UNIVERSITY OF EDUCATION, WINNEBA

LOWER PRIMARY TEACHERS' PERCEPTIONS AND PRACTICES OF INQUIRY-BASED SCIENCE INSTRUCTION IN THE EFFUTU MUNICIPALITY

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LOWER PRIMARY TEACHERS' PERCEPTIONS AND PRACTICES OF INQUIRY-BASED SCIENCE INSTRUCTION IN THE EFFUTU MUNICIPALITY

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DECLARATION

Student's Declaration

I, Isaac Kwakye, 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 it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: ………………………………..

Date:………………………………………

Supervisors' Declaration

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

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Signature: …………………………………

Date: ……………………………………….

DEDICATION

To my lovely family especially, my parents Mr. Joseph Kwakye and Mrs. Grace Amakye.

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ABSTRACT

The purpose of the study was to assess public lower primary teachers' perceptions and practices of inquiry-based science instruction in the Effutu Municipality in the Central Region of Ghana. The study adopted the sequential explanatory mixed method research design. Census sampling was used to obtain 82 respondents (public lower primary teachers) for the quantitative phase of the study whiles a sub-sample of 12 public lower primary teachers from the 82 respondents were used for the qualitative phase. Questionnaires, semi-structured interview and observational framework were the instruments used to gather data. The questionnaire was used for the quantitative phase which was analysed using mean, standard deviation, frequency counts and Pearson Correlation whiles the semi-structured interview guide was analysed using the directed content analysis with the observation analysed using the 5E observational framework for the qualitative phase. It emerged from the study that teachers possessed high (good) perception of inquiry-based science instruction. The study further revealed that, teachers in the Effutu Municipality do practice inquiry-based instruction to some extent in their classrooms based on topic and their preferred method. While the extent of practices varies among teachers, it was evident that they value its use in enhancing students' engagement and understanding in science education. It was also revealed that, a positive but moderate relationship existed between teachers' perceptions and practices of inquiry-based instruction signifying that, teachers increased practices of the approach is as a result of an increased in perceptions. It also emerged from the findings that, classroom-based challenges were significant challenge to the lower-primary teachers as compared to pupil-based challenges and teacher-based challenges. It was recommended from the study that, the Effutu Municipal Directorate of the Ghana Educational Service and heads of schools, should design training programs and targeted professional development programs, that aim to standardized and enhance lower primary teachers' implementation of inquiry-based instruction in the Effutu Municipality.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter focused on the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, and significance of the study. It also looked at the delimitation of the study and organization of the study.

1.1 Background to the Study

The discipline of science is concerned with training learners to equip them to deal with changes and problems in life, rather than preparing them for a static and fixed reality. It is often regarded as a method of gaining knowledge through experimentation and observation. The implication is that, scientific knowledge is generated through extensive interaction with the physical and natural world. The teacher's role then, is to provide learners with the necessary tools to embark on this journey of discovery, curiosity, and wonder. With proper practical educational resources, learners' interest is awakened and sustained to quickly and fully learn the science content Shamsudin et al. (2013) as cited in Tortella et al. (2021). It is important for teachers to use hands-on and minds-on approaches which learners find interesting to learn science instead of relying on memorisation (National Council for Curriculum and Assessment [NaCCA], 2019).

One of the major issues in science education is that, learners consider science classes as not fascinating and engaging (Anderhag et al. 2016). The key reason for learners' perceptions is that science is taught without aligning concepts to learners' real-life experiences (Childs et al. 2015). This perception demotivates learners to pursue the study of science. To make the study of science more relevant to learners, Sjöström and Eilks (2018) mentioned that, learners should be prepared well enough to think critically, creatively, and responsibly in responding to societal issues that will lead to transformative development.

To support this claim, Eilks and Hofstein (2015) believed that, new approaches to curriculum and pedagogy are required beyond the mere learning of scientific theories and facts, and that conceptual learning should be framed by everyday life and societal situations in order for students to appreciate the significance of science. Hugerat et al. (2015) argued that, in order to provide more relevant science training, a theory-driven and evidence-based curriculum is required. This means that new pedagogies, topics worth learning and teaching, and methods for measuring learning should be included in the curriculum.

Decades of discussion and debate about how science is most effectively taught and learned have resulted in the evolution of inquiry-based instruction in the twentieth century to the present; it is thus not a new phenomenon in education, having begun in the 1950s, particularly in science education (Taylor & Bilbery, 2011). The National Scientific Teaching Standards (NSES), established by the National Research Council [NRC] (2007) in the United States, treat inquiry-based learning as a centralised and effective method to scientific teaching.

It is further characterised as a multi-dimensional process in which learners make observations, ask questions, research existing information from books and other sources, plan their research, compare existing information to experiment results, and use tools to analyse, interpret, discuss, and propose hypotheses, explanations, and results (NRC, 2000; 2007 as cited in Bogar, 2019).

According to Constantinou et al. (2018), inquiry-based instruction refers to the process of actively engaging learners in the learning process with emphasis on supporting knowledge claim with observations, experiences or complementary sources of credible evidence, tackling of authentic and problem-based learning activities, consistent practice and development of the skills of systematic observation, questioning, planning and recording with a purpose to obtain credible evidence. This allows learners to actively participate in collaborative group work, peer interaction, construction of discursive argumentation and communication with others as the main process of learning. It also developed in them the spirit of autonomy and self-regulation through life's experiences as important goals of learning.

Also, inquiry-based instruction is defined as a learning approach that enables learners to be active throughout the learning process by making them ask questions, analyse information and making inquiries of them. It develops in learners the skill of using scientific processes (putting forth the problems, planning experimental processes, making guesses, generating hypotheses, collecting and analyzing data and interpreting the results) and creativity (Bogar, 2019).

Inquiry-based instruction is an instructional practice where learners are placed at the center of the learning experience and taking ownership of their own learning by posing, investigating, and answering questions (Caswell & LaBrie, 2017). This helps learners to consider it as a form of self-directed learning where they take responsibility for their learning. Guido (2017) examined inquiry-based learning from both learner and teacher's point of view. He explained that from a learner's perspective, inquiry-based instruction focuses on investigating an open question or problem, while from a teacher's perspective, inquiry-based teaching focuses on moving students beyond basic curiosity into the realms of critical thinking and understanding.

The rationale for teaching inquiry is to promote understanding and development of skills needed by learners to meet 21st Century standards as well as to develop key science concepts which will enable them to understand events and natural phenomena and how scientific knowledge is obtained using evidence to solve problems (Harlen, 2013). Overall, inquiry-based instruction which leads to child centered pedagogy aims at developing individuals to become scientifically literate and good problem solvers who would have the ability to think creatively and have both the confidence and competence to participate fully in societal issues as responsible local and global citizens (NaCCA, 2019).

Inquiry –based instruction is effective in the sense that, it provides an insight into the world of scientist, as doing it motivates and stimulates interest in science learning (Breslyn & McGinnis, 2012 as cited in Ramnarain & Hlatswayo, 2018). It also contributes to the development of conceptual understanding in Science (Leonor, 2015). Thus, inquiry-based instruction enhances conceptual understanding of learners and improves their reasoning ability. Scientific inquiry, normally helps in the development of higher-order thinking skills such as analysis, synthesis, critical thinking and evaluation (Conklin, 2012). This provides the means of better understanding of Nature of Science (NOS).

Most Africa countries especially Ghana, still use the traditional direct instruction which focuses on mastery of content with less emphasis on the development of scientific skills and attitudes during science instruction (Acquah, 2019) even after the introduction of inquiry-based instruction into the new Standardized Science

Curriculum as an emerging pedagogy for science learning (National Council for Curriculum and Assessment [NaCCA], 2019). The effectiveness of IBI especially in the teaching of Science has therefore been recommended by the Ministry of Education (MoE) to design and implement the new Standardized Based Curriculum to be used at all levels of schools.

According to Eyong (2020), Science teachers use of inquiry-based instruction always comes with lapses as a result of teachers' perception, lack of knowledge or refusal to shift to new methods of teaching Science which they are not comfortable with. Long and Bae (2018), affirmed this in their study which showed that basic school science teachers were not knowledgeable when it comes to inquiry-based instruction to put theory in action. This implies that, they lacked sufficient pedagogical and content knowledge necessary to implement inquiry-based instruction. Though they have positive belief of inquiry, it is hardly practiced in the classroom, hence a mismatch between their beliefs and practice.

A caution by Miranda and Damico (2015) indicates that, teachers need to have enough content knowledge so that inquiry-based instruction can be effective. Science teachers' belief and practice may constrain their ability to enact Inquiry-Based Instruction (IBI) hence curriculum developers need to take into account teachers' knowledge and their sociocultural factors when designing the curriculum (Mansour, 2010). This is because teacher's curriculum knowledge affects their classroom practice (Ampiah, 2015) yet these are not done in many African countries where Ghana is no exception.

Despite positive benefits of using inquiry in Science teaching and learning, several drawbacks impede its implementation. For instance, a study by Bogar (2019), showed that most Science teachers are of the view that using IBI involves lots of hands-on-activities which requires much time but the time allotted for teaching Science is limited with the teacher playing the role of a facilitator. He continued to argue that science teachers find it difficult in channeling, communicating and maintaining learners' interest as they engage in inquiry activities which is an indication of unpreparedness among those teachers for the social demand of inquiry-based teaching.

According to Sijali Magar (2023), inadequate knowledge and experience of inquiry impedes its implementation as many teachers do not holistically understand what inquiry really entails and few who does attribute it to mean hands-on learning (Capps & Crawford 2012). All these demands are what pushed most teachers away from the implementation of IBI, hence the urge to use the traditional direct approach to teach Science by most teachers.

Again, the annual Chief Examiners report for Science, has recounted poor performance of student with few average and outstanding performances (Chief Examiners Report [CER], 2019-2021). The Chief Examiner therefore, suggested that the teaching and learning of Science should be taken seriously and recommended teachers engage learners in lots of practical activities through inquiry-based instruction to enhance learner's comprehension of Science concepts (CER, 2021).

Against this backdrop, there appears to be much focus on teaching Science by inquiry at the higher levels than the lower level in Ghanaian basic schools resulting in a gap between lower-level teachers' perception and actual practices in the classroom. This gap has necessitated the need to assess lower primary teachers' perception and practice of inquiry-based instruction in the Effutu Municipality.

1.2 Statement of the Problem

Research has proven that inquiry-based instruction contributes to learners' ability to study efficiently. This is because it allows learners to explore scientific issues mean fully through their own life experiences. This notion is supported by Eley (2022) who posits that, inquiry-based instruction serves as a link between the leaners and the learning process where the teacher does not only plan the inquiry but also plans how it ends. This gives the learner the opportunity to reason and think critically to evaluate scientific problems to bring results.

According to Ramnarian and Hlatswayo (2018), teachers hold positive attitudes of inquiry in the teaching and learning of Science and recognised some benefits of it as, supporting learners to better understand Science concepts that are abstract and motivates learners. It also helps build curiosity in learners, develop lifelong learning, critical and higher-order thinking skills and learners becoming problem solvers (Subba et al. 2019) among many others. However, despite these benefits of inquiry-based instruction, it seems to be less enacted during science lessons.

Despite these values of inquiry-based instruction to the learning of Science, there seems to be many challenges for many science teachers to implement inquiry-based instruction. For instance, at the international front, Baroudi and Rodian Helder (2021) made it clear that factors such as low quality of professional development and lack of time for lesson preparation impedes IBSI implementation. Also, Gray (2021) added that, difficulties in classroom management complicate the process of inquiry-based science instruction implementation for teachers. Similarly, Gholam (2019), mentions lack of background knowledge in content and pedagogy on the part of teachers to implement IBI.

This problem is not exceptional in the Ghanaian context where science teachers find IBI implementation challenging or even avoid the use of IBI in the teaching and learning of science concepts. They rather tend to rely more on teacher-centred approach to teaching of science. This was evident in Acquah's (2019) and Ampiah's, (2010) studies, where they pointed out teachers' use of teacher-centered approach to the teaching of Science in schools. Supporting Acquah (2019) and Ampiah (2010), Ngman-Wara et al. (2015) and Ngman-Wara and Acquah (2019) emphasise that teacher's notion of relying on teachers-centered approach to teaching Science is on acquisition of scientific knowledge and skills.

Apart from this, teachers hold many perceptions in relying on the traditional or teacher approach. A case in point is Effutu Municipality where most Science teachers at the lower primary level still use the traditional approach to teaching science. Teachers' perceptions are that, learners at this level are very young and know nothing hence a waste of time to allow them to construct their own knowledge and envisage the difficulties that comes with IBSI which they thought would be cumbersome for learners and even thinks are a waste of time to engage learners in IBSI.

If science teachers are not teaching Science using inquiry-based science instruction, we wouldn't find solutions to our problems hence the problem of producing learners who are not scientifically inclined would still exist which becomes a challenge. There is the need to solve scientific problems in the society and if learners are taught Science using inquiry to assist them find solutions to theses problems, then we are improving. However, if they are only able to solve head-knowledge questions but have difficulty solving problems when the focus is shifted to application where they would have to use their knowledge gained during IBSI to solve problems, then there is a problem with the implementation.

If this problem persists, learners would continue to fail in Science causing them to lose interest in the subject which may lead to refusal to pursue it at higher levels hence the need to assess how teachers perceive IBSI, how they practice it in the classroom and the challenges in its implementation especially at the lower primary level as this is the fundamental stage that will determine learners progress in Science and interest at higher levels.

It is based on this that, the NaCCA along with the Ministry of Education (MoE) designed and implemented the new standardized science curriculum based on inquiry**,** to assist science teachers practice and create that inquiry environment as facilitators to help learners construct knowledge on their own with ease. Various workshops on the curriculum and seminars such as Ghana Accountability for Learning Outcomes Project (GALOP), Common Core Programme (CCP), Science Technology Engineering and Mathematics (STEM), as well as resource packs to aid in lesson delivery have been organised to enlighten teachers on the concept of IBI, its effectiveness and the need for its implementation yet to no avail.

Many studies have looked into IBI in Ghanaian schools involving science teachers in relation to their beliefs and attitudes (Adofo, 2017), extent of the implementation of IBI in Junior High School (JHS) (Mohammed et al. 2020) and knowledge and practices in Upper Primary (Mensah, 2018). Despite numerous studies that have looked into the teaching of Science in Ghanaian schools involving lower primary teachers (Ngman-Wara et al. 2015; Amo-Darko,2017), very little studies have been done in the Effutu Municipality as teachers in this locality do not have the enthusiasms to use IBI.

1.3 Purpose of the Study

The purpose of this study was to assess lower primary teachers' perceptions and practices of inquiry-based science instruction in the Effutu Municipality in the Central Region of Ghana.

1.4 Objectives of the Study

The following objectives were developed to guide the study;

1. Determine lower primary teachers' perception of inquiry-based science instruction in the Effutu Municipality.
2. Ascertain lower primary teachers' classroom practice of inquiry-based science instruction in the Effutu Municipality.
3. Examine the relationship between lower primary teachers' perception and practice of inquiry-based science instruction in the Effutu Municipality.
4. Explore the challenges faced by lower primary teachers in the implementation of inquiry-based science teaching in Effutu Municipality.

1.5 Research Questions

The following research questions were raised;

1. What are lower primary teachers' perceptions of inquiry-based science instruction in the Effutu Municipality?
2. What practices do lower primary teachers engage in the classroom as a way of practicing inquiry-based science instruction in the Effutu Municipality?

3. What is the relationship between lower primary teachers' perceptions and practices of inquiry-based science instruction in the Effutu Municipality?
4. What challenges do lower primary teachers face in the implementation of inquiry-based science instruction in the Effutu Municipality?

1.6 Research Hypothesis

H_0: There is no statistically significant relation between lower primary teachers' perceptions and their practices of inquiry-based science instruction in the Effutu Municipality.

H_1: There is statistically significant relation between lower primary teachers' perceptions and their practices of inquiry-based science instruction in the Effutu Municipality.

1.7 Significance of the Study

This study will be useful to teachers, educators, curriculum developers and educational researchers who showed interest in constructivism and science inquiry in basic education. It will also contribute information on how lower primary teachers perceive and practice inquiry-based instruction during Science instruction in the Effutu Municipality in the Central Region of Ghana. The study can be used by curriculum developers to design a comprehensive framework to improve science instruction in basic schools in Ghana which will serve as a guide to future educational policies necessary to improve science teaching in Ghana and the world at large.

The study would also bring to light science teachers' current perception towards the implementation of the Science curriculum. This will inform Science curriculum planners to know if the content in the Science curriculum has helped to achieve this purpose or not and if there is the need to put in place strategies and measures to address the implementation of it. The study would also highlight challenges lower primary teachers face in their practice of inquiry-based instruction in the Effutu Municipality as well as recommendations. It will in turn inform them on rectifying these challenges in the designing and implementing of the science curriculum. Findings from the research can also be used by organizations for in-service training and workshops for teachers in the use of inquiry-based instruction to gain both content and pedagogical knowledge of the approach in order to implement it with ease.

The study will also inform educational leaders and policy makers on the improvement of inquiry-based professional development programs for basic school level Science especially for lower primary teachers to serve them and reform the science curriculum. Science educators who want to implement professional development programs for science teachers in the basic schools from the study will gain deeper understanding in doing so. The study in all will serve as a reference material for others who would want to conduct similar research.

1.8 Delimitation of the Study

The study was focused on only lower primary teachers' perceptions and practices of inquiry-based instruction in the teaching of Science. The findings from this study mainly reflected on situations in the Effutu Municipality in the Central Region of Ghana hence was delimited to this particular Municipality. As a result, the findings thereof may not be considered a reflective of all lower primary science teachers in Ghana.

1.9 Limitations of the Study

The latent limitation or weakness identified for the study was the small sample size, which reduces generalizability to other contexts other than the Effutu Municipality. The reliance on personal report and the sole focus on lower primary teachers' perceptions and practices of inquiry-based science instruction in their classrooms which is the recommended strategy from the curriculum.

Some of the teachers hesitated to provide very candid evidence in response to their perceptions and practices especially if they were sure that the study was meant to provide them with more information and materials on their perceptions and their practices of inquiry-based instruction.

1.10 Organization of the Study

This study was organised into five chapters. Chapter One comprised of the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, delimitation of the study, limitation and organization of the study. Chapter Two was about the literature review. It looked at the theoretical framework and review of relevant literature on topics related to subject under study. Chapter Three covered the methodology employed in the study. This captured the research paradigm or the philosophical underpinning of the study, the research approach, the research design, the population, sample and sampling techniques, the research instruments, validity and reliability, the setting of the study, ethical considerations, data collection procedures, and data analysis procedure. Chapter Four focused on the data analysis; discussions of findings; and presentation. Chapter Five dealt with the summary of the findings, conclusions, and recommendations of the study as well as suggestions for further studies.

CHAPTER TWO

REVIEW OF RELATED 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 theory and the cognitive theory; teachers' perception about inquiry-based instruction; teachers' practice inquiry-based instruction; relationship between teachers' perceptions and practices of inquiry-based instruction, challenges lower primary teachers' face in the implementation of inquiry-based science instruction, conceptual framework, and summary of literature review.

2.1 Theoretical Framework

The theoretical framework of the study is based on the constructivist theory of learning and the cognitive learning theory.

2.1.1 Constructivist Theory.

The constructivist theory fundamentally hinges on the efforts of Piaget's cognitive theory of learning. Piaget's (1967) constructivism theory posits that children learn by constructing their 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. The 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 those 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. The 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 assess the issues related to current teaching and learning of science and the implementation of inquiry-based instruction by teachers at the lower primary level in the Effutu Municipality. It is important to emphasis 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 lower primary science teaching by investigating teachers' knowledge and practice of inquiry-based instruction in the Effutu Municipality.

