UNIVERSITY OF EDUCATION, WINNEBA

JUNIOR HIGH SCHOOL INTEGRATED SCIENCE TEACHERS' KNOWLEDGE AND PRACTICE OF INQUIRY-BASED INSTRUCTION IN TANO SOUTH MUNICIPALITY

FRANK WILLIAMS GYENING
(8180030017)

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MARCH, 2021

DECLARATION

Student's Declaration

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

Signature: …………………………………

Date: ………………………………………

Supervisor's Declaration

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

Dr. James Azure, (Principal Supervisor)

Signature: …………………………………

Date: ………………………………………

Prof. Sakina Acquah, (Co-Supervisor)

Signature: …………………………………

Date ………………………………………

DEDICATION

I dedicate this work to my parents: Mr. and Mrs. Fosu Gyeabour.

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LIST OF ABBREVIATIONS

ISI:	Interdisciplinary Science Inquiry
PD:	Professional Development
IBI:	Inquiry-Based Instruction
NOS:	Nature of Science
NOSI:	Nature of Science Inquiry
UNESCO:	United Nations Scientific and Cultural Organization
JHS:	Junior High School
NRC:	National Research Council
IAP:	Inter Academy Panel

ABSTRACT

The purpose of the study was to investigate Junior High School (JHS) integrated science teachers" knowledge and practice of inquiry-based instruction in Tano South Municipality of Ghana. In this study, convergent mixed method design was employed. The study was conducted in Tano South Municipality in the Ahafo Region of Ghana. The sample for the quantitative study was 75 Junior High School (JHS) integrated science teachers. In the qualitative study, a sub-sample of 8 Junior High School (JHS) integrated science teachers was sampled. The teachers who participated in the study were included through the census method. The researcher used questionnaire and interview guide as the primary tools for collecting data. The questionnaire and interview guide were employed to collect quantitative and qualitative data respectively. The quantitative data was analysed using frequency, percentages, mean and standard deviation whereas the qualitative data was analysed using the cross-case analysis procedure. From the findings, it was revealed that a large number of JHS integrated science teachers do not acknowledge the fact that inquiry-based instruction depicts science as an ongoing process of exploration and discovery rather than a content domain to be memorized. Also, the study findings again revealed that, majority of the teachers do not know that inquiry in science stresses on dialoque, reporting, deliberations as well as debate. Again, the study revealed that a large number of teachers lack the requisite knowledge on how to use the inquiry-based instruction. The study concluded that JHS integrated science teachers although demonstrated some kind of knowledge about inquiry-based instruction but, on average it found out to be low. The study recommends that the Municipal Education Directorate should organize regular in-service training for teachers on the use of inquiry-based approach in teaching.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter captures the background to the study, statement of the problem, purpose of the study, research objectives, research questions, and significance of the study, delimitation, limitations and organisation of the study.

1.1 Background to the Study

Inquiry-based learning (IBL) is a key thrust in school science education, and has for decades been the prominent and central theme of science curriculum improvement (Aldahmash, Mansour, Alshamrani & Almohi, 2016; Wang, Zhang, Clarke & Wang, 2014). Most of the educational reforms in the teaching and learning of science include the word „inquiry." This is because, inquiry is often used to characterise good science teaching and learning (Conklin, 2012). In other words, the effective use of scientific inquiry is one hallmark of outstanding science teachers.Inquiry exists within different contexts–scientific inquiry, inquiry-based learning and inquiry-based teaching (Marshall & Smart, 2013).

Inquiry-based instruction therefore is not a new phenomenon to education. According to Taylor and Bilbrey (2011), IBL had its start in the 1950s, particularly in science education. During this time, the space race between the United State of America and the Soviet Union was increasing the necessity for the development of a more intense science curriculum. Haury (1993) postulates that "If a single word had to be chosen to describe the goals of science educators that began in the late 1950s, it would have to be inquiry" (p. 4). Just as inquiry-based learning has been a departure from the more traditional teaching methods, constructivism is a departure as well. The traditional philosophies surrounding the cognitive abilities of students have been challenged by the more modern constructivism. Instead of simply trying to control the behavioral environment and promote the sterile, objective absorption of material, constructivist believe that determining truth requires a value judgment on the part of the individual (Ssempala, 2017).

Inquiry can be defined in many different ways. Short (2009) defined inquiry as the constructive approach of connecting to and reaching beyond current understandings to explore tensions significant to learners. Short further emphasised that, inquiry is more than just posing and answering a series of questions at differing levels, but that inquiry is a stance; a belief in the way learners gain new knowledge through an inquiry cycle. NRC (2012) also defined inquiry as a multifaceted activity that involves observations; posing questions, examining books and other resources of information to see what is already known; planning investigations; reviewing what is already known in the light of experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanations, and predictions; and communicating the results. In other words, inquiry is the process by which scientific knowledge is developed.

Inquiry exists within different contexts – scientific inquiry, inquiry-based learning and inquiry-based teaching (Hasson & Yarden, 2012; Marshall & Smart, 2013). According to Lustick (2009), IBL consists of experiences that help learners to understand the world around them through the development and use of inquiry skills. Inquiry-based curriculum assumes learners learn gain new knowledge by asking questions, identifying problems, and conducting investigations. This is followed by collecting, analyzing and interpreting data for the purposes of creating comprehensive explanations before drawing conclusions.

United Nations Scientific and Cultural Organization (UNESCO) (2010) arguments points to the fact that science through inquiry should continue to be regarded as an integral part of the pre-primary curriculum as it enables young learners to generate new ideas about the world around them, which is critical in establishing a suitable climate for scientific literacy. The experience gained from undertaking scientific inquiry allows children to appreciate how science works. Science through inquiry can help children have a clear picture of how science directly impacts various aspects of their lives such as health and safety. Involvement in scientific activity leads to the realization of the significance of reasoning about evidence, which is a prerequisite of future learning in science and beyond. According to National Research Council (NRC, 2012), inquiry skills are foundational for the development of the more complex science skills hence should be given due emphasize in the early years of primary education.

It is emphasised that students should experience inquiry-based practices and not merely learning about them (National Research Council (NRC), 2012). NRC (2012), identified the following practices regarding inquiry-based instruction: asking questions; defining; developing and using models; planning and carrying out investigations; analysing and interpreting data; using mathematics and computational thinking; constructing explanations; designing solutions; engaging in argument from evidence; and obtaining, evaluating and communicating information. Science teachers who use this approach develop within their students an understanding that science is both a product and a process (Banchi & Bell, 2008; Leonor, 2015). Leonor (2015) emphasised that, not only do students of these teachers learn the rudimentary knowledge and skills possessed and employed by scientists, but they also learn about the nature of science (NOS).

Once IBL is undertaken, the open communication, motivation and achievement outcomes that result lead to positive perceptions of inquiry-based learning on the part of classroom teachers. According to Njagi (2009), the positive teacher perceptions of inquiry-based learning are sometimes due to the long-term positive relationship between teacher and students that contribute to a classroom environment in which trust and mutuality were constructed. Teachers who have a positive perception of instructional programs often have greater job satisfaction and are far more likely to utilize emerging instructional technologies to further the learning gains possible through inquiry-based instruction (Demir & Abell, 2010).

Surprisingly, inquiry-based instruction continues to be more effective than traditional teacher-directed methodologies even when employed by teachers opposing the implementation of initiatives supporting inquiry-based learning (Aldahmash et al., 2016). One method employed for increasing positive perceptions of inquiry-based instruction is the reorganization of teacher education programs. By introducing pre-service teachers to inquiry-based instruction before they begin teaching careers and then following the new teachers through early implementation phases of inquiry-based instruction, the number of practicing teacher with positive perceptions of inquiry-based learning will increase (Lustick, 2009).

The benefits of IBL are well-established from empirical research studies. Affectively, doing inquiry is motivational, and stimulates interest in science learning (Breslyn & McGinnis, 2012; Osborne, 2010).Thus, inquiry provides an insight into the world of the scientist. IBL has also been shown to contribute to the development of conceptual understanding in science (Lederman & Lederman, 2012; Leonor, 2015). In other words, inquiry provides the means to understanding the nature of science. Scientific inquiry according to Conklin (2012), may lead to the development of higher-order thinking skills such as analysis, synthesis, critical thinking and evaluation.

Miranda and Damico (2015) however, cautioned teachers that there needs to exist enough content knowledge so that the inquiry can be effective. In addition, the importance of meeting the learners where they are in their development is essential for cognitive growth. Students should have a varying amount of control dependent upon their age. The role of the teacher in inquiry learning has been described as a facilitator of learning, one who crafts conceptual frameworks about which students will inquire. In addition, the teacher creates educational spaces in which students can collaborate and discuss new questions and new learning. Inquiry-based teaching also utilizes high motivating strategies, engages student interests, exists in an active learning environment with a multitude of resources, and provides many opportunities for social interaction (Breslyn & McGinnis, 2012). Through inquiry, learners engage in the following process skills: observing, questioning, hypothesizing, predicting, investigation, interpreting, and communicating.

Despite the potential benefits of using inquiry in science learning, there are several drawbacks with the use of inquiry instruction. For instance, Cobern, Schuster, Adams, Undreiu, Applegate, Skjold and Gobert (2010) study show that curriculum and pedagogical reforms, inadequate teacher training on pedagogical approaches and lack of support from Government and Education Ministries on implementation of IBL bring about the disconnect between the way the science curriculum is structured and the way teaching is being implemented in classrooms. Also, many science teachers do not understand what inquiry is (Demir & Abell, 2010). Demir and Abel found that beginning teachers often left out evidence, explanation, justification, and communication. Another study by Capps and Crawford (2012) discovered that few highly-motivated teachers could describe what inquiry-based instruction was; most equated it with hands-on learning

Inadequate knowledge and experience with inquiry instruction could also act as a barrier. Crawford and Capps (2012) postulate that, many science teachers also have a naive understanding of scientific inquiry and are therefore not able to teach authentic inquiry. Among these reasons is that science teachers often do not, themselves, possess a holistic understanding of scientific inquiry and the nature of science (Lederman & Lederman, 2012; National Research Council, 2012; Osborne, 2010). This in all likelihood stems from the nature of traditional science teaching at college/university level that commonly uses didactic-teaching-by-telling approach (Miranda & Damico, 2015).

1.2 Statement of the Problem

Despite growing consensus regarding the value of inquiry-based teaching and learning, research has found that the implementation of such a pedagogical practice continues to be a challenge for many teachers (Miranda & Damico, 2015). Many science teachers do not understand what inquiry is which consequently affects their practice of inquiry-based instruction. For example, Ramnarian amd Hlatswayo (2018) found that teachers possessed positive attitudes towards inquiry in the teaching and learning of Sciences, and recognised the benefits of inquiry, such as addressing learner motivation and supporting learners in the understanding of abstract science concepts. However, despite this positive belief towards inquiry-based learning, teachers were less inclined to enact inquiry-based learning in their lessons. Teachers claim that the implementation of inquiry-based learning is fraught with difficulty, such as availability of laboratory facilities, teaching materials, time to complete the curriculum, and large classes, which creates tension in their willingness to implement it. Demir and Abell (2010) argue that beginning teachers often left out evidence, explanation, justification, and communication.

Most of the research studies have been carried out to establish the beliefs and attitudes of science teachers towards inquiry-based instruction in Ghana. However, few studies (e.g., Adofo, 2017; Mensah-Wonkyi & Adu, 2016; Taylor & Bilbrey, 2011) have explored science teachers" perceptions about inquiry-based instruction and its effect on students" conceptual understanding Ghana. Therefore, this study attempts to address this gap in literature as far as the integrated science teachers" knowledge and practice of inquiry-based instruction in Tano South Municipality is concern.

1.3 Purpose of the Study

The purpose of this study was to investigate Junior High School (JHS) integrated science teachers" knowledge and practice of inquiry-based instruction in Tano South Municipality.

1.4 Objectives of the Study

The objectives of the study were to:

1. explore JHS integrated science teachers" knowledge about inquiry-based instruction in Tano South Municipality.
2. investigate the extent to which JHS integrated science teachers practice inquiry- based instruction in Tano South Municipality.
3. investigate the background factors that influence JHS integrated science teachers practice of inquiry-based instruction in Tano South Municipality.

1.5 Research Questions

The study was guided by the following questions:

1. What knowledge do JHS integrated science teachers have about inquiry-based instruction in Tano South Municipality?
2. How do JHS integrated science teachers practice inquiry-based instruction in Tano South Municipality?
3. What are the background factors that influence JHS integrated science teachers‟ practice of inquiry-based instruction in Tano South Municipality?

1.6 Significance of the Study

The findings of this study may be useful to teachers, teacher educators, curriculum developers and educational researchers who are interested in science inquiry and constructivism in basic education. This study would contribute to the current knowledge of how JHS integrated science teachers understand and practice inquiry-based instruction in basic schools in Tano South Municipality. Also, this study provides information to guide future educational policies that are necessary to improve the teaching and learning of science in Ghana and the world at large. Thus, curriculum developers could use the findings of this study to come up with a comprehensive frame work for improvement of science teaching and learning in basic schools Ghana.

The findings of this study may also inform the delivery of science lessons in basic schools and provide insights for science educators who want to implement quality professional development programs for science teachers in basic school systems. This study is beneficial to educational leaders and policy makers by informing them about the required improvements of inquiry-based professional development programs to better serve science teachers as well as support current reform of science education.

1.7 Delimitations of the Study

There are specific delimitations to this study. The study was delimited to Tano South Municipality of Ghana and therefore the findings mainly reflected the situation in this Municipality. Specifically, the study focused on JHS integrated science teachers. Hence, the findings thereof may not be deemed reflective of all JHS integrated science teachers in Ghana. The study was also delimited to JHS integrated science teachers‟ knowledge and practice of inquiry-based instruction in the teaching of Integrated Science at Junior High School.

