as a "guides on the side", providing opportunities to test the adequacy of students' current understandings (Hoover, 1996). Hoover also argues that because new knowledge has to be actively built, it takes time to do so. This means that any inquiry-based approach courses should allow ample time for student reflection about new experiences and how these fit with current understandings.

Atherton (2013) maintains that in the process of learning, the focus is on the one described as "maker of meanings". The teacher's role is to dialogue with learners, guide them to make meaning of the material to be learned, and to help them to revise their understanding until it is in tune with that of the teacher. Teacher may gradually challenge the learners to achieve more as he or she observes them to bridge the two developmental levels of Proximal Development (ZPD) (Gray & Macblains, 2015). The lower level gives the threshold measure of what could be achieved independently by a learner. The higher level is what the learner achieves through teacher's guidance. Learning strategies of constructivists are self-regulated and allow the individual learners to take full responsibility of their own learning and to engage with the external world to construct new knowledge (Woolfolk et al., 2008).

Draper (2002) opines that the implementation of the theory of inquiry learning may require an overhaul of practices that already exist in the classroom. The implementation of inquiry learning approach may be difficult for most teachers in their respective classrooms because there are many problems which come with their application especially during the teaching of concepts that are abstract in nature.

The application of cooperative or group learning, a characteristic of inquiry-based approach in the classroom poses several challenges. Gillies (2003) is of the view that some cooperative learning may not lead to conceptual understanding since merely grouping students and giving them work to do may not in itself encourage cooperative learning. Pijls, Deker and Hout-Wolters (2007) have established that a teacher may find it extremely difficult to observe students as they work collaboratively. A study by Boaler (2006) found out that when students work in groups, not always does it yield the expected result since some students often do more compared to others in the same group.

2.2 The Concept of Inquiry-Based Approach

The use of appropriate teaching method is very important in education. The selection of strategies and appropriate learning methods enhance students' creativity in learning. The use of appropriate methods also facilitates the achievement of the desired objectives. Using appropriate teaching methods is aimed at solving the problems that arise in the learning process. One of the methods suggested by educationist is the inquiry-based method. This method directs the learners to find the problem and then being able to solve the problems found scientifically.

Inquiry-based learning falls under the realm of 'inductive' approaches to teaching and learning, an excellent review of which is provided by Prince and Felder (2006). Inductive approaches to teaching and learning begin with a set of observations or data to interpret, or a complex real-world problem, and as the students study the data or problem, they generate a need for facts, procedures and guiding principles. According to Prince and Felder (2006) inductive teaching encompasses a range of teaching methods including inquiry learning, problem-based learning, project-based learning, case-based teaching, and discovery learning. They classify the teaching methods by considering the context for learning and other features, such as the amount of student responsibility for their learning and the use of group work. Common to all these inductive methods of teaching are several characteristics:

1) A student- or learner-centered approach (Kember, 1997) in which the focus of the teaching is on student learning rather than on communicating defined bodies of content or knowledge;
2) active learning is about learning by doing (Gibbs, 1988; Healey & Roberts, 2004) and may involve, for example, students discussing questions and solving problems (Prince & Felder 2006);
3) The development of self-directed learning skills in which students take more responsibility for their own learning;
4) A constructivist theoretical basis which proposes that students construct their own meaning of reality; it is the students who create knowledge rather than

> knowledge being imposed or transmitted by direct instruction. Many of these inductive methods also utilize collaborative or cooperative learning with much work both in and out of formal class time being done by students working in groups.

Inquiry–based method is a pedagogy which enables students experience the processes of knowledge creation and one of its key attribute is learning stimulated by an inquiry, a student-centered approach, a more to self-directed learning and an active approach to learning (Spronken-Smith, 2007). Inquiry-based method can also be defined as an approach to teaching and learning that places students' questions, ideas and observations at the center of the learning experience (Friesen & Scott, 2013).

According to Sanjaya (2006, as cited in Adrini, 2016), inquiry learning is a series of learning activities that emphasizes the process of thinking critically and analytically to seek and find their own answer to the problem in question. Inquiry learning is built on the assumption that humans have an innate urge to find their own knowledge. The main objective of inquiry-based learning is helping students to develop intellectually disciplined and thinking skills by providing questions and getting answers on the basis of curiosity. The inquiry learning method train students to dare to express opinions and find their own knowledge that is useful for solving problems.

"Tell me and I forget, show me and I remember, involve me and I understand."

This well-known adage signifies such teaching approach by learning through inquiry. The use of inquiry learning approach efficiently and effectively will reduce the monopoly of teachers in mastering the course of the learning process and the boredom of the students in the lesson will be reduced (Soerwarso, 2000, as cited in Adrini, 2016).

Inquiry based learning draws inspiration from Socrates' questioning method in Ancient Greece and from work on inquiry by the educational thinker John Dewey in the early part of the 20th century. Newly emerging insights and empirical findings in the learning sciences suggest that traditional approaches to education that emphasize the ability to recall disconnected facts and follow prescribed sets of rules and operations should be replaced by "learning that enables critical thinking, flexible problem solving, and the transfer of skills and use of knowledge in new situations" (Darling-Hammond, 2008).

Perkins (2009) argues that students should be given opportunities to "play the whole game" where they can experience junior versions of how knowledge is created and communicated within specific disciplines. The key attributes of inquiry-based approach include learning stimulated by inquiry, a learner-centered approach in which the role of the teacher is to act as a facilitator, a move to self-directed learning, and an active approach to learning. Students should develop research skills and be prepared for lifelong learning. They should achieve outcomes that include critical thinking, the ability for independent inquiry, responsibility for own learning and intellectual growth and maturity. One of the primary reasons for advocating an inquiry approach is because it is thought to motivate learners more strongly. Bransford, et al., (2000) provide a comprehensive review of cognition research. They discuss studies which find that motivation affects the amount of time and energy that people are willing to devote to learning. Further they suggest that tasks must be challenging but at the proper level of difficulty to remain motivating if they are too easy students will be bored, while if they are too hard, students will become frustrated. As Ciardello (2003) argues, learners will be better stimulated and motivated to learn by sparking their curiosity. Thus, by confronting students with a state of perplexity, students are prompted to seek questions and evidence that will help them resolve the discrepancy or problem. Learners are also motivated when they can see the usefulness and relevance of what they are learning – especially in their local community (Bransford et al., 2003). The implications for inquiry-based learning are clear: students can be strongly motivated by complex, personally relevant questions.

2.3 Forms of Inquiry

As the scope of inquiry-based approach is being delved into by researchers and experts in the field, so are different authors dealing with the classification of the concept into levels depending on the degree of teachers' involvement in comparison with that of their students. NRC (2000) categorise inquiry-activities into a wide-range of methods, including structured inquiry, guided inquiry and open inquiry. Dunkhase (2003) adds another level of inquiry called coupled inquiry found between guided and open inquires and which exhibits the characteristics of these two levels. Banchi and Bell (2008) describing a continuum of four inquiry levels begin with confirmation which is lower than structured inquiry.

2.3.1 Confirmation inquiry

According to Banchi and Bell (2008) confirmation inquiry is the one that provides students the opportunity to confirm facts their teacher presents. Teacher gives questions and procedures to be followed by students with end results that are already known. Students practice some specific sub skills of inquiry.

2.3.2 Structured inquiry

Structured inquiry also called directed inquiry is usually guided by the teacher. Teacher formulates questions and students are asked to investigate through prescribed procedure. At each stage, instructions are given to students until they arrive at a predetermined discovery. Due to its nature and administration, this sort of inquiry is like working with a recipe towards desired outcome. The importance of this kind of inquiry is to enable students to gradually develop their ability to conduct more open-ended inquiry. It is also a good level to start for teachers who are new to inquiry-based teaching method.

2.3.3 Guided inquiry

Guided inquiry provides students the opportunity to investigate teacher-formulated question for investigation. The students with the help of the teacher then determine the process and draw their own conclusions. Teachers might have an idea of expected results but allow students to lead the process and reach conclusions that are unforeseen and self-formulated (NRC, 2000; Dunkhase, 2003; Banchi & Bell, 2008). Guided inquiry gradually leads students to open inquiry at which point students take full responsibility of their learning and knowledge construction. Guided inquiry has proven to promote learning. A study by Blanchard, et al., (2010) to compare the impact of guided inquiry-based teaching to traditional laboratory verification teaching, found out that students instructed through guided inquiry obtained higher post-test scores compared to their peers who were instructed through verification laboratory instruction. A similar study conducted by Conway (2014) for pre-nursing and paediatric students offering combined chemistry and biochemistry course showed statistically significant improvement in grades obtained by students who were instructed using all guided inquiry and those partially guided inquiry over their colleagues who were instructed through lecture only.

2.3.4 Coupled inquiry

In-between guided inquiry and open inquiry is an intermediate stage referred to as coupled inquiry. Dunkhase (2003) opines that in other to address the issue concerning content control as well as curriculum goals, teacher employs coupled inquiry through the combination of or by "coupling" guided inquiry with open inquiry. To him, couple inquiry require that teacher still adhere to student centered full inquiry. Dunkhase (2003) explains that coupled inquiry follows a cycle of components which include:

1. Invitation to inquiry: This stage of the cycle referred to as the "motivator" or "hook" is a designed activity aimed at arousing or stimulating the interest of students in the concept or topic under investigation. It is not enough for the teacher to announce what to be learnt but rather the teacher may use field trips, demonstrations, guest speakers, current events and other strategies that will arouse students' interest coupled with 16 excitement so that they will fully participate in pursuing the understanding which the inquiry process seeks to promote.
2. Guided inquiry: this stage of the cycle opens the door for the teacher to direct students towards objectives of specific concept required by the curriculum. The teacher controls the direction of the investigation and its expected outcomes and approach is more tilted towards the teacher's comfort zone. Students can choose a question for inquiry from a data bank of a range of pre-set questions. Students are however not involved in the formulation of questions. Results usually amazes students giving room for lively class discussion.
3. Plan your own: Dunkhase contends that the most important of the stages of coupled inquiry is the plan your own since it provide the grounds for students' curiosity as it encourages them to explore phenomena of interest. Students have the chance to "play around" with provided apparatus or materials. They can also

determine their own questions for the next stage which is the open inquiry stage thereby creating a link between the guided and open inquiry. Students are given a reasonable amount of time to explore at this stage after which they have the chance to list pressing question that arise. They discuss them and select the best question for investigation in an open inquiry.

4. Open inquiry: this stage is purposefully intended to be an entirely student centred that offers students the opportunity to take control of their learning (knowledge creation). Students at this stage are given the opportunity to discuss questions generated at the "plan your own" stage and negotiate for selecting the most appropriate question for further investigation. Students are asked to refine their question to make it clearer and one that can be investigated with materials that are available in the classroom or within their environment. Serious consideration must be given to curriculum, time as well as materials and concerns on safety while deciding on the question for investigation. Students can design the investigations on their own, conduct them, do data analysis and then present their findings and explanations they the whole class and sometimes the whole community.

5. Inquiry resolutions: Many teachers do have a concern on their comfortability of using inquiry in teaching because students might not have learnt anything when an investigation has ended. The resolution stage of inquiry is aimed at helping students get an understanding of the science concepts and to reach the goal of the curriculum. To achieve this, the teacher may review the inquiry presentations of students to get a common conclusion for understanding. The teacher also may engage students in discussion to find out what they have learnt so far and what next, they wish to investigate. A demonstration challenging or confirming students' findings could be performed by the teacher. It is also essential for teacher

to use direct instruction if necessary, to clarify concepts of science when students are in a dilemma or when closely related concepts interfere to create state of confusion in student' mind. The resolution stage is the most appropriate platform for discussing how new acquired science concepts together with the inquiry results could be applied to student's lives.

6. Inquiry assessment: To assess students' progress and issues they are bothered with; formative assessment is to be employed at each stage of the cycle of inquiry. When the cycle has ended, the teacher needs to conduct summative assessment to evaluate it success or otherwise. The summative evaluation should be "authentic" or "performance component" rather than simply being a traditional paper and pencil test which is only conducted for evaluation. For example, teacher may give students a task that involves the application of knowledge acquired from the targeted concepts to solve a problem. Teacher can also create a situation for students to apply the acquired knowledge to make personal or societal decision: informed decision-making assessment grounded on scientific literacy. The assessment stage could be structured to cause students to initiate additional inquiries to ensure the continuation of the cycle bearing in mind the available time and curriculum pressures. Dunkhase (2003) believes coupled inquiry can assist teachers in hesitation to use student-centred inquiry to successfully experience it.