2.1.2 Theory of Cognitive Development

Piaget (1967), was a Swiss philosopher and well known for his theory of cognitive development. According to him, people construct their own understanding and knowledge of the world, through material experiences and reflecting on those experiences. When someone encounters something new, he or she has to reconcile it with his previous ideas and experience, maybe changing what he or she believes, or maybe discarding the new information as irrelevant. In any case, the learner is an active creator of his own knowledge. He believed that intelligence organises the world by organizing itself (Piaget, 1977).

The cognitive development proceeds through assimilation, accommodation and equilibration. In the process external events are assimilated into thoughts and, on the other, new and unusual mental structures are accommodated into the mental environment. Finally, the learner develops equilibration between himself and the environment. The process of assimilation, accommodation and the equilibration repeat when the equilibrium of the learner breaks.

He also described the four different stages in child development. Each stage has its own separate role in child development:

- Sensorimotor - birth to 2 years: at this age the child is extremely egocentric and they experience through the six senses,
- Preoperational - 2 years to 7 years; At this stage the child starts his magical thinking,

- Concrete operational - 7 years to 11 years; the child begins his logical thinking, and
- Formal operational (abstract thinking) - 11 years and up.

Besides, he advocated that through cooperate learning, formal instruction by expert adults is less effective as a cognitive development stimulus than is a peer-mediated instruction.

Piaget believed in authentic learning and his focus was always on cognitive development. According to him, the learner is motivated, and gets more interested when he has the authority of the problem. He suggested considering the learner's age as one of the important factors in the learning process which he explained in the developmental stage. Overall, taking into account from the Piaget's perspectives of learning, it can be said that the inquiry approach is highly influenced by his philosophy since it embodies key features of inquiry-based instruction (cooperate learning, authentic learning, authority on the problem and process, teacher role as facilitator). He gave importance to social and cultural aspects of learning, but his research stressed more on individual cognitive processes.

2.2 The Concept of Inquiry-Based Instruction

Inquiry-based teaching and learning originated from the constructivist approach suggested by Dewey (1938). He argued that people learn when they seek answers to questions that matters to them which implies that inquiry-based learning is related to experiential learning where knowledge is constructed by learners who make sense of their daily lives (Yilmaz, 2008)

According to Constantinou et al., (2018), inquiry-based instruction is the process of actively engaging students in the learning process with an emphasis on supporting knowledge claims with observations, experiences, or complementary sources of credible evidence; tackling of authentic and problem-based learning activities; consistent practice and development of the skills of systematic observation, questioning, planning, and recording with a purpose to obtain IBSE has sometimes been interpreted incorrectly as a teaching strategy for better engaging students or as a scaffolding structure for constructing learning environments.

According to Sullivan (2017), inquiry-based science instruction is simply using hands-on activities to teach kids so they can investigate scientific ideas, as well as instruction where the emphasis is on applying process skills to learn. Teachers help students use an analytical approach to comprehend their environment and create new knowledge by employing an inquiry-based teaching method. The prerequisites for conducting an inquiry are recognizing presumptions, using analytical and critical thinking, and considering alternate answers. Students engage in a variety of activities in their chosen fields of inquiry to gain an understanding of the methods scientists use to understand the natural world. Through these activities, it is hoped that students will acquire the necessary abilities for handling comprehensive inquiries independently.

Inter Academy Panel [IAP] (2012), sees inquiry-based instruction as a progressive evolution of students' key scientific ideas as they pick up the right investigative techniques and successfully broaden both their knowledge and understanding of the natural world. Typically, students use the techniques employed by scientists, such as asking questions, gathering data, analyzing and reviewing the evidence using what is already known, drawing conclusions, and debating the findings. The teaching activities and its justifications are supportive of learning when they are inquiry-based (IAP, 2012). A variety of educational techniques known as inquiry-based learning are linked at a convergence location where students go to investigate and seek solutions to issues and answers to questions.

There are various stages in organizing inquiry-based instruction, including problem diagnosis, experiment analysis, alternative determination, investigation planning, hypothesis creation, information exploration, model construction, peer discussion, and argumentation (Linn, Davis, & Bell, 2004). Using inquiry in the classroom requires some key concepts, which Minner, Levy, and Century (2010) outline. The inclusion of science information is essential, as are student engagement with the subject matter, student responsibility for learning, student critical thinking, student-driven questions, experiment design, data collection, and conclusion and communication. Scientific inquiry places a strong emphasis on people's capacity for problem-solving, method of learning scientific information, and capacity for critical and logical thought. According to social constructivism, scientific inquiry places an emphasis on discussion, reporting, deliberation, and debate (Keys & Bryan, 2001). To foster knowledge and accomplish the goals of the course, teachers must encourage students to practice these abilities.

In inquiry learning, students are no longer passive recipients of knowledge (Anderson, 2002), but rather self-regulated learners charged with taking control of the learning process (Grandy & Duschl, 2007). Teachers respond swiftly to support students who are having trouble while also assisting those who are progressing well with their investigations by asking questions that will facilitate good learning. Teachers value both the contributions of their students and their errors. The use of students' rational thought and practical knowledge serves as a learning scaffold. Everyone in the class is engaged, which motivates them to put a lot of effort toward the stated objective.

It should be noted that inquiry-based curricula are dynamic in nature, portraying science as a continuing process of exploration and discovery rather than a subject domain to be remembered (Brigham, Scruggs, & Mastropieri, 2011). Teaching Science is often equated to preparing students to cope with challenges of their lives (Shamsudin, et al. 2013). Most science subjects necessitate inquiry-based training because it involves students in the exploratory aspect of science, allowing for greater knowledge.

As such science education should provide students with opportunities to reflect on how science as a subject helps promote their general understanding of society and contribute to the development of the higher order critical thinking skills in a diverse population of learners. Learners are expected to actively participate in the learning process using their hands and minds. It is for these reasons and majority more that the use of inquiry-based instruction is of majority importance if a nation is ready to help its young learners develop their potentials to the best of their abilities and also develop their diverse brains to help in the building of the nation.

2.3 Features of Inquiry-Based Instruction

Teachers promote students' learning by acting as facilitators during the inquiry process. To determine the ensuing learning needs and curiosity for knowledge production, students must instead use their own methods of inquiry based on experience and knowledge (Kahn & O'Rourke, 2005). According to Kahn and O'Rourke (2005) and Ng (2006), students will be expected to analyse, present, and present their ideas either collectively or separately with the assistance of others while also making reasoned judgments. Cooperative learning, authentic learning, the authority of the topic and process, and the teacher's facilitative role are a few characteristics of inquiry-based education. The following explains these.

2.3.1 Cooperative Learning

Inquiry-based learning has been thought to benefit greatly from cooperative learning. Working in groups encourages students to support one another and advances each student's cognitive growth. Students gain a new perspective on a single subject, and interacting with students their own age helps them gain confidence. Students should connect with one another, share their ideas and findings, and be willing to accept the findings of others in order for group learning to be successful. In other words, a student needs to come up with a justification for their perspective before they can present it in a group.

This motivates the learner to investigate, create, justify, and discuss the findings in order to reach a clear conclusion. Reviewers of the cooperative learning literature have long come to the conclusion that organizations that are acknowledged or rewarded based on the individual learning of their members benefit from cooperative learning most (Slavin 1996). In addition, collaboration exposes students to disciplinary language, beliefs, and methods of knowing, according to Goodrum, Hackling, and Rennie (2001). Students must clearly express their thoughts in conversation while also taking into account and utilizing the knowledge of others. In inquiry-based learning, group activities where each student completes a separate assignment and the group produces the final output should be promoted.

2.3.2 Authentic Learning

Authentic learning is an educational strategy that allows students to investigate, discuss, and meaningfully develop concepts and relationships in situations including real-world problems and projects relevant to the learner. Learning through activity and experiencing the actual world, in other words, authentic learning can be defined as building skills through real-world activity that will be useful in future situations. Linn et al. (2004) define inquiry as "the intention of diagnosing problems and critiquing experiments.

In inquiry-based learning, students identify a problem and plan an activity in a real-world environment based on their personal experience. The learner is not only surprised and inspired by this real-world context learning, but things also start to make more sense than merely what the teacher or the books are saying. Students may perform complex, expensive, and difficult science experiments in the classroom using computer programming, which allows for more authentic learning. Field visits are a staple of inquiry-based learning and support students' exploration of science in a practical setting.

2.3.3 Authority of the problem and process

In inquiry-based learning, the learner is free to select both the method and the final output. This inspires the student and makes them accountable for the issue. Today's scientific and technological age demands critical thinkers rather than mere followers. Students feel a feeling of urgency and responsibility for their learning when they are given the opportunity to participate in the entire learning process (Ryan & Deci, 2000). This method encourages higher student involvement and intrinsic motivation. In inquiry-based learning, the learner is free to select both the method and the final output. This inspires the student and makes them accountable for the issue. Today's scientific and technological age demands critical thinkers rather than mere followers. Students feel a feeling of urgency and responsibility for their learning when they are given the opportunity to participate in the entire learning process (Ryan & Deci, 2000).

This method encourages higher student involvement and intrinsic motivation. The learner gains the self-assurance to ask insightful questions, uncover answers, confer with professionals, and even express inferences as a result of this control over the issue. This not only boosts their drive to become a scientist but also helps them get more self-confidence. This corroborates the claim made by Friesen and Scott (2013) that inquiry-based learning enables students to become more proficient in the scientific method.

2.3.4 Teacher's Role in inquiry-based Instruction

In the inquiry process, a teacher's job is to assist the student's exploration. Zone of Proximal Development (ZPD) by Vygotsky (1978) is the term used to describe the extent to which children can succeed with the help of a teacher. The student and the learning process are strongly connected by the teacher. The teacher not only organises the investigation but also how it will conclude with a worthwhile experience that will be useful in the future. What is vital to consider is what causes the kids' conceptual development. Similar to any other learning theory used in inquiry-based teaching, teachers design their classes with an eye toward how students will build their knowledge rather than how they can transmit it to them. Inquiry-based teaching places a high value on past knowledge and student curiosity while creating any new knowledge.

2.4 Inquiry-based science instructional cyclic model

In its 2000 report, the National Research Council (NRC) outlines the five components of successful inquiry-based learning experiences. Now, these components are; learner engages in scientifically oriented questions, learner gives priority to evidence in responding to questions, learner formulates explanations from evidence, learner connects explanations to scientific knowledge, learner communicates and justifies explanations. These areas are covered below.

2.4.1 Learner engages in scientifically oriented questions

Students must be encouraged to consider scientifically oriented questions that are connected to the curriculum in order for inquiry-based science instruction to be effective (NRC, 2000). Only those elements of natural works—items, creatures, events—that relate to scientific ideas covered in the science syllabus should be the focus of the query. The issue ought to be amenable to empirical research that explains scientific occurrences. Inquiry questions should focus on "how" rather than "why," and they shouldn't be overly complex or challenging. The question ought to be suitable for the learners' age. In an inquiry-based classroom, the instructor will often ask more introspective questions.

Bybee, et al. (2006) warn that the knowledge and procedures students use to answer the question must be accessible and manageable as well as appropriate to the pupil's developmental levels, stressing the importance of teachers' abilities to guide the selection of the question. This implies that effective questioning strategies are crucial in a classroom that emphasizes inquiry, particularly in the lower grades when guided inquiry serves as a foundation for later, self-initiated asking. Learning by inquiry is centered on asking questions, whether they are self-initiated or posed by others.

Although questions are present in a regular classroom, their origin, goal, and difficulty level are all very different. In a traditional classroom, the teacher is frequently the one who asks the questions, and the goal of such questions is frequently to determine whether or not the pupils have understood and retained a certain concept.

2.4.2 Learner gives priority to evidence in responding to questions

According to NRC (2000), science sets itself apart from other forms of knowledge by using actual data as the foundation for its explanations of how the natural world functions (Bybee, 2000). During this phase of inquiry-based instruction, students use their senses and devices to collect data from observations and measurements made in natural environments in order to support their claims (NRC, 2000). Repeated actions are used to verify accuracy. Bybee et al. (2006) claim that in the classroom, students use evidence to create an explanation for scientific events. Students should be given the chance to engage in inquiry rather than merely study it. Participation in experiments by students alters myths, individual convictions, religious ideals, mystical inspiration, superstition, and authorities that may be socially and personally beneficial but are not scientific.

2.4.3 Learner formulates explanations from evidence

According to Bybee et al. (2006), explanations are a tool students use to connect what they see to what they already know. Although this stage may resemble the one before it, it differs from it in that it places more emphasis on the process of moving from evidence to explanation than on the standards and properties of the evidence. Students in inquiry-based learning construct explanations using their past knowledge. The evidence gathered should provide an explanation for the new knowledge that was learned. The explanation should be based on logic, which has a known connection to reason, and be consistent with experiments and other types of data concerning nature. Bybee et al, the explanation should follow the standards of evidence, be accessible to scrutiny, and necessitate the employment of several cognitive and affective processes connected to science. It indicates that the explanation should go beyond the student's current understanding and suggest a new understanding.

2.4.4 Learner connects explanations to scientific knowledge

Making sure that students relate their findings to scientific information relevant to their level is a key component of this step. In order for students to compare their answers with competing ones and inquire about any abnormalities, however, students' explanations must be in line with current scientific knowledge. Evaluation and examination of the explanation are crucial for accomplishing this. The students should continue to ask these questions:

- Can the solution better be provided by the explanation?
- Does the explanation corroborate the information gathered?
- Can the evidence support a different theory?

2.4.5 Learner communicates and justifies explanations

The last element of an effective inquiry-based learning experience is communication. Other students might use the stage's skeptical assessment of the findings and methods when scientists present their findings to the class. Scientists disseminate their results so that others might duplicate their study and apply the findings. Students must also discuss and argue their conclusions and justifications with others. The students are required to express precise questions, steps, supporting details, and recommended explanations. Other students have the chance to challenge, review the facts, spot fallacious thinking, and offer alternate interpretations. In the end, students use the stage to clarify ambiguities and support an empirically supported thesis. Figure. 1 below shows inquiry-based instructional cyclic model of the learning stages

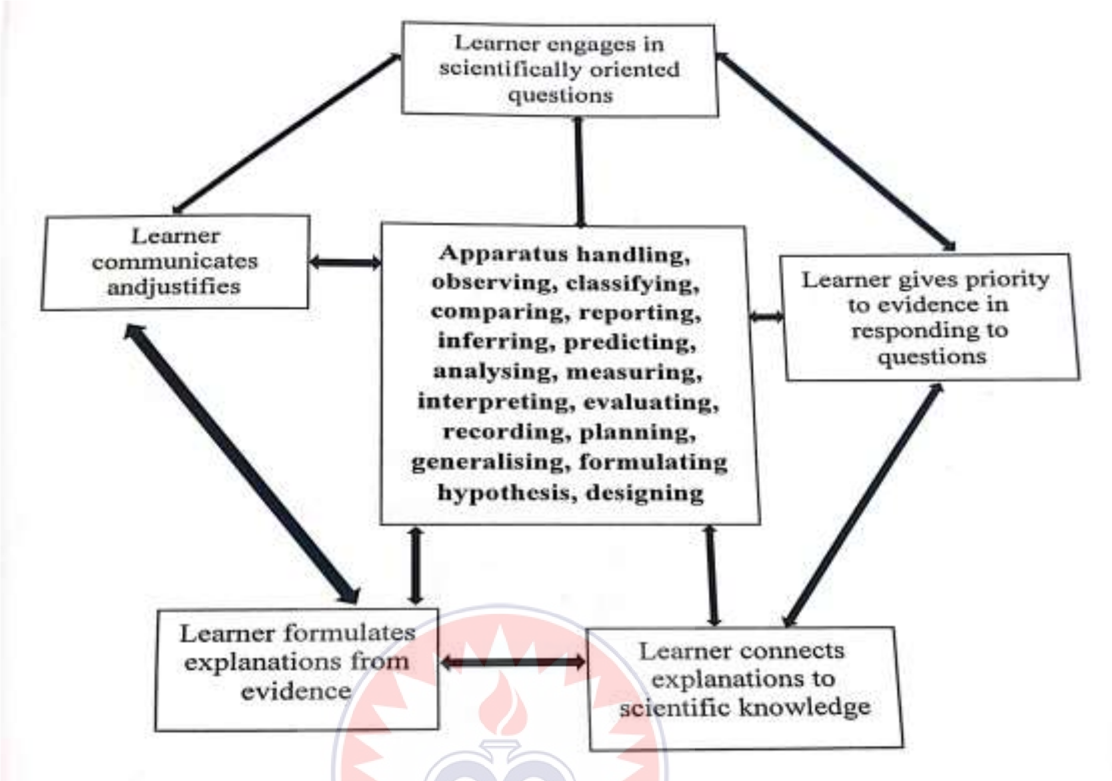


Figure 1: Inquiry-Based Instructional Model

The square is a representation of the process skills that students who participate in inquiry-based science training must learn. The stages have been divided for clarification purposes only; they are not recognized as independent entities. The interconnectedness of the stages is shown by the long arrows connecting the little rectangles. The learner may return to the earlier step to retry it if they are unsuccessful at one stage. The arrows connecting the rectangles to the square imply that the learner is free to apply any of the process skills in the square for a successful completion of each stage of the learning process.

2.5 The 5E model of inquiry-based instruction cyclic model

As previously said, inquiry-based instruction is versatile for science teachers to adopt because it is available in a variety of forms. From a different angle, some researchers utilize 5Es learning cycling to implement inquiry-based instruction (Fig. 2). According to modern learning theories, students should enter learning situations knowing something about and having an explanation for their surroundings (Flick & Lederman, 2006; Bybee, 2000).

Students cannot just read, memorize, and recite isolated bits of knowledge if they are to understand science and build valuable abilities. Meaningful learning does, in fact, require time. Each 5E lesson model is built on an inquiry-based approach to science and includes practical activities to engage a variety of students. The five Es are used throughout the module's science lessons, as shown in the paragraphs that follow. Figure 2. shows the cyclic model of the 5E

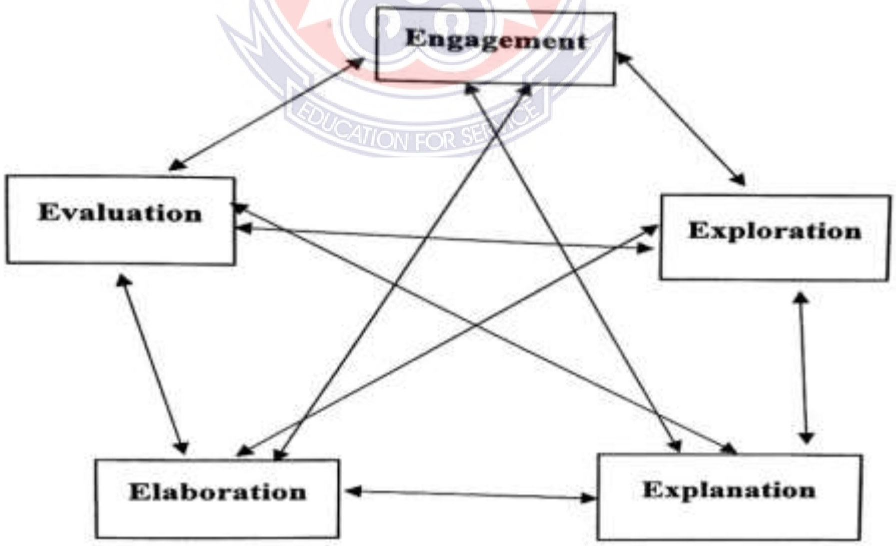


Figure 2: 5 E cyclical model for inquiry-based instruction

The goal of the 5Es approach is to encourage sequential learning experiences that provide students the chance to gradually build their conceptual understanding. The researcher has changed it as seen in Fig. 2 above. Engagement is followed by investigation, explanation, elaboration, and evaluation in the module. It has been realized that science training should use a procedural approach that is participatory, dynamic, and adaptable. This implies that the model's various stages can have an impact on one another. For instance, a learner in the discovery stage can still analyse the process and describe it. The way the module is set up, it is a backward and forward process. The small arrows show how interactive the module could be utilized in scientific instruction while the bold arrows show the standard 5Es method. However, the model's steps are described in more detail below:

2.5.1 Engagement

The learner accesses and creates connections with prior knowledge and experiences at this stage, which piques their curiosity and motivates them to read, write, draw, analyse, and follow the what-to-know, what-you-want, and what-you-have-learned principle (KWL), demonstrate, and brainstorm. In order to find out what the students know or think about the subject or issue, the instructor helps the students develop interest, curiosity, and answers to questions.