1.8 Limitations of the Study

The limitations of this study must be considered as we interpret findings. Among the limitations, the study only explored the knowledge and practice of inquiry-based instruction. Other critical issues associated with inquiry-based instruction such as challenges could be studied. Therefore, the findings are biased toward the knowledge and practice of inquiry-based instruction among JHS Integrated Science teachers. This study was also limited by the level of detail provided by the participants in their responses to the items posed by the researcher especially in the interview.

1.9 Organisation of the Study

This study was organized into five chapters. Chapter one presents the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, hypotheses, and significance of the study, limitations and delimitations of the study, organisation of the study and operational definition of terms. Chapter Two deals with literature review, that is, the review of relevant literature on topics related to subject under study. Chapter Three presents the methodology employed in the study. This captures research design, researchers‟ methodological position, research setting, population, sample and sampling techniques, research instruments, issues of validity and reliability, pre-testing, data collection procedures, data analysis procedures, and ethical consideration. Chapter Four focuses on the report and analysis results of the study and also captures the discussion of the findings. Chapter five also presents a summary of findings, conclusion and recommendations based on the findings of the study.

1.11 Abbreviations

ISI: Interdisciplinary Science Inquiry

PD: Professional Development

IBI: Inquiry-Based Instruction

NOS: Nature of Science

NOSI: Nature of Science Inquiry

CHAPTER TWO

REVIEW OF LITERATURE

2.0 Overview

This chapter presents the literature reviewed for the study. The review covered theoretical and empirical evidences. This includes the following: Theoretical framework – Constructivism; the concept of inquiry-based instruction; teachers‟‟ knowledge about inquiry-based instruction; teachers‟‟ practice inquiry-based instruction; background factors that negatively influence teachers‟‟ practice of inquiry-based instruction; conceptual framework, and summary of literature review.

2.1 Theoretical framework

This study was based on constructivism theory. The constructivist theory fundamentally hinges on the efforts of Piaget‟‟s cognitive theory of learning. The Piaget‟‟s (1967) constructivism theory posits that children learn by constructing own understanding and knowledge of the world through varied experiences. A constructivist approach to basic education is based on the understanding that knowledge is constructed by children themselves instead of being transferred or transmitted to them. In this approach, children are regarded as theory builders and intellectual explorers. The assumption here is that children develop their own complex and varying theories about the world as they continue to interact with their surroundings. According to Piaget (1967), learners take part in the physical construction of knowledge when they engage in active learning. It also adds that knowledge is symbolically constructed by learners who are making their own representations of action.

Socially, learners construct knowledge by attempting to convey the meaning of certain information to others. On the other hand, theoretical construction of knowledge can take place when learners try to come up with explanations of the things they do not adequately understand. Constructivist approach requires teachers to provide supportive and favorable environment where young learners are motivated to go about testing and revising their original theories. Creating such an environment requires first a variety of interesting materials that children can explore and manipulate. Moreover, there should be unstructured time for children to develop and test their own ideas as well as a social climate where children can note that questions and experimentation are as valuable as knowing the right answers.

Orton (2004) holds that within the constructivist paradigm, students have the chance to make use of their already existing knowledge, encounters, findings and conceptions to construct new concepts, and the focal point is the formation of new concept. Ward (2001) opines that teachers play crucial roles in guiding and assisting students to construct accurate knowledge as they explore the environment and meet varieties of ideas. Productive questions posed by the teacher play a significant role in helping children construct their own understandings. Productive questions are, in fact, one of the most effective tools for supporting constructivist learning. The rationale for using this theory to support children‟s learning using inquiry was based on the fact that the majority of children have difficulty engaging in constructive learning because they fail to make adequate connections that are necessary in arriving at a desired understanding without hypothesizing and questioning as is the practice in most basic school classrooms in the country.

Piaget"s constructivism theory was further found relevant to this study because it helped the researcher to conceptualize that teachers have to use teaching approaches which enhances their learners' logical and conceptual growth. Children should therefore be allowed to construct knowledge by being active participants in learning and investigation as that influences what is learned and the experiences the learner draws upon to construct new understandings, inquiry based learning approach to teaching and learning science may help move learners away from the rote memorization of facts to metacognition and self-evaluation and that teachers level of training on pedagogical imparts on the teachers ability to implement inquiry teaching and learning.

Inquiry-based learning has a strong theoretical foundation in constructivism. Constructivist approach requires teachers to provide supportive and favorable environment where young learners are motivated to go about testing and revising their original theories.

Therefore, constructivism theory provided a theoretical framework for the present study to explore and investigate the issues related to current teaching and learning of science and the implementation of inquiry learning by teachers at the junior high school level in Tano South Municipality. It is important to substantiate that constructivism is not an instructional approach; rather it is a theory about how learners construct knowledge. The theoretical propositions emerging from the constructivist theory were of particular relevance to this study as they guided the researcher to describe the complexity of junior high school integrated science teaching by investigating teachers" knowledge and practice of inquiry-based instruction in Tano South Municipality.

2.2 The Concept of Inquiry-Based Instruction

The meanings and approaches to the application of inquiry have also been interpreted differently, leaving science teachers in a dilemma in implementation of these approaches in the actual classroom (Anderson, 2002; Kielborn & Gilmer 1999). However, Demir and Abell (2010) believe that what is generally agreed by science educators is that the focal point of science teaching and learning must be geared towards the development of science inquiry skills and not a mere knowing of scientific facts and concepts, and that the best approach to developing these inquiry skills is doing science.

According to Sullivan (2008), inquiry-based instruction is simply using hands-on activities in teaching children so that that they are able to explore scientific concepts, as well as instruction in which the focus is on using process skills to gain. Through inquiry approach, teachers guide children in using an analytical approach to understand their world and construct new knowledge. In conducting inquiry, the inquirer needs to identify assumptions, apply critical and analytical thinking, and take into cognisance alternative explanations which are the prerequisites. Students undertake some activities in chosen areas of inquiry through which they gain insight into the procedure scientists use to know the natural world. The expectation is that students through these activities develop the needed skills to handle full inquiries on their own.

Inter Academy Panel (IAP) (2012) view inquiry-based instruction as a gradual development of principal scientific concepts of students as they learn the appropriate ways of doing investigation and successfully enhance their knowledge as well as how they understand the natural world. Usually, students adopt the skills used by scientists including questioning, collecting data, analysing and making review of evidence using what is known already, making deductions, and exchanging views about the results. Inquiry-based instruction aids the learning (the teaching act together with its supporting justifications) (IAP, 2012). Inquiry-based learning covers a collection of instructional strategies connected at a convergent area where students go to explore to find answers to questions and solve problems.

In organizing inquiry-based instruction, there are different stages in organising inquiry including problem diagnose, analysis of experiments, alternatives determination, investigations planning, making hypothesis, exploring for information, models construction, exchanging views among peers, and making reasonable arguments (Linn, Davis & Bell, 2004). Minner, Levy & Century (2010) give some essential ideas for using inquiry in teaching: Science content must be included, engaging students with content of science, responsibility of students to learn, critical thinking of students, provision of questions to motivate students, designing experiment, data gathering, drawing conclusion and communicating it. Scientific inquiry lays emphasis on problem-solving capabilities of people, way of discovering scientific knowledge, critical thinking and logical thinking capabilities. As considered by social constructivism, inquiry in science also stresses on dialogue, reporting, deliberation as well as debate (Keys & Bryan, 2001). Teachers must draw students to practicing these skills to promote understanding and achieve lesson objectives.

The principal focus of inquiry-based learning „develop the inquiring minds‟ as well as positive orientation needed to surmount the unforeseeable future. This learning strategy premises on the assumption that students dynamically embrace the attitude of questioning. Students identify problems relevant to them, make inquiry into them as they raise questions, investigate and analyse their results. When questions are open with several strategies for solving the problem, learning is propelled. Teachers respond quickly to assist students who encounter some difficulties while at the same time helping those who are sailing smoothly through their investigations by strategically asking questions leading to effective learning. Students‟ contribution as well as mistakes is appreciated by teachers. Learning is scaffold using student‟s logical thinking and practical knowledge. Everyone in the classroom feels involved and therefore work extensively towards the stated goal.

In a description of The National Science Education Standards (NRC, 1996), inquiry is an activity with multiple sides having variations in form as well as instruction. The process is characterised by five essential elements, comprising engaging learners through questioning, evidence for proof, the developing successive explanations, evaluating other possible explanations and justifying the findings (NRC, 1996). In other words, inquiry-based instruction refers to the use of hands-on activities in enabling children explore the scientific concepts with the aim of generating process skills that are necessary for deeper understanding of the scientific ideas.

It is worth noting that the inquiry-based programs are dynamic in nature and hence depict science as an ongoing process of exploration and discovery, rather than a content domain to be memorized (Brigham, Scruggs & Mastropieri, 2011). Most science concepts require inquiry-oriented instruction since it engages students in the investigative nature of science thereby facilitating deeper understanding. In inquiry learning, the role of students is no longer passive receiver of knowledge (Anderson, 2002), but self-regulated learner entrusted with the responsibility of taking over the learning process (Grandy & Duschl, 2007). The expectation is that learners use their hands as well as minds to actively get involved in the learning process.

2.3 Teachers' Knowledge of Inquiry-Based Instruction

Teaching science through science inquiry is the cornerstone of good teaching. Regrettably, an inquiry approach to learning science is not the custom in schools as instructors are often still struggling to build a shared understanding of what science as inquiry means (Luchmann, 2007), and at a more practical level, what it looks like in the classroom. Science teachers have divergent views about what IBI is. Some teachers view inquiry as a process, not a vehicle of learning science content (Assay & Orgill, 2010). The prior learning or knowledge of some teachers affected their understanding of IBI (Eick & Reed, 2002; Luchmann, 2007). As pointed out by Wang (2016) teachers" understanding of inquiry was influenced by their culture yet at the same time it is worth noting that there is no shared understanding of IBI between many countries as seen in a case study in Rwanda (Mugabo, 2015).

Various studies highlight the difference between conceptions about inquiry science and beliefs about inquiry science. According to Morrison (2013), "conceptions" are defined as ideas, thoughts, and understandings, whereas "beliefs" hold the connotation of conviction, trust, and faith. Teachers may hold a variety of ideas about inquiry (Demir & Abell, 2010; Kang, Orgill & Crippen, 2008), and the conception they hold about inquiry science may affect how they implement inquiry (Crawford, 2007; Jones & Carter, 2007). It can be said that conception means opinion, views, feelings or beliefs, hence the need to find out how these affect teachers" implementation of inquiry, which we can call investigation.

Teachers" previous learning orientations and previous experiences may also impact their learning about inquiry (Eick & Reed, 2002). This is supported by Luchmann (2007), who stated that, "one of the main challenges in developing a teacher"s ideas about reform is to reconcile the teacher"s personal prior beliefs about the subject matter as well as learning and teaching developed as the result of their experiences as students in schools with the recommendation made for teaching inquiry science" (p. 823). This assertion implies that a teacher‟s previous experiences have a direct impact on his/her ability to implement inquiry yet at the same time the world is changing and may require new experiences which are in line with the changing needs of the students. The challenge, therefore, is adjusting to the new environment of implementing inquiry.

Researchers (Atar, 2011; Avsec & Kocijancic, 2016; Cavas, 2012) have found that teachers‟ ideas about the nature of science as an objective body of knowledge created by a rigid scientific method, hindered their teaching of an accurate view of scientific inquiry. The researchers argue that, teachers with a more accurate understanding of the nature of science can implement a more problem-based approach to science teaching. What is learned from literature is that implementation of proper inquiry is a function of teachers‟ understanding of the nature of science. Larrivee (2008) recommends the developing of reflective practitioners who can infuse personal conceptions and values into professional identity, resulting in the development of a deliberate code of conduct. These personal factors may determine whether teachers feel strong enough to work to overcome any barrier to teaching inquiry science they may face.

One of the challenges to IBI is that there are not many publications/articles describing full inquiry. For example, Assay and Orgill (2010) analyzed the articles published in The Science Teacher from 1998 to 2007 for explicit evidence of feature of inquiry to provide a picture of how inquiry is practiced in the everyday science classroom. Inquiry in this study was operationally defined by the essential features detailed in Inquiry and National Science Education (NRC, 2000). They established that few articles described full inquiry. Gathering and analyzing evidence were significantly more prominent than the other features of inquiry, which were present in less than 25% of the articles. Each feature was also rated for whether it was a student or learner-directed. They found out that most activities were teacher-directed. They concluded that this pattern might be related to teachers viewing inquiry more as a process than as a vehicle for learning science content. However, it is important to note that Assay and Orgill‟s (2010) study was based on the articles of research conducted in US contexts. Hence, their findings may not be generalized to all teachers, especially those in developing countries like Ghana.

Divergent views about what IBI still prevail as a challenge and what is learned here is that the lack of a common understanding is itself a hindrance. For example, in a study conducted by Ireland, Watters, Brownlee and Lupton (2011), the researchers used a phenomenological research method to examine 20 elementary school teachers‟ conceptions of inquiry teaching. The researchers defined inquiry as involving students in learning their way by drawing on direct experience fostered by the teacher and active engagement in experiences. The data consisted of interviews. The researchers reported three kinds of conceptions: (a) the experience-centered conceptions in which teachers focused on providing interesting sensory experiences to students, (b) the problem-centered conception in which teachers focused on engaging students with challenging problems, and (c) the question-centered conception in which teachers focused on helping students ask and answer their questions.

Another tension highlighted in this review is differences of teachers‟ perceptions of the nature of science and the lack of a common perception. For example, in investigating the relationship between three teachers‟ perceptions of nature of science (NOS) and inquiry teaching practices, Atar (2011) collected views of Nature of

Science form C, online postings, interviews, emails, lesson plans, and videos of inquiry lessons. Improving teachers‟ conceptions of NOS appeared to impact positively on the use of inquiry practices; teachers with more sophisticated NOS views conducted a less structured inquiry and more student-centered activities.