2.3.5 Open inquiry

The last and the most challenging level of inquiry is the open inquiry. In this level of inquiry, teacher only gives the knowledge framework definition in which the inquiry is carried out and allows learners to formulate several questions. Students investigate these topic-related questions through their own designed or students' selected procedures. Questions are posed by the students and that teacher only acts as a facilitator. Cochran-Smith, et al., (2009) are of the firm conviction that the pivot of higher inquiry level is student's involvement in questioning. This they believe gives students the opportunity to have personal control of learning and promotes students interest. At each stage of the open inquiry process, students make decisions themselves. Colburn (2000) defines open inquiry as a student-centred approach that starts with student's question and continues with student or groups of them designing and conducting experiment and investigations and finally ends with communicating their results. Martin-Hansen (2002) postulates that higher-order thinking is a fundamental ingredient for open inquiry as students normally work 'directly with the concept and materials, equipment' and all other resources required to make it successful. Open inquiry requires the teacher to provide the needed resources and materials and ask students what investigations could be carried out using the provided resources. Students then devise a plan and carry out investigation into the questions with the provided materials which they by themselves gather and collect data. The recorded data is analysed after the completion of the investigation. Students then present their results based on the collected and make claims and share the processes and the outcomes for critiquing by the class (Martin-Hansen, 2002). According to Minner, Levy and Century (2010) active participation or involvement of students in open inquiry promotes greater learning compared to those forms that are leaned toward teacher-directed. A study conducted by Jiang and McComas (2015) however revealed the opposite that students' achievement in science peaks when their level of involvement in inquiry activities are restricted to 'conducting activities and drawing conclusion from data only' but not in activities of inquiry at higher level including investigation design or raising self-questions. A similar study conducted in Israel by Sadeh and Zion (2009) on the impact of guided inquiry as against open inquiry instruction among students in high schools revealed that students group who were instructed through open inquiry showed a significantly higher performance compared to their counterparts who were instructed through guided inquiry. Golding (2013, p.21) maintains there exist a tension that arises as the teacher uses inquiry learning in the classroom. Whether the teacher should direct students as they strive to find solutions to questions or allow students to do the inquiry by themselves ding is of the view that teachers must work harder to overcome this tension if they are to make gains in the use of inquiry as strategy for teaching and learning. The study proposes that teachers should strike a balance between the two paths. For example, teacher may use questions to "lead students to the answer the teacher thinks is the best, or to invite students to share their responses without critical evaluation, or to encourage critical reflection" (Golding, 2013 p. 23).

2.4 Inquiry-Based Science Education

Inquiry learning has been used as a teaching and learning tool for thousands of years, however, the use of inquiry within public education has a much briefer history. Ancient Greek and Roman educational philosophies focused much more on the art of agricultural and domestic skills for the middle class and oratory for the wealthy upper class. It was not until the Enlightenment, or the Age of Reason, during the late 17th and 18th century that the subject of Science was considered a respectable academic body of knowledge. Up until the 1900s the study of science within education had a primary focus on memorising and organising facts. John Dewey, (1938) a well-known philosopher of education at the beginning of the 20th century, was the first to criticize the fact that science education was not taught in a way to develop young scientific thinkers.

Dewey proposed that science should be taught as a process and way of thinking – not as a subject with facts to be memorised. While Dewey was the first to draw attention to this issue, much of the reform within science education followed the lifelong work and efforts of Schwab (1978). Schwab was an educator who proposed that science did not need to be a process for identifying stable truths about the world that we live in, but rather science could be a flexible and multi-directional inquiry driven process of thinking and learning. Schwab believed that science in the classroom should more closely reflect the work of practicing scientists. Schwab developed three levels of open inquiry that align with the breakdown of inquiry processes that we see today.

1. Students are provided with questions, methods and materials and are challenged to discover relationships between variables.
2. Students are provided with a question, however, the method for research is up to the students to develop.
3. Phenomena are proposed but students must develop their own questions and method for research to discover relationships among variables.

Today, we know that students at all levels of education can successfully experience and develop deeper level thinking skills through scientific inquiry. The graduated levels of scientific inquiry outlined by Schwab (1978) demonstrate that students need to develop thinking skills and strategies prior to being exposed to higher levels of inquiry. Effectively, these skills need to be scaffolded by the teacher or instructor until students are able to develop questions, methods, and conclusions on their own.

America's National Science Education Standards (1996), outlines six important aspects pivotal to inquiry learning in science education.

- Students should be able to recognise that science is more than memorising and knowing facts.

- Students should have the opportunity to develop new knowledge that builds on their prior knowledge and scientific ideas.
- Students will develop new knowledge by restructuring their previous understandings of scientific concepts and adding new information learned.
- Learning is influenced by students' social environment whereby they have an opportunity to learn from each other.
- Students will take control of their learning.
- The extent to which students are able to learn with deep understanding will influence how transferable their new knowledge is to real life contexts.

Historically, two pedagogical approaches in science teaching can be contrasted. These are deductive and inductive approaches. In deductive or so-called top-down transmission approaches, teachers' role was confined to presenting the scientific concepts and their logical deductive implications and to giving examples of applications, whereas learners, as passive receivers of knowledge, were forced to handle abstract notions. The inductive or so-called bottom-up approaches gave space to observation, experimentation and the teacher-guided construction by the learners of their own knowledge (Rocard, et al., 2007). According to Rocard et al.'s (2007) report, "The terminology evolved through the years and the concepts refined, and today the Inductive Approach is most often referred to as Inquiry-Based Science Education, mostly applied to science of nature and technology". The last two decades have seen growing calls for inquiry to play an important role in science education (Rocard et al., 2007). This call for inquiry-based learning is based on the recognition that science is essentially a question-driven, open-ended process of constructing coherent conceptual frameworks with predictive capabilities and that students must have personal experience with scientific inquiry and engage in its practices, in order to be enculturated in these fundamental aspects of science (Linn, Songer, & Eylon, 1996; NRC, 1996). However, one difficulty for efforts to promote inquiry is the lack of specificity of what it can mean, in classroom terms. Other researchers (Anderson, 2002; Minner et al., 2010) have discussed this problem of ambiguity in the term inquiry and described three distinct meanings of the term;

1. scientific inquiry, referring to the diverse ways in which scientists practise to generate and validate knowledge
2. inquiry learning, referring to the active learning processes in which students are inevitably engaged
3. inquiry teaching, which is the main focus of literature around inquiry, for which there is no clear operational definition. What is worth mentioning is that the educational process by itself consists of two major actors: the teacher and the learner(s). Hence, it involves two processes, namely, teaching and learning, which may rely on different methods, strategies and principles. The educational process has a cognitive as well as a cultural facet, applied through communications among the different actors.

2.4.1 Inquiry-based science learning

In any of the three perspectives discussed by Anderson (2002) and Minner et al. (2010), namely, whether we refer to scientists, students or teachers who do inquiry, some core components characterise those enactments. From the learners' perspective, those core components are described by the National Research Council as "essential features of classroom inquiry" (NRC, 2000, as cited in Minner et al. 2010, p.15), including:

1. Learners being engaged by meaningful scientifically oriented questions

2. Learners giving priority to evidence, which allows them to develop and evaluate ideas that address scientific questions
3. Learners formulating knowledge claims and arguments from evidence in order to settle scientific questions
4. Learners evaluating their explanations in light of alternative explanations, particularly those reflecting scientific understanding;
5. Learners communicating and justifying their proposed explanations.

According to Arnold, Kremer, and Mayer (2014), while learners engage in inquiry as a means, they are supposed to also learn scientific content knowledge through inquiry. Since in such lens inquiry leads to knowledge construction, thus in this vein, "inquiry" can be also seen as an outcome. Students learn how to do science and acquire relevant skills or abilities, and they develop an understanding of scientific inquiry itself (NRC, 1996). There has been a shift from the notion of "inquiry skills" to the notion of "science practices" (Bybee, 2011). The term "practices" is meant "to stress that engaging in scientific inquiry requires coordination both of knowledge and skill simultaneously" (NRC, 2012 p.11). With this respect, the process of scientific inquiry in science education involves the development of an understanding of scientific aspects of the world around through identifying and refining investigation questions; formulating hypotheses and/or making predictions; planning, managing and carrying out investigations with a purpose to obtain evidence, analysing and evaluating data; interpreting results; developing explanations; constructing and using models; engaging in argumentation from evidence; and being able to communicate scientifically in different situations and at all steps of the inquiry process. Alongside the acquisition of scientific practices (Bybee, 2011) and an understanding of scientific concepts and phenomena (Schroeder, Scott, Tolson, Huang, & Lee, 2007), classroom inquiry also fosters learners' thinking skills and critical thinking offers experiences with science, promotes the development of an epistemological awareness of how science operates (Chinn & Malhotra, 2002) and develops positive attitudes towards science. Moreover, the acquisition of core practices, such as modelling and argumentation, is deemed essential for responsible citizenship and success in the twenty-first century (Pellegrino & Hilton, 2013; Beernaert, Constantinou, Deca & Grangeat 2015). Inquiry also provides the opportunity to acquire specific investigation skills, relying on different methods of investigation and different sources of evidence. From an educational perspective, the following forms of inquiry have been proposed by researchers: controlled experimentation, modelling, synthesis of primary sources and exploration of quantitative. (Linn, Bell & Hsi 1998) All these forms constitute structured collections of evidence from systems and involve the use of evidence to represent, interpret and communicate credibility. In inquiry-base science education, modelling and argumentation constitute key practices that need to be fostered at all educational levels (NRC, 2012 p.10). Inquiry itself can promote a culture of collaborative group work, a peer interaction and consequently a construction of discursive argumentation and communication with others as the main process of learning. Argumentation refers to the process of constructing and negotiating arguments (Osborne, Erduran & Simon 2004), either individually or cooperatively, which can be expressed either verbally in discussions or any oral statements or in writing (Driver, Newton, & Osborne, 2000). The development of argumentation skills is recognised as a key aspect of scientific literacy and is widely recognised as an important practice for citizenship and also as a significant learning objective of science teaching (Jiménez-Aleixandre, Rodriguez & Duschl 2000; Osborne et al., 2004; NRC, 2012). The other core practice in science education, which is also important in inquiry, is modelling. Modelling is conceptualized as a process of constructing and deploying scientific models (Pellegrino & Hilton, 2013; Beernaert et al., 2015). The development of modelling practices is thought to also facilitate student learning of science concepts, methodological processes and the development of an awareness of how science operates (Saari & Viiri, 2003; Schwarz & White, 2005). Moreover, learners communicate adequate evidence in supporting scientific claims and constructing scientific explanations while modelling a phenomenon. With the presence of appropriate scaffolding, learners can develop evidence-based reasoning and construct scientific explanations (Kyza, Constantinou & Spanoudis, 2011). Overall inquiry learning processes are thought to be powerful in developing scientific literacy, since it involves such practices as experimenting, argumentation, modelling, reasoning, etc. All these aspects are deemed important for understanding environmental, medical, economic and other issues that confront modern societies, which rely heavily on technological and scientific advances of increasing complexity (Rocard et, al., 2007).

2.4.2 Inquiry-based science teaching

Inquiry is used in a variety of ways with respect to teaching. As inquiry learning is recognized by academics, teachers and practitioners as vital in science learning and children's development overall, it is expected that it will be also prominent in science teaching, without implying that in this context one unique teaching approach may be pursued in science education. Inquiry-base science teaching emphasize, among others, the teacher's role: a shift from "dispenser of knowledge" to facilitator or coach for supporting students' learning (Anderson, 2002). Therefore, the role of the teacher switches from being the authority to becoming a guide who challenges students to think beyond their current processes by offering guided questions (Windschitl, 2002) and/or preparing wisely planned scaffolds. Teachers' capabilities on orchestrating and facilitating inquiry-oriented learning processes are essential. These capabilities cover issues such as efficacy, teacher motivation and enthusiasm for teaching (Tschannen-Moran & Hoy, 2001). It seems that one of the central strategies for teaching science in agreement with the idea of teaching for meaningful learning proposed by Mayer (2002) is involving students in inquiry activities with questions that are meaningful to them and with the explicit aim to develop coherent knowledge and rigorous understanding of phenomena. This will also help them to understand how scientists study the natural world and what ideas they have developed in the process. For achieving that, the teacher needs to prepare an ingenious and planned scaffolding, for assisting the students through modelling and coaching in particular by the use of questioning strategies (Barrow, 2006; Prince & Felder, 2007). The teacher also facilitates appropriate discussion and helps students to focus on experimental data and facts, for example, by highlighting the purpose of the experimentation by using formative assessment methods or simply by asking meaningful questions. Considering the fact that Inquiry-base science teaching has brought fundamental changes in several aspects of pedagogy, as well as the main dimension of science inquiry (Baker & Leyva, 2003), Grangeat (2016) presents and evaluates a six-dimensional model describing the different modalities of inquiry-based teaching. The six dimensions upon which the model is built represent the crucial characteristics of inquiry-based teaching:

1. The origin of questioning
2. The nature of the problem
3. Students' responsibility in conducting the inquiry
4. The management of student diversity
5. The role of argumentation
6. The explanation of the teacher's goals.