2.5.2 Exploration

In order to satiate their interest in the topic they have chosen to learn, students must now explore the natural world. Students should have the freedom to think as they choose within the parameters of the activity. Students are encouraged to forecast, formulate hypotheses, conduct experiments, record observable concepts, and discuss their findings at this stage. At this point, it is the teacher's responsibility to serve as a facilitator and encourage students to collaborate without excessive adult supervision. When required, the science teacher should watch and listen to the students while also asking them pointed questions to refocus their research. It's crucial to give students enough time to solve difficulties. In a nutshell, this stage fulfills students' curiosity by providing basic knowledge and allowing them to explore natural phenomena through self-directed teaching. Students also conduct investigations, study reliable sources to gather information, build models, and conduct investigations.

2.5.3 Explanation

At this point, more abstract concepts are introduced and described. The definition and introduction of new terminology related to the notion. Students analyse and provide evidence for their arguments. Thinking abilities like comparing, classifying, and mistake analysis is crucial to the implementation of this step. The description and explanation of the concept they have chosen should be obtained by the students via a variety of informational resources, group discussions, and teacher engagement. Students should refer back to earlier activities when a difficulty or misunderstanding arises. Science instructors should help students explain terms and definitions while looking for rationale and clarity. Students should be encouraged by their science teachers to explain new ideas using examples from their prior experiences.

2.5.4 Expansion/Extension/Elaboration

Bybee (2000) asserts that expansion/extension/elaboration stage requires pupils to broaden and apply their conceptual knowledge in a fresh setting. The students find methods to build on what they have studied and apply their newly acquired knowledge to other but related circumstances. They might extend their comprehension of the idea to different subject matters. They thoroughly evaluate concepts and look for more connections. Students should assess how well their peers understand the idea. Real-world situations should be included in the connection. The science instructor must anticipate that students will expand their concepts and abilities in new contexts by using formal labels, definitions, and explanations, as well as prior knowledge.

2.5.5 Evaluation

In the evaluation phase of inquiry-based science training, students are encouraged to evaluate their knowledge and skills. Additionally, it allows the science teacher to assess how well the students are doing in relation to the learning objectives. Techniques for formative and summative evaluation are both used to gauge how well students comprehend topics and abilities. A tool or rubric should be created by the science teacher to evaluate student work. The numerous assessment strategies that can be used to gauge students' conceptual understanding include selected responses, extended or open-constructed responses, performance evaluations, journals, concept maps, portfolios, observational frameworks, and projects. Regardless of the techniques employed, the science teacher must watch the students as they apply new knowledge and abilities and seek signs that they have altered their behavior or way of thinking (Bybee, 2000). It is important to let students evaluate their own learning results.

2.6 Creative inquiry-based instruction Model

The creative inquiry-based model put forth by Milne (2008) is shown in Table 1. The model is a revision of Bybee's (2000) 5E inquiry-based cycle. By describing the relevant phenomena, the focus is on exploring aesthetic perceptions and the accompanying desire. The final stage of "further investigation," in which students are encouraged to consider revisiting or expanding their inquiries, is a crucial component of the approach. The creative inquiry-based instructional model is displayed in the table.

Table 1: Creative Exploration Model Sequential Elements for Inquiry-Based Instruction

Creative Exploration		
Explore	A problem, situation, phenomenon, artefact, model, event, story	Wonder
Observe	What is happening? What changes happened? What material involved? What are the main parts, What are the key aspects, What do these parts /structure do?	Wonder about
Identify evidence	What is the cause and effect of changes? What is the function? What parts are interacting with other parts? What are the outcomes of these interactions? What trends and patterns keep occurring?	
Create explanations	Personal explanations supported evidence are created and processes by them are planned test	
Investigate	Find out, measure, verify, test clarify, identify compare,	
Evaluation	A self-evaluation of these investigations may lead to new or modified explanations, doubts about existing ideas or tentative conclusion. These tentative explanations need to be communicated to others for peer evaluation and feedback.	Wonder at
Further investigation	Evaluated explanations can lead to re-exploration, seeking further explanation, leading to further investigation.	Wonder Whether

2.7 Inquiry-based Concept / "big idea" Attainment Model

The idea or Big Idea Attainment model is another inquiry-based science teaching strategy. It is a model of instruction appropriate for teaching ideas having a number of characteristics. In science, a big concept has a name, a definition, instances, and qualities or characteristics. According to Lemlech (2010), the primary focus of using this paradigm is to ensure that abstract ideas, concepts, or big ideas are generated by classifying data into observable categories. However, according to Spencer and Walker (2012), the biggest problem with using this methodology is letting students develop their own definitions and understanding. Utilizing this methodology necessitates good science teacher preparation.

It is obvious that science teachers must first identify a concept's key components and create a list of examples, both favorable and unfavorable, that best demonstrate the notion. The science teacher should briefly explain to the students how they would construct the "mystery" based on the terms being supplied at the start of the inquiry attainment concept session. The science teacher explains the concept or key principle and provides examples and counterexamples. The scientific teacher logs the students' educated predictions in the "hypotheses". The science teacher reminds the students of their hypotheses as the procedure goes along and crosses out the appropriate concept material. This will make it easier to validate and support their answers.

Students are given the chance to observe, categorize, analyse, reason logically about a subject, and use the evidence to support their assumptions using the model. Given the significance of the hypothesis in an inquiry-based learning process, an effort should be made to distinguish between the two. According to Bybee (2011), a prediction is a declaration of the precise outcome of an experiment, but a hypothesis is a generalization that can be utilized to direct the investigation. Students should be permitted to test their hypotheses and compare the predictions in order to reinforce the concept's definition as the science teacher assists students in developing concept labels and definitions by focusing on positive examples. In order for the entire class to comprehend how they arrived at the definition, the science teacher and students discuss their aims, techniques, and discoveries in the concluding phase of the course (Lemlech, 2010).

To increase students' interest and enthusiasm for science in elementary school, inquiry-based learning methodologies are essential. The methodology links science to students' daily lives and fosters and increases their innate interest and motivation for learning. It aids students in creating fresh scientific discoveries and gaining a deeper knowledge of scientific principles. When creating learning activities, the science teacher should keep in mind the four significant outcomes of inquiry-based instruction. Regardless of the model used, the science teacher should follow the following learning objectives, as mentioned in the explanation of the models:

- Information processing abilities
- mental routines, or "ground rules,"
- content comprehension, and
- Conceptual understanding.

Science teachers will interpret and alter the theoretical conception of inquiry-based science instruction on students' prior beliefs, capabilities, experiences, and other factors as both the target and agents of change.

Despite the curriculum's prescription, there are a variety of elements influencing the effectiveness of inquiry-based education in the scientific classroom, according to the portraits of inquiry-based practices that emerged from classroom studies (Abell, 1999). However, without taking a closer look at the scientific instructors' views and expertise of both the subject matter and methodology, it would be impossible to improve their classroom practices of inquiry-based instruction. Once more, a mapping of the inquiry-based classroom approaches used by scientific instructors should be linked to their views, subject matter expertise, and other factors that affect how they choose to teach.

2.8 Teachers' Perception of Inquiry-Based Instruction

Implementing inquiry-based instruction (IBI) in science is a complex process demanding certain classroom conditions prepared with instructional materials to engage students in tasks, as well as adopting the social context that will shape the inquiry-based learning environment. Within this social context, teachers are the main agents who ensure successful inquiry-based implementation because their beliefs and perceptions significantly influence their practices within the classroom (Baroudi & Rodjan Helder, 2021). This section explores teachers' perception of inquiry-based instruction.

Science teachers have divergent views about what IBI is. some teachers view inquiry as a process, and not a vehicle of learning science contents (Assay & Orgill, 2010). In regard to teachers' knowledge, one important area of study is what the teachers know and how their knowing is expressed in their teaching. Eick and Reed (2002) and Luchmann (2007) affirmed this, when they highlighted in their studies that the prior learning or knowledge of some teachers affected their understanding of IBI. Keys (2006) stated that teachers' perception is described by the body of knowledge that comprises teachers' belief as well as five aspects of knowledge;

- Teachers' craft knowledge
- Teachers' practical knowledge
- Teachers' practical theories
- Teachers' personal pedagogical knowledge and

- Teachers' pedagogical content knowledge.

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 or 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 or perception 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.

Divergent views about what IBI is 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:

- the experience-centered conceptions in which teachers focused on providing interesting sensory experiences to students,
- the problem-centered conception in which teachers focused on engaging students with challenging problems, and
- the question-centered conception in which teachers focused on helping students ask and answer their questions.

Another tension highlighted in this review is the 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, 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.

Another study by Twahirwa, Ntivuguruzwa, Wizeyimana, and Nyirahagenimana, (2022) on 'Teachers' Perceptions of Inquiry-based instruction in Science Education' indicated that, most of the study participants either agreed or strongly agreed with the statements, which shows the usefulness of IBI in classroom practices. This study indicates that the inquiry-based instruction approach is of paramount importance in teaching and learning sciences. This is because all procedures followed during the implementation of IBL are centered on the learner and the teacher is considered as the facilitator during the process. Ruzaman, (2020) affirmed this from his studies when he pointed out that the paradigm of inquiry-based learning as the most useful approach in science education. Through the proper use of inquiry-instruction, learners are expected to construct their knowledge under the guidance of the teacher.

Kang, et al. (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 preservice 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.

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.

In a study in Rwanda, Mugabo et al. (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.

2.9 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 (Ssempala,, 2017). In addition, teachers' attitudes and beliefs in the use of IBL also differ (Hofer, & Lembens, 2019). 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. Findings from the study showed 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 IBI is also a function of the characteristics of the classes in question. Ssempala (2017) 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. His views are important because different contexts may result in different outcomes.

A review of literature also indicated that beliefs influence science teachers' practice of inquiry-based instruction. For an example; a study conducted by Correia & Harisson (2020) revealed that teachers' beliefs about inquiry are consistent with how they teach and assess inquiry, and that the promotion of student autonomy is influenced by teacher beliefs. Teachers who position themselves as facilitators adopt more open guided inquiry approaches, while teachers who position themselves as 'shepherds' adopt more directed approaches to inquiry. This has important implications for students' autonomy and self-regulation in inquiry lessons.

Another study by Ramnarian and Hlatswayo (2018), found out 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 are less inclined to enact inquiry-based learning in their lessons with the 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.

Hofer and Lembes (2019), in their study of Professional Developmental Project on teachers Pedagogical Design Capacity (PDC) and Pedagogical Content Knowledge (PCK), revealed that, teachers took a more positive attitude regarding both IBI in general and its implementation. The findings from their study shows that, this approach has proven successful and the teachers positively changed their beliefs and attitudes regarding IBI as well as their intentions regarding its implementation. It became apparent that the influence of a teachers' *attitude* on their *intentions* and *practice* is dynamic and cyclical and involving teachers immediately in implementing IBI in their own classes (*practice*) may be effective to subsequently change their *attitude, intentions* and *practice.*

Examining the development of three history teachers' conceptual and practical tools from their methods course through their fifth year or exit from the classroom by Martell (2020) revealed that, though teachers had inquiry-aligned beliefs and developed inquiry-related conceptual tools, a lack of practical tools and support during teacher preparation and within their eventual communities of practice had a major impact on their ability to frequently implement inquiry in their classrooms. Recommendations are offered for teacher preparation and in-service professional development programs. While beginning teachers may have strong inquiry-aligned beliefs, developed conceptual tools, and desire the ability to use inquiry with their students, a lack of practical tools and support during teacher preparation and afterward may have a major impact on their ability to implement it as often as they consider necessary. At the beginning of this study, the teachers had a strong desire to use the inquiry-based techniques that they learned about in their methods course and they had some success using it in practice. However, they were never able to make it a frequently used instructional technique and did not move beyond a primarily lecture and discussion-based pedagogy.

Another challenge highlighted here is the level of effectiveness of teacher education programs to enhance IBI. In support of this assertion, Masingila and Ssempala (2019) the effectiveness of a Professional Development (PD) workshop on Inquiry and Nature of Science (NOS) on chemistry teachers' understanding and practice of Inquiry-Based Instruction (IBI) in Kampala city public schools in Uganda. Half of the teachers (active group) attended the PD workshop on inquiry and NOS for whiles the control group did not. It was established that the participating chemistry teachers had insufficient understanding of IBI at the beginning of the study. Teachers from the active group improved their understanding and practice of IBI after attending the PD workshop. Based on the above findings, it was concluded that the explicit reflective PD workshop on inquiry and NOS that they conducted after listening to the in-service science teachers' concerns and challenges over time within the school context improved their understanding and practice of IBI and helped them to drop some of the common myths about IBI. Hence, there an urgent need for science educators to design PD programs that help teachers to reconstruct both their teaching philosophy and practice.

Moreover, a study undertaken by Masingila (2019) on Chemistry teachers in public schools in the Kampala City, to explore the factors that teachers perceive to influence their understanding and practice of IBI. They established that the main factors influencing teachers' understanding and practice of IBI were their attitudes; their teaching experience; their motivation; availability of instructional materials; mode of assessment; class size; their preservice and in-service training; peer support; and time constraints concluded that most of these factors are beyond the teachers' control because they are systemic challenges that lie beyond the schools where the teachers were teaching.

Another study by Niyitegeka (2020), teachers understanding has limited description of the components of inquiry-based instruction to only posing and answering the questions in Science classroom. The teachers failed to describe all components of inquiry-based instruction as listed in competence-based curriculum as the vehicle of the entire learning and teaching process which led to insufficient understanding of inquiry-based instruction. Their self-efficacy for inquiry-based instruction is high and their actual implementation is at lowest level of implementation.

2.10 Relationship between teachers' perception and practice of Inquiry-Based Instruction

In recent years, there has been a growing emphasis on incorporating inquiry-based instruction in classrooms to enhance students' critical thinking and problem-solving skills. Central to the success of implementing inquiry-based methods is the relationship between teachers' knowledge and their actual classroom practices. This section explores existing research on how teachers' perception of inquiry-based instruction influences their instructional practices.

Science teachers face important decisions about how to design instruction for their pupils. One prominent school of thought, inquiry learning, holds that students learn science best by conducting experiments to answer research questions. Thus, teachers should design opportunities for students to acquire knowledge through investigations, rather than providing it to them directly. The value of inquiry-based teaching is however strongly contested (Zhang, 2016). Critics of inquiry-based instruction argue that it overlooks important features of cognitive architecture (Rosenshine, 2012; Zhang, 2016). More specifically, they point to evidence that pupils limited working memory is likely to be overloaded by the difficulty of conducting scientific investigations which may serve to limit rather than facilitate the acquisition of new knowledge.

Various studies highlight the relationship that exist between teachers’ knowledge and their practice of inquiry-based instruction. It is to be noted that the knowledge of science teachers toward inquiry-based science teaching influences teachers' skills to practice it in the process of teaching and learning. From the study of Silm, Tiitsaar, Pedaste, Zacharia and Papaevripidou (2017), if teachers were exposed to inquiry-based science instruction through workshops or training, then teachers' skills in implementing them in the process of teaching and learning will be increased. This was evidenced when teacher training sessions were designed that enabled the teachers to experience IBL from different perspectives: teacher as a learner, teacher as a thinker, and teacher as a reflective practitioner to impact teachers' sense of efficacy (TE), which has been shown to be positively related to teachers' readiness to adopt new teaching methods, and their attitudes toward IBL. It was found that teachers' higher sense of efficacy was related to more positive attitudes toward IBL.

Another study conducted by Ibrahim et. al showed that high level or exposure to inquiry-based instruction results in its implementation during instruction. The analysis from their study showed that the level of teachers' knowledge of inquiry-based science teaching and the level of teachers' perceived skills in implementing inquiry-based science teaching which was divided into four phases (conceptualization, investigation, conclusion, and discussion) were high. The Pearson correlation test found that there was a strong and significant relationship between teachers' knowledge in inquiry-based science teaching and teachers' skills in four phases of inquiry.

A study by Xie, Talin and Sharif (2014) on 728 in-service primary science teachers in China on the relationship between teachers' knowledge on NOS, attitude and belief towards inquiry teaching and implementation showed, that teachers have moderate knowledge on NOS, thus, their attitude and belief towards inquiry teaching are also moderate. It is portrayed in their instructional practice, the implementation of IBL, which is also found to be at the moderate level. The results are consistent with some of the previous related studies. Sangsa-ard and Thathong (2014) find more than half of the teachers in their study have medial level of understanding of IBI.

Meanwhile, Sikko, Lyngved, and Pepin (2012) study found more than half of their teachers to disagree or strongly disagree to implement inquiry approach in classroom practice. Other studies show that the IBL approach is not popularly implemented in the classroom teaching (Kraus, 2008; Reaume, 2011). Another study by Samuel and Ogunkola (2013) found teachers´ beliefs as barely moderately favorable to their practice of IBL, therefore, the level of the implementation of IBL is at the unsatisfactory developing level. Bishaw (2010) also, showed that the level of teachers‟ beliefs is related to the implementation of the problem-solving teaching approach.

However, a study conducted by Ibrahim and Mahmud (2020), showed that the level of teachers' knowledge of inquiry-based science teaching and the level of teachers' perceived skills in implementing inquiry-based science teaching which was divided into four phases (conceptualization, investigation, conclusion, and discussion) were high. The Pearson correlation test found that there was a strong and significant relationship between teachers' knowledge in inquiry-based science teaching and teachers' skills in four phases of inquiry. The difference in results of this study from the above can be as a result of the methodology used, population or the place where the research took place.

2.11 Challenges Teachers face in the Implementation of Inquiry-Based Teaching

Researchers have highlighted several factors affecting teachers planning and practice of inquiry-based instruction. For example; a study on teachers' views and understanding about IBI and the factors that inhibit and promote the implementation of IBI by Baroudi and Rodjan Helder (2021), revealed lots of challenges in IBI implementation which includes; limited ICT and lab resources, low quality of professional development, lack of time for lesson preparation, and difficulties in classroom management that complicate the process of IBI implementation in classrooms hence confirming the statement above.

Another study by Ramnarain and Hlatswayo (2018) confirms the study of Baroudi and Rodian (2021), as they highlighted different barriers that impedes the implementation of IBSI. Their study on teachers beliefs and attitudes of inquiry-based learning in rural school district in South Africa revealed that; despite teachers positive belief towards inquiry-based learning, they are less inclined to enact inquiry-based learning in their lessons claiming that the implementation of it 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.

Other research has shown that though teachers are posed with many barriers to the implementation of inquiry-based instruction, there are different levels at which the barriers affect the implementation of IBI. For an example the findings from the study of Effendi and Mukminim (2019), on challenges teachers face in the implementation of IBSI under four major constraints (lack of time, number of students, lack of equipment and lack of knowledge, skills and experience with practicing inquiry), lack of time was the most cited constraint amongst the other barriers'

Another study conducted by Gray (2021), on Elementary Teachers' Implementation of inquiry-based instruction outlined certain barriers of which teachers' knowledge came least among instructional time, lack of confidence and resources that elementary teachers face in their implementation of IBSI. From Gray findings, one can conclude that, teachers' knowledge is least a problem which may be as a result of difference in settings. Though, the barriers outlined in both studies of Gray and Effendi et al. has both similar and different barriers, it is clear that availability of time and knowledge of teachers highly and least respectively affects the implementation of IBI.