However, teachers who did not possess adequate content knowledge were reluctant to change their teaching practices. The inability of teachers to change their teaching practices still takes us back to the view that a teacher‟s previous experiences have a direct impact on his/her ability to implement inquiry; yet at the same time the world is changing and the teacher may require new experiences that are in line with the changing needs of the students.

The nature of science as a multi-disciplinary subject is also poses a challenge. For example, Breslyn and McGinnis (2012) examined the question, how do exemplary secondary science teachers‟ disciplines (biology, chemistry, earth science or physics) influence their conceptions, enactment, and goals for inquiry-based teaching and learning? Participants included 60 national board-certified science teachers. Researchers employed mixed methods, using portfolio texts and interviews to assess enactment and views of inquiry. The discipline in which these teachers taught was found to be a major influence on conception and enactment of inquiry. The classroom context did not appear to be as large a factor as the structure of the discipline. In the context of this study and because of these differences, a uniform view of how to implement inquiry in science may not be attained. Breslyn and McGinnis (2012) study provide the justification for studying science teachers‟ understanding and practice of inquiry-based instruction of specific disciplines like chemistry, biology and physics instead of just studying the general science teachers. Hence, this study is done to address that need accordingly.

Another challenge highlighted here is the level of effectiveness of teacher education programs to enhance IBI. In support of this assertion, Windschitl and Thompson (2012) studied the effectiveness of teacher education programs designed to enhance prospective teachers‟ knowledge of inquiry, in particular, their understanding of models and modeling. Data sources included observations, student artifacts, informal interviews, and questionnaires. Participants included 21 prospective secondary science teachers with an undergraduate degree in science, all in a secondary methods course. While prospective teachers could talk about models in a sophisticated way, they had a difficult time creating models themselves. Further, these prospective teachers viewed models as being separate from the process of inquiry, hence taking us back to the view that science teachers have divergent views about what IBI is.

In support of the views of Windschitl and Thompson (2012), Kang, Branchini, and Kelly (2013) examined what one cohort of eight pre-service secondary science teachers said, did, and wrote as they conducted a two-part inquiry investigation and designed an inquiry lesson plan. They identified success and struggles in pre-service teachers‟ attempts to negotiate the cultural border between a veteran student and a novice teacher. They argued that pre-service teachers could benefit from opportunities to navigate the border between learning and teaching science; such opportunities could deepen their conception of inquiry beyond those exclusively fashioned as either student or teacher. So, the key observation highlighted here is lack of deep conception of inquiry beyond which from the previous assertions is tangled with science teachers‟ divergent views about what IBI is.

Kang, Bianchini, and Kelly (2013) further pointed out that pre-service teachers and mentors have difficulty in connecting appropriate inquiry features to each teaching episode, which indicate their lack of understanding of inquiry.

It is also likely that there is limited understanding of what IBI is among the pre-service teachers and mentors. Seung, Park and Jung (2014), noted that even though mentors are normally experienced teachers, they have sometimes showed a lack of understanding about each feature of inquiry (Seung et al., 2014). Also, many elementary teachers, including the mentors in their study, do not teach science regularly in their classrooms since science is not included in state student achievement test. Seung et al.‟s (2014) study is one of the few studies that has examined inquiry-based teaching and learning focusing directly on the five essential features (Asay & Orgill, 2010; Kang, et al., 2008). This study is useful in the sense that it calls for more exploration of what IBI is to come up with a common understanding. However, this study was conducted in the US context that is very different from many sub-Saharan African countries including Ghana. For example, many classrooms in sub-Saharan African countries are crowded (contain more than 50 learners per classroom) due to the Free Compulsory Universal Basic School policy, hence, the findings from this study may not be useful in a country like Ghana.

Taylor and Bilbrey (2011) conducted a study to investigate the perceptions of fifth-grade teachers regarding the role of Alabama Math, Science, and Technology (AMSTI) in the broader curriculum? Input was obtained from fifth-grade teachers at the subject school utilizing teacher interviews to explore teacher perceptions of the relevance, quality, and significance (Stufflebeam, 2002) of AMSTI on student classroom learning. Following the thinking of Fuchs and Fuchs (2001), it was expected to see evidence of a strong lead teacher supporting the continued implementation and acceptance of AMSTI because the inquiry-based learning initiative has remained in place for 3 years. One-on-one interviews were conducted with each of the current fifth grade teachers to facilitate the process of grounded theory research.

It is sometimes hard for prospective elementary science teachers to make appropriate conclusions about whether obtained results support the hypothesis or not during inquiry. For example, another study in the US by Kim and King (2012) investigated 178 prospective elementary teachers" understanding of hypothesis testing with a developed questionnaire. The aim of the study was to examine prospective science teachers" understanding of the purpose of scientific inquiry. They found out that prospective elementary science teachers could not make appropriate conclusions about whether obtained results support the hypothesis or not. Rather, these prospective elementary teachers tended to draw out the conclusions based on their personal knowledge. They also noticed that most prospective science teachers viewed the purpose of the experiment as testing the prediction rather than testing the hypothesis; few prioritized rejecting the hypothesis as an essential process of learning and the majority associated the benefit of doing experiments with just hands-on experience. Very few of these prospective teachers took testing students" ideas into consideration. The researchers concluded that most prospective science teachers who participated in this study viewed inquiry teaching as a mere opportunity for students to be engaged in hands-on experience. Kim and King emphasized the point that even in developed countries like the US, most prospective science teachers misunderstand inquiry.

Like the work of Kim and King (2012), Korea, Youn, Joung, and Park (2013) explored 15 Korean prospective elementary teachers" views of IBI. During a science methods course, prospective teachers implemented a peer teaching lesson, had a group discussion to reflect on five teacher educators" comments on their first peer teaching practice, and revised and re-taught the lesson as a second peer teaching practice. Youn et al."s study established that prospective teachers changed their views of inquiry teaching from following the process of inquiry or completely unstructured discovery approach to facilitating students" inquiry learning with instructional guidance. This study emphasized the role of group discussion and reflection in improving prospective science teachers" views about inquiry-based learning. However, we may not be confident that these teachers are likely to practice inquiry-based instruction in real classroom contexts since this study was done in peer micro-teaching contexts, which are very different from the real classroom. Nevertheless, Youn et al."s (2013) study is useful in providing a different cultural context about prospective science teachers" views on IBI

Issues of IBI also become complicated when it comes to Interdisciplinary Science Inquiry (ISI). For example, in a recent study Chowdhary, Liu, Yerrick, Smith and Brook (2014) examined the effect of university research experiences, ongoing professional development, and in-school support on teachers" development of interdisciplinary science inquiry (ISI) pedagogical knowledge and practice. They found out that there was a variation of ISI understanding and practice among the teachers because of a combination of teachers" experiences, beliefs, and participation. Hence, to help teachers develop ISI knowledge and pedagogy, barriers to ISI knowledge development and implementation must also be addressed.

Science teachers" reflections on inquiry teaching before and during an in-service PD program have been found to differ. For example, a study in Finland by Kim, Lavonen, Juuti, Holbrook and Ranniknnae (2013) investigated science teachers" reflections on inquiry teaching before and during an in-service PD program by using a progress model of collaborative reflection. The audio-video data and their quantification allowed identification of the teachers" consistent prior beliefs and practices of inquiry teaching and their interwoven progress during the PD program. Their study established that the PD program played a greater role in improving science teachers" beliefs and practices of inquiry. They concluded that the PD program needs to facilitate both individual and collaborative reflections to enlarge teachers" prior beliefs of inquiry and to ensure their sustainable practices (Kim et al., 2013). Additionally, this study demonstrates the importance of having relevant PD programs to improve science teachers" ability to practice inquiry. Such studies need to be duplicated in the case of African countries to improve science teachers" beliefs and practice of inquiry.

In a study in Rwanda, Mugabo (2015) investigated the understanding of inquiry-based science teaching (IBST) of 200 high school teachers. He used a mixed-method approach, and data were collected using a science questionnaire administered to a purposeful sample of 200 science teachers, followed by illuminating semi-structured interviews with a sub-sample of 10 purposefully selected teachers. His study established that participants did not have a shared understanding of inquiry. Many of these science teachers associated inquiry teaching with a few of its specific characteristics while others had a very different understanding. Mugabo recommended that the working definition for inquiry should be provided in the Rwandan curriculum. We need more studies like these to improve science education in Africa. It should be noted that both the South Africa and Rwanda studies are based on the US standard documents (NRC, 1996, 2012, NGSS Lead States, 2013), and most of the literature cited in these studies were mainly in the US This provides evidence that science education research in US has significantly influenced science education research/policies and curricula in Africa, however, it has not been able to change the classroom practice. Hence, more studies by African scholars are required to improve the classroom practice accordingly.

In another comparative study, Wang (2016) investigated the understanding of NOS and scientific inquiry (SI) of science teachers from Shanghai (China) and Chicago (USA) using a mixed-method approach. The purpose of the study was to compare the NOS and SI understanding of science teachers in Shanghai (China) and Chicago (USA). Ninety (90) high school science teachers from Shanghai (45) and Chicago (45) were chosen to do open-ended questionnaires and interviews. Wang analyzed the data using both quantitative and qualitative techniques, complementing the two enriched the study with both numerical and descriptive data. He established that, overall, the levels of American teachers‟ views of NOS and SI were better than Chinese. He concluded that Chinese teachers are affected by the thought of logical positivism philosophy, which regards the scientific cognitive process as a copying process, and science as a real reflection of the object (Wang, 2016).

Using this philosophy, Chinese teachers tend to focus on "what is knowledge" and "what is the use of knowledge". Without considering the background of science learning experiences and teaching practices, teachers might have an imbalanced understanding of scientific knowledge (Wang, 2016). Meanwhile, science education in the US has emphasized teachers‟ understanding of NOS and SI for many years and achieves excellent results (Wang, 2016). Also, there are many reasons why Chinese science teachers‟ understanding of SI did not improve their understanding of NOS, such as the fact that they had little experience in doing inquiry, a culture of Confucian and so on, which originated from Chinese cultural traditions (Wang, 2016). Wang‟s study provides evidence of the influence of cultural and political dilemmas on teachers‟ understanding (conceptual dilemma) and practices (pedagogical dilemma).

Wang"s study was also sensitive to the influence of school context as he sampled schools from major cities in the two countries for better comparison.

2.4 Teachers' Practice of Inquiry-based Instruction

Various writers have indicated that there are many differences to science teachers" practice of IBI including differences in teachers" curricular interpretation (McNeill, 2009). In addition, teachers" attitudes and beliefs in the use of IBL also differ (Sun, Iooi & Xie, 2014). The reasons for this may be that science is a broad discipline with many sub-divisions such as biology, physics, agriculture and chemistry and every teacher in his respective discipline will certainly practice IBL differently.

Undoubtedly, the performance in science subjects is still below the required standards worldwide. Njagi (2016) conducted a study to investigate the determinants of early childhood teachers" use of inquiry based instructional approaches in science activities. The impetus for which he conducted this study stemmed from the fact that science education plays a significant role in the child"s development as it can bridge the gap in education achievement in science performance at higher levels of learning. The target population for this study was 270 teachers. Eighteen teachers were purposively selected to take part in the study. The instruments for data collection were phenomenological interview and science lesson observation schedules. Interview questions were pretested on two teachers from Maara Sub County. This study adopted in-depth phenomenological interviewing of participants for 30 minutes. The researcher randomly selected and observed three separate science lessons taught by each teacher in the study sample. Descriptive statistics including frequency counts and percentages were used to summarize and organize quantitative data while data elicited by interview questions and observation were analyzed qualitatively using content analysis. The responses were thematically discussed. The study found that there was limited use of inquiry-based instruction in science teaching. The result shows that the teacher‟s level of training, type of training institution and teaching experience had no significant influence on teachers‟ use of IBI. This study concluded that teachers were currently practicing inquiry-based instruction and that the level of training, experience and type of training institution did not significantly bring about differences in the use of inquiry-based instructional approaches.

Science teachers‟ practice of inquiry-based instruction is also a function of their intentions and actual classroom practices regarding IBI. This is supported by the publication of the NSES (NRC, 1996), researchers Keys and Kennedy (1999) in which they examined the teaching practice of elementary teachers with an average of 11 years of experience. The intentions included: (a) planned instruction to explore questions that arose in context naturally from science activity, (b) intention to help students take responsibility, (c) supporting children in constructing explanations and concepts from data, and (d) providing opportunities for students to apply scientific knowledge. However, Keys and Kennedy (1999) noted many challenges for science teachers‟ practice of IBI including lack of time, the challenge of turning questions back to students, and teaching mandated concepts was difficult through inquiry. This study provides empirical evidence that even experienced science teachers face challenges in implementing IBI.

The literature reviewed also indicates that beliefs influence science teachers‟ practice of IBI. For example, Crawford (2000) documented and examined the beliefs and practice of an experienced rural public high school science teacher to determine how this teacher created an inquiry-based classroom environment. The researcher collected data for more than a year. The study focused on 20 students in an ecology class. Data included teacher interviews, notes of informal conversations, videotapes of classroom and field trips, interviews with eight randomly selected students, student products, and end-of-year anonymous student questionnaires. The key characteristics of how this teacher created an inquiry-based classroom that were also linked to their beliefs were: (a) situating instruction in authentic problems, (b) grappling with data, (c) students and teacher collaboration, (d) connecting students with the community, (e) the teacher modeling behaviors of scientists, and (f) fostering students in taking ownership of their learning. Crawford identified ten different roles that the teacher played in implementing IBI. In the context of this study, what is challenging is the measurement of beliefs. Nevertheless, Crawford‟s study provides evidence of how beliefs influence science teachers‟ practice of IBI.