This six-dimensional model of inquiry-based science teaching might be of value to researchers and teacher educators who are confronted with the complexity of inquiry-based science teaching. Evaluation of the model with qualitative data from secondary science teachers' teaching practices has stressed, among others, the role of formative assessment within inquiry-based teaching as a way to support students in understanding teachers' goals and monitoring their own progress towards those learning goals (Grangeat, 2016). Although the concept of inquiry base science education has been widely described and in some cases over that last years was also adopted in many countries, its defining features are not brand new in many educational systems. Even though concepts, such as problem-based learning, project-based instruction, inductive thinking, critical thinking, experiential learning and scientific method of learning, are already familiar to many teachers, the concept of inquiry-based science education seems to them as rather distant. Teachers confront difficulties in understanding what is expected from them when asked to teach science by inquiry, and to the same extent, this confusion is understandable as there are many definitions on inquiry-based learning (Corbett, 2014). It is therefore reasonable to bridge the gap between newly introduced concepts and current teachers' experience through practices with which the teachers are currently familiar. The interpretation of what constitutes inquiry-based science teaching and inquiry-based science learning for the community of science educators is crucial for the practices to be endorsed and the principles to be satisfied while designing inquiry-based learning environments. Similarly, the discussion about inquiry-based science teaching features is linked to the assessment methods and the teacher professional learning and professional developments proposed and implemented. Likewise, educational policy priorities and recommendations from expert groups have an impact on the transformation of the pedagogies promoted in science education.

2.4.3 Opportunities and constraints of inquiry-based teaching and learning

Inquiry-based science teaching can be approached as a strategy for educational process rather than a method of learning and teaching. It is focused on providing suitable scaffolds for meaningful learning. Nevertheless, a critical question in this context is what are the opportunities and constraints that inquiry-based teaching and learning has generated for science education? Firstly, inquiry-based learning offers opportunities to learners for achieving a better understanding of science concepts, principles and phenomena. Within an inquiry-based teaching and learning context, learners are offered experiences in which they can develop an understanding of science concepts and generally connect concepts and ideas with phenomena experienced in everyday life. Meta-analysis conducted by Schroeder et al., (2007) has shown that inquiry strategies demonstrated a statistically significant positive influence on students' achievements and learning when compared with the traditional teaching methods used in instruction of the control groups. They defined inquiry strategies as: student-centered instruction that is less step-by-step and teacher-directed than traditional instruction; students answer scientific research questions by analyzing data (Schroeder et al., 2007; p. 1446). Another opportunity that inquiry-based teaching and learning has generated for science learning is the development of general inquiry skills (Edelson, Gordin, & Pea, 1999) and scientific practices (NRC, 2012), such as posing and refining investigation questions, planning and managing investigations, gathering facts, exploring possibilities, conducting research, thinking through discoveries and analysing and communicating results (Alisinanoglu, Inan, Ozbey, & Usak, 2012). When engaged with inquiry, especially with the aspect of science explorations, learners use and enhance their cognitive skills, such as analysing data and creating hypothesis which are essential competences for one's daily life (Alisinanoglu et al., 2012; Monteira & Jiménez-Aleixandre, 2016). Zoller (2011) introduced the concept of higher-order cognitive skills, referring to the same skills along with the ability to transfer those in different contexts. According to Zoller (2011), science learning should require the development of students' ability to be engaged in higher-order cognitive skills, based on forms of inquiry such as question asking, critical thinking, evaluative system thinking, decision-making and problem-solving capabilities in dealing with characteristically interdisciplinary everyday life. An important element in this higher-order cognitive skills model presented by Zoller (2011) is the transfer capability, which is the capability of transferring different learning situations into real-life problem-solving contexts. Therefore, inquiry-based education proves vital especially with respect to achieving complex and comprehensive "higher-order" objectives such as understanding science principles, comprehending scientific inquiry and applying science knowledge to personal and societal issues (Anderson, 2002). Moreover, inquiry-based approach offers opportunities to learners for developing scientific reasoning and gaining a better understanding of the nature of science, thus developing epistemological awareness (Chinn & Malhotra, 2002). According to recent science standards, the importance of learning to reason scientifically but also to comprehend the complex nature of scientific reasoning is stressed (Chinn & Malhotra, 2002). Inquiry-based learning offers opportunities to learners for developing positive attitudes towards science. The inquiry approach allows students to connect classroom activities with their personal experiences and in this vein, students are more motivated to learn. A study by Rissing and Cogan (2009), found a significant gain in student attitudes when students participated in an inquiry laboratory. Also, in his findings, Gibson and

Chase (2002), suggests that science programmes using an inquiry-based approach may help students with a high level of interest in science maintain that level of interest through their years in high school.

Empirical research provides evidence for the potential benefits that inquiry-based education might bring into students' cognitive, metacognitive and socio emotional domain, including cognitive achievements, development of process and thinking skills, development of attitudes towards science and provision of experiences with science (Engeln, Mikelskis-Seifert & Euler, 2014). Also, development of scientific practices and inquiry skills (Edelson et al., 1999; NRC, 2012) as well as development of epistemological awareness of how science operates (Chinn & Malhotra, 2002).

Large-scale evaluations have proven the effectiveness of inquiry learning over traditional modes of teaching (Linn, Lee, Tinker, Husic & Chiu, 2006). Spronken-Smith et al. (2008) provide a review of the potential benefits for teaching staff who use an Inquiry-based approach. They cite a strengthening of teaching-research links, the rewarding aspect of seeing students being so engaged and gaining improved understanding and skills. (Slatta, 2004). There are a host of other suggested benefits both for students and teachers including the mutual enjoyment of the approach by both students and teachers, even if there may be some adjustment and initial anxiety about learning or teaching in this manner. Students can become more engaged by the approach and enthusiastic for more inquiry courses (Kennedy & Navey-Davis, 2004).

Considering that inquiry experiences can provide valuable opportunities for students to improve their understanding of both science content and scientific practices, still the implementation of inquiry learning in classrooms presents a number of significant challenges (Edelson et al., 1999). In this respect, inquiry-based teaching and learning has generated several constraints for science education, including the actual realisation of what constitutes "inquiry" in classroom terms, the degree of instructional support or guidance needed, the difficulties that students may encounter when being engaged with inquiry-based teaching and learning and the teacher preparation and professional development towards inquiry-based teaching and learning. Even though science educators value opportunities that inquiry-based teaching and learning offers to learner, they often show reluctance in enacting inquiry-base science teaching approaches in their teaching, as they consider those approaches as time-consuming leading to conflict with the requirement to deliver curricula content (Rocard et al., 2007). This demands an application of changes to curricula and methodologies by policy-makers.

Learning environments that support inquiry-based approach should address certain characteristics of inquiry-based learning, such as considering and building upon students' prior knowledge (Sewell, 2002; Hess & Trexler, 2005), offering opportunities to students for supporting their findings with evidence and observations and prompting students to share and discuss their ideas with peers (Wolf & Fraser 2008).

Efforts to incorporate features of authentic scientific inquiry into classroom inquiry have led to much discussion about the degree of openness in inquiry learning which is the relative instructional support or guidance, even though inquiry learning has been widely recommended over the past years in science education (Chinn & Malhotra, 2002; Blanchard, Southerland, Osborne, Samson & Granger 2010). While some studies found positive effects of open inquiry (Dochy etal., 2003; Sadeh & Zion, 2009), others found negative effects in comparison to direct instruction (Klahr & Nigam, 2004).

The minimal guidance during instruction is significantly less effective and efficient than guidance specifically designed to support the cognitive processing necessary for learning (Kirschner, Sweller & Clark, 2006). These researchers explain this phenomenon referring to the human cognitive skills and constraints, such as cognitive load, epistemological differences between experts and novices, and human cognitive architecture. They also highlight that the advantage of offering guidance begins to recede only when learners have sufficiently high prior knowledge to provide "internal" guidance. Although these authors seem to misinterpret some of the strategies and methods in science education, generally they pointed out two reasonable problems: problems with students' prior content knowledge and the designing of accurate scaffolding by the teachers. A way to bridge this gap between direct instruction and open inquiry is guided inquiry, which combines the essence of open inquiry with instructional support (Furtak, 2006). It also indicates that this guidance should fade out while the educational process evolves. According to Hmelo-Silver, Duncan, and Chinn, (2007) the teacher's support actually "plays a key role in facilitating the learning process" p.45. The degree of direction or support offered by the teacher within each of the features of classroom inquiry identified above may vary along a continuum between open and guided inquiry (NRC, 2000). In practice, those distinctions and features of classroom inquiry are sometimes inadequately materialized by teachers and practitioners alike (Minner et al., 2010). This may come about from the lack of a shared understanding of the defining features of various instructional approaches that has hampered significant advancement in the research community on determining effects of distinct pedagogical practices. As an after effect, constraint for science education is also the difficulties that students may encounter when conducting systematic scientific investigations since data gathering, analysis, interpretation and communication comprise challenging tasks. It is also essential that students have solid background knowledge on the topic that they are asked to inquiry. In particular, the formulation of research questions, the development of a research plan and the collection, analysis and interpretation of data are processes that require science content knowledge. When designing inquiry-based learning, it is a challenge to provide opportunities for learners to both develop and apply that scientific understanding. If students lack this knowledge and the opportunity to develop scientific epistemology, then they will be unable to complete meaningful investigations (Edelson et al., 1999). In open-ended inquiry learning environments, learners should also be able to organize and manage complex, extended activities. If they are not able to do so, students may face difficulties when being engaged in open-ended inquiry or achieve the potential of inquiry-based learning. Moreover, challenges may be confronted in practical implications, such as restrictions imposed by available resources and fixed schedules. Addressing the constraints of the learning environment is a critical consideration in design that must be considered alongside learning needs in the design of curriculum and technology (Edelson et al., 1999). Research in the area of inquiry-based learning focuses on finding adequate scaffolds that help to prevent or overcome problems that students might confront while doing inquiry and that transform inquiry learning environments into effective and efficient learning situations (Hmelo-Silver et al., 2007). What is also still quite new and interesting in providing scaffolding for students is that computer environments can integrate cognitive scaffolds with the simulation (Linn, Bell, & Davis (2004); Quintana, Reiser, Davis, Krajcik & Fretz 2004; de Jong, 2006). Technological developments, such as computer simulations modelling a phenomenon or process (de Jong, 2006) and hypermedia environments (Linn et al, 2004), allow the effective implementation of inquiry learning. A fourth constraint that inquiry-based teaching and learning has generated for science education is the need for adapting the assessment methods used from deductive teaching approaches to inductive ones. Looney (2011) argues that large-scale tests often do not reflect the promoted development of higher-order skills such as problem-solving, reasoning and collaboration which are key competences in inquiry-based science education.

Moreover, the tradition of test-oriented and target-driven approaches of external testing leads to problems, including "teaching to the test", the detriment of the wider curriculum and motivational problems (Gardner, 2010). Especially high stakes connected to summative assessment often undermine innovative approaches to teaching (Looney, 2011). Formative assessment has been seen as a means to achieve a better alignment between learning goals and assessment and in science education, it has received emphasis as a mechanism for scaffolding learning in science (Bell & Cowie, 2001). This is also supported by more recent European documents on formative assessment or a possible integration of formative and summative assessment, respectively (Looney, 2011; Dolin & Evans, 2017). A fifth constraint that inquiry-base science teaching and learning has spawned for science education is the need for new teacher professional development (TPD) programmes. Even though many good examples for inquiry-based learning in science education have been put forward by researchers, teacher educators and experienced teachers, changing the prevailing deductive teaching style is a highly challenging issue (Engeln et al., 2014). Teachers' professional competences are of crucial importance for keeping a proper balance between instruction and autonomous construction in the teaching and learning of science. According to Colburn (2000), even though there's no such thing as a teacherproof curriculum, and there are lots of times when inquiry-based instruction is less advantageous than other methods. It's up to the teacher to find the right mix of inquiry and non- inquiry methods that engage students in the learning of science (Colburn, 2000). The confrontation of such constraints in inquiry-base science teaching and learning and ways of overcoming at least some of them demands the harmonization of educational standards and priorities. Changing the fragmented and colossal educational systems requires extensive long-term efforts and involvement of all stakeholders at all levels. Those efforts involve the professional developments and continuous training and support of science teachers, the application of changes to curricula, the methodologies and assessment practices by policy-makers and the essential understanding but also support by parents on the need to have such changes.