Gholam (2019) revealed that, teachers considered the following factors as hindering the implementation of IBL in the classroom: lack of background knowledge in content and pedagogy, classroom management, and curriculum design and infrastructure but participants in the study did not consider lack of background knowledge in content and pedagogy and classroom management challenging, but they did consider curriculum design and infrastructure as contributing.

This concern was also identified in research conducted by Nollmeyer, Morrison and Baldwin (2019), in which elementary teachers were interviewed to identify the barriers to teaching inquiry-based science instruction. In the above study, though teachers identified lack of knowledge as a barrier to implementing inquiry-based science instruction, it wasn't significant as compared to other factors which makes them feel unprepared to implement inquiry-based science methods.

Researchers has identified that; teachers feel unprepared with science content to fully implement science topics in the classroom. Though there has been an increased focus on inquiry-based learning in teacher preparation programs, little is known about the influences of these programs on teacher development over time to examine the development of three history teachers' conceptual and practical tools from their methods course through their fifth year or exit from the classroom. The findings revealed that, while the teachers had inquiry-aligned beliefs and developed inquiry-related conceptual tools, a lack of practical tools and support during teacher preparation and within their eventual communities of practice had a major impact on their ability to frequently implement inquiry in their classrooms. Recommendations are offered for teacher preparation and in-service professional development programs (Lee & Glass, 2019).

Also, a research study by Fitzgerald, Danaia and McKinnon (2019), on barriers inhibiting inquiry-based science showed that out of the lot, the most important barriers identified include the extreme time restrictions on all scales, the poverty of their common professional development experiences, their lack of good models and definitions for what inquiry-based teaching actually is, and the lack of good resources enabling the capacity for change. Implications for expectations of teachers and their professional learning during educational reform and curriculum change are discussed.

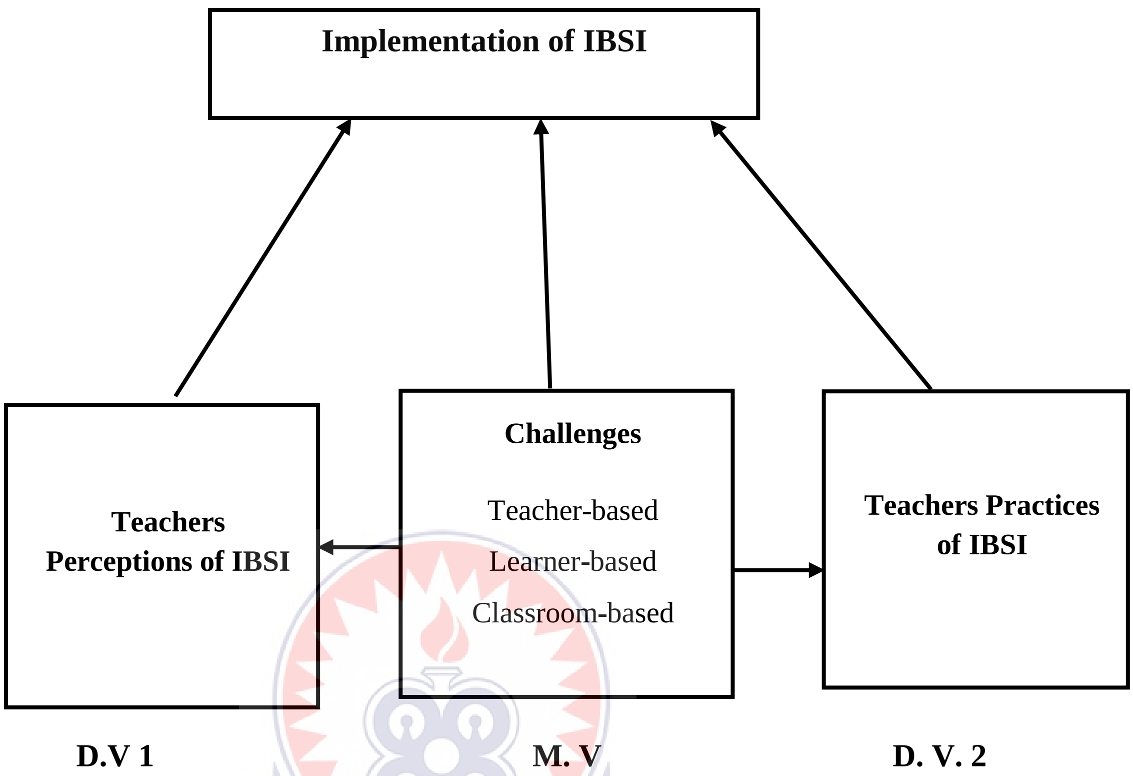
Mugabo and Nsengimana, (2020) from their study on the Impediments of inquiry-based instruction in and ways of overcoming them revealed common impediments of inquiry-based learning identified by this study feature; insufficient teaching time, resources for practical works, unsatisfactory teachers' confidence, heavy workload, large class size, and a relatively long syllabus. Among interventions teachers deemed as most relevant obstacle includes; the improvement of resources provision and adequate professional development programs were the most highlighted even though other aspects such as incentives for science teachers and reducing their workload were also pointed out. Since these impediments persisted particularly in sub-Saharan countries, real possibilities towards their alleviation are discussed.

2.12 Conceptual Framework

The study was conceptualized in Fig. 3. The conceptual framework is guided by literature, observation of variables and other researcher's experience. The conceptual frame work was the researcher's understanding of how the various variables in the study connected thus; identifying the variables required in the research investigation. Teachers' perceptions and practices of inquiry-based science instruction were the dependent variables while the implementation of inquiry-based Science instruction was the independent variable with challenges faced by these teachers' during the implementation of inquiry-based Science instruction as the mediating variable. The main idea of the study was teacher's perceptions and practices of inquiry-based science instruction. Figure. 3. showing the conceptual framework of the study.

Fig. 3. Conceptual framework of the Study

Independent Variable



The conceptual framework illustrated above, highlights how the various variables in the topic are connected. It reveals that, for effective implementation of inquiry-based science instruction by lower primary teachers, it is dependent on their perceptions and practices of inquiry-based science instruction since a positive perception will account for them designing and using various models or approaches during instruction in their classrooms as a way of practicing it. The implementation process is also affected by some challenges (teacher-based challenges, pupil-based challenges and classroom-based challenges) which serves as a mediating variable affecting both teachers' perceptions and practice of inquiry-based science instruction. Less challenge leads to high perception and practice of IBSI hence its implementation in the classroom and vice versa.

2.13 Summary

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 understand the concepts but there are variations in their way of understanding. A teacher within an in depth of knowledge of inquiry-base with favorable factors can better implement the inquiry approach than a teacher with low knowledge. Challenges such as large class size, resources, materials, time, affects the implementation of inquiry-based instruction on different scales. Teachers tends to exhibit varied ways in their implementation resulting in different outcomes of IBI. 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, it is clear from literature, information on the case of the less developed countries is in adequate leading to a gap in knowledge and practice.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter discussed the methodology used in the study. It described the research approach, research design, the study area, population, sample and sampling techniques, the research instruments, data collection procedures and data analysis as well as ethical considerations.

3.1 Philosophical Paradigm

Ataro (2020), stated that the philosophical paradigm predominantly influences the research design and the specific methods in a study. Although the philosophical ideas remain largely hidden in the research, they still determine the flow and direction of the research practice, hence the need to be identified (King et al., 2021). This implies that it is very important to clarify the larger philosophical ideas to be adopted since this helps to explain the choice of a particular approach and design for the research.

The philosophical paradigm which underpins this study is the pragmatic paradigm. The pragmatic paradigm is not committed to any one system of philosophy and reality, and as such, it implies to the mixed methods research where inquirers draw liberally from both the quantitative and qualitative assumptions when they engage in their research (Reed, 2021). According to Kelly and Cordeiro (2020), this paradigm is based on the idea that people make their reality by the meanings and interpretation they give to their experiences and that there are multiple truths and in essence, the reality is a result of our own making.

The reason for the use of this paradigm is that, it opens door to multiple methods, different world views, different assumptions and different forms of data collection and analysis to better comprehend what is being studied.

3.2 Research Design

According to Sileyew (2019), research design is the appropriate framework plan for a particular study which involves making a crucial decision on the type of research approach to be used as this will inform how information will be obtained for a study based on its relevance.

Sequential-explanatory mixed methods design was implemented for the study to sought out lower primary teachers' perception and practice of inquiry-based science instruction. Creswell (2009), points out that sequential mixed methods procedure is those in which the researcher seeks to elaborate on or expand on the findings of one method with another method. Sequential explanatory mixed method involves a two-phase project in which the researcher collects quantitative data in the first phase, analyses the results and then uses the results to plan the second qualitative phase (Pardede, 2019).

The quantitative phase of the research involved the use of questionnaire to collect data on demographic information of participants, lower primary teachers level of knowledge of inquiry-based science instruction, their practices and the challenges they face in its implementation whiles the qualitative data focused on the use of observational framework and semi-structured interviews to ascertain lower primary teachers level of perception of inquiry-based science instruction, classroom practices and challenges in the implementation of inquiry-based science instruction in the lower primary classroom.

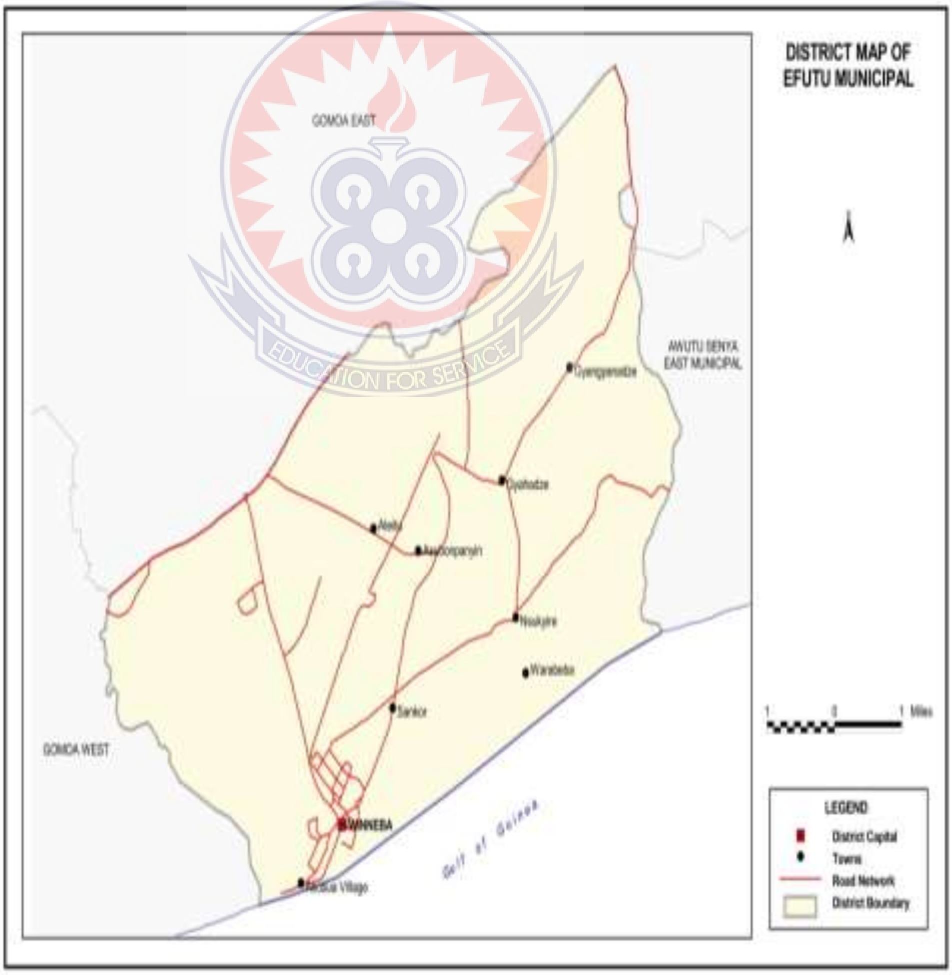
The qualitative data was needed to help explain in details the quantitative results which is the overall purpose for the use of this design. Merits of sequential explanatory method included its straightforwardness in nature serving as its main strength and how it is easy to be implement because the process involved falls into clear, separate stages. It is also easy to describe and report hence the preferred choice. The main demerit of this design is that much time is spent during data collection especially when the two phases are given equal priority (Buus, 2019) but this however can be rectified if enough time is allotted for the study.

3.3 Study Area

The Effutu Municipality is one of the 20 administrative districts in the Central region of Ghana. It is situated between latitudes 5°16' and 20.18"N and longitudes 0°32' and 48.32''W of the eastern part of Central Region. The Municipality lies between the Gomoa East District to Western, Northern and Eastern flanks. On the southern flank is the Gulf of Guinea. The administrative capital is Winneba, a town renowned for its major specialised institutions of higher learning such as the University of Education, Winneba, (UEW) and the Nursing Training College. There was a total of 247 educational institutions in the Municipality; of which 74 (30%) are public institutions and 173 (70%) are private institutions. The Municipality has 78 pre-schools (24 public and 54 private), 77 Primary Schools (27 Public and 50 Private) and 47 Junior High Schools (12 Public and 35 Private). The Winneba Senior High School is the only public second cycle institution. There are three private Senior High Schools and two Technical and Vocational Institutions in the Municipality.

The Municipality is made up of three circuits namely Winneba Central Circuit, Winneba East Circuit, and the Winneba West Circuit for the purposes of education management. Each of the schools in the Municipality falls within one of these circuits categories based on the school's location in the Municipality. In the Winneba Central Circuit, there are (8 public and 10 private) schools. In the Winneba East Circuit, there are 26 schools (8 public and 18 private) schools and in the Winneba West Circuit, there are 8 schools (6 public and 2 private) schools. The figure below shows a map that represents Effutu Municipality.

Fig. 4. Showing map of Effutu Municipality



Source: Ghana Statistical Service, GIS

3.4 Population

Population refers to the entire aggregation of cases that meet a designated set of criteria (Thibaut & Connolly, 2020). The population for the study was made up of all teachers in Effutu Municipality. The target population included all 395 public school teachers in the Effutu Municipality in the Central Region of Ghana. Accessible population for the study was all 82 public lower primary teachers in the Effutu Municipality in the Central Region of Ghana since they teach basic 1-3 and are the right respondents to provide the needed information to carry out this study.

3.5 Sample and Sampling Technique

Sampling, according to Conlon, Timonen, Elliott, O'Keeffe and Foley (2020), is a procedure used to select a sample from individual or a large group of population for a certain kind of research purpose. The sample for the study were all public lower primary teachers in Effutu Municipality in the Central Region. All the public basic schools under each circuit (Winneba Central-10, Winneba East-9, Winneba West-8) were used for the study since they weren't many therefor, the researcher employed the census sampling technique that involves all members of the accessible population to sample all the 84 teachers within the public schools for the quantitative phase.

According to Parker (2011), the census technique is often used when the population is small and data is gathered on every member of the population. Since all members participants are used, better demographic data on the population is obtained (Parker, 2011) even though it of higher cost and takes more time. Lower primary teachers were made to answer the structured questionnaire the researcher adopted for the first phase of the study.

Based on the quantitative results, convenience sampling technique was used to obtain a sub sample for the second phase of the study. Etican, Musah and Alkassim (2016) are of the view that convenience sampling is used where members of the accessible population meet certain criteria, such as easy accessibility, geographical proximity, availability at a given time or willingness to participate in the study. Respondents who were available and willing to participate in the the second phase of the study were used. Twelve (7 females and 5 males) respondents were conveniently sampled however, only six (4 females and 2 males) respondents were available to be observed.

3.6 Research Instrument

The instruments that were used to collect data for the study were structured questionnaire (*Lower primary Teachers' Perceptions and Practices Questionnaire [LTPPQ]),* semi-structured interview guide (*Lower primary Teachers Perceptions and Practices Interview guide [LTPPI])* and observation checklist (*5E model Teachers' Observational Framework* [5E-TOBF]) (see Appendix A, B and C respectively). The structure questionnaire was used to collect quantitative data whiles and the interview guide and observation checklist were used for qualitative phase of the study. According to Dzwigol (2020), the combination of several data collection strategies allows for triangulation. This involves confirming evidence from different sources to shed light on a particular issue.

3.6.1 Structured Questionnaire

According to Castells et al. (2022), a questionnaire refers to a written document that contains a series of questions or information called items that attempts to collect information on a particular topic. Participants who responded to the questionnaires are literate and can read and respond to items on it as well as provides quantifiable answers for a research topic which are also easy to analyse. The LTPPQ was made up of four sections (Section A-D) designed and prepared by the researcher. The first section (Section A) contained five items which focused on *demographic characteristics* of the respondents and collected data on gender, age, years of experience, educational level, and academic background.

The second section (Section B) was made up of ten items relating to *level of lower primary teachers' perception of inquiry-based science instruction.* There were another ten items relating to the extent to which public *lower primary teachers practice of inquiry-based science instruction* in the classroom on the third section (Section C). Adding on, the fourth section looked at the challenges lower primary teachers face in the implementation of inquiry-based science instruction. This section was divided into three sub-sections (*teacher-based challenges, pupils-based challenges, classroom-based challenges*) with teacher and classroom-based challenges having five items where has pupil-based challenges had three items. and five items in all giving 13 items. The researcher used four-point Likert scale which consisted of: Strongly Agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2 and Strongly Disagree (SD) = 1 for both Sections B and D while Section C had five-point Likert scale with ratings Always (A)=5, Regularly (R)= 4, Quite Frequently (QF)=3, Once in a while (OW)= 2 and Never (N)=1. Teachers were required to select one of the options that best explains their opinion on corresponding items.

3.6.2 Semi-Structured Interview

The researcher developed LTPPI that was used to collect qualitative data for the second phase of the study. Creswell (2012) defined interview as an interactive process between a researcher and a participant within which the researcher records answers posed by the researcher to the respondent. Thus, collecting data from participant by oral question posed by the researcher. Saou (2014), identified three types of interviews namely; structured interview, semi-structured interview and unstructured interview. The use of face-to-face semi-structured interview was used by the researcher in order to observe and read the expressions of the participants to find out the authenticity of their responds to the research question. The researcher used the research question to help shape the interview questions in the manner that it appears to be significant to the research study.

The areas covered by the structured interviews were: **Section A**- *lower primary teachers' level of knowledge on inquiry-based science instruction*, **Section B**- *lower primary teachers' practices of inquiry-based science instruction*, and **Section C**- *challenges they face in the implementation of inquiry-based science instruction*. Three questions were asked under Sections A and B whiles four questions were asked under Section C.

3.6.3 Observational Framework

According to Katz-Buonincontro and Anderson (2020), observation is an empirical research method used in quantitative and qualitative naturalistic studies focused on understanding behavior and interactions as they unfold in real-time, which makes it particularly salient for examining the processes associated with the generation and adoption of creative ideas. The use of observation protocol was recommended by Kelly, Bringe, Aucejo and Fruehwirth (2020) as a method of recording notes. This enabled the researcher to know precisely what was going on in the classroom allowing a follow up on the results emanating from the other instruments. This gives the researcher the opportunity to directly look at what is taking place rather than relying on second-hand accounts. The observational framework was also used to verify some of the participants responses to some of the questionnaire items as well as responses from the interview on how inquiry-based instruction is done in the Science classroom.

Thoman, Yap, Herrera and Smith (2021) also pointed out that, observation is essential because articulated beliefs and attitudes may not fully reflect the actual pedagogical practices but be inferred from what people do in reality in the classroom. It is therefore suggested that respondents may exaggerate about their use of inquiry-based science instruction practices in the questionnaire and interview phase hence; observation was conducted to cross-check if what the respondents answered in the questionnaire and during the interview are indeed practiced in their actual teaching. The study used an observational framework adopted from Bybee's 5E model framework (Bybee, 2011) which is for classroom observation with some characteristics of inquiry-based teaching for the observational phase of the study. The model looked at how teachers incorporate the 5E models of inquiry; engagement, exploration, explanation, elaboration and evaluation during instruction based on stated observable characteristics outlined under each of the 5E's. The observational framework had four responses to it; "Yes", "No", "Partially" and to "some extent" with items describing the outcomes of each of the 5E's to rate teachers in the classroom.