Science teachers‟ practice of IBI is also a function of the characteristics of the classes in question. Crawford (2000) noted that with different characteristics of classrooms, some being elementary classrooms and others secondary classrooms, and the uniqueness of each teacher‟s background, particular school setting, and student populations, it is difficult to employ a uniform practice of IBI. The views of Crawford (2000) are important because different contexts may result in different outcomes. More closely related to the views of Crawford (2000), is the quality of science student teachers‟ practice of IBI. For example, Maskiewicz and Winters (2012) in their longitudinal observations of one elementary teacher‟s fifth-grade classroom found out that students can have a substantive and generative influence on the nature and form of inquiry carried out by the teacher in any given year, underscoring the importance of context. The change in students from one year to the next is a component of the context. What can be learned from the views of Maskiewicz and Winters (2012) is that application of science teachers‟ practice of IBI should be situational depending on the category of classes and students.

Science teachers‟ practice of IBI is also dependent on the available curriculum. For example, Fogleman, McNeill, and Krajcik (2011) examined 19 teachers‟ use of inquiry-oriented middle school science curriculum. Using hierarchical linear modeling, researchers aimed to determine the influence of teachers in curriculum adaptations on student learning. Data included curriculum surveys, videotape observations, and pre-and post-tests from 1,234 students. Researchers found that two variables significantly predicted students‟ learning: teacher experience and the amount of student initiation during instruction. Teachers who had taught the inquiry-oriented instruction curriculum previously had a greater student gain. Students who completed investigations had greater learning gains as compared with students whose teachers used demonstration or carried out the inquiry themselves. The research results imply: (a) it takes time for teachers to implement effectively innovative science curriculum, and (b) it is important that students engage actively in inquiry investigation.

The influence of curriculum on science teachers‟ practice of IBI is further highlighted by McNeill (2009) who studied the enactment by six middle-level teachers of an eight-week chemistry-based unit. The curriculum focused on students constructing arguments using an adapted version of Toulmin‟s model of argumentation. A total of 568 middle school students participated in the study. Data included videotaped classroom lessons, student pre- and post- tests, and teacher questionnaires. Findings revealed a significant teacher effect on students‟ learning about scientific explanations, evidence, reasoning, and content knowledge. The teacher who defined scientific explanation differently than in the curriculum had the lowest students‟ gains regarding scientific explanation. The study highlighted that different teachers carry out reform-based curricula in different ways, something curriculum designers need to consider. This study provides evidence that the teacher is a very important factor for the success of any curriculum innovation. In the case of Uganda, we have reviewed our curricula to resemble that in developed countries like US and UK, however, the science teachers have not been prepared to implement such curricula. Hence, this study explored how to improve the chemistry teachers" ability to implement IBI in their classroom.

In Spain, Pozueloso and Gonzales (2014) investigated the implementation of an inquiry-based curriculum in two Spanish primary schools. The aim of the study was to explore the conceptions, difficulties, obstacles and facilitative factors that influenced the teachers" attempt to introduce inquiry-oriented practices into their classrooms. Qualitative data were collected through interviews and classroom observation from the two science teachers of the two case study schools. The researchers established that participating teachers focused on three areas of need: a suitable working environment that enables and facilitates collaborative work, access to alternative materials, and greater social recognition and willingness of colleagues to cooperate, along with other types of support specific to each school community (Pozueloso & Gonzales, 2014). They concluded that the project had improved science teachers" ability to implement IBI through the PD activities. Pozueloso and Gonzales"s study provides evidence of the importance of context-specific qualitative studies to improve the science teachers" ability to implement IBL by listening to the needs of teachers and addressing their concerns. More studies of this nature are required in African countries to address the problems science teachers face when trying to implement IBL in their classrooms.

Included in the review of this literature is another area of investigation related to the extent to which qualification and motivation influences science teachers‟ practice of IBI. In a study by Capps and Crawford (2012) in the US, the researchers examined the teaching practice of inquiry of 26 qualified and highly motivated teachers. Although the teachers were qualified, few aspects of inquiry or nature of science were evident in the teachers‟ lesson and this included motivation. In the context of this study, it can be said that proper application of science teachers‟ practice of IBI is not only a function of qualification but also motivation is an incentive factor. Capps and Crawford indicated that, even in the US, it seems that many teachers do not practice inquiry-based teaching in their classroom which in the context of this study can be attributed to low levels of motivation. Hence, this study should inform the science education scholars in sub- Saharan African countries to conduct similar studies in their countries to inform their pre-service and in-service teacher training programs.

As pointed out earlier, science teachers‟ practice of IBI is a function of teachers‟ experience at work. For example, Ozel and Luft (2014) investigated the conceptions and use of inquiry during classroom instruction among beginning secondary science teachers. The 44 participants were beginning secondary teachers in their first year of teaching. To capture the participants‟ conceptions of inquiry, the teachers were interviewed and observed during the school year. The interviews consisted of questions about inquiry instruction while observation documented the teachers‟ use of inquiry. A quantitative analysis of data indicated that the teachers frequently talked about "scientific questions" and giving "priority to evidence". The study found a constancy between the way new teachers talked about inquiry and the way they practiced it in their classroom.

Overall, the study revealed that the beginning secondary science teachers tended to enact a teacher-centered form of inquiry, and could benefit from induction programs focused on inquiry. In the same study by Ozel and Luft (2014), they found that experience in the classroom did not change the conception and enactment of inquiry among the beginning teachers. The researchers recommended that pre-service teachers need ample opportunities to build their knowledge and practice about the inquiry, and they need explicit instruction about the different features of inquiry. The way teachers incorporate learning about scientific inquiry (SI) into laboratory work, also influences science teachers‟ practice of IBI.

For example, a study in Germany by Strippel and Sommer (2016) explored how teachers incorporated learning about scientific inquiry (SI) into laboratory work in the chemistry classroom. Semi-structured interviews were conducted with 14 secondary school chemistry teachers (8 of whom had earned a Ph.D. in chemistry) from Germany. Their study established that teaching NOS was not a primary goal for teachers, and also some aspects of nature of scientific inquiry (NOSI) seemed to be more easily incorporated in the chemistry lesson, for example, critical testing and hypothesis and prediction. The teachers stated two main criteria to identify suitable chemical laboratory work for teaching NOSI: adaptable parameters and a low level of required content knowledge.

More closely related to the above is the assertion that, science teachers‟ practice of IBI is based on the available learning platform. In support of this assertion, Sun and Xie (2014) in Singapore explored the Teacher Enactments of science lessons supported by a web-based learning platform, namely collaborative science inquiry, by two experienced teachers in their respective teachings. The collaborative science inquiry system was built on a model-based inquiry framework investigated with computer-supported collaborative learning elements which was used in grade 7. Through examining the ways in which teachers instructed, questioned, and interacted with students, they identified the commonalities and differences in TEs that subsequently influenced students‟ conceptual understanding and their involvement in collaborative inquiry. They concluded that teacher attitudes and beliefs toward technology and their knowledge and skill predicted their technology use. There is little use of classroom enactment data to explore this issue more deeply (Sun & Xie, 2014). Sun and Xie‟s study is one of the few recent studies to explore the role of ICT in inquiry-based learning.

Nevertheless, most teachers use IBL to promote higher-order thinking skills among students. For example, in India, Maskiewiez.A.C.& Winters, (2012) explored how IBL can be used to promote higher-order thinking skills among engineering students taking a chemistry module course in a university located in central India. The aim of the study was to find out how meaningful learning of chemistry can take place using IBI. The study established that engineering students developed critical thinking, problem-solving ability and integration of knowledge at the end of the chemistry module course taught through an inquiry-based approach. They conclude that inquiry-based pedagogy has better outcomes compared to a conventional recipe lab approach, and, it motivates engineering students by showing them the relevance of chemistry to engineering discipline.

The need to enhance practical approach to learning can be said to be one of the reasons why teachers use IBL. In Taiwan, Chang and Wu (2015) investigated how experience in learning to teach SI using a practical approach affected teachers‟ attitudes, evaluation of the use of inquiry, and their actual design of IBI. The methodology used included an approach incorporating inquiry methodology combined with a technology-infused and engineering rich approach called "Intelligent Robotics" to help teachers learn and use a new approach to teaching scientific inquiry. The study established that teachers moved progressively from more teacher- centered thinking about teaching to student-centered thinking, and actions incorporating SI. The participating teachers also worked together in designing an interdisciplinary inquiry curriculum, providing an effective alternative to traditional rigid standard based curriculum and teacher directed instruction. Chang and Wu‟s study contributes to the engineering field by showing that teachers could move progressively from teacher-directed to student-centered actions incorporating inquiry. Also, it provides evidence of the role PD can play to improve science teachers‟ ability to practice inquiry, and assess students in inquiry lessons. Since Taiwan is between a developed and developing country, the findings of this study may apply to some developing countries with similar contexts (Ogunniyi & Rollnick, 2015).

In another comparative study, Taso (2011) examined the similarities and differences in how the US and Japanese middle-school science teachers teach through science inquiry. Classroom practices were studied through observation in the US (N = 9) and Japan (N= 4). The observation data were coded and quantified based on a rubric that incorporated two dimensions: student self-directedness and depth of conceptual links. The results showed that little IBI was observed in either of the two countries for apparently different reasons; the observation data indicated scientific concepts under classroom discussion were not clearly identified in many of the US lessons, whereas the Japanese lessons often exhibited lack of teachers‟ support for students in constructing their understanding of scientific concepts (Taso, 2011). Teacher interviews were also conducted to examine US and Japanese teachers‟ definition of

IBI. The results indicated that most teachers (79%) in the two countries thought that IBI involves both teachers and learners‟ exploration of scientific concepts.

The above finding by Taso (2011) implies that teachers‟ beliefs about the importance of student self-directedness in IBI might be acting as an obstacle for increasing IBI in both US and Japan. Also, Taso‟s study provides evidence that science teachers‟ understanding and practice of inquiry teaching is influenced by context because the science teachers in these two countries had different reasons for not implementing IBI in their lesson. This supports my argument that research about inquiry in developed countries may not be directly utilized in African nations due to the very significant difference in school/classroom contexts between developed and developing countries.

2.5 Background Factors that Influence Teachers Practice of IBI

Despite growing consensus regarding the value of inquiry-based teaching and learning, the implementation of such a pedagogical practice continues to be a challenge for many teachers, especially at rural schools. It has been documented by researchers (e.g., Crawford, 2000; Keys & Kennedy, 1999) 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. 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.

Research has shown that factors such as class size (Johnson, 2011), classroom management (Wong, Wong, Rogers & Brooks, 2012), pre-service preparation (Tatar, 2012) and state assessments (Cocke, Buckley & Scott, 2011), serve to reduce the amount of time that is spent on science in elementary grades, while professional development and a strong preservice program (Jones & Egley, 2007; Powell-Moman & Brown-Schild, 2011) can provide the encouragement and confidence that teachers need to implement inquiry-based science investigations. Some of the above factors may appear like those affecting science teachers‟ abilities to implement IBI in African countries, but with different magnitude. For example, the classroom management problems in the US may be very different from African countries due to the difference in a number of learners in classroom and cultural background of learners.

According to Crawford (2000), the classroom itself may be a barrier to implementing IBI. For teachers to adequately engage in IBI in science with their students, they may need to engage in new roles that require mentoring, guiding, or collaborating (Crawford, 2000). Roehrig and Luft (2004) found that beginning secondary teachers had five constraints that impacted their implementation of science IBI; these constraints were the teachers‟: (a) understanding of inquiry and nature of science, (b) strength of content knowledge, (c) pedagogical content knowledge, (d) beliefs about teaching in general, and (e) management and students‟ concern‟s. This last factor concerns the ability of students to engage in science IBI. Keys and Bryan (2001) also found this as a factor in teachers‟ implementation of IBI. Teachers may also have concerns about letting go of authority (Hayes, 2002) and dealing with students‟ requests for the "right" answers (Furtak, 2006). In the context of this study, focus was on the extent such factors are applicable to junior high schools in Tano South Municipality. Capps and Crawford (2012) noted that teachers‟ qualifications were not a guarantee for practicing IBI. What is highlighted as a factor influencing practice of IBI was teachers‟ work experience and McNeill (2009) asserted that teachers with long teaching experience and students who actively engaged in the investigation greatly benefited from IBL. This was emphasized by other studies (e.g., Chang & Wu,

2015) in which it was re-emphasized that teachers with more years of experience were more likely to embrace IBI than their counterparts with less years of teaching experience.

Ramnarian and Hlatswayo (2018) in their study observed the interaction between Grade 10 Physical Sciences teachers" beliefs about inquiry-based learning, and their practice of inquiry in their classrooms. This research adopted a mixed methods design. In the first phase of the research, quantitative data were collected by distributing a validated questionnaire to Physical Sciences teachers in an education circuit in rural Mpumalanga, South Africa. The next phase of the research involving teacher interviews provided a more in-depth explanation of some of the findings, which emerged from the questionnaire survey. It was found that sampled teachers from the rural district have a positive attitude towards inquiry in the teaching and learning of Physical Sciences, and recognise the benefits of inquiry, such as addressing learner motivation and supporting learners in the understanding of abstract science concepts. However, despite this positive belief towards inquiry-based learning, teachers were found to be less inclined to enact inquiry-based learning in their lessons. Teachers claim that the implementation of inquiry-based learning is fraught with difficulty, such as availability of laboratory facilities, teaching materials, time to complete the curriculum, and large classes, which creates tension in their willingness to implement it.

These impediments were similar to what Anderson and Helms (2002) reported in their study to 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.

Some authors have also questioned the effectiveness of inquiry. To them, many of the minimally led inquiry learning experiences „do not work‟. In assessing challenges faced by pre-service teachers on the use of inquiry based teaching, Yoon, Joung and Kim (2012) found out that six difficulties are usually encountered which included: (i) helping students to develop ideas on their own as well as their curiosity; (ii) assisting students to design an experiment to suit hypotheses they have set; (iii) scaffolding students‟ interpretation of data as well as their discussion; (iv) friction emanating from guided inquiry and open inquiry; (v) partial insight into hypothesis; and (vi) lost confidence in the content knowledge of science.