Also, universities, business, local actors, informal science educators and civil society play a role in making science education more meaningful and linked to societal challenges, and research has to guide the change (Rocard et al., 2007)

2.5 Characteristics of Inquiry-Based Learning

Behaviours in learning could greatly affect the outcome of education. Apart from teaching quality, learners' strategies, characteristics, and styles of learning play an important role in deciding the success of an education setting. In science education, learners are expected to learn systematically along with scientific processes. Therefore, it is important to develop the students to access authentic exploration, critical discourse, experience-based hypothesising, and conclusion-based transfer (Reitinger et al., 2016). To contribute to such learning components, class activities should be open, motivating, joyful, and meaningful. To simplify, learners should be encouraged to start discussions, ask questions, share ideas, and give and receive comments.

Moreover, learners should realize the purposes of each class and be instructed in a preferable environment. To achieve these goals, students should have the following characteristics in learning.

2.5.1 Motivation

Hoffman (2016) defined motivation in learning as a positive attitude in learning. Learners with motivation would eager to perform tasks and exercises. They also search further for information related to the subject matter. Motivation influences how learners manage their time and energy in doing given tasks, perceive tasks and put effort to complete tasks.

2.5.2 Attention in inquiry-based teaching

Attention is a state of mental alertness and a focusing activity (Posner & Peterson, 1990). When the individual gathers his attention on a particular stimulus, s/he realizes the fit for purpose features more easily, and a feature which is paid attention to is placed in the consciousness. Thus, it becomes easier to choose and learn the information, the mind does not engage in unnecessary details (Prakash, 2015). Therefore, attention is emphasized as a mechanism to initiate learning (Ainley & Luntley, 2007; Chen & Huang, 2014). Students who pay attention in class do not distract peers and teacher instruction. They cooperate with learning activities and intent to put the best performance in tasks. The characteristic is important for inquiry learning which allows learners to take control of their learning. Moreover, learners should realize the purposes of each class and be instructed in a preferable environment. To achieve these goals, students should have the following characteristics in learning.

1. **Learning Endeavour**

De Houwer and Hughes (2020), suggested that failure in learning is inevitable, and learners have to overcome the hardship to achieve their learning goal. Students with learning endeavors could cope with the problems in learning. They understand the failure and are ready to put effort to fix learning mistakes. The characteristic is important for science education where experiments are unpredictable and endeavor is needed.

2. **Independent Learning**

Independent learning has been discussed in the new era of educational management. To empower students and shift the role of teachers in class, learners need to be able to take responsibility in learning. Livingston (2012) defined independent learning as a state in which learners take control of their learning. They can set goals, choose the direction of learning, and monitor their progress of learning. Information searching and self-study are needed to achieve the goal of independent learning. This characteristic is desirable in most modern instructional approaches where student-center is emphasized.

2.6 The Role of the Teacher in the Inquiry Method

There are two distinctions that are often used in the context of inquiry-based education in terms of the teacher's role in inquiry-approach. These are amount of teacher direction and type of teacher regulation. The first distinction refers to the amount of direction that teachers give in the process of inquiry: is it only the teacher who decides what students do, or does the teacher give students much influence on choices concerning their own inquiries (Furtak, Seidel, Iverson, & Briggs, 2012; Donnely, Linn, & Ludvigsen, 2014). Furtak et al. (2012) state that in reform-based science teaching, there are many transitions of responsibility of learning from teacher to student and back, as students are actively engaged in constructing understanding, rather than being passive recipients of scientific knowledge. Most often, studies differentiate between teacher-directed and student-directed inquiry, sometimes including a middle category of mixed direction. In teacher-directed inquiry, the teacher has decided on the questions to be investigated, how these are to be investigated, etc., while in student-directed inquiry, the students determine what they want to study, how they will do so and what they will present. In mixed directed inquiry, the teacher determines some aspects of the research, but there is also room for the pupils to make choices. In general, Furtak et al. (2012) conclude from their meta-analysis that studies involving teacher-led activities had mean effect sizes that were about 0.40 higher than studies involving student-led activities. Hence, teacher direction in the process seems to be of great importance. (Dobbler et al., 2017). The second distinction looks more closely at the kind of direction the teacher gives. Based on the examined literature (Furtak et al., 2012), we can distinguish between three types of regulation by teachers: (1) meta-cognitive regulation, (2) social regulation, (3) conceptual regulation. We present these separately, but in practice they are often closely intertwined and not explicitly aimed for by teachers. Meta-cognitive regulation has to do with planning, monitoring and evaluation. Kuhn, Black, Keselman, and Kaplan (2000) stress the importance of exercises that encourage students to think about possible solutions on a meta-level. Manlove, Lazonder, and de Jong (2009) studied collaborative scientific inquiry learning and found that a tool that provided regulative directions by giving goals and sub-goals, and providing hints to achieve these goals and to monitor progress (for example by writing down intermediate results) had a positive influence on both initial planning and learning. Social regulation centres on cooperative principles and has to do with guiding the social processes of problem-solving. Some authors (Kaartinen & Kumpulainen, 2002; Sawyer, 2004) found that collaboration has a positive effect on inquiry-based learning. Discussion in the classroom such as exploratory talk, (Mercer, 2000) has been found to enhance learning outcomes. Rojas-Drummond, Gomez, and Velez (2008) have shown that pupils aged 10-12 years performed better in reasoning and problem solving in an experimental condition with exploratory talk compared to a control group. Conceptual regulation has to do with subject-specific knowledge and rules. In the context of ICT, Lohner, van Joolingen, Savelsbergh, and van Hout-Wolters (2005) found that modelling tools could be of use in an inquiry-learning environment. These authors discovered that the use of graphical representations leads to a better research process than the use of textual representations. Several studies illuminate the positive effects for pupils' learning outcomes when conceptual models are used in an inquiry process (Terwel, Van Oers, Van Dijk, & Van den Eeden, 2009). Scaffolding has also been found to have a positive influence on inquiry-based learning (Hmelo-Silver et al., 2007; Simons & Klein, 2007).

Although the inquiry method is student-centered, it does require a lot of teacher involvement. The role of the teacher in the inquiry method is to be the primary mentor, advisor, and planner. In the early stages of the implementation of the inquiry, teachers should provide topics consistent with students' cognitive thinking and development so that they understand and are interested in a topic. Teachers should also plan the objectives of their students' goals, looking for resources that can guide their students toward their goals. In this regard, teachers must also ensure that students use legitimate resources in their studies. Teachers can tell students where and how a resource is available for reference. This will help students find the right information if they are having trouble finding important information; students should do their research. Besides that, teachers should encourage different interpretations of an idea so that not all the students give the same answers. Accordingly, the teacher will receive different answers from the students. Teachers should, therefore, be prepared to listen to and accept different responses from students to a problem. In this regard, teachers should create an atmosphere that promotes and strengthens the relationship or interaction between students and teachers and students with students. Also, teachers should help students through questions, comments, and suggestions so that students can gain additional knowledge.

2.7 Effectiveness of Inquiry-Based Approach

Generally, inquiry-based science instruction is effective in promoting learning outcomes of diverse students, in various disciplines, at various grades, in various contexts, and for both sexes. It is effective in improving students' science achievements (Furtak et al., 2012), conceptual understanding, content knowledge (Chang & Mao, 1999), motivation (Romero-Ariza, Quesada, Abril, Sorensen, & Oliver, 2020), critical and higher-order thinking skills and problem-solving skills (Gillies, 2008). It is also effective in improving attitudes toward science (Chang & Mao, 1999), and science process skills. Inquiry is a process of active learning that is driven by questioning and critical thinking. The understandings that students develop through inquiry are deeper and longer lasting than any pre-packaged knowledge delivered by teachers to students. A study by Ferguson, (2010) concluded that the inquiry-based teaching approach has a positive effect on the mathematics achievement of students. In his study, two high school geometry classes were taught area formulation using a traditional lecture-based approach to instruction. A third geometry class was taught area formulation utilizing inquiry-based instructional methods. Students in both groups took both a pre-test and post-test. At the end of the exercise, Students involved in the inquiry-based lessons exhibited better retention, a better ability to problem solve, and better performance on decontextualized mathematical problems than their peers who were taught in the traditional fashion. He therefore recommended that teachers of mathematics should apply the inquiry-based teaching and learning approach in both at the junior levels through to the tertiary levels.

Studies conducted by Crawford and Snider, (2000) and Riordan and Noyce, (2001) found out that students taught through inquiry scored higher than the group taught through the traditional method. Similar study by Oliver (2007) and Prince and Felder (2007), revealed that the inquiry-based teaching style increases student's motivation. More importantly, the inquiry-based learning actively involves the students in the learning process and allows the students to learn the contents on their own, which provides more opportunities for the students to gain a deeper understanding of the concepts and become better critical thinkers (Wang & Posey, 2011).

Prince and Felder (2006) provide a good overview of four studies evaluating inquiry-based approach (Shymansky, 1990; Haury, 1993; Rubin, 1996; Smith, 1996; all cited in Prince & Felder, 2006). The research concludes that inquiry-based approach is generally more effective than traditional teaching for achieving a variety of student learning outcomes such as academic achievement, student perceptions, process skills, analytic abilities, critical thinking and creativity. Other related studies compare the learning outcomes of students taking an inquiry-based approach version with those of students taking a more traditional course.

Berg, Bergendahl and Lundberg (2003) compared the learning outcomes of an open-inquiry and an expository version of a first-year chemistry laboratory experiment. Data on student experiences of the two approaches were gained from interviews, questions during the experiment and students' self-evaluations. The key findings of this study were that students taking the open-inquiry experiment version had more positive outcomes including a deeper understanding, higher degree of reflection, the achievement of higher order learning and more motivation. Justice, Rice, Warry, and Laurie, (2007) used five years of data to examine whether taking a first-year inquiry-based approach course made a difference in students' learning and performance. In a comparative study between students taking an inquiry-based approach course and those who did not, and, taking into consideration factors such as age, gender, high-school grade point averages etc., they found that students who took the inquiry course had statistically significant positive gains in passing grades.

There are however a few reported negative aspects associated with Inquiry–based approach. Justice et al., (2003) found that students perceived an increased workload in Inquiry–based approach courses, while Luke (2006) and Plowright and Watkins (2004) suggest that anxiety occurs over the need to become self-directed learners. Plowright and Watkins (2004) also noted student difficulties in coping with group dynamics.

2.8 The Relationship of Inquiry Learning and Students' Achievements

In schools, the target is to ensure that learning has taken place because the process of educational goals is achieved in the form of personal changes in the behavior of learners however, this can happen when there is effective teaching. Effective teaching of any subject does not only stimulate the interest of students in the subject but also enhance students' overall outcome (Nwike & Onyejegbu, 2013). This means teachers and their approaches to teaching are important in the school system. It has been found by several researchers such as Cuttance (2000) and Reynolds, Creemers, Stringfield, Teddlie, and Schafer (2002) that the difference in the quality of teaching is a major determinant of academic achievement than other school factors. The study of Cuttance (2000) as well as that of Reynolds et al. (2002) pointed to the fact that regardless of the conditions in a school, the quality in the teaching can greatly affect academic work of students. Thus, in essence, improving the quality of teaching can improve the academic performance of students. Therefore, the teacher must have an overall picture of how the process of teaching and learning occurs and what steps are necessary so that tasks can be performed well and obtain results as expected. One of the needs is to have an insight into teaching and learning strategies that outline how to act in order to achieve the objectives that have been outlined. With this strategy, teachers have guidelines with respect to various alternative options that may be, can be, or should be taken so that teaching and learning activities can take place on a regular, systematic, purposeful, smoothly and effectively manner.

Using appropriate learning methods aims to solve the problems that arise in the learning process. It certainly can improve student learning outcomes. To examine how effective inquiry-based instruction is, Wilson, Taylor, Kowalski, & Carlson, (2010), conducted a study on 58 students of age range 14-16 years. The students were randomly placed in two groups with one being instructed through inquiry while the other was instructed through commonplace teaching strategies. Findings from the study showed significantly higher achievement levels for the inquiry-based group in comparison with their counterpart in the common place teaching. Again, Haddock (2014) also sought to determine the difference between inquiry-based teaching strategies and student achievement. Results from the study indicated strong beliefs among participants of inquiry-based teaching indicators within three domains: planning, enactment, and reflection. In addition, Sinnema and Robinson (2007) reported on a series of empirical studies that investigated the extent to which teacher evaluation policies and procedures promote teachers' inquiry into the relationship between their teaching and their students' learning. Bilgin (2009) also conducted a study to examine the effects of guided inquiry through cooperative learning environment on students in relation to students' achievements and attitudes on acids and bases concepts. Results from the study revealed that students in the experimental group (those who were instructed through inquiry) had better understanding of the concepts and showed more positive attitude toward guided instruction.