3.7 Validation and reliability of Questionnaire

3.7.1 Validity of Questionnaire

Validity, according to Sürücü and Maslackci (2020), is concerned with whether an instrument measures the behaviour or quality it is intended to measure and a measure of how well the measuring instrument performs its function. The focus of validity is not on the instrument itself but the interpretation and meaning of the scores derived from the instrument (Finch & Fafinski, 2023). It is the duty of any researcher to ensure that the instrument used to collect data is truly valid hence a pilot-test was conducted to ensure both the content validity and face validity of the questionnaire. King et al. (2020) defined face validity as a subjective judgement of a construct operated. It is the degree to which a measure appears to be related to a specific construct in the judgement of experts. It evaluates the appearance of the questionnaire in terms of feasibility, readability, consistence of style and formatting, and the clarity of language used (King et al. 2020) to ensure relevant, reasonable and unambiguous instrument.

Content validity refers to the degree to which elements of an instrument are relevant to and represents the targeted construct for a particular assessment purpose (Yusoff, 2019). Evaluation by more than one referee helps obtain face and content validity (Sürücü & Maslackci, 2020). To ascertain face and content validity, the researcher showed items constructed for the instruments to both supervisor and senior lecturers in the Department of Basic Education, Winneba. This was to examine whether the instruments were; related to the research question, elicit the appropriate responses from the respondents, appropriately structure in terms of vocabulary, ambiguous and misleading, appropriate for each section and well arranged. Their suggestion was used to improve instrument thereby used to establish face and content validity.

3.7.2 Reliability of the Questionnaire

Internal consistency is one of the ways for checking for the reliability of the questionnaire. Vu, (2021) stated that reliability is the consistency of a measurement instrument to gives the same results each time it is used, assuming what is being measured is not changed. Paulsen and Brekalorenz (2017) stated that, internal consistency is the extent to which a group of items measure the same construct, as evidenced by how well they vary together or inter-correlate. The researcher used Cronbach's alpha to estimate the reliability of the instrument after the pilot study. This was done by inputting the data from the questionnaire, which consisted of thirty-three items from the pilot study into Statistical Package for Social Sciences (SPSS) Version 26. Cho (2021) argued that, any scale with Cronbach's alpha of less than 0.7 could not be considered reliable. Based on this, the value of 0.82 is above 0.7; hence the scale can be considered as reliable.

3.8 Validation of Qualitative Instruments

3.8.1 Validity of the Semi-Structured Interview and Observational Framework

The semi-structured interview and the observational framework were scrutinized by colleagues of the researcher before it was given to the supervisor for consideration. The instruments were further piloted to identify potential deficiencies before using it for the actual study. When assessing the scope of the guide, it was important to review whether it allows participants to give full and coherent account of the central issues and issues they think are important. The recorded data that were transcribed was cross-checked with the recordings done to ensure that there were no default and omission in its description.

3.8.2 Reliability of Observational Framework

The 5E model observational framework was also piloted using three teachers from Basic 1, Basic 2 and Basic 3. Two raters, the researcher and an M. Phil collegues, undertook the rating during the pilot study. Inter-rater reliability analysis using the Kappa statistics was performed to determine consistency among raters. Inter-rater reliability is a measure used to examine the agreement between two people. It is an important measure in determining how well implementation of a measurement system works. The inter-rater reliability for the raters was found to be Kappa = 0.72 ($p<0.001$), 95% CI (0.504, 0.848). This measure of agreement, while statistically significant, is only substantially convincing. As a rule of thumb, values of Kappa ranging from 0.40 to 0.59 are considered moderate, 0.60 to 0.79, substantial, and 0.80 outstanding. Lanndis and Kotch (1977) as cited in Cibulka and Strube, (2021) opined that most statisticians prefer Kappa values to be at least 0.6 and most often higher than 0.7 before claiming a good level of agreement. The suggests that the observational framework could be used for the study.

3.9 Data Collection Procedure

According to Brittain et al. (2020), respecting the site where research takes place and gaining permission before entering the site is paramount in research. The researcher obtained an introductory letter from the Head of Department of Basic Education, University of Education Winneba, to be used to obtain permission from the GES Municipal Directorate of Education. The Directorate gave permission letter to the researcher to obtain authority from the Heads of the basic schools to collect data for the study (see Appendix D). Copies of the letter were sent to heads of primary schools where the research was meant to be conducted to have access to public lower primary teachers. Each school was visited thrice; the first visit was to seek permission from the school heads and teachers on their concern to carry out and participate in the study and set day and time for administering the questionnaire.

The quantitative data was collected first followed by the qualitative data. Participants were informed to freely discontinue with their participation at any point in time and not obliged to answer the questionnaire for any reason. They were also assured of their anonymity. Day and time were set for the second phase which involved classroom observation and interview (qualitative data).

3.9.1 Quantitative data Collection

For the quantitative phase, the researcher administered the questionnaire to eighty-two public lower primary teachers selected from the twenty-seven public basic schools in the municipality. The respondents were met in their respective classrooms since many of these schools did not have a common staff room. The researcher made a brief self-introduction to explain the purpose of the study to the respondents before the questionnaires were distributed to them. The researcher stayed with them and had interactions with them. This motivated the respondents to attend to the questionnaire and asked for further clarification on some of the items they needed more information on. The researcher appealed to all the respondents to take their time to read the questionnaire and respond to it appropriately. The researcher visited the schools at different times and distributed the questionnaires to the respondents. The researcher took the questionnaires the same day it was administered. The researcher was able to retrieve all questionnaires, representing a 100% return rate. The researcher used five weeks to administer the questionnaires in the various selected schools in the municipality. The answered questionnaires were later analysed using the analytical tool SPSS to generate findings from it. The findings from the quantitative data informed the second phase to confirm the responses from the teachers in relation to their perceptions, practices and challenges in the implementation of inquiry-based science instruction.

3.9.2 Qualitative data Collection

Based on the quantitative results, the researcher had access to only twelve and six teachers for the interview and the observational phase respectively as they were the only respondents available and willing to partake in the second phase. Each participant was visited twice. The first visit was used to arrange with each of them the date and time for classroom observation and interview. The second visit was used to observe the participants' lessons and interview them after the lesson. The observations of each teacher took between 35 and 70 minutes to complete depending on the level of class and the number of periods for the lesson.

Participants' permission was sought to audiotape and videotape the lesson to capture instances that were not indicated on the checklist. The interview with the teachers took place at their own convenience especially during break hours or right after school which also lasted for a period of 30 minutes. The researcher remained passive by using the checklist to check on the principles that govern the use of inquiry-based strategies and recorded answers to question being asked in the classroom. Using the occurrences of characteristics from Bybee's framework model, the researcher noted down points as the teacher taught in the lower primary science classroom.

Notes were also taken during the lesson to take care of relevant issues not covered by the observation schedule, such as the topic and the objectives for the lesson, list of materials, and equipment (teaching/learning materials) used in each observed lesson. Notes were also taken on the nature of classroom activities and the involvement of the students in these activities. The researcher specifically focused on how teachers facilitated activities and how learners were engaged in the activities. Instances of participants' use of inquiry-based were checked many times they occurred. The recorded interview was played back for them to confirm if it was a true recording of the interview. Finally, the researcher paid attention to the challenges encountered in the use of an assessment tool.

3.10 Data Analysis

Data analysis, according to Creswell (2009), is a process which involves explaining findings in words about a study or explaining the information gathered from the field for study and drawing conclusions. Quantitative and qualitative data methods of analysis will be used to organise the qualitative and quantitative data respectively.

3.10.1 Quantitative Data Analysis

McNabb (2020), in mixed-method research, the analysis of data involves the analysis of both quantitative and qualitative data.

Descriptive statistics function of the Statistical Product for Social Sciences (SPSS version 23) was used to organise participants' responses to the questionnaire items into frequencies and percentages. According to Donkor and Obeng (2013), descriptive statistics do not only allow researcher to use numbers but also provide them with data that create room for inferences on the population and directions for answering research questions.

In analysing responses from the four-point Likert scale questionnaire to answer research questions 1 and 3, mean and standard deviation were used. The mean and standard deviation of each of the items were calculated as well as the overall mean and standard deviations to aid in the interpretation of the responses in answering the research questions. However, analysis of responses from the five-point Likert scale in answering research question 2 employed frequency counts and percentages.

The hypothesis stated was analysed using the Pearson Correlation to determine the relationship that exist between lower primary teachers' perceptions and practices of inquiry-based science instruction. This was done to find out if the perceptions of the teachers had any effect on their practices.

3.10.2 Qualitative data Analysis

The qualitative data was analysed using the directed content analysis. The researcher identified key concepts from the existing frame of IBSI and turned them into codes. These codes were used to create codebook based on the framework. The interview data gathered was used to probe on concepts in the framework and transcriptions with codes in them were identified and evaluated to sort out those that fit within the codes and those that didn't. Frequency on the use of codes were recorded and used to produce the analysis. To answer research questions 1, 2 and 4 the researcher transcribed the tape-recorded interview under appropriate themes to do so. The observational frame work was analysed with the help of the 5E model framework. The researcher from the observation and video tape, used the framework to identify which of the 5E (engagement, exploration, explanation, elaboration, evaluation) was employed most by the lower primary teachers.

3.11 Ethical Consideration

Ethics is the standard of the researcher's behavior concerning the rights of those who becomes the subject of a research project or who are affected by it (Bell & Wynn, 2023) hence every study requires the researcher to adhere to the ethics concerning research. The researcher took due cognizance of ethical responsibility in collecting, analyzing data and reporting the information. Permission to conduct the study was obtained from the Effutu Municipality Directorate of GES. The researcher encouraged the respondents' voluntary participation and ensured that the respondents' rights to be informed, right to privacy and right to choose was respected by maintaining the confidentiality of all the information given to aid this study.

Respondents involved in the study was assured of their anonymity by ensuring that the purpose of the study was clearly explained to them as well as their names and other forms of identification excluded from data collection. In addition, respondents were given the chance to drop out of the study by their own will and all citations in the work are duly referenced in the reference section.

CHAPTER FOUR

RESULT, DISCUSSION AND ANALYSIS

4.0 Overview

This chapter presents the results and discussion of the study. This study assessed pubic lower primary teachers' perception and practice of inquiry-based science instruction in the Effutu Municipality in the Central Region of Ghana. This chapter presents quantitative and qualitative data in attempts to answer the stated research questions. The chapter is structured into two sections, the first section focused on the demographic characteristics of the participants and the second section dealt with the presentation of findings in relation to the research questions.

4.1 Demographic characteristics of Teachers

This section presents the demographic characteristics of the teachers sampled from the public lower primary schools at the Effutu Municipality in the Central Region of Ghana. The demographic information reported on the gender, age, years of experience, educational level and academic background. The outcome of the analysis of the data is presented in Table 2 to 5. Table 2 represents gender distribution of teachers

Table 2: Gender of Teachers

Gender	**f**	**%**
Male	11	13.4
Female	71	86.6
Total	**82**	**100**

Source: Field Data (2023)

Table.1 shows that majority of the participants 71(86.6%) of the teacher respondents were females whereas 11(13.4) were males. The indication here is that, there were more females teaching at the lower level in the public sector than males.

Table 3 represents the age range of the teachers.

Table 3: Age Range of Teachers

Years	**f**	**%**
20-25	2	2.4
26-30	26	31.7
31-35	20	24.4
36-40	14	17.1
41 and above	20	24.4
Total	**82**	**100**

Source: Field Data (2023)

The ages of the teachers ranged from 20 – 41 years and above. The age range 26-30 years recorded the highest number of participants 26 representing 31.7%, those between the ages 31-35 and 41 and above recorded the same participants 20 (24.4%) whereas 14 (17.1%) participants were between the ages of 36-40. The ages range 20-25 recorded the lowest participants 2 (2.4%).

The age range of the participants suggest that few of the participants (26.8%) are in their early youth and adult stage whiles majority of them (73.2%) are in their late youth hence had 30or more years to teach before retirements.

Table 4 represents years of experience of teachers.

Table 4: Years of experience of Teachers.

Years of Teaching	**f**	**%**
0-3	18	22.0
4-5	10	12.2
6-9	11	13.4
10 and above	43	52.4
Total	**82**	**100**

Source: Field Data (2023)

With regards to the years of teaching experience of teacher participants, results in Table 3 reveals that 43 (52.4) of the participants have taught for 10 years and above whereas 18 (22%) of the participants have thought for 0-3 years and the remaining 21 teachers out of the 82 have teaching experience between 4- 9 years with 10 (12.2%) having experience between 4-5 and 11 (13.4%) with experience between 6-9. This implies that most of the teachers who teach at the public lower primary schools have more teaching experience.

Also, the educational level of the teachers was explored and the detail presented in Table 5.

Table 5: Teachers Educational Level

Educational Level	**f**	**%**
Diploma	19	23.2
Degree	55	67.1
Masters	8	9.8
Total	**82**	**100**

Source: Field Data (2023)

Table 5 above shows that majority of the teachers 55 (67.1%) had bachelors degree, 19 (23.2%) had diploma whiles only 8 (9.8%) of the teachers had masters. This implies that most of the public lower primary teachers had first degree and diploma as compared to the second-degree certificate (masters).

Finally, the academic background of the teachers was explored and their details illustrated in Table 6 below.

Table 6: Academic Background of Teachers

Variable	f	%
Science	34	41.5
Non-Science	48	58.5
Total	**82**	**100**

Source: Field Data (2023)

With regards to the academic background of the participants, results in Table 6 shows that 34 (41.5%) of the participants had Science background whereas the remaining 48 (58.5%) did not have Science background. The analysis from the data shows that the majority of the public lower primary teachers didn't read science as a main course of study and had little background on Science.

4.2 Research Question 1: What are lower primary teachers' perceptions of inquiry-based Science instruction in the Effutu Municipality?

This research question sought to determine lower primary teachers' perceptions of inquiry-based science instruction in the Effutu Municipality. Respondents were presented with 10 statements to indicate their agreement or disagreement using a four-point Likert scale of 1-SD, 2-D, 3-A and 4-SA. For the purpose of the analysis, options SD and D were combined as indicating ‘disagreement with the statement while SA and A were interpreted as indicating agreement. Based on the level of perception of inquiry-based instruction, a mean of mean between 1.0-1.4 indicates lower perception, 1.5-2.4 indicates low perception, 2.5-3.4 indicates high perception and 3.4-4.0 illustrates higher perception. Similarly, a standard deviation below 1 indicates a similar response while a standard deviation of 1 and above indicates a heterogeneous response.

Table 7: Lower primary teachers Perceptions of Inquiry-Based Science Instruction.

	Statement	N	Mean	Standard Deviation
1.	Inquiry-based science instruction deals with learners investigating and finding solutions to topics or problems as a way of constructing knowledge for themselves.	82	3.3537	.77574
2.	There are different types of inquiry-based instruction	82	3.2683	.68581
3.	The main focus of inquiry-based science learning is to demonstrate how it is done rather than to excite learners’ interest in the topic	82	2.7927	.91271
4.	Learners are to be engaged in scientifically oriented questions and give priority to evidence in responding to these questions.	82	3.1098	.68504
5.	In the inquiry-based science process, learners are to formulate explanations from evidence and connect it to scientific knowledge.	82	3.1707	.75039
6.	Learners are provided opportunities to communicate and justify their explanations during the injury-based process.	82	3.2195	.64835
7.	In the inquiry-based science process, the teacher is a facilitator whiles learners become researchers.	82	3.2683	.86136
8.	Inquiry learning in science is usually a result of collaborative effort between students.	82	3.0976	.65940
9.	Inquiry-based learning takes place only in the classroom	82	1.8171	.87669
10.	In the inquiry process the teacher become the researcher who provides information to the learners.	82	1.8780	.86624
Overall mean			**2.90**	**0.77**

Source: Field Data (2023)

Data on Table 7 shows that on average, teachers tend to agree (M=3.35, SD=0.78) with the statement that inquiry-based science instruction deals with learners investigating and finding solutions to topics or problems as a way of constructing knowledge for themselves. A lower standard deviation suggests a homogenous response. Similarly, teachers generally agreed (M = 3.27, SD = 0.69) that there are different types of inquiry-based instruction. A lower standard deviation suggests a consensus among the teachers. Also, teachers generally agreed (M = 3.11) that learners should engage in scientifically oriented questions and prioritize evidence in their responses. The mean score indicates a shared understanding of the importance of these principles within inquiry-based instruction. The standard deviation of 0.69 suggests that while there is consensus, there is also some variability in the extent to which teachers emphasize these aspects in their teaching. Again, teachers agreed (M = 3.17, SD= 0.75) with the notion that, in the inquiry-based science process, learners should formulate explanations from evidence and connect them to scientific knowledge. The standard deviation of 0.75 indicates some variation in how teachers implement this concept, but overall, there is alignment with this principle. Similarly, teachers agreed (M = 3.22) that learners should have opportunities to communicate and justify their explanations during the inquiry-based process. The standard deviation of 0.65 suggests that while there is consensus, there is also relatively little variation in how teachers approach this aspect. Also, teachers consented (M = 3.27, SD= 0.86) with the idea that, in the inquiry-based science process, the teacher serves as a facilitator while learners take on the role of researchers. The standard deviation of 0.86 indicates some variability in how teachers enact this role, but overall, there is alignment with this principle. In the same way, teachers also agreed (M = 3.10) that inquiry learning in science often involves collaborative effort between students. The standard deviation of 0.66 indicates that while there is consensus, there is also relatively little variation in how teachers perceive this collaboration.

However, teachers agreed (M=2.79, SD= 0.91) with the statement that the main focus of inquiry-based science learning is to demonstrate how it is done rather than to excite learners' interest in the topic. A relatively high standard deviation of 0.91 suggests significant variability in opinions, with some teachers strongly disagreeing while others may somewhat agree with this perspective. Similarly, a disagreement was recorded (M=1.82, SD=0.88) for the notion that inquiry-based learning takes place only in the classroom. The standard deviation of 0.88 suggests heterogeneous responses, reflecting diverse opinions on this aspect and a range of beliefs about where inquiry-based learning can occur. Lastly, on the statement that in the inquiry process, the teacher becomes the researcher who provides information to the learners, teachers also disagreed (M=1.88, SD=0.87). The standard deviation of 0.87 suggests a variation in their response. In these responses, though the teachers demonstrated a disagreement with the statements, it was revealed that they have good knowledge of inquiry-based instruction since they knew the statements were actually false.

Based on the analysis of the individual responses accumulating into the overall mean of 2.90, with a standard deviation of 0.77, lower primary teachers in the Effutu Municipality demonstrated high perception of inquiry-based science instruction and a standard deviation of 0.77 showed that though teachers had idea on IBSI, they had varied options of perception on inquiry-based science instruction.

Semi-structured interviews were conducted with twelve public lower primary teachers to seek further clarification on some of the responses to the questionnaire items. The theme generated from the analysis of the data collected was *understanding of IBSI*.

Understanding of IBI

As far as the above theme was concerned, the following excerpts were taken:

Researcher: How would you explain the term inquiry-based science instruction?

"This is giving the learners the opportunity to at least find out something themselves" (Teacher 1)

Another teacher added

> *"So, what I know about it is for me, using science or any subject material to teach for the kids to handle in what you are teaching as in demonstrating for them to see. And looking at how my kids are when you demonstrate for them to see they are perfect but when you go with the theory, the next day as if you didn't even teach anything." (Teacher 2)*

Another teacher also remarked:

> *"For inquiry-based instruction, normally you helping the child to explore him or herself to find meaning of different things or understanding of different ideas by his own okay, the only thing you got to do is provide the child the guidelines to do that or giving the child the flexibility to find the meaning of different things linking to the real world". (Teacher 11)*

Researcher: Are there types of IBSI? If yes highlight on them.