Other challenges and constraints were also discussed by Windschitl (2002) that teachers reported when attempting to implement constructivist reform pedagogies like IBI. Windschitl categorized them into four domains of "dilemmas": conceptual, pedagogical, cultural and political. The conceptual dilemma is related to the teachers‟ understanding of constructivism (i.e., the philosophical, psychological or epistemological basis) while the pedagogical domain is associated with approaches taken toward curriculum design and learning experiences that accommodate the demand of constructivism. The cultural domain includes new classroom roles and expectations of the teacher and students during classroom interactions, and the political domain describes relationship regarding the norms and routines of school and larger educational community. Windschitl (2002) argued that acknowledging these challenges and constraints and addressing them within the design of professional development program may allow for more successful implementation among participating teachers.

Other problems prospective science teachers face when teaching science through inquiry were investigated by Kramer, Nessler, and Schluter (2015) who conducted an exploratory study in Germany. To draw the holistic picture of the problems, they identified problems from three different points of view leading to the research question: what problems regarding Inquiry-Based Science Education (IBSE) do prospective science teachers have from an objective, a subjective, and a self-reflective perspective? They used video analysis and observation tools as well as qualitative content analysis and open questionnaires to identify problems from each perspective.

They found out that the objectively stated problems were comprised of the lack of essential features of IBSE, especially concerning supporting learners‟ investigations and guiding analysis and conclusion. The subjectivity perceived problems were comprised of concerns about teachers‟ ability and learners‟ abilities, differentiated instruction and institutional frame conditions, while the self-reflectively noticed problems were mainly comprised of concerns about allowing inquiry, instructional aspects and learners‟ behavior (Kramer et al., 2015). They concluded that each of the three perspectives provide plenty of problems, partially overlapping, partially complementing one another, and partially revealing completely new problems. Kramer et al. recommended that science teacher educators consider these three perspectives in the training of prospective science teachers.

Another concern is science teachers‟ perceptions of intrinsic factors and extrinsic factors. For example, Ramnarain, Nampota and Schuster (2016) conducted a mixed methods study in South Africa to investigate science teachers‟ perceptions of intrinsic factors and extrinsic factors influencing implementation of inquiry-based science learning in township (underdeveloped urban area) high schools in South Africa. Quantitative data were collected using an adapted version of the Science Curriculum

Implementation Questionnaire (SCIQ). Ramnarain et al. found a lack of professional science knowledge as contributing towards teachers" uncertainty in IBI. Furthermore, extrinsic factors such as school ethos, professional support, resource adequacy, and time served as significant constraints in the application of IBI at the school. This study is useful in as far as the literature on the challenges in implementing of inquiry teaching and learning in basic science, especially in African countries, is concerned.

However, Ramnarain et al. (2016)"s study was limited in a sense in that he did not carry out classroom observation and it was not discipline specific. Classroom observation would have provided a clearer perspective on the teachers" experiences of implementing inquiry, casting more light on the factors influencing the way this implementation is done.

2.6 Conceptual Framework

The conceptual framework illustrates the independent variables that influence the use of inquiry-based instructional approaches in teaching science in junior high schools; they are teacher"s level of training, type of training institution and teachers" experience in the use of inquiry method. The study perceived science activities by learners as a function of teacher related factors. The junior high school teacher would utilize his/her academic ability and experience to understand, internalize and construct knowledge. He/She would use his/her training to come up with appropriate methodology for imparting science concepts. The intervening variables subject to influencing both the independent and dependent variables includes class size and school management. Hence the dependent variable is the use of inquiry-based instructional approaches by teachers in junior high schools in teaching integrated science.

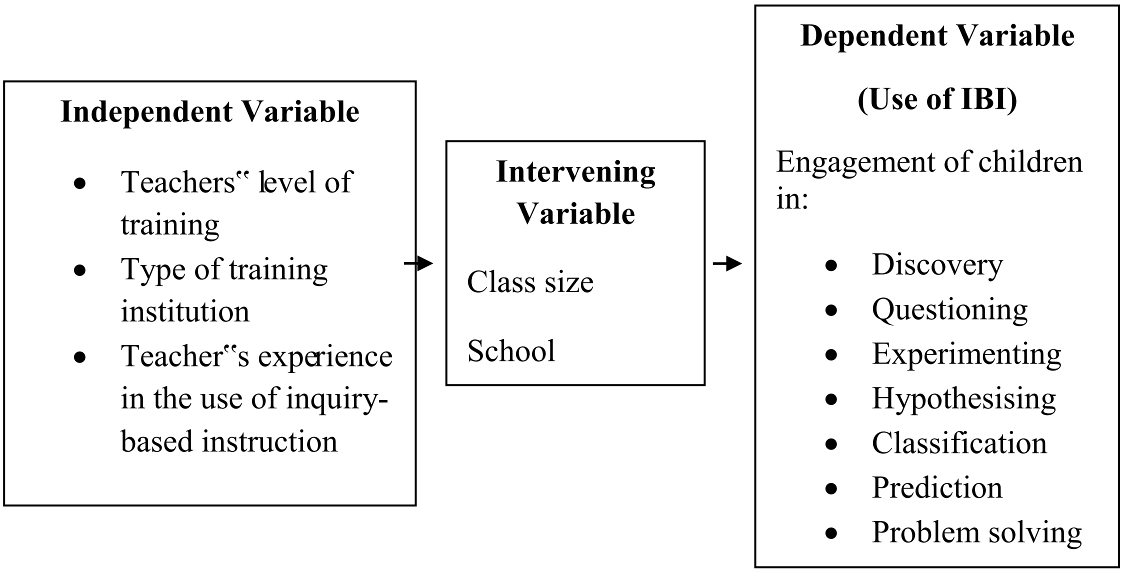


Figure 2.1: Conceptual Framework of Inquiry-Based Instruction

2.7 Summary of Literature Review

In view of the preceding review, it could be concluded that the inquiry-based approach to the teaching and learning of science is beneficial and recommended. Research on teachers" knowledge of IBI leads to the conclusion that different teachers may understand the approach differently. A teacher with an indepth knowledge on inquiry base with favourable factors can better implement the inquiry approach like discovery, problem solving, questioning than a teacher with low knowledge. Other factors like large class size affect effective implementation of inquiry-based instruction. As a corollary, differences are notable in the different teachers" implementation of the approach and the outcomes of such application. Some of these differences are noted at the institutional, systemic or even regional levels. Also, little is known about the ways in which IBI is understood and implemented by teachers relatively. However, as is clear from the literature, information on the case of the less developed countries is generally inadequate. This has left an important gap in knowledge and practice, hence, I explore it in this study focusing on the Ghanaian context.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter presents the methodology that guides the study. Specifically, the chapter covers research design, study setting, population (target and accessible), sample, sampling technique, data collection instruments, issues of validity and reliability, trustworthiness of the data, data analysis, and ethical considerations.

3.1 Researcher's Methodological Position

Research paradigm is the philosophical or motivation for undertaking a study (Cohen, Manion & Morrison, 2007). The study is situated within the pragmatic paradigm. Pragmatism is not committed to any one system of philosophy, but focuses on „what" and „how" of the research problem. In general, pragmatists believe in employing research methodology that involves collecting, analyzing, and interpreting quantitative and qualitative data in a single study or in a series of studies that investigate the same underlying phenomenon. Hence, the study employed mixed methods approach due to the nature of the research questions and advantages derived from applying two different approaches in garnering the required data. This approach according to Creswell (2012) involves combining or integration of qualitative and quantitative research data in a research study.

These two approaches allowed the researcher to study the Junior High School (JHS) integrated science teachers" knowledge and practice of inquiry-based instruction in Tano South Municipality, both quantitatively and qualitatively. Basically, no single approach either qualitative or quantitative methods can perfectly be effective or so, each method can be improved significantly through data triangulation from various sources (Teddlie & Yu, 2007).

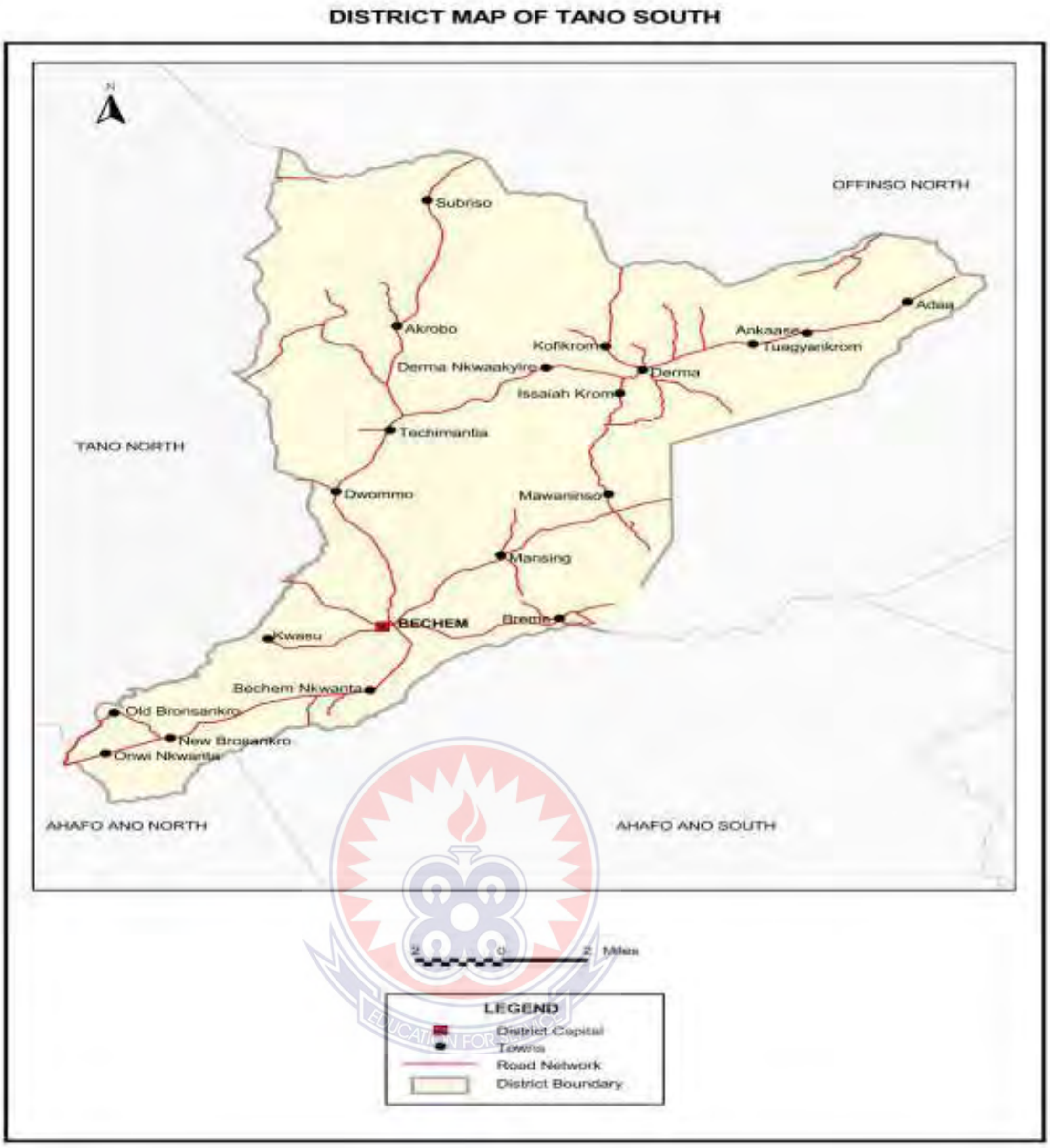
3.2 Research Design

A research design is a plan that describes the conditions and procedures for collecting and analyzing data (McMillan & Schumacher, 2010). A good and careful design ensures that the research is valid and could yield consistent results every time. This study employed convergent mixed method design. Convergent mixed method design is an approach to research where the researcher collects both quantitative and qualitative data, analyses them separately, and then compares the results to see if the findings confirm or disconfirm each other (Creswell, 2012). Mixed methods researchers call this side-by-side approach because the researcher makes the comparison within a discussion, presenting first one set of findings and then the other. The key assumption of this approach is that both quantitative and qualitative data provide different types of information – often detailed views of participants qualitatively and scores on instruments quantitatively – and together they yield results that should be the same.

Researchers of mixed methods argue that the intent of quantitative and qualitative research differs and that each provides adequate count. The interpretation in the convergent approach is typically written into a discussion section of the study, whereas the results section report on the findings from the analysis of both the quantitative and qualitative databases. This method is deemed appropriate as it is used to confirm, cross-validate or corroborate findings. This enables the researcher to overcome a weakness in one method with the strengths of another. It can also be useful in expanding quantitative data through collection of open-ended qualitative data.

3.3 Settings

The study was conducted in some selected public junior high schools in Tano South Municipality in the Ahafo Region of Ghana. Tano South Municipal is one of the 6 districts in the Ahafo Region of Ghana. It lies between lattitudes $7^0$00‟N and $7^0$25‟N and $1^0$45‟W and $2^0$15‟W. It covers an area of 489 square kilometres. The municipality lies in the moist semi-deciduous forest zone and this has necessitated people‟s engagement in farming. Farming has engaged about 60% of the population in the district. The municipality has a total of 85 public schools, of which 55 are primary school, 29 junior high schools, and 4 second cycle institutions including a School for the Deaf. In addition to these, the Municipal also has one tertiary institution, St. Joseph‟s College of Education. The district has 505 trained teachers and 348 untrained teachers in the public schools. The number of private schools in the District at the time of the study was 18 (Ghana Education Service, 2013).