Suwondo and Wulandari (2013) in their study concluded that students' attitudes changed after using inquiry base learning model. In addition, the findings indicated that the learning outcomes of the inquiry learning model, the achievement of the majority of students from the two groups are at a good level. This means that inquiry-based learning can be used as one method to improve student achievement.

Another study by Abdi (2014), concluded that there are differences in learning outcomes of students who take the group inquiry learning model with a group of students who take the conventional learning model. The results indicate that students who took the inquiry learning model obtain a higher value than the group of students who take conventional learning models.

2.9 Barriers of Implementing Inquiry-Based Learning

The effectiveness and efficiency of implementing inquiry-based learning come with a few limitations that need to be addressed by the teacher. Though it is largely agreed by many teachers that inquiry is an important tool and effective for teaching and learning of science (DiBiase & McDonald 2015), the knowledge, skills and capabilities of teachers in its implementation remains a problem that needs to solved. Roehrig and Luft (2004) indicate that there are barriers for the implementation of inquiry-based teaching. For instance, as it is often done, detailed information is provided by traditional teachers in the form of lecture, teacher led discussion and lab work aimed helping students to conceptualise or confirm a given concept. It has also been documented by researchers that many science teachers do not have the requisite knowledge needed to implement inquiry-based teaching; and this has become a barrier for them to successfully implement this pedagogy (Keys & Kennedy 1999; Crawford 2000; Wallace & Kang 2004; Windschitl 2004). It is always difficult for one to successfully put into practice any method that one has limited or no knowledge about and that science teachers' limited knowledge will impede the implementation of inquiry in their classrooms. Some challenges that confronts teachers when using inquiry have been documented by others. According to Anderson and Helms (2002) and Luera and Otto (2005) some impediments to inquiry -based approach include: large class size, interest and abilities of students, inadequate time, weak comprehension of nature of science on the part of the teacher, inadequate skills in pedagogy, the inappropriateness of curricula, existence of tensions between emerging roles to be played by teachers during inquiry lessons, views held by teachers on inquiry and the culture of the school. They also mention the conflict that exist between model standards and true revelations in science classes. It must be noted here that most researchers have criticized the idea that the duty of the teacher is to prepare students to perform in test. For example, Amrein and Berliner (2002) maintain that emphasis on test preparation may improve test scores in the short term, however, they do little to improve student learning. The student must be developed holistically to be able to acquire the needed skill to be able to contribute meaningfully to solving problems confronting the society. These skills are acquired through active participation of the student in scientific processes. A survey conducted by Doorman, Fechner, Jonker, & Wijers, (2014) on the use of inquiry-based approach. The study identified three categories of factors which affect the implementation of inquiry-based learning, namely: System restrictions, classroom management and resources. It is reported that these three factors hinder the smooth implementation of inquiry-based learning. System restrictions was found to be most desirable for predicting the use of inquiry-based learning whereas classroom management was most preferable for predicting attitude towards inquiry-based approach. Some authors have also questioned the effectiveness of inquiry. To them, many of the minimally led inquiry learning experiences 'do not work' (Kirschner, et al., 2006). Bevins and Price (2016) postulate that models of inquiry are too limited, revolve around extensive practical work and omit the wealth, power and complexity of the scientific endeavour. Anderson (2002) argues that teaching through inquiry is hindered by three dimensional limitations: technical problems, political limitations, and cultural issues. He further explains the technical challenge constitute teacher's inability to fully teach due to inadequate teaching skill development. The political dimension encompasses frictions resulting from inadequate supply of resources as well as limitation on time. The cultural problem is associated with the perception that students must be prepared for promotion to the following school level. In assessing challenges faced by teachers on the use of inquiry-based approach, Yoon, Joung & Kim (2012) found out that six difficulties are usually encountered which included:

(a) helping students to develop ideas on their own as well as their curiosity,

(b) assisting students to design an experiment to suit hypotheses they have set,

(c) scaffolding students' interpretation of data as well as their discussion,

(d) friction emanating from guided inquiry and open inquiry,

(e) partial insight into hypothesis

(f) lost confidence in the content knowledge of science. To them, a, b and c are experienced when the lesson is ongoing therefore are referred to as 'on the lesson' difficulties. The last three difficulties: d, e and f are difficulties in the minds of preservice teachers called 'under the lesson' difficulties. The researchers opine that under the lesson difficulties are likely to impact negatively and create difficulties that appeared 'on the lesson' in class. These difficulties were intertwined and featured in the decision-making process preservice teachers' and affected their inquiry teaching based on hypothesis. Research has found out that teachers' practical knowledge drives the decisions they make in their classroom, while teachers' epistemological views about science influence their instructional beliefs and classroom practices (Lederman & Latse 1995). Research has shown that teachers' beliefs about students, learning, teaching, and the nature of science influence teaching practices and act as barriers to the implementation of reformed curricula (Brickhouse, 1990; Cronin-Jones, 1991; Gallagher, 1991; Tobin & McRobbie, 1997). Other barriers that impede the use of inquiry teaching in science classrooms include lack of equipment, laboratory safety issues, school policies such as preparing students for standardized tests and official exams, and finishing mandated curriculum content within a set time limit (Wallace & Kang, 2004). Finally, teachers' negative beliefs about inquiry and their lack of knowledge about inquiry and inquiry skills are major hurdles for implementing inquiry teaching and learning (Jarrett, 1997). Overcoming the various barriers associated with using inquiry in science classrooms requires a concerted effort from policy makers, university educators, school administrators and other stakeholders interested in improving the quality of science education. However, there is a pressing need for understanding teachers' beliefs as they relate to their classroom practices. Some problems of inquiry approach

Some researchers argue that the following problems may affect inquiry-based approach

1. Knowledge necessary for participation in democratic society.

Inquiry-based learning emphasises having the learner to pursue investigations based on the immediate situation and personal experience. What is the guarantee that essential knowledge will be developed during the inquiry? This is especially the case for knowledge necessary to participate fully in a democratic society (Hirsch, 2006).

2. Lack of experiences to draw upon.

If learning has to draw on, build on, and be relevant to a learner's previous experiences, what happens when those experiences are limited? Does everything have to be based on what you already know? If so, how is new learning even possible? The importance of experiences implies that we find ways to incorporate richer experiences into learning. Dewey argues for making learning social-centered, rather than just child-centered. A related approach is to ask learners to critically engage with books, websites, and ideas that extend their world. Yet another is to expand direct experiences through field trips, service learning, nature study, or challenging problems. The inquiry-based learning claim is not that it's a guaranteed method to ensure learning, but that learning based on restricted experiences will be limited, no matter what you do. Yet each of the means just suggested for enlarging experiences has its own problems and none are guaranteed to work.

3. Effectiveness for learning specific skills and knowledge

Inquiry-based learning, and other minimally guided instruction, is less effective and less efficient than instructional approaches emphasizing guidance. "The advantage of guidance begins to recede only when learners have sufficiently high prior knowledge to provide 'internal' guidance" (Kirschner et al., 2006; Cazden, 1992) has made the case for "whole language plus," where the "whole language" refers to a more holistic, child-centered, open-ended kind of learning, and the "plus" says that it's wrapped around some more basic aspects of learning.

4. Certification of skills.

Learning independently as with inquiry-based learning, may work in some ways, but success in modern societies depends upon certification of skills taught through an organized procedure. It's difficult to certify learning when it is individualized, extended, and embedded in life beyond the classroom.

5. Cultural mismatch

Inquiry-based learning may work for some learners, but others, especially those from marginalized groups, there is the need for access to the societal codes for knowledge in a more direct fashion (Delpit, 2006).

2.10 Teachers' Knowledge of Inquiry-Based Approach and Classroom Practice

A study by Hutchins and Friedrichsen (2012), revealed that teachers with better knowledge towards inquiry instruction can use inquiry practice better. According to Nespor (1987) and Tobin and McRobbie (1997), teachers' Knowledge influence their practices in different ways. Nespor conducted his study with eight teachers teaching math, history, or English in middle school classrooms. The teachers did not have much guidance from the school and it was left to them to choose the content and instructional methods that they thought appropriate to their classrooms. Nespor found that the teachers' knowledge about teaching methods were aligned with their teaching practices. Tobin and McRobbie (1997), on the other hand, conducted their qualitative study with one grade 11 public school chemistry teacher and head of the science department and found that teachers' knowledge about the nature of science and inquiry were acceptable but the teacher's practices were at odds with that knowledge. However, the teacher's practices were aligned with his knowledge about teaching methods and the nature of student learning. Thus, according to Tobin and McRobbie even though teachers may profess that they were inquiry oriented, they still use direct instruction in their classrooms. Results of the study by Tobin and McRobbie (1997) showed that teachers' knowledge about inquiry and practices are not necessarily aligned.

In their study, DiBiase and McDonald (2015) surveyed 257 science teachers and found that more than 90% of them agreed that inquiry -based approach is an important instructional approach, suitable for developing students' critical-thinking and problem-solving skills. Moreover, about three quarters (78 %) of the respondents considered it important in exploring and constructing knowledge. Similar results are described by Wallace and Kang (2004), who investigated the beliefs of six experienced science teachers: These teachers stated that Inquiry Based Approach would promote students' independent thinking and problem-solving skills as well as their conceptual understanding and their scientific thinking practices.

Majority of teachers lack an elaborated model of inquiry – based approach and have difficulties in grasping inquiry – based approach as a complex instructional approach (Lotter, & Singer, 2011; Reiff, 2002). Whether and in what way teachers implement Inquiry –Based Approach in their own classes depends on the teachers' attitudes emerging from their knowledge, skills and beliefs as well as on the external constraints they perceive (Wallace & Kang, 2004).

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter discusses, research design, description of the study area, population of the study, sample size, sampling procedures, data collection method, data analysis, presentation and ethical issues.

3.1 Research Design

The research design that was used in the study was descriptive survey using the mixed method approach. The significance of using this methodology is to concentrate on some occurrence or entity (Merriam, 1998). This approach seeks to uncover the interaction of major factors characteristic of the knowledge of inquiry-based teaching and practices of inquiry-based teaching by teachers and also help provide a means to understand the essence of the school-based research experience.

3.2 Description of the Study Area

The research was carried out in Sekondi -Takoradi Metropolis of Western Region of Ghana. The western region is located in the south western part of Ghana and shares boundaries with central region on the east. To the west it shares border with Cote D'Ivoire. It includes the capital and large twin city Sekondi- Takoradi on the coast, coastal Axim, and a hilly inland area including Elubo. It includes Ghana's southernmost location; Cape Three Points where crude oil was discovered in commercial quantities in June 2007. The region covers an area of 23,921 sq. m. It has a population of 2,060,585 according to 2021 population and housing census (Ghana statistical service). Sekondi-Takoradi the capital of the Western Region of Ghana is About 229 kilometers from Accra the capital city of Ghana. The region has about 35 public senior high schools.

3.3 Research Population

A research population is a large well-defined collection of individuals or objects having similar characteristics (Castillo, 2009). The target population was all biology teachers in Senior High Schools (SHS) in western region. The accessible population for this study comprised SHS biology teachers in the Sekondi- Takoradi Metropolis.

3.4 Sample and Sampling Procedures

According to Kombo and Delno (2006), sampling is a procedure the researcher uses to gather particpants to study. It is a process of selecting a number of individuals or objects from a population such that the selected group contains elements of representative characteristics found in the entire group. The sample was made up of 30 Biology teachers at the senior high schools in the Sekondi – Takoradi Metropolis. The researcher selected 10 Senior High Schools from the Metropolis using convenience sampling whiles 3 biology teachers were selected from each school using simple random sampling.

3.4.1 Sampling techniques

According to Castillo (2009), sampling procedures are the strategies applied by researchers during the sampling process. In this study simple random sampling was used. West (2016), explains simple random sampling as the most basic method of sampling where each and every member of a population has the same chance of being included in the sample and where all possible samples of a given size have the same chance of selection. It shows no bias and selection of one member does not affect the probability of selection of another member.

The study sample was randomly drawn from Sekondi -Takoradi Metropolis, and used a two-stage sampling design with schools as the first level sampling units and teachers as the second level sampling units. In the first stage of sampling, 10 senior high schools were selected from 18 senior high schools for inclusion in the study. The list of senior high schools in the Metropolis and their location, available from the Regional Education Directorate was obtained for this purpose. Under this procedure the researcher used convenience sampling to select schools that are very close each other.