> *"Yes, I think so because there are some that you the teacher will maybe provide the materials or something for them to use to at least arrive at what you are looking for and others you send them out without anything for them to go and look for solutions themselves and do the experiment." (Teacher 3)*

Another teacher added:

> *"Something like, me I mentioned demonstration first and sometimes it applies to the improvisation. Not everything that you have to make it theory. Something like a circuit you will have to let them see how it is and how it functions and something like teaching day and*

> *night. It's not about do this or that, let the pupils do it themselves so that they appreciate nature". (Teacher 8)*

Another teacher stated that:

> *Yes! we have about three types of it that is; the structured, guided, and open ended. With the guided you provide the learners with instructions or guidelines to find solution to a problem and another you present them with a problem and task them to find their own solution.*

The above excerpts highlight the varied perspectives and approaches to inquiry-based instruction among the lower primary teachers. While all teachers acknowledge the importance of student engagement and exploration, their definitions, views on types, and models of IBI differ. The main focus from the results is the emphasis on active learning, practical demonstration, and the use of various teaching tools and techniques to make science education more interactive and effective. These insights provide a glimpse into the diverse ways in which teachers implement IBI in their science lessons. It is deduced that the level of knowledge regarding inquiry-based science instruction among the lower primary teachers in the Effutu Municipality varies widely. The teachers' level of perceptions ranged from limited to more comprehensive.

4.3 Research Question 2: What practices do lower primary teachers engages in the classroom as a way of practicing inquiry-based science instruction in the Effutu Municipality?

This research question sought to ascertain practices lower primary teachers engages in as a way of implementing inquiry-based science instruction in the classroom. Data was gathered through a questionnaire and analysed descriptively using frequencies and percentages. This was supported by qualitative data gathered through observation and interviews with sub-sample of the participants. The observation was made on six teachers before the implementation of the semi-structured interview. Table 8 shows some practices of inquiry-based science instructions teachers employ in their classroom.

Table 8: Lower primary teachers practices of inquiry-based science Instruction.

	Perceived frequency of use (Counts and Percentages)				
Statements	**Always**	**Regularly**	**Quite frequently**	**Once in a while**	**Never**
I always plan lessons to actively involve learners	45 (54.9)	26 (31.7)	4 (4.9)	6 (7.3)	1 (1.2)
I always begin my lessons with a question to allow learners explore the topic under study on their own	35 (42.7)	29 (35.4)	12 (14.6)	6 (7.3)	0 (0)
I use experimentation to help learners ask questions.	18 (22.0)	25 (30.5)	28 (34.1)	11 (13.4)	0 (0)
I use group work to enable learners exchange ideas and thoughts to understand lessons better.	18 (22.0)	43 (52.4)	14 (17.1)	7 (8.5)	0 (0)
I ensure that learners are presented with real world problems for them to investigate.	25 (30.5)	20 (24.4)	20 (24.4)	16 (19.5)	1 (1.2)
I deliver lessons in a way that enable learners to ask questions and explore their natural curiosities	33 (40.2)	29 (35.4)	18 (22.0)	2 (2.4)	0 (0)
I provide learners with resources to ensure hands-on Science learning.	14 (17.1)	30 (36.6)	25 (30.5)	12 (14.6)	1 (1.2)
I mostly adopt the lecture method in my lesson delivery	2 (2.4)	1 (1.2)	7 (8.5)	35 (42.7)	37 (45.1)
I provide opportunities for learners to do research outside the classroom in order to complete various tasks.	3 (3.7)	3 (3.7)	4 (4.9)	17 (20.7)	55 (67.1)
I use projects as part of my teaching approaches in Science.	6 (7.3)	7 (8.5)	11 (13.4)	22 (26.8)	36 (43.9)
Overall Frequency count	**19.9**	**21.3**	**14.3**	**11.2**	**13.1**

Source: Field Data (2023)

The results on Table 8 shows that 45 teachers (54.9%) indicated that they always plan lessons to actively involve learners in inquiry-based science instruction. Also, 26 teachers (31.7%) reported that they regularly plan lessons to actively involve learners. Four teachers (4.9%) mentioned that they quite frequently plan lessons in a manner that actively involves learners in inquiry-based science instruction. Six teachers representing (7.3%) stated that they engage in active learner involvement through inquiry-based teaching once in a while. One teacher (1.2%) reported never planning lessons to actively involve learners in inquiry-based instruction. This means that majority of the teachers always plan lessons to actively involve learners in inquiry-based science instruction

On the statement that "I always begin my lessons with a question to allow learners explore the topic under study on their own" majority of the teachers 35 (42.7%) reported that they "Always" started lessons with a question, and 29 (35.4%) stated they do so "Regularly." With 12 (14.6%) and 6 (7.3%) teachers responding to quite frequently and once in a while respectively. No teachers indicated that they "Never" employ this approach. Twenty-eight teachers representing 34.1% reported they use experimentation to help learners ask questions. Twenty-five (30.5%) and 18 (22.0%) of them do so regularly and always with 11 (13.4%) of them responding to once in a while. With the statement, "I use group work to enable learners to exchange ideas and thoughts to understand lessons better" majority of teachers 43 (52.4%) use group work "Regularly," and 18 (22.0%) do so "Always." A smaller percentage (17.1%) representing 14 employs this method "Quite frequently." with 7 of them doing so once in a while. A percentage of (30.5%) representing 25 teachers ensure that learners are presented with real-world problems for them to investigate whiles 20 teachers (24.4%) regularly and quite frequently ensures that. 16 (19.5) of the teachers and only

1 (1.2%) do likewise. This implies that teachers appear to frequently incorporate real-world problems during instruction.

Also, with the statement "I deliver lessons in a way that enables learners to ask questions and explore their natural curiosities" 33 (40.2%) and 29 (35.4) respondents responded to "Always" and regularly ensure that respectively whiles 18 (22.0%) and 2 (2.4%) of the teachers respectively chose "quite frequently" and "once in a while". Also, 30 (36.6) of the teachers agreed on providing learners with resources whereas 25 (30.5%), 14 (17.1), 12 (14.6) and 1 (1.2) do so "quite frequently" "Always", ". Once in a while" and "Never" respectively. For the adoption of lecture method in lesson delivery, 37 (45.1) teachers responded to have never used it, 35 (42.7) responded to have done so ''once in a while'' whiles 7 (8.5%) of the do so quite frequently with 2 (2.4%) and 1 (1.2%) of them responding to always and regularly respectively. 67.1% representing 55 teachers never provides opportunities for learners to do research, 17 (20.7%) do so once in a while and 4 (4.9%) of the teachers quite frequently do so. Three (3) of the teachers representing (3.7%) each responded to always and regularly. With the statement "I use projects as part of my teaching approaches in Science ". The responses suggest that the majority of teachers 36 (43.9%) "Never" use projects as part of their teaching approaches in Science. An additional 22 (26.8%) reported doing so "Once in a while ". Lastly, 11 (13.4%) responded to doing so "quite frequently", 7 (8.5%) regularly and 6 (7.3) Always".

The assertion of the practice of inquiry-based instruction was based on the frequencies and percentages provided by the respondents for each item in the Likert scale. Based on the analysis of the interpretation, from the 10 items listed, 5 of them had a frequency responding to "Always", 2 each for "Regular" and "Never" while only 1 item recorded “Quite Frequently”. This is evident that lower primary teachers in the Effutu Municipality are consistently implementing inquiry-based practices however there are still room for improvement relating to the use of projects and out-of-class research. This suggests that while some elements of inquiry-based instruction are being employed regularly (active lesson planning, question-based lessons, group work, and real-world problem presentation) others are not therefore making the IBSI moderately practiced in the Municipality.

Lesson Observations

The researcher had the lessons of six teachers observed to identify the use of inquiry-based science instruction strategies in their classroom practices. Every inquiry-based classroom has certain feature to identify with. The researcher observed the seating arrangement, teaching approaches used and the implementation of the 5E model in their lessons.

Table 9 provides a summary of the lesson observed discussing classroom arrangement, teaching strategies used in the classrooms by the teachers and the way teachers use 5Es in their lesson.

Table 9: Summary of observed lesson of six lower primary teachers.

S/N	Seating Arrangement	Teaching Method	5E's Implementation
Tr. 1	Traditional	Lecture	Engagement
Tr. 2	Traditional	Lecture	Engagement
Tr. 3	Traditional	Lecture	Elaboration
Tr. 4	Traditional	Lecture	Engagement/exploration
Tr. 5	Traditional	Lecture	Engagement
Tr. 6	Traditional	Lecture	Elaboration

Source: Field Data (2023)

The classroom observations were mostly dominated by teachers having physical environment in the traditional way. There were less opportunity for learners to freely participate in group discussions with that kind of environment. The seating arrangements were the usual desks in rows and columns facing the chalkboard that are mostly found in the Ghanaian classrooms. This traditional classroom setting does not encourage inquiry-based science instruction.

The strategies mostly employed by teachers in the various lessons observed were the lecture method which was a teacher-centred approach. The lecture method does not encourage the use of inquiry-based science instruction especially at that level since learners at the lower-level stage learn by doing that, when involved during instructional period. The researchers use of the 5E model framework was mainly to find out if teachers actually used the inquiry-based strategies that the science curriculum lays emphasis on. Teachers mostly used the engagement which is the first E of the 5E model. That is, they began their lessons with probing questions to get learners relevant previous knowledge. They also asked learners for information on what they know about the topic and continued with teachers explaining the rest of the concepts to the learners. The lessons were evaluated by teachers writing exercises on the chalkboard for learners to answer in their exercise books. As to whether learners understood the concept or not was another issue since they were not given the opportunity to apply new skills learned. The teacher who engaged the learners in role-play made use of exploration where the learners were made to act to explain a concept which supports inquiry-based instruction.

The observations indicated that teachers practically did not use inquiry-based science instruction comprehensively to educate learners about the environment in the selected schools. In other words, instruction was mainly subject centred, direct instruction with limited pupil-centred activities. Again, most of the lower primary teachers taught without Teaching Learning Resources (TLR's). the few that were used were not used appropriately because learners were not allowed to interact with the materials.

Though teaching of science in the selected schools dominated by direct instruction, it was also characterized by teacher-learner interactions which took place in whole class discussion, usually at the beginning of lessons. However, the findings also revealed that learners' verbal interactions with the teachers were limited to single words or phrase and most of all the interactions were teacher initiated with little cooperative learning and learner-learner interaction. Semi-structured interviews were conducted to seek further clarification on why teachers used particular teaching strategies in their classroom lesson.

Result from semi-structured interview

Result from semi-structured interview on respondent practice of IBSI. Analysis from the interview revealed two themes with its associated codes. The themes were; variable IBSI implementation and enthusiastic IBSI advocate.

Variable IBSI implementation

Researcher: Have you used inquiry-based instruction as a teaching approach?

If yes, how do you employ inquiry-based instruction in your teaching?

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

"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 predictions" (Teacher 7)

Another replied:

> *"In my bit to engage students through inquiry-based Science instruction, I usually take the students out of the classroom to the school compound to explore nature, collect, analyse and share findings with others." (Teacher 10)*

Another respondent also added that:

> **"***The models I normally employ are group work, discussion, demonstration and experiments to arrive at a solution to a particular problem. I sometimes also give them real materials for them to manipulate". (Teacher 12)*

Another teacher stated 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" (Teacher 5)*

The captured statements revealed that, teachers in the Effutu Municipality do practice inquiry-based instruction to some extent in their lower primary classrooms. Their approach varies based on the topic and their preferred methods, which can include hands-on activities, group work, picture-based learning, and facilitative teaching. While the extent of IBSI practice varies among the teachers, it is evident that they value its use in enhancing student engagement and understanding in science education.

4.4 H0: There is no statistically significant relation between lower primary teachers' perceptions and their practices of inquiry-based science instruction in the Effutu Municipality.

A Pearson Correction analysis was conducted to determine the relationship between lower primary teachers' perception and practice of inquiry-based science instruction in the Effutu Municipality. Pearson Product Moment correlation was employed since it contributes to determining linear correlation between two variables (Pallant, 2020). The results of the analysis are shown on Table 10 as follows;

Table 10: Showing a Pearsons' Correlation analysis on the relationship between lower primary teachers' perceptions and practices of Inquiry-based Science Instruction

		TPe.	TPr
	Pearson Correlation	1	0.316**
Teacher perception (TPe)	Sig. (2-tailed)		0.004
	N	82	82
Teacher practice (TPr)	Pearson Correlation	0.316**	1
	Sig. (2-tailed)	0.004	
	N	82	82

Source: Field Data (2023)

The Pearson product-moment correlation result in Table 10 showed that there was a statistically significant positive but moderate relationship between teachers' perceptions and practices of inquiry-based science instruction in the Effutu Municipality with r =0.32, p < .01, 2-tailed). The Pearson Correlation between teacher perceptions (TPe) and teacher practice (TPr) was 0.316, which is positive signifying that as teachers' perception increases, there tends to be an increase in their practice of inquiry-based science instruction in the lower primary classrooms of the Effutu Municipality. The statistically significant p-value of .004 indicates that this relationship is not likely due to chance. However, the correlation value of 0.316 showed a moderate relationship between teacher's perception and practice of inquiry-based science instruction. This aligns with the recommendation by Pallant (2020) who classified correlation coefficient below 0.3 as a weak, 0.5 as moderate and 0.7 and above as strong relationship.

Based on the correlation analysis, it is concluded that there exists a significant, positive but moderate relationship between lower primary teachers' perception and their practice of inquiry-based science instruction in the Effutu Municipality. Therefore, the null hypothesis that there is no statistically significant relation between lower primary teachers' perception and their practice of inquiry-based science instruction in the Effutu Municipality was rejected.

4.5 Research Question 4: What challenges do lower primary teachers face in the implementation of inquiry-based science instruction in the Effutu Municipality?

This research question sought to look at the challenges lower primary teachers face in the implementation of inquiry-based science instruction in the Effutu Municipality. Respondent were presented with 13 statements spread across three sections; teacher-based challenges, pupil-based challenges and classroom-based challenges to indicate their agreement or disagreement using a four-point Likert scale of 1-SD, 2-D, 3-A and 4-SA.To aid the interpretation mean and standard deviation were employed where a mean of 1.0-1.4 indicates *Strongly Disagree (SD)*, 1.5-2.4 illustrates *Disagree (D)*, 2.5-3.4 indicates *Agree (A)* and 3.5-4.0 illustrates *Strongly Agree (SA)*. Similarly, a standard deviation below 1 indicated a similar response while a standard deviation of 1 and above indicated heterogeneous response.

Table 10 below shows lower primary teachers challenges of inquiry-based science instruction.

Table 11: Lower primary teachers challenges of inquiry-based science Instruction

Statement	Mean	S.D	Interpretation
Teacher-Based Challenges			
Motivating students poses a challenge to my implementation of inquiry-based instruction as a lower primary teacher	2.3659	.97515	D
My level of knowledge of inquiry-based science instruction as lower primary teacher poses a challenge to its implementation	2.4390	.81797	D
I am not familiar with the contents of the Science curriculum and this influences my implementation as a teacher	1.9878	.80881	D
I face difficulties in implementing IBSI because as a lower primary teacher I do not have a Science background	2.0000	.76980	D
I am not encouraged to implement IBSI based on my working conditions as a teacher	2.1585	.83842	D
Pupil-Based Challenges			
Learners attitude during inquiry-based science instruction challenges my implementation of it.	2.8049	2.35932	A
Learners difficulty in collaboration and team work relatively affects the implementation of inquiry-based science instruction	2.6220	.69638	A
The low academic abilities of my learners discourage me from implementing IBSI	2.2073	.73262	D
Classroom-Based Challenges			
Lack of resources poses a challenge to my implementation of inquiry-based science instruction.	2.9878	.88183	A
Inadequate time allotted for the teaching of Science in the classroom affects the implementation of inquiry-based science instruction.	2.6707	.94353	A
The large class size affects my ability to implement inquiry-based science instruction.	2.7561	.95013	A
I am unable to implement IBST due to lack of support from school authorities.	2.4390	.83293	D
Absence of regular in-service training impedes my ability to implement IBSI	2.6707	.84700	A

Source: Field Data (2023)

For the teacher-based challenges, result on Table 11 showed that on average, teachers tend to disagree (M=2.36, SD=0.97) with the statement that “Motivating students poses a challenge to my implementation of inquiry-based instruction as a lower primary teacher” A lower standard deviation suggests a homogenous response. Similarly, teachers disagree (M = 2.44, SD = 0.82) that their level of knowledge possess a challenge to implementing inquiry-based science instruction. A lower standard deviation suggests a consensus among the teachers. Also, teachers generally disagree (M = 1.99) of not being familiar with the contents in the science curriculum. The mean score indicates that teachers disagree that the lack of familiarity with the curriculum is a significant challenge. The low standard deviation of 0.81 suggests that while there is consensus, there is also some variability in their responses. Again, teachers disagree (M = 2.00, SD= 0.77) with the notion that, they face difficulties in implementing IBSI due to not having a science background. The standard deviation of 0.77 indicates some variation in how teachers implement this concept, but overall, there is alignment with this principle. Similarly, teachers disagree (M = 2.16) that working conditions do not strongly encourage the implementation of IBSI. The standard deviation suggests varying perceptions among teachers.

Also, with pupil-based challenges, teachers consented (M = 2.81, SD= 2.36) with the idea that, learners’ attitudes are a significant challenge during IBSI. The high standard deviation indicates a wide range of responses, with some teachers facing this challenge more than others. Teachers are also in moderate agreement (M = 2.62) that learners’ difficulties in collaboration and teamwork have a moderate impact on IBSI with the low standard deviation (0.69) suggesting relatively consistent responses. From the data teachers are in disagreement (M = 2.21, SD=0.73) that the low academic abilities of learners are not a significant discouragement. The standard deviation suggests consistent responses.

In relation to the classroom-based challenges, teachers agreed (M=2.99, SD=0.88) with the statement that "Lack of resources poses a challenge to my implementation of inquiry-based science instruction" The standard deviation suggests varying perceptions among teachers. Similarly, teachers agreed (M = 2.67, SD = 0.94) that that inadequate teaching time affects the implementation of IBSI. A lower standard deviation suggests varying perception among the teachers. Also, teachers agreed (M =2.75, SD=0.95) that that large class sizes affect their ability to implement the low standard deviation indicates that while there is consensus, there is also some variability in their responses. Furthermore, teachers disagreed (M =2.44, SD=0.83) that lack of support from school authorities is a challenge and with a low standard deviation, it indicates varying perceptions among teachers. Lastly, teachers agreed (M = 2.67, SD= 0.85) with the notion that, the absence of regular in-service training impedes their ability to implement IBSI. The standard deviation of 0.85 suggests varying perceptions among teachers.

In summary, the challenges faced by lower primary teachers in the Effutu Municipality vary in significance, classroom-related challenges appearing to become more substantial in their impact since majority of the lower primary teachers agreed to most of the items under it as compared to pupil-based challenges and teacher-based challenges

Excerpts from the challenges faced by lower primary teachers in the implementation of IBSI was examined through interviews with some participants. Four (4) themes emerged from the analysis and these were***; "Resource and Material Challenges", "Student-Related Hurdles"*** **and** ***"Time Management Dilemmas*"**

Knowledge Challenges

Researcher: Does the level of teachers' knowledge pose a challenge in the implementation of IBSI?