Source: Ghana Statistical Service, GIS (2014)

Figure 3.1: District Map of Tano South Municipal

3.4 Population

A target population is the larger group which one aspires to apply findings. The target population of the study was all the Junior High School (JHS) science teachers in Ahafo Region of Ghana. The accessible population of this study was all the 75 Junior High School (JHS) integrated science teachers in Tano South Municipality of Ghana.

3.5 Sampling Technique

The teachers who participated in the quantitative study were sampled through census method. This was to engage all the Junior High School (JHS) integrated science teachers in the study considering that the total population relative to the teaching staff was not vast. They were 75 teachers. This method provided the researcher the opportunity to collect a lot of data about the subjects studied for detailed analysis required.

In the qualitative phase of the study, a sub-sample of 8 Junior High School (JHS) integrated science teachers was employed through purposive sampling. Yin (2014) proposed six sources of evidences in qualitative study, therefore, 8 participants are deemed appropriate.

3.6 Research Instrument

The study employed a questionnaire of 4-point Likert-point scale and a semi-structured interview guide in gathering the quantitative and qualitative data respectively. The questionnaire and semi-structured interview guide were designed by the researcher.

3.6.1 Questionnaire

A questionnaire is a research instrument consisting of series of questions that is administered to generate information about the trends in attitude, opinions, behavior or characteristics of a group of respondents (Creswell, 2012). Questionnaire was the first instrument used to collect data in the study. The questionnaire was used to collect quantitative data on Junior High School (JHS) integrated science teachers‟ knowledge and practice of inquiry-based instruction. Kusi (2012) asserts that, most research participants feel more comfortable responding to pre-determined response than items that require them to express their views and feelings. Accordingly, the items on the questionnaire were close-ended and required participants to check a box to show their degree of acceptance to each item.

The questionnaire consisted of two sections: A and B (Appendix B). Section A comprised demographic items such as age range, sex and education level. Section B comprised 18 items that used a 4-point Likert type scale (labeled strongly disagree, disagree, agree, strongly agree). The items were related to the Junior High School (JHS) integrated science teachers‟ knowledge and practice of inquiry-based instruction. The researcher considered questionnaire as an appropriate instrument for the study due to the fact that it is a common and familiar data collection instrument that is widely used in educational research. Similarly, it also serves as a means of minimizing bias and requires less time to administer (Denzin & Lincoln, 2005).

3.6.2 Semi-Structured Interview

Being aware that questionnaires alone cannot provide an in-depth understanding of the phenomenon, interviews were also conducted. According to Creswell (2012) an interview is an interactive process between a researcher and a subject within which the researcher poses a question and records answers supplied by the subject. In other words, interview is a means of collecting data whereby a researcher orally ask participants questions. Denscombe (2014) asserts that "although there are a lot of superficial similarities between a conversation and an interview, interviews are actually something more than just a conversation" (p. 172). He further identified three categories of interviews namely; structured interview, semi-structured interview and unstructured interview.

In this study, a semi-structured interview was used to collect qualitative data on the Junior High School (JHS) integrated science teachers‟ knowledge and practice of inquiry-based instruction (Appendix C). Babbie and Rubin (2007) point out that, if one decides to use interviews, one has to decide on whether one will take notes (which is distracting) during, or whether one will tape (accurate but time consuming) the interview. The other alternative is to rely on one‟s memory to recall what has been said or to ask the respondents to write down their answers.

The interview guide was designed based on emergent issues from literature. Semi-structured interview was considered to be flexible and provides room for the interviewee to speak widely on the phenomenon (Kusi, 2012). It enables participants to express their views and concerns freely and explicitly. Finally, unstructured interview are open and provides room for both interviewer and interviewee to deliberate at length on the topic.

3.7 Validity and Reliability of the Questionnaire

3.7.1 Validity of the Questionnaire

A validity refers to the extent to which the instrument accurately measure a desired concept in a quantitative study (Tavakol & Dennik, 2011). In determining the content and face validity of the questionnaires, the researcher presented the drafts to the researcher‟s supervisors at the University of Education, Winneba to assess the questions. This is because, the inputs of research supervisors are vital in determining content validity since it relies on expert judgment.

3.7.2 Reliability of the Questionnaire

Reliability relates to the consistency of a measure (Tavakol & Dennik, 2011). A participant completing an instrument meant to measure motivation should have approximately the same responses each time the test was completed. In ensuring reliability, the researcher piloted the study among teachers who were not part of the selected sample. The internal reliability of the questionnaire was determined using Cronbach's alpha. According to Tavakol and Dennik (2011), Cronbach"s alpha is an important and most common means of evaluating the internal consistency of a research statistical instrument. Kothari (2004) offered the following guidelines regarding interpretation of Cronbach's alpha scores: ≥0.9 is excellent, ≥0.8 is good, and ≥0.7 is acceptable, ≥0.6 is questionable, ≥0.5 is poor, and ≤0.5 is unacceptable. Using this guide of the Cronbach"s alpha score, the reliability test results of the research instrument yielded 0.72 which is acceptable.

3.8 Trustworthiness of the semi-structured interview guide

Trustworthiness is used to evaluate the worth of qualitative research. To establish the trustworthiness of a qualitative data researchers have to ensure: credibility, transferability, dependability and confirmability of qualitative findings (Babbie, Mouton, Voster & Prozesky, 2009). In this study the researcher adopted Babbie *et al.* (2009) model of establishing trustworthiness as a means of evaluating the worth of the study. The model was adopted due to the fact that it is developed conceptually and is widely used by qualitative researchers.

3.8.1 Credibility

Credibility is defined as the confidence that can be placed in the truth of a research finding (Babbie *et al.,* 2009). To ensure credibility of the present study, the researcher spent sufficient time in the studied schools and with participants to gain insight into the context of the study (prolonged engagement) and also, presented collected data to participants to verify (member checking).

3.8.2 Transferability

Transferability is explained to mean the degree to which qualitative results can be applied with participants in other context (Patton, 2002). To facilitate transferability of the results, the researcher provided detailed description of the enquiry and participants were selected purposively.

3.8.3 Dependability

According to Patton (2002) dependability is described as the stability of findings over time. To ensure the study dependability, the researcher submitted the findings for external audit to a lecturer in the Department of Basic Education who was not involved in the research process to examine the process and product of the study. The feedback generated from the external audit was used to improve upon the trustworthiness of the study.

3.8.4 Confirmability

Confirmability is a proof that data and interpretation of findings are not fabrications from the researchers" imaginations, but are truly derived from participants (Babbie *et al.,* 2009). To establish the confirmability of the study qualitative findings, the researcher highlighted every step of data analysis that was made in order to provide justification for the decision made (audit trial).

3.9 Ethical Considerations

Ethical considerations are important in every research method involving human subjects. Polit, Hungler and Beck (2001) explain research ethics as a system of moral values that are concerned with the degree to which procedures follow professional, legal, and sociological obligations of the study participants.

Firstly, an introductory letter was obtained from Department of Basic Education of the University of Education, Winneba for permission to carry out this study in the selected schools.

Secondly, a letter of permission was sought from the Municipal Director to the head of the selected schools.

According to Kusi (2012), after securing permission from the authorities in charge of the research context, it is important to gain consent of the target participants of the participants. Respondents were informed about the significance of the study and their consent was sought.

Participants were informed that their participation was voluntary, and they were permitted to refuse to respond to questions or withdraw from the study at any stage if they wished.

Anonymity requires that nobody could link a participant with any information given (Polit, Hungler & Beck, 2001). A participant is therefore considered anonymous when the researcher or another person cannot identify the participants from information provided. This was ensured by the researcher not asking the participants to introduce themselves throughout the interview sessions. Again, codes were assigned to the individual participants (Kusi, 2012) to help with data checking and management.

Confidentiality occurs when participants are protected in the study such that individual information provided is not made public without their consent (Polit, Hungler & Beck, 2001). Participants were assured that the information provided would not be shared with any other person, and would only be used for the purpose of the research.

Privacy is the control over the extent, timing, and circumstances of sharing oneself with others. Participants were therefore allowed to decide the time and place they wanted to respond to the questionnaire and to have the interviews held.

3.10 Data Collection Procedure

The administration questionnaire and the interview spanned six weeks and were delivered to the respective schools personally by the researcher for the teachers to respond to them. The administration of the questionnaire and the interview were done concurrently. This was after permission has been sought and granted by the District Directorate of Education with a letter of introduction from the Department of Basic Education, University of Education, Winneba (Appendix A) Upon reaching the schools, the researcher went to the headteachers to introduce himself and sought permission by handing over the letter of authorisation from the Municipal Director of Education office before administering the questionnaire and the interview. (Appendix A).

In order to ensure that the instruments were well completed, enough time was given to the teachers so that they could have time to complete them well. The instruments were returned two days after. The return rate for the instrument was 100% since its administration was personally done by the researcher.

3.11 Data Analysis

3.11.1 Quantitative Data Analysis

With the aid of Statistical Package for Social Science (SPSS) software, quantitative data was analysed using descriptive analysis of frequency counts, percentages and the mean and standard deviation were employed to analyse the questionnaire. The use of descriptive statistics according to Agyedu, Donkor and Obeng (2013) do not only allow researchers to use numbers but also provide them with data that create room for inferences on the population and directions for answering research questions.

The questionnaire had its scales of measurement reduced from 4-point Likert scale to 2-point Likert scale for easy analysis of the data. For instance, the researcher combined "Strongly Disagree" and "Disagree" to Disagree and "Strongly Agree" and "Agree" An item-by-item analysis of data was conducted. The percentage of the total sample responding to each question was stated with their means and standard deviations calculated. The data was presented according to the responses of the respondents. to Agree.

In the quantitative phase, the scales for the research questions were collapsed during the data preparation using stage. In the analysis, the researcher dichotomised the original 4-point scale of the questionnaire responses on school-related factors, environmental factor and strategies (1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree) by collapsing responses for 1 and 2 into a disagree category, and 3 and 4 into an agree category, yielding a 2-point scale: 1=disagree and 2=agree. This enables the study to gain more interpretability in terms of capturing the trends in the data. The study also used cross-case analysis procedure to analyse the qualitative data collected using the interview guide.

3.12.2 Qualitative Data Analysis

In the interview report, the narrative accounts of eight respondents were presented alongside the results of the questionnaire. The data was analysed thematically (Braun& Clark, 2007). The data was scrutinized through many analytical phases like; familiarizing yourself with your data, transcribing, reading and re-reading the data, noting down initial ideas. Interesting features of the data are coded in systemic manner across the data. The codes are collated into themes and all data relevant to each code, which help to get a thematic map of analysis (Braun& Clark, 2007)

The responses from the respondents were audio-taped and transcribed verbatim.

The transcript is read severally in order to familiarize with the data so as to establish relationship among ideas. The data was organized under the various themes generated from the codes to facilitate the discussion. Anonymity was used and Tr1, Tr2, toTr8 were assigned to the respondents.

CHAPTER FOUR

DATA RESULTS, ANALYSES AND DISCUSSION

4.0 Overview

This chapter presents the results and discussion of result of the study. The purpose of the study was to investigate Junior High School (JHS) integrated science teachers‟ knowledge and practice of inquiry-based instruction in Tano South Municipality of Ghana.

4.1 Demographic Characteristics of Respondents

The demographic characteristics of the sample considered in the study were gender, years of teaching experience and educational qualification. The details are presented in tables 1, 2 and 3 respectively

The sex distribution of teacher respondents was explored and its detail is illustrated in Table 1.

Table 1: Sex Distribution of the Participants

Gender	Frequency	Percentages
Male	52	69
Female	23	31
Total	**75**	**100**

Source: Field Data (2020)

Table 1 is about the gender distribution of respondents. From Table 1, the data showed that 52 (69%) of the teacher respondents were males whereas 23 (31%) were females. The indication here is that, there were more males than female in the study.

Also, participant‟s years of teaching experience were explored and the detail presented in Table 2.

Table 2: Participants Years of Teaching Experience

Years of Teaching	Frequency	Percentage
1-10	26	35
11-20	35	47
21-30	14	18
Total	**75**	**100**

Source: Field Data (2020)

Table 2 is about participant"s years of teaching experience. From Table 2, the results revealed that 35 (47%) of the JHS integrated science teachers had taught for a period between 11-20years, whereas 14 (18%) of them had taught for a period of 21 to 30years. The remaining twenty-six (35%) teachers had also taught for a period between 1-10years, no teacher taught beyond 30 years. This means that, JHS integrated science teachers who partook in this study were more experienced.

Finally, the educational qualification of teacher participants was explored and their detail is illustrated in Table 3.

Table 3: Teacher Participants' Educational Qualification

Educational Qualification	Frequency	Percentage
Diploma	32	43
Bachelor"s degree	43	57
Total	**75**	**100**

Source: Field Data (2020)

With regards to the educational qualification of teacher participants, results in Table 3 revealed that 43 (57%) of the teachers had bachelor"s degree while 32 (43%) of them who had diploma. This shows that, majority of JHS integrated science teachers who were considered in the study had bachelor"s.

4.2 Research Question 1

What knowledge do Junior High School integrated science teachers have about inquiry-based instruction in Tano South Municipality?

Junior High School integrated science teachers knowledge of inquiry-based instruction in Tano South Municipality

In relation to the first research question, the study aimed at gathering data on JHS integrated science teachers" knowledge about inquiry-based instruction in Tano South Municipality using questionnaire. Table 4 present data gathered in response to that effect.