The second stage of sampling involved selecting biology teachers from the sampled schools. For this purpose, a list of biology teachers from each school was obtained from the school's administration. On the average there are four biology teachers per school. The researcher selected three biology teachers from each school using simple random sampling. In this method numbers from 1 – 4 were written on a card and put into a small box and shuffled. Using the lottery method teachers were made to pick. All those who picked card numbers 1-3 were selected for the study. In all three teachers were selected from each school. The total number of teachers included in the sample was 30.

3.5 Data Collection Tools

3.5.1 Research instrument

Two research instruments used for the data collection were questionnaires and observation chart.

3.5.2 Questionnaire

The Merriam -Webster Dictionary (2022), defined questionnaire as a set of questions for obtaining statistically useful or personal information from individuals. This technique involves written questions to which the respondents were required to write answers individually with no researcher's guide. A Teachers' knowledge on Inquiry

Questionnaire (TKIQ) was designed and used to measure teachers' knowledge on inquiry-based strategies, and classroom practice.

The items in the questionnaire were in two sections. Section A was made of 8 closed ended questions aimed at finding out about participants' background data and the methods they employ in their teaching and facilities available in participants' school. Section B on the other hand consisted of 5-point Likert scale questions ranked on a scale of 1-5 with1 being strongly disagree and 5 being strongly agree. These questions were primarily focused on finding out participants' knowledge of inquiry-based approach, the usefulness of the approach and limitations which need to be addressed for its effectiveness in science classrooms.

3.5.3 Observation chart

Observation in research is one of the oldest and most fundamental research methods approaches. observations are important for understanding people's actions, roles and behaviour. Mckechnie (2008) describes observation as an approach that involves collecting data using our senses, especially looking and listening in a systematic and meaningful way. According to Cohen, Manion and Morrison (2000) one of the distinctive features of observation as a research process is that it offers the investigators the opportunity to gather live data from naturally occurring social situation. Therefore, we can say that observation is one way to gather information directly on what is happening directly in a school or classroom rather than relying on second hand information.

A classroom observation chart developed by Lawson, Devito, and Nordland dated 1976, was adopted and slightly modified and used by the researcher. The original version contains 25 items. Each item was scored from zero to four, where four indicated a superior performance and zero poor performance. The items were organised into four categories; the first category described how the lesson is conducted and the materials and activities used during the lesson. The second category described student-learning behaviour. The third category described teachers' behaviour such as self-confidence, handling classroom interruptions, and playing the role of an investigator. The fourth category described teachers' questioning techniques (divergent or convergent questions), teachers' acceptance of students' opinion, and the allocation of time for students' responses.

Few changes were made on the original instrument, for instance background information about the teacher being observed; teacher 1, 2 or 3, the school, date of observation, the level of education of the teacher, the number of students in the classroom and the kind of room and equipment used were included. The 25 items were revised to 10 items by taking out those not applicable to this research and organised into four categories. The final observation schedule consisted of sections A and B. Section A consisted of items to collect background information on teacher's sex, years of teaching, academic and professional qualification, number of students in class, topic being taught and materials used during the lesson while section B consisted of items grouped into three categories to collect information on the contexts used during instruction. The first category described the materials and activities used during the lesson. The second category described teachers' behaviour such as self-confidence, handling classroom interruptions, and playing the role of an investigator. The fourth category described teachers' questioning techniques, teachers' acceptance of students' opinion, and the allocation of time for students' responses.

The observation chart was used as a guide during the observation phase of the study to determine how teachers' knowledge on inquiry relate to their classroom practices. A total criterion score of more than twenty indicate the practice of inquiry approach of teaching by the teacher.

3.6 Validity of the Instruments

The primary objective of a research is to provide valid information that could be used in describing, predicting, and explaining phenomenon. According to Golafshani (2003), validity describes whether the means of measurements are accurate and are actually measuring what they intend to measure. Two lecturers from the University of Education, Winneba science department were consulted to judge the sufficiency and suitability of the questions used in the questionnaires.

3.7 Pilot Testing and Reliability of the Questionnaire

The questionnaire was pilot-tested at St. Mary's Boys' Senior High School in the Ahanta West Municipality. 3 respondents were randomly selected for the pilot testing of the instrument. Teachers who were selected were spoken to and the rationale for the data collection explained to them. They were given one hour to complete the questionnaire to which they obliged. In the end, all the all questionnaires were retrieved from respondents. After the questionnaires had been retrieved, they were edited and all misleading items were revised to make sure that each questionnaire contained relevant data sought for by the researcher. The items were coded with numerical values which facilitated the keying process into the computer software, SPSS version 16.0. This software helped to run frequency tables and which also helped to work out the Cronbach's alpha coefficient of reliability of 0.716 after the item analysis. This Cronbach's alpha value gave an indication that the questionnaire was reliable according to Trochim (2009) and hence good to be used for the final data collection. The observation chart was also piloted in the same school a week after the analysis of the questionnaire.

3.8 Data Collection Procedure

The researcher obtained permission from the school authorities to undertake the study and administer the instruments in the selected schools. The head teachers in selected schools introduced the researcher to the heads of departments and the heads of departments further introduced the researcher to the biology teachers. All the participants were informed about the purpose of the study and sought their involvement and cooperation. Participants' anonymity, confidentiality, privacy, freedom and right of participation and withdrawal were observed in the study. Paper-based self-completion questionnaires were administered to the Biology teachers. To ensure high response rate, the questionnaires were filled and collected in front of the researcher. Each respondent was given about an hour to complete. This was done in all the 10 selected schools. The questionnaires were analysed. From the analysis of the questionnaire, teachers who indicated they have knowledge in inquiry – approach were later observed twice in their classrooms. Their teaching practices were recorded by using an observational chart adopted for the purpose of the study.

3.9 Data Analysis

Quantitative data were analysed using simple tables, frequencies, and percentages where necessary.

3.10 Ethical Considerations

Ethics in research is what the researcher does to ensure that the well-being and interests of participants are catered for so that they are not harmed because of the research being conducted. In this study, the participants were given all the assurance concerning the protection of their privacy, identities and were given the opportunity to agree on whether to participate in the study. Participants were also given an hour to respond to the questions. They were encouraged to ask for clarity on questions they did not understand.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The purpose of this chapter was to present data from the study which sought to evaluate senior high school biology teachers' knowledge and classroom of practices of inquiry base strategies. This chapter is also concerned with the discussion of data findings.

4.1 Biographical Data of Respondents

Table 1: Biographical Data of Respondent

Number of Teachers	Age	Professional Qualification	Years of Teaching Experience
6	25 - 30	BED	1 - 5
14	31 - 35	MED	6 - 10
5	36 - 40	MPHIL (SCIENCE EDUCATION)	11 - 15
5	41 - 45	PGDE	15 - 20

The Biographical data of study participants are presented in Table 1. Six teachers were between the ages of 25 -30. Majority of the participants were between the ages of 31-35. Five participants were between the ages of 36- 40 whiles 5 were also between the ages of 41- 45. The number of years of teaching experience ranged from 1 to 20 years. Six participants hold Bachelor of Education in Science whiles 14 hold master of education in science (MED). Five participants hold Master of Philosophy in Science Education (MPHIL) whiles 5 participants hold Post Graduate Diploma in Education. (PGDE)

4.2 Research Question One: What are teachers' knowledge about inquiry method of instruction?

Question 7 of section A of the questionnaire sought to find out the knowledge of the teachers about inquiry. Table 2 shows the distribution of the response of the teachers' knowledge.

Table 2: Teachers' Knowledge on Inquiry-based Approach

Approach	Frequency (f)	Percentage (%)
Lecture	0	0
Discussion	7	24
Demonstration	9	30
Inquiry-based	14	46
Other	0	0
Total	**30**	**100**

From table 2 there is a clear indication teacher often use discussion, inquiry and demonstration as teaching methods in biology lessons. 14 respondents representing 46% of the entire sampled population showed that inquiry-based teaching from their perception is the most effective approach that enhance students' motivation and participation, 9 respondents representing 30% of the sample population use demonstration, 7 representing 24% prefer discussion while none use lecture method.

Findings from Table 2 show that many of the teachers believe that inquiry-based approach from their perception is the most effective approach that enhances student's motivation and participation. This belief by the teachers is an indication that they have knowledge of inquiry-based approach. Either they have read about it or were taught during their teacher training programme. This perception by teachers is an indication that teachers are heeding to the call to move from teacher-centered approaches to student-centered methods which provide opportunity for students to actively participate in science lessons. The findings also indicate that methods including but not limited to discussion, demonstration and inquiry promote student's participation in science classrooms. Using these methods enhance the students understanding as well as their ability to participate fully in class. This is in consonance with Billings and Halstead's (2009) assertion, 'participation is the central theme for students' critical thinking and maximizing their understanding'. Active participation in classroom discussion by students has been echoed by Weaver and Qi (2005) as having the tendency to give them better understanding than their mates who fail to actively participate. Providing an opportunity for students to fully participate in classroom activities will help these students to enlarge their scope of knowledge through experience and practice.

Again, the results from the study supports evidence by Oliver, 2007; Prince and Felder (2007), which revealed that the inquiry-based teaching style increases student's motivation and participation. Also, Suwondo and Wulandari (2013) in their study concluded that students' attitudes changed after using inquiry base learning model.

Section B of the questionnaire sought further responses on teachers' knowledge of inquiry. The results are summarized in Table 3.

Table 3: Teachers' Responses on their Personal Knowledge of Inquiry Teaching Strategy

S/N	Statement	SD F (%)	D F (%)	U F (%)	A F (%)	SA F (%)
1	The inquiry-based approach makes lessons pragmatic	2(7)	3(10)	4(13)	16(53)	5(17)
2	I was taught on how to use inquiry approach in teaching during my training	2(7)	4(13)	2(7)	14(47)	8(26)
3	The inquiry-based approach is suitable to develop students thinking.	1(3)	1(3)	7(23)	14(48)	7(23)
4	My role as a teacher is to facilitate students' own inquiry	(0)	0(0)	7(23)	20(67)	3(10)
5	There are a lot of challenges when using the inquiry-based approach in class.	0(0)	0(0)	4(13)	15(50)	9(37)
6	The lack of teaching materials inhibits the use of an inquiry-based approach	0(0)	1(3)	2(7)	21(70)	6(20)
7	Lack of time and space inhibits the use of the inquiry-based approach in class	0(0)	0(0)	4(13)	16(54)	10(33)
8	It is important for students to construct new knowledge in inquiry practice.	2(7)	2(7)	6(20)	16(53)	4(13)
9	The inquiry-based is a complex teaching method.	2(7)	2(7)	3(10)	15(50)	8(26)
10	I frequently engage students in inquiry task	9(37)	6(20)	3(10)	9(30)	3(10)

SA = Strongly Disagree, **D**= Disagree, **U**=Undecided, **A**= agree, **SD**= Strongly Disagree.

In Table 3, the majority of the respondents representing 71% that is, (48% agree and 23% strongly agree) believed that inquiry-based approaches make lessons pragmatic, 13% were undecided whiles10% of the respondents strongly disagrees.

A greater proportion of the respondents representing 73% indicated that they were taught inquiry-based approach in their teacher training programme, however 7% of the respondents were undecided whilst 13% of them disagreed. Only 2 respondents representing 7% strongly disagreed. It can be concluded that, majority of the teachers know about and were taught the inquiry method during their teacher training programme. The findings that teachers had knowledge about teaching as inquiry confirmed the claims of New Zealand's Education Office (2016) that teaching as inquiry is practiced because teachers had the skills needed for teaching as inquiry. Some other studies have indicated that teachers believed in themselves concerning their knowledge of teaching as inquiry (Byrum, Jarrell, & Munox, 2002; McDougall et al, 2007; Oakley, 2000; & Puchner & Taylor, 2006).

It has also been documented by researchers that many science teachers do not have the requisite knowledge needed to implement inquiry-based teaching and this has become a barrier for them to successfully implement this pedagogy (Crawford 2000; Kang et al. 2008; Keys & Kennedy 1999; Wallace & Kang 2004; Windschitl 2004). It is always difficult for one to successfully put into practice any method that one has limited or no knowledge about and that science teachers' limited knowledge will impede the implementation of inquiry in their classrooms.

On the suitable approach to develop students thinking, 71% of the respondents agreed that, inquiry-based approach is suitable to develop students thinking, 6% disagreed to this whilst 23% were undecided. This evidently supports study by DiBiase and

McDonald (2015), who stated in their study that, inquiry-based approach is an important instructional approach, suitable for developing students' critical-thinking and problem-solving skills. Similar conclusions were also made by Wallace and Kang (2004) that Inquiry Based Approach would promote students' independent thinking and problem-solving skills as well as their conceptual understanding and their scientific thinking practices. Also 77% of the respondents agreed that it is the teachers' role to facilitate students' own inquiry. None of the respondents disagreed, but 23% of the respondents were undecided.