A teacher was of the view that:

> "*It's not necessary the level of knowledge of the teacher but the thing is sometimes you have the level, you have the knowledge but in its implementation you will by all means face challenge due to materials available. So, for me, I don't think it is the level of knowledge that poses the challenge but availability of material. If you have the knowledge and you know how to prepare a car and don't have the materials still you will face challenges" (Teacher 12)*

Another teacher was of the view that:

> *"Sometimes because of my in-depth knowledge of the concepts, my level of knowledge interferes with the pupils' freedom. I am sometimes forced to impose facts on them rather than allowing them to identify their faults and reconstruct their own understanding of the situation". (Teacher 7)*

Resource and material constraints

Another mentioned that:

> *"My major challenge in the implementation of inquiry-based instruction is the unavailability of the resources and the materials to aid the proper practice of inquiry-based instruction. (Teacher 3)*

Another teacher was of the view that:

> *"This is a major problem because without appropriate TLM's, practicing inquiry-based instruction is very difficult and time wasting."* *Material such us text books, diagrammatic TLM's, charts regalia, pictures and other useful materials to aid lesson delivery are not adequate". (Teacher 8)*

Student-Related Hurdles

Researcher: Do your pupils attitude affect your ability to implement IBSI? If yes briefly explain.

An interviewee said:

> *"It is very difficult to use the inquiry-based instruction approach 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." (Teacher 5)*

Another was of the view that:

> *I'm having 57 pupils and it is only I who is handling them. Today I have to teach 6 subjects given 1 hour each, give exercise and mark before moving to the next subject. Their number is huge and within this 1 hour, how would you identify those who did not understand and you also have to go to their level and teach of which the time do not permit this and this gives us a problem. Time sometimes doesn't permit us because looking at the class size some of them are not equal. In the teaching process, some will get it and others will not so you will have to consume others period at time before you get the required objective. (Teacher 4)*

Researcher: Are there any other factors that affect your ability to implement IBSI?

Environmental and Logistical Obstacles

An interviewee said that:

> *"Sometimes some of things to be studied requires the children to be sent out on excursion to explore but this isn't easy to come by because to do that you will have to take permission from here and there and so looking at the long process you will have to go through as a teacher you intend to forget about it and move forward but maybe if they had gone, it would have helped them understand the topic well but because of the environment which is not friendly, we are talking about the environment in education, the office is included is not friendly and the teacher do not have access to take the children to anywhere they like. Sometimes you have to even seek permission from parents and I cannot go to that extreme. So, I just do it in the classroom and that will be all" (Teacher 9)*

Another was of the view that:

> *"Ah yes, depending on the kind of area you are. In an area like this, you can't give them group work. yes, it's very difficult to give because giving them group work especially in the form of assignment, they don't live together and some they sell so how would they do the work together? So, depending on the community and the kind of resources or the particular thing you want them to do and the resources that they will need to do the things will determine. Still there will be a challenge so you have to find means and ways to deal with it.***"** *(Teacher 12)*

The environment in which these teachers work can also pose challenges. This includes constraints related to the community's nature, which may limit the use of certain teaching methods, as well as limitations in conducting excursions due to logistical and permission issues.

Time Management Dilemmas

> *Yeh sure, especially sometimes time management. You see we have fixed time and looking at the number of pupils in the class, you can't say you are using demonstration to teach in 1 hour or for any of the activity method. What time are they going to copy note? What time are they*

> *going to do exercise and what time are you going to mark? It's all in the 1 hour. (Teacher 3)*

Another said:

> *"Hmm! I will say inquiry-based instruction wastes time. You now have to give ample time for students to compete their inquiry and report their results." (Teacher 1)*

Another was of the view that:

> *"You will agree with me that the schools' time-table does not support this kind of approach and alone discourages me from using inquiry-based instruction". (Teacher 2)*

Teachers often struggle with time management when implementing IBSI. Balancing the various aspects of the curriculum, including teaching, assigning tasks, marking, and providing individualized support, can be challenging within the allocated class time.

In summary, the challenges faced by lower primary teachers in the Effutu Municipality in implementing IBSI encompass a range of factors. These include teacher knowledge, pupils' attitudes, limitations in teaching and learning resources, environmental factors, and the community context. Each teacher's perspective provides valuable insights into the distinct challenges they encounter in their classrooms, contributing to a comprehensive understanding of the difficulties in implementing inquiry-based science instruction.

4.6 Discussion of Findings

4.6.1 Public lower primary teachers' perceptions of inquiry-based science instruction.

Teachers' perception is crucial for the success of inquiry-based instruction, particularly when the aim is for learners to do intellectual work and get involved in designing and investigation which calls for greater range of science teachers knowledge skills. This research sought to assess perceptions that lower primary teachers in the Effutu Municipality possess about inquiry-based science instruction (IBSI). The study employed a sequential explanatory research design, involving both quantitative and qualitative phases to assess teachers' perspectives and practices. The quantitative phase involved survey data analysis, while the qualitative phase provided deeper insights through interviews and observations.

The findings from the study indicated that lower primary teachers generally have good perception when it comes to inquiry-based science instruction. Teachers demonstrated general agreement on several key principles associated with IBI, such as learners actively participating in investigations and the existence of different types of inquiry-based instruction. They also recognised the importance of scientific questioning and the prioritisation of evidence in students' responses. Teachers generally agreed on the roles of the teacher as a facilitator and the collaborative nature of inquiry learning. This study aligned with that of Twahirwa et al. (2022) from whose study indicated that inquiry-based instruction approach is of paramount importance in teaching and learning sciences. This is because all procedures followed during the implementation of IBL are centered on the learner and the teacher is considered as the facilitator during the process.

However, there were points of contention, especially concerning the primary focus of inquiry-based instruction, the locations where it takes place, and the role of the teacher as the primary information provider. These disagreements reflected variations in teachers' interpretations of certain aspects of IBSI. This affirmed the study of Mugabo et al. (2015) who investigated the understanding of inquiry-based science teaching of 200 high school teachers in Rwanda. 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.

The qualitative phase enriched these findings by revealing a diverse spectrum of perspectives and approaches among teachers. The result highlighted that all teachers value student engagement and practical demonstrations, but their definitions and models of inquiry-based instruction vary. Some teachers emphasized practical demonstrations, while others focused on active learning or the use of various teaching tools and techniques to make science education more interactive and effective. These insights provide a glimpse into the varied ways in which teachers implement IBI in their science lessons. The findings also provided an exact understanding of the perceptions regarding inquiry-based science instruction among the lower primary teachers which ranged from limited to more comprehensive. The finding that lower primary teachers in the Effutu Municipality possess high (good) perception of inquiry-based science instruction is positive; showing their readiness to effectively engage in the process during Science instruction. This affirmed what Hakim and Ikhsan (2018) stated in their study that, teachers with high (good) perception about the characteristics of the inquiry approach engages in its implementation.

4.6.2 Public lower primary teachers practice of Inquiry-Based Science Instruction

The research objective investigates how upper primary teachers practice inquiry-based science instruction in the classroom. Currently the Ghanaian Science education advocates the implementation of inquiry-based instruction to make learners more engaged in their Science activities and encourage them to learn Science. The findings from this study revealed that, teachers do practice inquiry-based instruction to some extent in their lower primary classrooms of which their approach varies based on the topic and their preferred methods, including hands-on activities, group work, picture-based learning, and facilitative teaching. Findings from the study affirmed that of Pozuelos and Gonzales (2014) in Spain in whose study revealed that teachers focused on three areas of need in their practice of inquiry-based instructions; a suitable working environment that enables and facilitates collaborative work, alternative materials and greater social recognition.

Majority of lower primary teachers in the Effutu Municipality engage in various aspects of inquiry-based science instruction. For example, a significant percentage always or regularly plan lessons to actively involve learners in inquiry-based instruction, start lessons with questions, use group work, and present real-world problems to investigate.

However, there are variations in the extent to which some aspects of inquiry-based science instruction are practiced. For instance, the use of projects and opportunities for learners to do research are less common. The findings indicated that many elements of inquiry-based science instruction are being implemented regularly, while others, such as projects and out-of-class research, are practiced less frequently. While the extent of IBSI practice varies among the teachers, it is evident that they value its use in enhancing student engagement and understanding in science education. This finding, suggests that inquiry-based science instruction is moderately practiced in the Effutu Municipality, with some elements being consistently implemented and others showing room for improvement.

Observations of classroom environments and teaching methods indicates that traditional classroom settings are prevalent, with desks arranged in rows and columns and the lecture method commonly used by teachers during instruction, with only a minority employing the inquiry-based approach. This is evident from the study of one author who was of the view that; the teacher-centred teaching approach often accepts the notion that all students have the same degree of prior experience in the subject matter and can learn information at the same rate (Yamagata, 2018), makes instruction easy to implement rather than the IBSI which is difficult to implement therefore the constant use of it. This shows that despite the implementation of IBSI, teachers still adopt the rote method of teaching.

The use of the 5E model of inquiry-based instruction, which is emphasized in the science curriculum, varies among teachers. Notably, the “Evaluate” phase, which is crucial for assessing students' understanding and the effectiveness of instructional methods and encouraging students to apply concepts and skills is less frequently used where as teachers excel in the “Engage” and “Explore” phases, which involve engaging questions and fostering student interactions, but there is room for growth in the "Elaborate" phase. This is of concern as it plays a vital role in improving teaching strategies and enhancing the overall learning experience. Some studies have revealed the usefulness of the 5E model.

Findings from the qualitative phase indicated that lower primary teachers do practice inquiry-based instruction to some extent. This contradicts the findings of Yamagata (2018) from whose study, stated that, the traditional approach is used in teaching Science. This may result from the difference in in location and period in conducting research. The variations in practice varies based on topics and teaching methods, including hands-on activities, group work, picture-based learning, and facilitative teaching. While some teachers are proficient in certain aspects of inquiry-based instruction, others may not hence the need of improvement.

In general, the research findings suggest that while there is implementation of inquiry-based science instruction in lower primary classrooms in the Effutu Municipality, there are variations in how different teachers approach it, and there is room for enhancing specific aspects, such as the "Evaluate" phase, projects, and opportunities for learners to do research.

4.6.3 Relationship between the perceptions and practices of inquiry-based science instruction among public school lower primary teachers.

The findings from the study revealed a Pearson product-moment correlation coefficient (r) value of 0.32 which indicated a significant positive but moderate relationship between teachers perceptions (TPe) and practices (TPr) of inquiry-based science instruction. This indicates that there is a tendency for teachers with higher knowledge of inquiry-based science instruction to implement it more effectively in their lower primary classrooms. This confirms what Ibrahim, and Mahmud (2020), discovered in their study that, high level or exposure to inquiry-based instruction results in its implementation during instruction.

In the context of this analysis, this means that while teacher knowledge does impact classroom practice positively, the connection isn't extremely strong implying that other factors may also influence how teachers implement inquiry-based science instruction in their classrooms and that increasing knowledge alone may not be sufficient to guarantee high-quality implementation of inquiry-based science instruction. It is to be noted that the knowledge of science teachers toward inquiry-based science teaching influences teachers' skills to practice it in the process of teaching and learning. If teachers were exposed to inquiry-based science instruction through workshops or training, then teachers' skills in implementing them in the process of teaching and learning will be increased (Silm et al., 2017). Failure to expose teachers to inquiry-based science instruction will not improve and may decline their skills of practicing it causing them not to be confident about implementing this approach.

The findings contradicted with the study of Xie et al. (2014), who reported a significant and strong relationship between perception and practice of the inquiry approach among teachers. This may be as a result of the nature of participants used and the setting. The exposure of the inquiry approach to teachers is important to enhance better practice and understanding (Hakim & Iksan, 2018) because effective teaching requires in-depth knowledge and skills of the pedagogy used (Hamdan et al., 2017). It is clearly shown that teachers' knowledge level of inquiry-based science teaching affects the teachers' skills in practicing it during instruction.

4.6.4 Challenges that impede the implementation of inquiry-based science instruction among public lower primary teachers.

The challenges faced by lower primary teachers in the Effutu Municipality regarding the implementation of inquiry-based science instruction (IBSI) are multifaceted as shown from data analysis from the quantitative and qualitative data. Ramnarain and Hlatswayo (2018) confirms this as they highlighted different barriers that impedes the implementation of IBSI. Teachers from the findings, generally express disagreement with teacher-based challenges but moderate agreement on pupil-based and classroom-based challenges. This is evident from the data which shows that teachers tend to disagree, on average, with the statement that motivating students poses a challenge, suggesting a relative consensus among teachers. However, there is moderate agreement on the challenges related to their level of knowledge, working conditions, and familiarity with the science curriculum. The overall mean of 2.19 suggests a mild disagreement among teachers regarding teacher-based challenges, with a relatively similar response.

Teachers also expressed agreement that learners' attitudes and difficulties in collaboration pose significant challenges, with varying responses among teachers with an overall mean of 2.48 suggesting a moderate level of agreement, indicating some degree of disagreement as well. The standard deviation of 1.26 suggests a relatively heterogeneous response, signifying varying perceptions among lower primary teachers. Also, teachers moderately agree that lack of resources, inadequate teaching time, large class sizes, lack of support from school authorities, and absence of regular in-service training are challenges in implementing IBSI. The overall mean of 2.70 suggests a mild agreement, with a relatively heterogeneous response among participants. These findings suggest that challenges related to student attitudes, resource availability, and classroom constraints are perceived as more substantial highlighting the significance of material and resource availability, student attitudes, environmental factors, and time management as key challenges.

The findings from this study corroborates with that of Effendi, M.H., and Mukminin (2019), in their study sought to find out challenges teachers face in the implementation of IBSI under four major constraints (lack of time, number of students, lack of equipment and lack of knowledge, skills and experience with practicing inquiry), lack of time was the most cited constraint amongst the four, followed by the large number of students, the lack of equipment and facilities, and the lack of knowledge, skills and experience with practicing inquiry. Another study conducted by Gray, (2021) on *Elementary Teachers' Implementation of Inquiry-Based Instruction* outlined certain barriers of which teachers' knowledge came least among instructional time, lack of confidence and resources that elementary teachers face in their implementation of IBSI. In her study, Gholam (2019) revealed that, teachers considered the following factors as hindering the implementation of IBL in the classroom: lack of background knowledge in content and pedagogy, classroom management, and curriculum design and infrastructure but participants in the study did not consider lack of background knowledge in content and pedagogy and classroom management challenging, but they did consider curriculum design and infrastructure as contributing. This concern was also identified in research conducted by Nollmeyer et al. (2019) in which elementary teachers were interviewed to identify the barriers to teaching inquiry-based science instruction. In the above study, though teachers identified lack of knowledge as a barrier to implementing inquiry-based science instruction, it wasn't significant as compared to other factors which makes them feel unprepared to implement inquiry-based science methods.

According to the teachers in the Municipality, heavy teaching and curriculum load affects their implementation process causing them in rushing to cover the entire curricular contents as a result of insufficient time. From the timetables observed in the various classrooms, Science and other related subjects are offered twice in a week with Mathematics and English offered five times in a week with time allocation of 1 hour for each subject. This implies that in a week, Science is only taught for 2 hours in a week which isn't enough causing them to feel pressured to cover curriculum that make them leave almost no time for practical lessons. This makes teachers feel unprepared with science content to fully implement science topics in the classroom (Lee & Glass, 2019). Also, in a class there are about 50 -60 students in the classroom which reduces teachers' eagerness to conduct an inquiry-based activity due to the classroom management and disciplinary issues as well as plenty of time spent for preparation of materials and arrangement of the classroom. Undoubtedly, the teachers thus prefer to employ a teacher-centered instruction method such as lecturing for their overcrowded classrooms. Professional development is, therefore, believed to be the key to meet the goals of teaching reform. Elementary teachers often teach all subjects as a result professional development is needed. One that will aim at enhancing the content and pedagogical (Gardner, Glassmeyer & Worthy, 2019), empowers teachers to become directors of instruction and facilitators of investigations permitting them to shift their pedagogical practice and build their pedagogical content knowledge (Lotter, Smiley, Thompson, & Dickenson, 2017) and develop teachers' self-efficacy that allows them to practice skills and gain experience (Mitchell, Roy, Fritch & Wood, 2018) in implementing inquiry-based science instruction.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter presents the summary of the findings, conclusion and recommendation on the study.

5.1 Summary of Findings

In this study, sequential explanatory mixed method was employed to address the research topic lower primary teacher's perceptions and practices of inquiry-based science instruction in the Effutu Municipality in the Central Region of Ghana. Eighty-two public lower primary teachers were recruited for the quantitative study. In the qualitative study, a sub-sample size of twelve lower primary teachers from the eighty-two lower primary teachers were employed. The teachers who participated in the study were included through the census method where questionnaire and semi-structured interviews were employed as instruments for both the quantitative and qualitative phase respectively. The quantitative data was analysed using descriptive analysis of frequency counts, percentages, mean, standard deviation and Pearson Correlation whereas the qualitative phase employed thematic analysis.

1. The first objective of the study was to determine lower primary teachers' perceptions of inquiry-based science instruction in the Effitu Municipality of Ghana. The combined analysis of quantitative and qualitative data underscores that lower primary teachers in the Effutu Municipality possess a high level of perception and understanding of inquiry-based science instruction. While there is general agreement on core principles; student engagement, practical demonstrations, and the use of various teaching tools and techniques to make

science education interactive and effective. However, it also underscores that there is no uniform understanding of IBI among teachers as their definitions, views on types and models of IBI, and implementation strategies vary widely, indicating a broad spectrum of knowledge levels. Some teachers demonstrate a limited understanding, while others adopt more comprehensive and innovative practices in their classrooms. The variations in interpretation and practice suggest the need for targeted professional development.

2. The second objective of the study was to ascertain some practices employed by lower primary teachers in their practice of inquiry-based science instruction in the classroom. It is revealed that, teachers in the Effutu Municipality do practice inquiry-based instruction to some extent in their lower primary classrooms. Their approach varies based on the topic and their preferred methods, which can include hands-on activities, group work, picture-based learning, and facilitative teaching. While the extent of IBSI practice varies among the teachers, it is evident that they value its use in enhancing student engagement and understanding in science education.
3. The third research objective sought to examine the relationship that exist between public lower primary teachers' perceptions and practices of inquiry-based science instruction. Findings from the study revealed that, the analysis provides evidence of a significant, positive, and moderate relationship between lower primary teachers' perception and their practices of inquiry-based science instruction in the Effutu Municipality. This indicates that though teachers' perception impact classroom practice positively, the connection is not extremely strong implying that other factors may also influence how teachers implement inquiry-based science instruction in their classrooms and

that increasing knowledge alone may not be sufficient to guarantee high-quality implementation of inquiry-based science instruction but a moderate relationship signifies teachers increasing practice of the approach as their knowledge increases. The findings also showed the significance of the p-value as $p < .01$ which rejects the null hypothesis that there is no significant relationship between lower primary teachers' knowledge and practice of IBSI.

4. The last research objective targeted the challenges public lower primary teachers face in their implementation of inquiry-based science instruction. The integration of quantitative and qualitative data enriches the analysis, offering a comprehensive view of the challenges faced by lower primary teachers in the Effutu Municipality in implementing IBSI. From the findings, teachers were faced with multifaced challenges including teacher-based challenge, pupil-based challenges and classroom-based challenges. It was evident from the analysis that public lower primary teacher tends to agree to the fact that pupil-based challenges and classroom-based challenges is a significant challenge to their implementation of IBSI as compared to the teacher-based challenges.

5.2 Conclusions

The perceptions of lower primary teachers in relation to inquiry-based instruction were high (good). They integrated other forms of teaching pedagogies to improve the inquiry-based instructional process. The teachers could improve on their content knowledge if the appropriate avenues are created.

Though public lower primary teachers acknowledged the importance of inquiry-based Science instruction, their classroom arrangements did not favour the implementation of the approach with most of the teachers still using the traditional method of teaching.

Public lower primary teachers from the study showed that they practiced inquiry-based Science instruction in the classroom but do not do so holistically. Common approaches which were easy to practice such as demonstrations, group work, discussion, were favored and practiced more than project, field trips, nature trail and others which makes the practice moderately done. Also, the teachers focused more on Engagement and Exploration phases of the 5E model than the Evaluative, Explanation and Elaboration phases.