Table 4: Descriptive Statistics of Teachers' Knowledge about Inquiry-Based Instruction

Items		D f (%)	A f (%)	M	SD
1	Scientific theories can be developed to become laws.	26 (35)	49 (65)	1.65	0.42
2	Scientific knowledge is verifiable.	35 (47)	40 (53)	1.53	0.40
3	Accumulation of evidence makes scientific knowledge more stable.	44 (61)	31 (41)	1.41	0.50
4	Scientific model expresses a copy of reality.	43 (57)	32 (43)	1.43	0.50
5	Inquiry in science stresses on dialogue, reporting, deliberation as well as debate.	45 (60)	30 (40)	1.40	0.49
6	Inquiry-based instruction depicts science as an ongoing process of exploration and discovery rather than a content domain to be memorized.	38 (51)	37 (49)	1.49	0.38

Source: Field data (2020) Key: f–Frequency, %–Percentage, *M*–Mean, *SD*–Standard Deviation

A mean score that ranges from 1.0 to 1.4 was considered as low knowledge whiles a mean score that range from 1.5 to 2.0 was considered as high knowledge. A cursory look at Table 4 indicates that, teachers" mean scores ranged from 1.40 to 1.65 and standard deviation from 0.38 to 0.50. This means that, most of the JHS integrated science teachers on average had low knowledge about inquiry-based instruction. For instance, 30 (40%) of the teacher participants conceded to the statement that „Inquiry in science stresses on dialogue, reporting, deliberation as well as debate.‟ whereas 45 (60%) of them disagreed to the statement with a mean score of 1.40 and standard deviation of 0.49. This indicates that, majority of the participants do not know that inquiry in science stresses on dialogue, reporting, deliberation as well as debate. Moreover, 37 (49%) of the teacher participants agreed to the statement that „Inquiry-based instruction depicts science as an ongoing process of exploration and discovery rather than a content domain to be memorized.‟ whereas 38 (51%) of them declined to the statement with a mean score of 1.49 and a standard deviation score of 0.38. The indication here is that, most of the teachers do not acknowledge the fact that inquiry-based instruction depicts science as an ongoing process of exploration and discovery rather than a content domain to be memorized. In contrast, results showed that 49 (65%) of the teacher participants forming the majority conceded to the statement that „Scientific theories can be developed to become laws.‟ whereas 26 (35%) of them disagreed to the statement with a mean score of 1.65 and standard deviation of 0.42. This means that, most of the teacher participants hold the view that scientific theories can be developed to become laws.

The study employed convergent mixed method design and for this reason, the qualitative data was analysed as follows.

The researcher through an interview further present the understanding of "inquiry-based instruction". Some of the teachers exhibited some fair knowledge about inquiry-based instruction. This is evident in the narration made by one of the respondents:

> *"If you ask me about inquiry-based instruction, I will say, it is a student-centred approach where the instructor guides the students through questions posed, methods designed, and data interpreted by the students." (Tr. 4)*

Similarly, another teacher stated that:

> *"Inquiry-based instruction can be said to be a form of active learning process that focuses more on teachers posing questions, problems or scenario." (Tr. 8)*

Another teacher participant is also with the view that:

> *"It is an approach to teaching and learning that emphasizes the students' role in the learning process rather than teachers telling students what they need to know." (Tr. 2)*

The above quotes show that from the perspective of the teachers, inquiry-based instruction is a comprehensive instructional activity that involves observations; posing questions, investigation, analyzing and interpreting gathered data.

4.3 Research Question 2

How do Junior High School integrated teachers practice inquiry-based instruction in Tano South Municipality?

Junior High School integrated science teachers' practice of inquiry-based instruction in Tano South Municipality.

In relation to the second research question, the study aimed at gathering data on how JHS integrated science teachers practice inquiry-based instruction using questionnaire. Table 5 details the results as follows:

Table 5: Descriptive Statistics of Teachers' Practice of Inquiry-Based Instruction

	Items	D f (%)	A f (%)	*M*	*SD*
1	I discuss with students what they will do.	10 (13)	65 (87)	1.87	0.48
2	I give students much influence on choices concerning their own inquiries.	15 (20)	60 (80)	1.80	0.20
3	I determine the questions to be investigated and how these questions are to be investigated.	20 (27)	55 (73)	1.73	0.22
4	I give exercises that encourage students to think about possible solutions on a meta-level.	54 (72)	21 (28)	1.28	0.45
5	I give goals to students, provide hints to achieve these goals and monitor their progress.	46 (71)	22 (29)	1.29	0.46
6	I provide students with tools to explore objects and materials.	32 (43)	43 (57)	1.57	0.50
7	I encourage hypothesizing and sharing of ideas among students.	29 (39)	46 (61)	1.61	0.52

Source: Field data (2020)   Key: f–Frequency, %–Percentage, *M*–Mean, *SD*–Standard Deviation

As it is evident in Table 5, the data show that teachers‟ mean scores ranged from 1.28 to 1.87 and standard deviation from 0.20 to 0.52. This means that, most of the JHS integrated science teachers on average do not practice inquiry-based instruction as expected. For example, 65 (87%) of the teacher participants agreed to the statement that „It is only I who decides what students do.‟ whereas 10 (13%) of them disagreed to the statement with a mean score of 1.87 and standard deviation of 0.48. This means that, JHS integrated science teachers solely decide what students do as admitted by majority of the teacher participants. Again, 60 (80%) of the teacher participants agreed to the statement that „I give students much influence on choices concerning their own inquiries.‟ whereas 15 (20%) of them declined to the statement with a mean score of 1.80 and a standard deviation score of 0.20. The indication is that, most of the JHS integrated science teachers give students much influence on choices concerning their own inquiries.

However, from Table 5, 61% of the teacher participants conceded to the statement that „I encourage hypothesizing and sharing of ideas among students." whereas 29 (39%) of them disagreed to the statement with a mean score of 1.61 and standard deviation of 0.52. This means that, a good number of JHS integrated science teachers encouraged hypothesizing and sharing of ideas among students.

The researcher through an interview asked participants whether they had ever used inquiry-based instruction as a teaching approach and if so, how do they employ it in their teaching of Integrated Science.

All the teachers had in one way or the other used inquiry-based instruction as a teaching approach in their Science class. The teachers also disclosed that they posed questions and create opportunities for students to explore phenomena. This is evident in the following excerpts:

> "*In my bit to engage students through inquiry-based instruction, I usually take my class [students] out of the classroom to the school compound to explore nature, collect, analyse and share findings with others." (Tr. 5)*

A teacher also commented that:

> *"In my case, I pose questions and scenarios that encourage my students to think and share ideas. Students are given the opportunity to observe and make reasonable predictions." (Tr.1)*

Another respondent also added that:

> *"As part of the plan to implement inquiry-based instruction, I lead students through experimentation by posing critical questions. I also support them [students] with learning materials to work with." (Tr. 8).*

The quotes above depict that teachers practice inquiry-based instruction by exclusively determining what students should do. Students, however, are provided with some learning materials and opportunity to explore phenomena.

4.6 Research Question 3: what are the background factors that influence JHS integrated science teachers" practice of inquiry-based instruction?

Background factors that influence JHS integrated science teachers' practice of inquiry-based instruction

The research question, aimed at gathering data on the background factors that influence the practice inquiry-based instruction using questionnaire. Table 6 portrays the results as follows:

Table 6 presents data on the background factors that influence the practice of inquiry-based instruction.

Table 6: Descriptive Statistics of the Background Factors That Influence the Practice of Inquiry-Based Instruction

Items		D f (%)	A f (%)	*M*	*SD*
1	Pedagogical content knowledge	16 (21)	59 (79)	1.79	0.41
2	Understanding of inquiry and nature of science	19 (25)	56 (75)	1.75	0.44
3	Mode of assessment	29 (39)	46 (61)	1.61	0.52
4	Class size	33 (44)	42 (56)	1.56	0.40
5	The nature of pre-service and in- service training.	17 (23)	58 (77)	1.77	0.42
6	Support from peer teachers	25 (33)	50 (67)	1.67	0.48
7	Limited time in relation to many lessons and much content to cover	27 (36)	48 (64)	1.64	0.46

Source: Field data (2020) Key: f–Frequency, %–Percentage, *M*–Mean, *SD*–Standard Deviation

Data from Table 6 show that teachers" mean scores ranged from 1.56 to 1.79 and standard deviation from 0.40 to 0.52. This means that, most of the JHS integrated science teachers on average admitted that there are background factors that influence their practice of inquiry-based instruction. For example, 48 (64%) of the teacher participants agreed that „limited time in relation to many lessons and much content to cover influences their practice of inquiry-based instruction while 27 (36%) of them disagreed to the statement with a mean score of 1.64 and standard deviation of 0.48. This indicates that, majority of JHS integrated science teachers are of the view that the limited time in relation to many lessons and much content to cover poses a challenge in employing inquiry-based instruction.

Also, 46 (61%) of the teacher participants agreed to the statement that „mode of assessment influences their practice of inquiry-based instruction whereas 29 (39%) of them declined to the statement with a mean score of 1.61 and a standard deviation score of 0.52. The indication here is that, most of the JHS integrated science teachers acknowledge that mode of assessment influences their practice of inquiry-based instruction. Moreover, 58 (77%) of the teacher participants admitted that the nature of pre-service and in- service training influences their practice of inquiry-based instruction whereas 17 (23%) of them declined to the statement with a mean score of 1.77 and standard deviation of 0.42. This means that, most of the JHS integrated science teacher participants have the view that the nature of pre-service and in-service training influenced their practice of inquiry-based instruction.

The researcher through the interview also explored teachers" views on factors that negatively influence their practice of inquiry-based instruction in the classroom. Judging from the responses given by teachers in the interview, it was revealed that integrated science teachers encounter a number of challenges including large class size. This is captured in the following excerpt:

> It *is very difficult to use this approach [inquiry-based instruction] in a class with a large size. Look at the situation of having a class size of 50 students and providing them with learning materials which are not readily available. This is a very difficult task for me as a teacher." (Tr. 6)*

Some of the teacher respondents recounted that:

> *"Hmm! I will say it [inquiry-based instruction] wastes a lot of time. You now have to give ample time for students to complete their inquiry and report their results." (Tr. 3)*
> *"I believe you will agree with me that the school time-table does not support this kind of approach. And that alone discourages me from using inquiry-based instruction." (Tr. 5)*

One teacher also commented that:

> *"Frankly speaking, I don't have adequate knowledge on how to use this [inquiry-based instruction] approach to teach science because, I was not taught about that in college days. Also, I have gone for any in-service training that focuses on the use of inquiry-based instruction in science classroom."(Tr. 2)*

The quotes from respondents revealed among other negative factors that influence teachers' practice of inquiry-based instruction in the classroom that, teachers' inadequate training on inquiry-based instruction hindered them from using inquiry-based instruction.

4.7 Discussion of Findings

The understanding and practice of inquiry-based instruction in classroom are said to be diverse; hence, leaving science teachers in a dilemma as to what and how to implement this approach in the actual classroom (Anderson, 2002). However, what is commonly agreed by science educators is that the focal point of science instruction should be geared towards the development of inquiry skills and not a mere knowing of scientific facts and concepts. The purpose of the study was to investigate Junior High School (JHS) integrated science teachers" knowledge and practice of inquiry-based instruction in Tano South Municipality of Ghana. Primary quantitative data was collected by means of closed ended questionnaire while qualitative data was collected using semi-structured interview guide.

From the perspective of integrated science teachers in the interview conducted, inquiry-based instruction is a comprehensive instructional activity that involves observations; posing questions, investigation, analyzing and interpreting gathered data. This corroborates the view of Inter Academy Panel (IAP) (2012), who defines inquiry-based instruction as a gradual development of principal scientific concepts of students as they learn the appropriate ways of doing investigation and successfully enhance their knowledge as well as how they understand the natural world. Inquiry-based instruction therefore aids the learning as students adopt the skills used by scientists including questioning, collecting data, analysing and interpreting findings.

As part of the findings, it was revealed that most of the teachers do not acknowledge the fact that inquiry-based instruction depicts science as an ongoing process of exploration and discovery rather than a content domain to be memorized. Science teachers have divergent views about what IBI is. Some science teachers view inquiry as a process, not a vehicle of learning science content (Assay & Orgill, 2010). Teaching science through science inquiry is the cornerstone of good teaching. Regrettably, an inquiry approach to learning science is not the custom in schools as instructors are often still struggling to build a shared understanding of what science as inquiry means, and at a more practical level, what it looks like in the classroom.

Minner, Levy and Century (2010) give some essential ideas for using inquiry in teaching: Science content must be included, engaging students with content of science, responsibility of students to learn, critical thinking of students, provision of questions to motivate students, designing experiment, data gathering, drawing conclusion and communicating it.

The study findings again revealed that, majority of the teachers do not know that inquiry in science stresses on dialogue, reporting, deliberation as well as debate. This misconception confirms what Seung, *et al.* (2014) discovered in their study findings that, teachers have sometimes showed a lack of understanding about key features of inquiry. Researchers (Avsec & Kocijancic, 2016; Cavas, 2012) have found that teachers‟ ideas about the nature of science as an objective body of knowledge created by a rigid scientific method, hindered their teaching of an accurate view of scientific inquiry.

Several studies have indicated that there are many differences to science teachers‟ practice of IBI including differences in teachers‟ curricular interpretation (McNeill, 2009). What have accounted for this difference may be that science is a broad discipline with many sub-divisions such as biology, physics, agriculture and chemistry and every teacher in his respective discipline will certainly practice IBL differently. In the interview conducted among integrated science teachers, it was found that all the teachers have in one way or the other used inquiry-based instruction as a teaching approach in their Science class. In this way, they disclosed that they pose questions and create opportunities for students to explore phenomena. However, most of the JHS integrated science teachers on average were found not to practice inquiry-based instruction as expected. This finding corroborates that of Capps and Crawford (2012) which showed that, even in the United States of America, many science teachers do not practice inquiry-based teaching in their classrooms which in the context of this study can be attributed to inadequate pedagogical know-how.

Spain, Pozuelos and Gonzales (2014) explored the conceptions, difficulties, obstacles and facilitative factors that influenced the teachers‟ attempt to introduce inquiry-oriented practices into their classrooms. The researchers established that participating teachers focused on three areas of need: A suitable working environment that enables and facilitates collaborative work, access to alternative materials, and greater social recognition and willingness of colleagues to cooperate, along with other types of support specific to each school community.