These findings support the study by Crawford, (2000). His study concluded that in order to conduct inquiry in school, several roles are required of science teachers, such as 'motivator, diagnostician, guide, innovator, experimenter, researcher, modeler, mentor, collaborator, and learner' and, subsequently, requires teachers to divide their time and efforts between preparing the experiment and its equipment, and answering unpredictable questions from students at different levels.

On the challenges when using inquiry- based approach, 50% of the respondents agree, 37% strongly agree whiles four were undecided on the challenges of inquiry-based approach. The results show that majority of respondents believe there are challenges in implementing the inquiry-based approach. This is in line with a study by DiBiase and McDonald (2015) that the effectiveness and efficiency of implementing inquiry-based learning come with a few limitations that need to be addressed by the teacher. Though it is largely agreed by many teachers that inquiry is an important tool and effective teaching and learning of science the knowledge, skills and capabilities of teachers in its implementation remains a problem that needs to be solved. Also, Roehrig and Luft (2004) indicate that there are barriers for the enactment inquiry-based approach. For instance, as it is often done, detailed information is provided by traditional teachers in the form of lecture, teacher led discussion and lab work aimed at helping students to conceptualise or confirm a given concept. It has also been documented by researchers there are many barriers confronting the implementation of inquiry-based approach such as lack of requisite knowledge on the part of science teachers to implement inquiry-based teaching. According to these researchers it is always difficult for one to successfully put into practice any method that one has limited or no knowledge about and that science teachers' limited knowledge will impede the implementation of inquiry in their classrooms. (Keys & Kennedy 1999; Crawford 2000; Wallace & Kang 2004; Windschitl 2004 Kang, Orgill & Crippen, 2008).

The study revealed that the respondents had heard of teaching as inquiry and that most of them had acquired training on teaching as inquiry in their years of schooling. Overall, it appeared from the results that the teachers were knowledgeable about teaching as inquiry. This is a good indication that lecturers at the teacher training institutions are training science teachers on students centered pedagogies.

4.3 Research Question Two: To what extent do teachers utilise inquiry-base strategy in their classroom practice?

Question 8 of section A of the questionnaire sought to find out how often respondents use the inquiry-based approach of teaching in their class. Table 3 shows the distribution of the responses.

Table 4: How often Inquiry-based Approach is SED

Response	Frequency (f)	Percentage (%)
Never	18	60
Sometimes	2	7
Often	4	13
Always	6	20
Total	**30**	**100**

From table 4, it can be observed that the majority of the respondents representing 60% of the sampled population do not make use of inquiry-based teaching in their class at all. 4 respondents representing 13% of the sampled population indicated they often use inquiry-based teaching in their class. 2 respondents representing 7% of the sampled population stated they sometimes use inquiry-based approaches in their delivery of lessons whiles 6 respondents representing 20% indicated they always use inquiry approach in their classroom always. This result supports evidence by Tobin and McRobbie (1997) that, even though teachers may profess that they were inquiry oriented, they still use direct instruction in their classrooms. Their findings showed that teachers' knowledge about inquiry and practices are not necessarily aligned. Similar to this, Gejda and LaRocco (2006) conducted a survey of 305 in-service secondary science teachers about the use of inquiry-based approach.

Findings from the Table 4 revealed that most of the teachers in this study did not practice inquiry teaching in the classrooms and if they did, it was for short periods. This situation might be a reflection of the fact that teachers might have forgotten what they learnt in teacher training school due to lack of continuous practice or due to some challenges. It may also be due to teachers' not attending any workshop or conference on teaching as inquiry. There is therefore the need to provide some additional professional training for teachers to maximize its usage. This creates a sense of responsibility among teachers and school authorities.

Table 5: Teachers' Knowledge on Inquiry in Relation to Classroom Practices (n=12)

	Creterion/ Creterion Score				
Number of Teachers	**Materials and Activities Used**	**Teacher Behaviour**	**Teachers' Questioning Techniques**	**Total Criterion Score**	**Remarks**
T1	5	15	7	27	A practice
T2	7	14	6	30	A practice
T3	0	5	5	10	Not a practice
T4	0	1	6	7	Not a practice
T5	7	13	6	26	A practice
T6	8	10	5	23	A practice
T7	0	3	0	3	Not a practice
T8	0	1	0	1	Not a practice
T9	0	0	1	1	Not a practice
T10	3	1	2	6	Not a practice
T11	1	0	3	4	Not a practice
T12	0	3	3	6	Not a practice

NB Total criterion score above indicates practice of inquiry while a total criterion score less than 20 indicate non practice of inquiry

Table 5 is a summary of the results of the observation of 12 teachers who profess the knowledge of inquiry approach in the questionnaire. From the table teachers 1, 2, 5 and 6 provided their students with adequate materials. Students were therefore able to use the materials provided to pursue investigations at their own level and own direction. This is in line with one of the principles of inquiry which states that in a typical inquiry-based learning framework student act as researchers by way of being introduced to a topic and tasked with developing their own research questions to guide their process of discovery (Pedaste, Maeots, Silman, & de Jong, 2015). According to Martin-Hansen, (2002) inquiry learning requires the teacher to provide the needed resources and materials and ask students what investigations could be carried out using the provided resources. Students then devise a plan and carry out investigation into the questions with the provided materials which they by themselves gather and collect data. The recorded data is analysed after the completion of the investigation. Students then present their results based on the collected data and make claims and share the processes and the outcomes for critiquing by the class. Also, while students were performing the activities teachers 1, 2, 5 and 6 moved round the class assisting the students and behaving as a fellow investigator. An inquiry-based learning model often flips the roles of the teacher and student. Students become the researchers, and teachers assume the role of the assistant or guide to their learning (Dobbler et al., 2017). Again Crawford, (2000) in his study concluded that in order to conduct inquiry in school, several roles are required of science teachers, such as 'motivator, diagnostician, guide, innovator, experimenter and a researcher. Teachers 1, 2, 5 and 6 engage their students in a group activity and the use of effective questioning techniques thus encouraging Peer-to-Peer Collaboration. According to Ismael and Elias (2006), Learning from peers and sharing ideas with others is another core principle of inquiry-based learning. Students in an Inquiry Based approach classroom become each other's soundboards, which gives them an authentic audience from which to draw alternative perspectives from their own and test the validity of their ideas. According Keys and Bryan (2001) Peer-to-Peer Collaboration help students to practice the skills of dialogue, reporting, deliberation as well as debate to promote understanding and achieve lesson objectives. Teachers 3, 4, 8, 9, 12 on the other hand did not provide their students with any materials hence students were not given the opportunity to generate their own learning through hands on activities. Teachers 10 and 11 however did provide some materials but were inadequate to offer students the opportunity to do their own research.

Teachers 3, 4, 9, 10, 11 and 12 used a lot to questions to engage their students however their questions were not too effective to help their students think critically while teachers 7 and 8 did not use questioning technique at all. Cochran-Smith, et al., (2009) are of the firm conviction that the pivot of higher inquiry level is student's involvement in questioning. This they believe gives students the opportunity to have personal control of learning and promotes students interest. Colburn (2000) is of the view that inquiry as a student-centred approach starts with student's question and continues with student or groups of them designing and conducting experiment and investigations and finally ends with communicating their results. Since teachers 3, 4, 7, 8, 9, 10, 11 and 12 did not apply any of the core principles of inquiry approach in their class it can be concluded that they did not practice inquiry approach in their class. In order to state that a teacher is practicing inquiry-based approach in this study, the teacher must have a criterion score above 20. It can be seen from table 5 that out of 12 teachers observed only 4 representing 33. % of the teachers who had knowledge on inquiry strategy had a total criterion scored above 20. And 8 representing 67 % scored below 20. Only 33.3% of teachers who profess knowledge of inquiry strategy practiced it in the classroom.

Findings From table 5 show that most of the teachers in this study are teachers that have knowledge of inquiry-based approach and profess to practice inquiry strategy but do not necessarily inculcate it in their classroom practice. This finding suggests that implementation of traditional instruction persists in the selected senior high schools, despite the emphasis of current curricula rationale for all students to be actively engaged in inquiry investigations (CRDD, 2010)

This finding supports evidence by Tobin and McRobbie (1997) that even though teachers may profess that they were inquiry oriented, they still use direct instruction in their classrooms. According to Tobin and McRobbie (1997) teachers' knowledge of inquiry-based approach and practices are not necessarily aligned. This study further revealed that most teachers teach without teaching and learning materials. Few who brought teaching learning materials to class did not use it appropriately to match the lesson objectives so as to sustain students' interest and motivation. The implication here is that teachers are tempted to resort to traditional lecture method. This prevents interaction and causes boredom. The study also revealed that some teachers have good questioning skills however most of the teachers in this study did not make use of a good questioning skills. The implications are that students are not asked questions that will stimulate learning, develop their potentials and stir their imagination.

4.4 Research Question Three: What are the difficulties biology teachers encounter in the classroom practice of inquiry-based learning?

To effectively answer this question the researcher sought to found out whether the selected schools had a science laboratory and if it is well equipped. Item one of the section A of the questionnaire sought to find out the availability of a science laboratory in the school of the respondents. All 30 respondents representing 100% of the respondents indicated the presence of a science laboratory in their school. Item two of the section A sought to find out whether the laboratory was equipped and well resourced. Out of the 30 respondents, 22 respondents representing 73.3% indicated that their laboratory is not well equipped whilst only 8 respondents representing 26.6% of the respondents agreed to this. A study conducted by Wallace and Kang (2004) highlighted lack of equipment, laboratory safety issues as barriers that impede the use of inquiry teaching in science classrooms. The findings of this study indicated most of the laboratory of the respondents were not well equipped. This finding also supports Studies by Kikis-Papadakis and Chaimala (2014) and Davis (2003) that insufficient school resources can affect teachers' decisions on conducting inquiry strategy of teaching.

This finding is also consistent with Beck, Czerniak and Lumpe's (2000) views that difficulties encountered by teachers when implementing inquiry-based learning include inadequate time, resources and appropriate curriculum materials.

Question 4 of section A of the questionnaire sought to find out the number of classes the sampled teachers for the study teach in their school. Table 6 below shows the number of classes teachers teach in their various schools.

Table 6: The Number of Classes Taught by a Teacher

Number of Classes	Frequency (f)	Percentage (%)
2 – 4	5	16.6
5 – 6	18	60
More than 6	7	23.3
Total	**30**	**100**

Table 6 showed that, majority of the teachers representing 18 (60%) of the sampled population teach 5-6 classes in their school whilst the rest of the teachers numbering 7 representing 23.3 % of the sampled population teach more than 6 classes. Only 5 respondents representing 16.6 % teach 2- 4 classes.

Findings from Table 6 shows that teachers in this study teach too many classes. Hence do not have adequate time to prepare for inquiry approach. A study by Goodenough

(2004) has maintained that time is of essence as teachers are required to guide students to uncover their critical thinking capabilities required for inquiry-based learning.

Question 6 of section A of the questionnaire sought to find out the number of students in the class of each respondent. Table 7 shows the distribution of the number of students in each respondents' class.

Table 7: Number of Students in a Class

Number of Students	Frequency (f)	Percentage (%)
40 -45	8	27
46– 50	5	17
51-55	12	40
56 – 60	5	16
Total	**30**	**100**

From Table 7 above, it can be observed that, 12 of the respondents have class size of 50-55 students representing 40% of the sampled population, 8 teachers have a class size of about 40-45 students representing 27%, 5 respondents representing16 have a class size of 46-50 whiles 5 respondents representing 17% of the sampled population has 56-60 students' in their class.

Findings from Table 7 shows that majority of respondents teach a large class which makes it very difficult to implement inquiry strategy due to lack of space. The findings of a study by Ayeni and Olowe (2016) revealed that large class size has negative implications on teaching and learning it leads to poor classroom management, ineffective students' control, poor planning and assessment and increase strain on teachers. Large class size encourages disruptive behaviour, frustrate the teacher's effort and affect teacher's health. Anderson and Helms (2002), Luera and Otto (2005) reports that impediments of inquiry-based approach include: large class size, interest and abilities of students and inadequate time.

Item three of section A of the questionnaire sought to find out whether there is a policy in the school in terms of content selection and instructional materials appropriate for a particular class.

Table 8: School Policies in Terms of Content Selection

Policy on Content Selection	Frequency (f)	Percentage (%)
Undecided	3	10
No	5	17
Yes	22	73
Total	**30**	**100**

Out of the all the respondents, only 3 respondents representing 10% were undecided about the existence of such a policy in their school, 5 respondents representing 17% indicated the non-existence of such policy while 22 of the respondents representing 73% indicated the existence of such policy in their school. This finding supports the study by Wallace and Kang, (2004), who stated that school policies such as preparing students for standardized tests and official exams, and finishing mandated curriculum content within a set time limit as a barrier to the implementation of inquiry-based teaching approach. Also, Trautman, (2004), empahasized in their study that when there is a fixed curriculum established by the government, teachers consider their principal roles to be maintaining the rigor of the curriculum. This tendency put a high level of pressure on teachers to help students prepare to succeed in exams.

For these reasons, teachers tend to avoid time-consuming inquiry strategy in spite of students' positive experiences in authentic scientific investigation and its positive impact on students' attitudes and achievements, and to focus more on preparing students for assessments. Hence, teachers put more emphasis or value on examinations (Veronesi & Voorst, 2000). Amrein and Berliner (2002) maintain that emphasis on test preparation may improve test scores in the short term, however, they do little to improve student learning. The student must be developed holistically to be able to acquire the needed skill to be able to contribute meaningfully to solving problems confronting the society. These skills are acquired through active participation of the student in scientific processes through inquiry-based approach.

Findings from the study revealed 4 difficulties that impede the practice of inquiry-based approach in the classroom by the teacher. These are lack of laboratory equipment, teachers teaching a lot of classes, large class size and existence of school policies.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter summarises the findings of the study, conclusion, recommendations and suggestions for other researchers have also been discussed in this chapter.

5.1 Summary of Findings

The study assed senior high school Biology teachers' knowledge and classroom practices of Inquiry Approach. The study was conducted using descriptive survey. The researcher used questionnaire and classroom observation chart to gather the needed information for the study. Thirty biology teachers were sampled for the study using simple random sampling. Participants were asked questions relating to their background and teaching strategies. Simple tables and percentages were used to analyse the information. Summary of key findings are presented below.

5.1.1 Teachers' knowledge on inquiry approach

The study established that most teachers agreed that inquiry approach is one of the best methods of teaching biology in the senior high schools. About 71% of the respondents have adequate knowledge on guided inquiry and structured inquiry approach. This is probably due to professional development of inquiry pedagogies during their teacher training programmes.

The findings further showed that teacher's knowledge on inquiry learning approach, is the main predictor of the implementation of inquiry learning approach in the teaching of biology in the Senior High School.

5.1.2 Teachers' knowledge on inquiry and classroom practices

The study established that majority of the teachers that have knowledge on inquiry strategy did not practice inquiry teaching in the classrooms and if they did, it was for short periods Instead they continue to use the traditional lecture method. The study established teachers do not implement inquiry-based approach because they do not attend workshop or conference on teaching as inquiry.

5.1.3 Challenges in conducting inquiry in biology lessons

Even though much could be said about the usefulness of inquiry in today's biology teaching and learning, there are some challenges that confront teachers in using this approach in their lesson. Findings from the study shows that problems such large class size is a major challenge for the implementation of inquiry-based approach. Large class size affect classroom management which is undoubtedly one of the most critical aspects associated with effective instruction and learning. Large class size can lead to poor classroom management. Poor classroom management can destroy any chance for meaningful learning including inquiry.

Another challenge confronting the implementation of inquiry-based approach in biology lessons was inadequate time and resources according to the study. Another challenge according to the study is Curriculum demands on the teacher. The demand of the curriculum always gives teachers little time to be able to fully and effectively implement inquiry learning approach. The implication here is that the use of inquiry may be limited in biology lessons. Also lack of resources in the schools' science laboratory is a major impediment to the implementation of inquiry-based approach in the selected senior high schools.

5.2 Conclusion

Successful implementation of any curriculum is fully dependent on the quality and quantity of teaching strategies available to teachers. The Inquiry approach is no doubt one of these strategies because it is a pedagogy which best enables students to experience the processes of knowledge creation. It's key attributes include learning stimulated by inquiry, a student- or learning-centered approach in which the role of the teacher is to act as a facilitator, a move to self-directed learning, and an active approach to learning. It helps students to develop research skills and be prepared for lifelong learning and achieve outcomes that include critical thinking. Furthermore, with the recent movement towards strengthening teaching and research links` Inquiry approach is an enticing and convincing pedagogy that offers a way for teaching and research to be strongly integrated to the benefit of all stakeholders. However, the research on learning styles gives rise to caution, as many teachers may be uncomfortable with inquiry approaches and thus need adequate support to make the transition. This study revealed that though teachers may have an adequate knowledge on inquiry approach, many decline to practice it in their biology lessons.

5.3 Recommendations

Reflecting on the summary of the findings of this study the following recommendations were made:

1. Teachers should be given needed staff development programmes (refresher courses) to be abreast with the changing dynamics of teaching biology. Teachers must be taken through the appropriate ways of successfully using inquiry in biology lesson to achieve the aims enshrined in the biology teaching syllabus.
2. Senior high schools with science laboratories should be well equipped in order to overcome the challenges of implementing inquiry strategy.

3. Government must build more classrooms and train more teachers to solve the problem of large class size.
4. Teachers could adopt improvisation especially in situations where some other resources could be used in place of the original when they are unavailable at all.
5. The National Council for Curriculum and Assessment Division of Ministry of Education must encourage the active involvement of students in their own learning process, through group work and hands-on activities in the curriculum.
6. Since teachers often show reluctance in enacting inquiry-base teaching approaches in their teaching, as they consider those approaches as time-consuming leading to conflict with the requirement to deliver curricula content, there is need for an application of changes to curricula and methodologies by policy-makers.

5.4 Suggestions for Further Research

The results of this study demonstrate a need for further research to investigate the relationship between teacher's beliefs and attitudes about inquiry and their classroom practices. An in-depth qualitative study of a number of teachers in this study would be a useful addition to this research. Such a study could focus on understanding the factors that impede or facilitate the implementation of inquiry by teachers of different ages, years of experience, and content matter backgrounds. Moreover, different tools can be used to collect more accurate data such as videotaping the teachers in class, teachers' notes, teachers' reflections on their teaching, and more detailed discussions with teachers.

Furthermore, more research could be done to investigate the practical applications of inquiry in classrooms on a large scale to ascertain the strengths and weaknesses of teachers in using this approach. This would give base-line information upon which staff development programmes could be organised for teachers to get them acquainted with effective ways of conducting inquiry lessons in biology. Another area that will warrant research is teachers' experience and its relation to practicing inquiry in the classroom.

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APPENDIX

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

MASTER OF PHILOSOPHY, SCIENCE EDUCATION

A TEACHERS' KNOWLEDGE ON INQUIRY QUESTIONNAIRE (TKIQ)

TEACHERS' QUESTIONNAIRE

Dear Sir/Madam,

This questionnaire is part of a study aimed at obtaining information on biology teachers' knowledge on inquiry in science education.

Confidentiality in respect of whatever information you give is fully assured. Thank you.

Name of school…………………………………………………………………………

Serial number………………………………………………………………………..

Teaching experience 1 – 4 years [ ] 5 -10 years [ ] 11 -15 years [ ] 15 -20 years [ ]

Professional qualification BED [ ] MED [ ] MPHIL SCIENCE EDUCATION [ ] PGDE [ ] NONE [ ]

Section A

Please answer the following questions by selecting the appropriate response by ticking (√)

1. Does your school have a science laboratory Yes [ ] No [ ]
2. If yes is it well equipped Yes [ ] No [ ]
3. Is there any policy in your school in terms of selection of content and instructional materials appropriate for a particular class Yes [ ] No [ ]
4. How many classes do you teach? 2-4 classes [ ] 4-6 classes [ ] more than 6 [ ]

5. How many years have you been teaching biology? 1-5 years [ ] 6-10 years [ ] 11-15 years [ ] Over 15 years [ ]
6. What is the number of students in a class? 40-45 [ ] 50-55 [ ] above 60 [ ]
7. Which of the following approaches in your opinion enhance students' participation and understanding? Lecture [ ] Discussion [ ] Demonstration [ ] Inquiry-based learning [ ] Other [ ]
8. How often do you use inquiry-based learning as a teaching approach?

   Never [ ] Sometimes [ ] Often [ ] Always [ ]

Section B

I would like to ask about your personal knowledge on teaching and learning. To what extent do you agree or disagree with the following statements? *The statements are mainly on elements of engaging students in inquiry task*. ***Please complete the following by placing a tick in one space only.***

Statement	Strongly Degree	Disagree	Undecided	Agree	Strongly Agree
1. Inquiry- based approach makes lesson pragmatic).	[ ]	[ ]	[ ]	[ ]	[ ]
2. During your teacher training programme you were taught about inquiry approach.	[ ]	[ ]	[ ]	[ ]	[ ]
3. Inquiry- based approach is suitable to develop students thinking.	[ ]	[ ]	[ ]	[ ]	[ ]

4. My role as a teacher is to facilitate students' own inquiry.	[ ]	[ ]	[ ]	[ ]	[ ]
5. there are a lot of challenges when using inquiry- based approach in class	[ ]	[ ]	[ ]	[ ]	[ ]
6. Lack of teaching learning materials inhibits the use of inquiry -based approach	[ ]	[ ]	[ ]	[ ]	[ ]
7. Lack of time and space inhibits the use of inquiry -based approach in class.	[ ]	[ ]	[ ]	[ ]	[ ]
8. It is important for student to construct new knowledge in inquiry practice.	[ ]	[ ]	[ ]	[ ]	[ ]
9. Inquiry based approach is a complex teaching method.	[ ]	[ ]	[ ]	[ ]	[ ]
10. I frequently engage students in inquiry task	[ ]	[ ]	[ ]	[ ]	[ ]

DEPARTMENT OF SCIENCE EDUCATION

MASTER OF PHILOSOPHY (SCIENCE EDUCATION)

OBSERVATION CHART HOW'S YOUR IQ (INQUIRY QUOTIENT)

Serial Number…………… School...……………………………………………..…

Date of Observation ……………………………… Enrolment …………………..

Topic…………………………………………………………………………….

Materials Used…………………………………………………………………

Criterion	**Scale**					**Criterion Score**
1.Materials and activities i. Materials and activities of interest	0 Students are bored	1 Some Students not paying attention	2 Students are mildly interested	3 Students are somehow interested	4 Students very interested	
ii. materials and activities which provoke thinking, questioning and discussion	0 No questioning or discussion	1 Less than 15% students are stimulated to think, question and discuss	2 50% of students stimulated to think, question, discuss	3 More than 50% of the students are able to pursue investigation at own level and direction	4 All students are able to pursue investigation at own level and own direction	
2. Teacher behaviour ii. Is fellow investigator	0 No	1 25% of the time	2 50% of the time	3 75% of the time	4 Yes	
iii. tied new material to previous learning	0 No	1 25% of the time	2 50% of the time	3 75% of the time	4 Yes	
iv. Provided opportunities for student practice	0 No	1 25% of the time	2 50% of the time	3 75% of the time	4 Yes	
iv. Monitored and was alert to student behaviour; redirected for productive learning	0 No	1 25% of the time	2 50% of the time	3 75% of the time	4 Yes	

v. Engages students in critical thinking and problem-solving skills	0 No	1 25%	2 50%	3 75%	4 All the time	
3. Teachers' questioning <u>techniques</u> i. Use effective questioning techniques of the level of students	0 No	1 questioning techniques used but not very effective	2 Few questioning techniques used but effective	3 50% all the time and very effective	4 question techniques used effectively More than 50%	
ii. Students are given adequate time to respond to questions	0 No	1 25% all the time	2 50% all the time	3 75 % all the time	4 More than 75% all the time	

Table 5: Teachers' Knowledge on Inquiry in Relation to Classroom Practices (n = 12)

Creterion	Criterion Score /Number of Teachers											
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**
Materials and Activities used												
Materials and activities of interest	2	4	0	0	3	4	0	0	0	1	1	0
Materials and activities which provoke thinking questioning and discussion	3	3	0	0	4	4	0	0	0	2	0	0
Teacher behaviour												
Act as a fellow investigator	3	3	2	0	3	3	1	0	0	1	0	0
Tied new material to previous learning	4	4	0	1	4	4	0	0	0	0	0	3
Provided opportunities for practice	4	3	1	0	3	2	1	0	0	0	0	0
Engages students in critical thinking and problem-solving skills	4	4	2	0	3	1	1	1	0	0	0	0
Questioning Techniques												
Use effective questioning techniques of the level of students	3	3	2	3	2	3	0	0	1	1	1	1
Students are given adequate time to respond to questions	4	3	3	3	4	2	0	0	0	1	2	2
Total	**27**	**30**	**10**	**7**	**26**	**23**	**3**	**1**	**1**	**6**	**4**	**6**

NB total criterion score of more than 20 indicates practice of inquiry while a total criterion score less than 20 represent non practice of inquiry.