In the case of Tano South Municipality, integrated science teachers practice inquiry-based instruction by exclusively determining what students should do. The effective implementation of inquiry-based instruction requires science educators to allow students some form of flexibility in the choice activity to engage. The study findings, however, show that teachers provide students with some learning materials and opportunity to explore phenomena.

In another comparative study, Taso (2011) examined the similarities and differences in how the US and Japanese middle-school science teachers teach through science inquiry. The results showed that little IBI was observed in either of the two countries for apparently different reasons; the observation data indicated scientific concepts under classroom discussion were not clearly identified in many of the US lessons, whereas the Japanese lessons often exhibited lack of teachers‟ support for students in constructing their understanding of scientific concepts. Consistent to these findings, the researcher found that most of the JHS integrated science teachers give students much influence on choices concerning their own inquiries. But, majority (61%) of JHS integrated science teachers were found to usually encourage hypothesizing and sharing of ideas among students.

Despite the potential benefits of using inquiry in science learning, there are several drawbacks with the use of inquiry instruction. It has been documented by researchers (e.g., Crawford, 2000; Keys & Kennedy, 1999) 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. This is confirmed by the findings from the study which indicated that most of the JHS integrated science teacher participants have the view that the nature of pre-service and in-service training influences their practice of inquiry-based instruction.

Consistently, it was revealed from the interview among other negative factors that, teachers" inadequate training on inquiry-based instruction prevents them from using inquiry-based instruction. 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 has tendency to impede the implementation of inquiry in their classrooms.

Crawford and Capps (2012) postulate that, many science teachers also have a naive understanding of scientific inquiry and are therefore not able to use authentic inquiry. Among these reasons is that science teachers often do not, themselves, possess a holistic understanding of scientific inquiry and the nature of science (Lederman & Lederman, 2012; National Research Council, 2012). This in all likelihood stems from the nature of traditional science teaching at college/university level that commonly uses didactic-teaching-by-telling approach (Miranda & Damico, 2015). In many teacher education programs, little attention is given to how the processes of scientific inquiry should be taught.

The findings from the study revealed that, majority of JHS integrated science teachers are of the view that the limited time in relation to many lessons and much content to cover poses a challenge in employing inquiry-based instruction. Again, judging from the responses given by teachers in the interview, it was revealed that integrated science teachers encounter a number of challenges including large class size. Ramnarian and Hlatswayo (2018) in their study found that teachers have a positive attitude towards inquiry in the teaching and learning of Physical Sciences, and recognise the benefits of inquiry. However, in spite of this positive belief towards inquiry-based learning, teachers were found to be less inclined to enact inquiry-based learning in their lessons.

These impediments were similar to what Anderson and Helms (2002) reported in their study to 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. Windschitl (2002) argued that acknowledging these challenges and constraints and addressing them within the design of professional development program may allow for more successful implementation among participating teachers.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter presents the summary of findings, conclusion and recommendations on the study. In this study, convergent mixed method design was employed. The purpose of the study was to investigate Junior High School (JHS) integrated science teachers" knowledge and practice of inquiry-based instruction in Tano South Municipality of Ghana.

5.1 Summary of Findings

The study was conducted in Tano South Municipality in the Ahafo Region of Ghana. Seventy-five Junior High School (JHS) integrated science teachers were recruited for the quantitative study. In the qualitative study, sample sizes of 8 Junior High School (JHS) integrated science teachers were employed. The teachers who participated in the study were included through the census method. The study employed questionnaire and interview guide as the primary tools to collect quantitative and qualitative data respectively. The quantitative data was analysed using descriptive analysis of frequency counts, percentages, means and standard deviation whereas the qualitative data was analysed using the cross-case analysis procedure.

The first objective of the study was to explore JHS integrated science teachers" knowledge about inquiry-based instruction in Tano South Municipality of Ghana. From the interview conducted in the study, it was indicated that inquiry-based instruction is a comprehensive instructional activity that involves observations; posing questions, investigation, analyzing and interpreting gathered data. The study also revealed among other findings that, most of the JHS integrated science teachers do not acknowledge the fact that inquiry-based instruction depicts science as an ongoing process of exploration and discovery rather than a content domain to be memorized. The study findings again revealed that, majority of the teacher do not know that inquiry in science stresses on dialogue, reporting, deliberation as well as debate.

The second objective of the study was to investigate the extent to which JHS integrated science teachers practice inquiry- based instruction in Tano South Municipality of Ghana. Findings from the study showed that, all the JHS integrated science teachers have in one way or the other used inquiry-based instruction as a teaching approach in their Science class. However, most of these JHS integrated science teachers on average were found not to practice inquiry-based instruction as expected. Moreover, it was disclosed that JHS integrated science teachers pose questions and create opportunities for students to explore phenomena. Also, it was also discovered that integrated science teachers practice inquiry-based instruction by exclusively determining what students should do.

The third objective of the study was to investigate the background factors that influence JHS integrated science teachers practice of inquiry-based instruction in Tano South Municipality of Ghana. The findings from the study revealed that, majority of JHS integrated science teachers hold the view that the limited time in relation to many lessons and much content to cover poses a challenge in employing inquiry-based instruction. Again, judging from the responses given by teachers in the interview, it was revealed that integrated science teachers encounter a number of challenges including large class size. Again, findings from the study which indicated that most of the JHS integrated science teacher participants have the view that the nature of pre-service and in-service training influences their practice of inquiry-based instruction. Consistently, it was revealed from the interview among other negative factors that, teachers‟ inadequate training on inquiry-based instruction refrains them from using inquiry-based instruction.

5.2 Conclusions

From the results obtained in this study it was concluded that although JHS integrated science teachers demonstrated some kind of knowledge about inquiry-based instruction, on average it was found out to be low. Also, all JHS integrated science teachers in one way or the other employed inquiry-based instruction in the teaching of science in the Tano South Municipality. However, JHS integrated science teachers‟ practice of inquiry-based instruction was not to expectation. Another important deduction that can be made from the findings of this study is that teachers‟ level of competence in employing IBI among other factors was significantly influenced by the quality of their training in inquiry-based instruction. In ensuring effective implementation of IBI in basic schools, there must be a change in teachers‟ attitudes towards IBI through the development of their knowledge and skills. It is therefore imperative that science teachers are supported in equipping them with pedagogical content knowledge on IBI in order for them make significant impact their area of teaching.

5.3 Recommendations

1. From the findings, it was revealed that inquiry-based instruction is a comprehensive instructional activity that involves observations; posing questions, investigation, analyzing and interpreting gathered data. However, most of the JHS integrated science teachers do not acknowledge the fact that inquiry-based instruction depicts science as an on-going process of exploration and discovery rather than a content domain to be memorized. It is therefore

recommended that teacher education institutions revise the existing JHS curriculum to integrate inquiry-based instruction to place science teachers a better position to practice IBI in the Ghanaian classrooms.

2. Results from the study revealed that all the JHS integrated science teachers have in one way or the other used inquiry-based instruction as a teaching approach in their Science class. However, most of these JHS integrated science teachers on average were found not to practice inquiry-based instruction as expected. Therefore, the study recommends that, the Ghana Education Service with collaboration with Head teachers should organise in-service training that focuses on addressing the specific pedagogical needs of teachers such as inquiry-based instruction in order to improve their competence in teaching integrated science in schools.
3. The study findings again revealed that integrated science teachers encounter a number of challenges including large class size. The researcher recommends the Ghana Education Service to address the issue of large classes by recruiting more science teachers and constructing adequate laboratories for all public schools.

5.3 Suggestions for Further Research

The following directions for future research were suggested:

First, this study could be replicated to explore Junior High School (JHS) integrated science teachers‟ knowledge and practice of inquiry-based instruction at different settings with larger sample sizes. The study investigated Junior High School (JHS) integrated science teachers‟ knowledge and practice of inquiry-based instruction in Tano South Municipality of Ghana. Future studies could look at the situation at different settings including private institutions. Also, there is need for further research on the knowledge and practice of inquiry-based instruction involving science teachers in a specific branch of science disciplines such as chemistry, physics and biology in Ghana since this study investigated integrated science teachers" knowledge and practice of IBI.

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APPENDICES

APPENDIX A

LETTER OF INTRODUCTION

UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF EDUCATIONAL STUDIES
DEPARTMENT OF BASIC EDUCATION
P. O. Box 25, Winneba, Ghana
+233 (050) 9212015

Date: September 17, 2020

The District Director
Tano South Education Directorate
Bechem.

Dear Sir/ Madam,

LETTER OF INTRODUCTION

I write to introduce to you, Mr. Frank Williams Gyening, a second year M.Phil student of the Department of Basic Education, University of Education, Winneba, with registration number 8180030017.

Mr. Frank Williams Gyening, is to carry out a research on the Topic "***Investigating Junior High Integrated Science Teachers' Knowledge and Practice of inquiry -Based Instruction in Tano South District".***

We would be grateful if permission is granted him to carry out his studies in the District.

Thank you.

Yours faithfully,

DEPT. OF BASIC EDUCATION
UNIVERSITY OF EDUCATION
WINNEBA, GHANA

MRS. SAKINA ACQUAH (PHD)
(Ag. Head of Department)

www.uew.edu.gh

APPENDIX B

QUESTIONNAIRE

This questionnaire is designed to investigate Junior High School (JHS) integrated science teachers‟ knowledge and practice of inquiry-based instruction in Tano South Municipality of Ghana. The first section of the questionnaire intends to obtain personal information on teachers, and in and the second are questions that seek to find out the JHS integrated science teachers‟ knowledge, practice, and challenges in inquiry-based instruction respectively. Please, respond honestly to the items and you can be assured that your responses will be kept strictly confidential.

Frank

Section A: Background Demographic Data – Please fill in or check the appropriate item below.

1. Sex of teacher.

(i) Male ☐ (ii) Female ☐

2. Highest Educational Qualification.

(i) Cert "A"☐ (ii) Diploma ☐ (iii) Bachelor‟s Degree ☐ (iv) Master‟s Degree ☐ (v) Others ☐

3. For how many years have you been teaching integrated science?

(i) 1-10 years ☐ (ii) 11-20 years ☐ (iii) 21-30 years ☐ (iv) 30 years and above ☐

Section B: Teachers' Knowledge about Inquiry-Based Instruction

Indicate your level of agreement on the teacher‟s knowledge using the scale below:

1=Strongly Disagree; 2=Disagree; 3=Agree; 4=Strongly Agree

S/N	STATEMENT	1	2	3	4
1.	Scientific theories can be developed to become laws.				
2.	Scientific knowledge cannot be changed.				
3.	Accumulation of evidence makes scientific knowledge more stable.				
4.	Scientific models expresses a copy of reality				
5.	Inquiry in science stresses on dialogue, reporting, deliberation as well as debate.				
6.	Inquiry-based instruction depicts science as an ongoing process of exploration and discovery rather than a content domain to be memorized.				

Teachers' Practice of Inquiry-Based Instruction

Indicate your level of agreement on the teacher‟s practice using the scale below:

1=Strongly Disagree; 2=Disagree; 3=Agree; 4=Strongly Agree

S/N	STATEMENT	1	2	3	4
1.	It is only I who decides what students do.				
2.	I give students much influence on choices concerning their own inquiries.				
3.	I determine the questions to be investigated and how these questions are to be investigated.				
4.	I give exercises that encourage students to think about possible solutions on a meta-level				
5.	I give goals to students and provide hints to achieve these goals and to monitor progress				
6.	I provide students with tools to explore objects and				

	materials.				
7.	I encourage hypothesizing and sharing of ideas among students.				

Background Factors that Influence the Practice of Inquiry-Based Instruction

Indicate your level of agreement on the background factors that influence the practice of inquiry-based instruction using the scale below:

1=Strongly Disagree; 2=Disagree; 3=Agree; 4=Strongly Agree

S/N	STATEMENT	1	2	3	4
1.	Pedagogical content knowledge				
2.	Understanding of inquiry and nature of science				
3.	Mode of assessment				
4.	Class size				
5.	The nature of pre-service and in-service training.				
6.	Support from peer teachers				
7.	Limited time in relation to many lessons and much content to cover				

APPENDIX C

INTERVIEW GUIDE

This interview is designed to solicit views on Junior High School (JHS) integrated science teachers" knowledge and practice of inquiry-based instruction in Tano South Municipality of Ghana You are kindly requested to provide answers to enable the researcher contribute to the knowledge in the field of study. Please, respond honestly to the items and you can be assured that your responses will be kept strictly confidential.

1. What do you understand by the term "inquiry-based instruction"?
2. Have you used inquiry-based instruction as a teaching approach?
3. If yes, how do you employ inquiry-based instruction in your teaching?
4. If no, are there any reasons why you would not want to use inquiry in your science lessons?
5. How would you describe the effectiveness of this approach from the viewpoint of learning outcomes?
6. What are the factors that negatively influence your practice of inquiry-based instruction in the classroom?
7. Thank you for your time

APPENDIX D

EXCERPT FROM THE INTERVIEW

This is captured in the following excerpt:

> It *is very difficult to use this approach [inquiry-based instruction] in a class with a large size. Look at the situation of having a class size of 50 students and providing them with learning materials which are not readily available. This is a very difficult task for me as a teacher." (Tr. 6)*

Some of the teacher respondents recounted that:

> *"Hmm! I will say it [inquiry-based instruction] wastes a lot of time. You now have to give ample time for students to complete their inquiry and report their results." (Tr. 3)*
> *"I believe you will agree with me that the school time-table does not support this kind of approach. And that alone discourages me from using inquiry-based instruction." (Tr. 5)*

One teacher also commented that:

> *"Frankly speaking, I don't have adequate knowledge on how to use this [inquiry-based instruction] approach to teach science because, I was not taught about that in college days. Also, I have gone for any in-service training that focuses on the use of inquiry-based instruction in science classroom."(Tr. 2)*