It was evident from the study that indeed there is a positive relationship between teachers' perception and practice which indicates that the increase in the perception of IBSI among public lower primary teachers results in increase in their practice of inquiry-based Science instruction.

Though there are lots of challenges that impedes the implementation of inquiry-based Science instruction among public lower primary teachers, there is the need with immediate effect to handle the issue of resource and materials constraints, student related hurdles, time management as this pose a major challenge for the teachers in the Municipality. If these challenges could be improved, there could be a greater improvement in the practice of inquiry-based instruction in the primary school science classroom.

5.3 Recommendations

The following recommendations were drawn based on the findings of the study:

1. The Effutu Municipality in collaboration with the Effutu Municipal Education Directorate of Ghana Educational Service and the various head teachers of the public lower primary schools should consider public lower primary teachers' level of knowledge on inquiry-based science instruction before assigning them to their classes since it is recommended as the best approach to teaching science in the primary school. Teachers should also be given the opportunity to go through in-service training, workshops, seminars and further education to improve on their perception and practice of inquiry-based instruction.
2. The Effutu Municipal Directorate of the Ghana Educational Service through professional training for public lower primary teachers can enhance specific aspects of the teachers such as how to effectively carry out the evaluate phase, projects and provide opportunities for learners to conduct research.
3. There is the need to conduct in-depth classroom observations by various heads of the public schools and SISSO's to gain detailed understanding of specific inquiry-based instructional practices employed in the classroom as means of providing insight into the frequency of implementation and variations across different topics.
4. The Effitu Municipal Directorate of the Ghana Educational Service, the head teachers and the various stakeholders should motivate the use of inquiry-based instruction and collaborate to make provision of the various teaching and learning materials available so as to encourage the use of inquiry-based instruction by the public lower primary teachers. They should design and educate the teachers on the various ways to overcome challenges during their

implementation of IBSI as this will go a long way to improve pupils' performance.

5.4 Suggestions for further Research

First, this study could be replicated to explore lower primary teachers' perceptions or practices of inquiry-based science instruction at different settings with larger sample size. It can also be looked at the at different levels of education (upper primary, JHS or SHS) at either the public sector or both or at the same level as the study but in the private sector in the same or different sector. Also, there is the need for further research on teachers' knowledge and practices of inquiry-based science instruction in specific branch of science disciplines such as biology, chemistry and physics in Ghana.

REFERENCES

Abell, D. L. (1999*).* Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education, 22*(T), 665-701.

Acquah, S. (2019). An illuminative evaluation of the influence of tessa science oer use on pre service science teachers' pedagogy. *European Journal of Research and Reflection in Educational Sciences Vol, 7*(12).

Adofo, S. (2017). Teachers' perceptions about inquiry in science education *(Master's thesis, Itä Suomen yliopisto).*

Amankwaa, L. (2016). Creating protocols for trustworthiness in qualitative research. *Journal of cultural diversity*, *23*(3).

Amo-Darko, B. (2017*). Primary teachers' curriculum knowledge and classroom practice in relation to implementation of natural science* (Unpublished M.Phil Thesis, University of Education, Winneba)

Ampiah, J. C. (2015). *Quality basic Education in Ghana: prescription at the experience sharing Service.* Journal of International Development, Vol 26, (1), 59-76

Ampiah, W.T. (2010). Comparison of student performance in cooperative learning and traditional lecture-based biochemistry classes. *Biochem. Mol. Biol. Educ., 33*(6), 387-393

Anderhag, P., Wickman, P. O., Bergqvist, K., Jakobson, B., Hamza, K. M., & Säljö, R. (2016). Why do secondary school students lose their interest in science? Or does it never emerge? A possible and overlooked explanation. *Science Education, 100*, 791–813.

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of science teacher education, 13*(1), 1-12.

Appiah, V. (2015). Can the theory of planned behaviour predict the maintenanace of physical activity? *Health Psychology*, 24(3), 235-245

Assay, L. & Orgill, M. (2010). Analysis of essential feature of inquiry. *Journal of Science Teacher Education, 21, 57-79.*

Atar, H. Y. (2011). Investigating the relationship between teachers' nature of science conceptions and their practice of inquiry science. *Asia-Pacific Forum on Science Learning and Teaching. 12(2), 1-6.*

Ataro, G. (2020). Methods, methodological challenges and lesson learned from phenomenological study about OSCE experience: Overview of paradigm-driven qualitative approach inmedical education. *Annals of Medicine and Surgery*, *49*, 19-23.

Avsec, S. & Kocijancic, S. (2016). A path model of effective technology-intensive inquiry-based learning. *Journal of Educational Technology & Society*. *19*(1), *308.*

Baroudi, S., & Rodjan Helder, M. (2021). Behind the scenes: teachers' perspective on factors affecting the implementation of inquiry-based science instruction. *Research in Science & Technological Education*, 39(1), 68-89. https://doi.org/10.1080/02635143.2019.1651259.

Bell, K., & Wynn, L. L. (2023). Research ethics committees, ethnographers and imaginations of risk. *Ethnography*, *24*(4), 537-558.

Bishaw, A. (2010). Teacher's beliefs and actual practice of problem-solving approach in teaching mathematics. *Journal of Education and Science*.*6*(1): 73-87

Bogar, Y. (2019). Literature review on inquiry-based learning in science education. *Uluslararası Bilim ve Eğitim Dergisi*, *1*(2), 91-118.

Breslyn, W., & McGinnis, J. R. (2012). A comparison of exemplary biology, chemistry, earth science, and physics teachers' conceptions and enactment of inquiry. *Science Education*, *96*(1), 48-77.

Brigham, F. J. Scruggs, T. E. & Mastropieri, M. A. (2011). Science education and students with learning disabilities. *Learning Disabilities Research & Practice*, *26*(4), 233-232

Brittain, S., Ibbett, H., de Lange, E., Dorward, L., Hoyte, S., Marino, A., ... & Lewis, J. (2020). Ethical considerations when conservation research involves people. *Conservation Biology*, *34*(4), 925-933.

Buus, A. (2019). *College readiness—a reflection moving forward: An explanatory sequential qualitative study*. California State University, Fullerton.

Bybee, A. A. (2000). The impact of constructivism on education: Language, discourse and meaning. *American Communication Journal (5)*3, retrieved January 17, 2010, from http://acjournal.org/holdings/volS/iss3/special/jones.html

Bybee, A. A. (2006). What do preservice teachers learn in an inquiry-based science methods course? *Journal of Elementary Science Education*, *19*(1), 1-13.

Bybee, A. A. (2011), *The BSCS SE instructional model: Origins and effectiveness. Colorado Springs*, CO: Office of Science Education, National Institutes of Health.

Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Carson Powell, J, Westbrook, A., et al. (2006). *Enhancing science teaching and student learning: A BSCS perspective.* Paper presented at the ACER Research Conference 2006, Canberra, ACT. Retrieved February 19, 2008, from http://www.acer.edu.au/documents/RC2006_Bybee.pdf.

Cakir, N. K. (2017). Effect of 5E learning model on academic achievements, attitude and science process skills; Meta-analysis study. *Journal of Education and Training Studies,* 5(11), 157-170

Capps, D. K. & Crawford, B. A. (2012). Inquiry-based instruction and teaching about nature of science: Are they happening? *Journal of Science Teacher Education.* doi:10.1007/s10972 012-9314-7

Castells, N., Minguela, M., Solé, I., Miras, M., Nadal, E., & Rijlaarsdam, G. (2022). Improving questioning–answering strategies in learning from multiple complementary texts: An intervention study. *Reading Research Quarterly*, *57*(3), 879-912.

Caswell, C. J., & LaBrie, D. J. (2017). Inquiry-based learning from the learner's point of view: a teacher candidate's success story. *Journal of Humanistic Mathematics*, *7*(2), 161- 186.

Childs, P. E., Hayes, S., & Dwyer, A. (2015). Chemistry and everyday life: Relating secondary school chemistry to the current and future lives of students. In I. Eilks & A. Hofstein (Eds.), *Relevant chemistry education - from theory to practice* (pp. 33–54). Rotterdam: Sense.

Cho, E. (2021). Neither Cronbach's alpha nor McDonald's omega: A commentary on Sijtsma and Pfadt. *Psychometrika*, *86*(4), 877-886.

Cibulka, M. T., & Strube, M. J. (2021). The conundrum of Kappa and why some musculoskeletal tests appear unreliable despite high agreement: a comparison of Cohen Kappa and Gwet AC to assess observer agreement when using nominal and ordinal data. *Physical Therapy*, *101*(9), pzab150.

Conklin, W. (2012). *Higher order thinking skills to develop 21st century learners. Huntington Beach, CA: Shell Education.*

Conlon, C., Timonen, V., Elliott-O'Dare, C., O'Keeffe, S., & Foley, G. (2020). Confused about theoretical sampling? Engaging theoretical sampling in diverse grounded theory studies. *Qualitative health research*, *30*(6), 947-959.

Connelly, M. (2016). Trustworthiness in qualitative research. *MedSurg Nursing*, *25*(6),435+. https://link.gale.com/apps/doc/A476729520/AONE?u=anon~2ddf3bcc&sid=googl eScholar&xid=ab1863c2

Constantinou, C. P., Tsivitanidou, O. E., & Rybska, E. (2018). *What is inquiry-based science teaching and learning?* (pp. 1-23). Springer International Publishing.

Correia, C. F., & Harrison, C. (2020). Teachers' beliefs about inquiry-based learning and its impact on formative assessment practice. *Research in Science & Technological Education*, *38*(3), 355-376.

Cresswell, J. W. (2012). *Educational research: Planning, conducting and evaluating quantitative and qualitative research* (4th ed.). Boston: Pearson

Creswell, J. W. (2009). Mapping the field of mixed methods research. *Journal of mixed methodsresearch*, *3*(2), 95-108.

Dewey, J. (1938). *Experience and education*. New York: Collier.

Dzwigol, H. (2020). Case studies in the research process related to managementsciences. *Journal of Media & Management*, *2*(2), 1-6.

Effendi-Hasibuan, M. H., & Mukminin, A. (2019). The inquiry-based teaching instruction (IbTI) in Indonesian secondary education: What makes science teachers successful enact the curriculum? *Journal of Turkish Science Education*, *16*(1), 18-33.

Eick, C. J. & Reed, C. J. (2002). What makes an inquiry-oriented science teacher? The influence of learning histories on student teacher role identity and practice. *Science Education*, *86,* 401-169.

Eilks, I., & Hofstein, A. (2015). *Relevant chemistry education*. Rotterdam: Sense.

Eley, A. (2022). Different approaches to teaching primary science: The role of the teacher is what makes the difference. *Primary Science*, *171*, 7-10.

Eltanahy, M., & Forawi, S. (2019). Science teachers' and students' perceptions of the implementation of inquiry-based learning instruction in a middle school in Dubai. *Journal of Education*, *199*(1), 13-23.

Eyong, H. T. (2020). *Teacher perceptions about science instructions in Cameroon* (Doctoral dissertation, Delaware State University).

Finch, E., & Fafinski, S. (2023). *Legal skills*. Oxford University Press.

Fitzgerald, M., Danaia, L., & McKinnon, D. H. (2019). Barriers inhibiting inquiry-based science teaching and potential solutions: Perceptions of positively inclined early adopters. *Research in Science Education*, *49*(2), 543-566.

Flick, L. B. & Lederman, N. G (2006). Teaching nature of science through inquiry: Results of a 3 year professional development program. *Journal of Research in Science Teaching*, 44, 653- 680.

Friesen, S. G. & Scott, P. (2013). *A case study of a teacher's progress toward using a constructivist view of learning to inform teaching in elementary science.* Science Education, 80, 165180.

Fuchs, I. S. & Fuchs, D. (2001). Principles for sustaining research-based practice in the schools: *A case study, focus on exceptional children*, 33, 1-14.

Gardner, K., Glassmeyer, D., & Worthy, R. (2019). Impacts of STEM professional development on teachers' knowledge, self-efficacy, and practice. *Frontiers in Education*. 4 https://doi.org/10.3389/feduc.2019.00026

Gholam, A. P. (2019). Inquiry-based learning: Student teachers' challenges and perceptions. *Journal of Inquiry and Action in Education*, *10*(2), 6.

Goodrum, D., Hacking, M. & Rennie, L. (2001). *The status and quality of teaching and learning of science in Australian schools*: a research report. Canberra, ACT: Department of Education, Training and Youth Affairs.

Grandy, R, & Duschl, R. A. (2007). Reconsidering the character and role of inquiry in school science: Analysis of a conference. *Science & Education, 16*(2), 141-166.

Gray, W. P. (2021). *Elementary Teachers' Implementation of Inquiry-Based Instruction* (Doctoral dissertation, Walden University).

Guido, M. (2017). Inquiry-based learning definition, benefits & strategies. Retrieved October 26, 2017.

Hakim, N. A., & Iksan, Z. (2018). Knowledge, implementation skills, and teachers' attituddes towards problem-based learning (PBL) in the subject of science. *International Seminar on Educational Issues*,72-82.

Hamdan, A.J., Ramli, J., & Musa, I. (2017). Level of interest, knowledge and skills, teacher training and teacher workload in the special remedial program of national schools in thePontian district, Johor. *Paper presented at the Annual Conference on Teacher Education,* Kota Kinabalu, Sabah.

Harlen, O. (2013). Reforming again, again and again. *Educational Researcher*, 19(1), 3-13.

Herranen, J., Kousa, P., Fooladi, E., & Aksela, M. (2019). Inquiry as a context-based practice–a case study of pre-service teachers' beliefs and implementation of inquiry in context-based science teaching. *International journal of science education*, *41*(14), 1977-1998.

Hofer, E. & Lembens, A. (2019). Putting inquiry-based learning into practice: How teachers changed their beliefs and attitudes through a professional development program. *Chemistry Teacher International*, *1*(2), 20180030. https://doi.org/10.1515/cti-2018-0030

Hugerat, M., Mamlok-Naaman, R., Eilks, I., & Hofstein, A. (2015). Professional development of chemistry teachers for relevant chemistry education. In I. Eilks & A. Hofstein (Eds.), *Relevant chemistry education* (pp. 369–386). Rotterdam: Sense.

Ibrahim, S. & Mahmud, S. N. D. (2020). inquiry-based science teaching: knowledge and skills among science teachers. *Humanities & Social Sciences Reviews*. 8. 110-120. 10.18510/hssr.2020.8413.

Inter Academy Panel (2012). *Taking inquiry-based science education into secondary education*. Report of a global conference.

Ireland, J. Watters, J. Brownlee, J. & Lupton, M. (2011). Elementary teachers' conceptions of inquiry teaching: message for teacher development. *Journal of Science Teacher Education*, *23*(2), 1-17

Kahn, F. & O'Rourke, Q. (2005). Confronting, challenging, and changing teachers' beliefs: Implications from a local systemic change professional development program. *Journal of Science Teacher Education*, *13*(2), 101-130.

Kang, E. J. S. Bianchini, J. A. & Kelly, N. J. (2013). Crossing the border from science student to science teacher: Preservice teachers' views and experiences learning to teach inquiry. *Journal of Science Teacher Education*, 24, 427-447, doi: 10.1007/s10972-012-9317-9.

Katz-Buonincontro, J., & Anderson, R. C. (2020). A review of articles using observation methods to study creativity in education (1980–2018). *The Journal of Creative Behavior*, *54*(3), 508-524.

Kelly, L. M., & Cordeiro, M. (2020). Three principles of pragmatism for research on organizational processes. *Methodological innovations*, *13*(2), 2059799 120937242.

Kelly, S., Bringe, R., Aucejo, E., & Fruehwirth, J. C. (2020). Using global observation protocols to inform research on teaching effectiveness and school improvement: Strengths and emerging limitations. *Education Policy Analysis Archives*, *28*, 62-62.

Keys, C. W. & Bryan, L. A. (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching*, *38*(6), 631 645

King, D. L., Chamberlain, S. R., Carragher, N., Billieux, J., Stein, D., Mueller, K. & Delfabbro, P. H. (2020). Screening and assessment tools for gaming disorder: A comprehensive systematic review. *Clinical psychology review*, *77*, 101831.

King, R., Van de Schoot, R., Depaoli, S., Kramer, B., Märtens, K., Tadesse, M. G., & Yau, C. (2021). Bayesian statistics and modelling. *Nature Reviews Methods Primers*, *1*(1), 1.

Kraus, R. (2008). Overcoming the difficulties of inquiry-based teaching through the use of coaching.UMI:3338026.

Landis, J. R., & Koch, G. G. (1977). An application of hierarchical kappa-type statistics in theassessment of majority agreement among multiple observers. *Biometrics*, 363-374.

Larrivee, B. (2008). Meeting the challenges of preparing reflective practitioners. *New Education, 4*(2), 87-106.

Lee, T. D., & Glass, B. (2019). Developing the next generation of elementary science teachers. *Journal of College Science Teaching*, *49*(2), 18–23.https://doi.org/10.2505/4/jcst19_049_02_18.

Lemlech, D. G. (2010). *Change in schools: Facilitating the process*. New York: State of NewYork Press.

Leonor, J. P. (2015). Exploration of conceptual understanding and science process skills: A basis for differentiated science inquiry curriculum model. *International Journal of Information and Education Technology*, *5*(4), 255-259

Linn, M. C. Davis, E. A. & Bell, P. (2004). Inquiry and technology. *Internet environments for science education*, 2, 3-28.

Lotter, C., Smiley, W., Thompson, S., & Dickenson, T. (2017). The impact of a professional development model on middle school science teachers' efficacy and implementation of inquiry. *International Journal of Science Education*, *38*(18), 2712–2741. https://doi.org/10.1080/09500693.2016.1259535

Luchmann, A. L. (2007). Identify development as a lens to science teacher preparation. *Science Education, 91*(5), 822-839

Mansour, N. (2010). Impact of the knowledge and beliefs of Egyptian Science Teachers in Integrating a STS based Curriculum: A Sociocultural Perspective. *Journal of Science Teacher Education*, 21(4), 513-534

Martell, C. C. (2020). Barriers to inquiry-based instruction: A longitudinal study of history teachers. *Journal of Teacher Education*, *71*(3), 279-291.https://doi.org/10.1177/0022487119841880

Masingila, J. O. (2019). Factors influencing chemistry teachers' understanding and practice of inquiry-based instruction in Kampala, Uganda. *International Journal of Scientific Research and Education*, *7*(1), 8062-8071.

Masingila, J. O., & Ssempala, F. (2019). Effect of professional development on chemistry teachers' understanding and practice of inquiry-based instruction in Kampala, Uganda. *International Journal of Scientific Research and Education*, *7*(2), 8085-8105.

McNabb, D. E. (2020). *Research methods for political science: Quantitative, qualitative andmixed method approaches*. Routledge.

Mensah, A. B. (2018). *Upper primary integrated science teachers' knowledge and practices of inquiry-based teaching.* (Unpublished M.Phil Thesis, University of Education, Winneba)

Ministry of Education, (2019). *Science Curriculum for Primary Schools*. Accra: National Council for Curriculum and Assessment (NaCCA)

Miranda, R. J. & Damico, J. B. (2015). Changes in teachers' beliefs and classroom practices concerning inquiry-based instruction following year-long RET-PLC program. *Summer*, 24 *(1), 28-36*

Mitchell, J. T., Roy, G., Fritch, S., & Wood, B. (2018). GIS professional development for teachers: Lessons learned from high-needs schools. *Cartography and Geographic Information Science*, *45*(4), 292–304. https://doi.org/10.1080/15230406.2017.1421482

Mohammed, S. M., Amponsah, K. D., Ampadu, E., & Kumassah, E. K. (2020). Extent of implementation of inquiry-based science teaching and learning in Ghanaian junior high schools. *Eurasia Journal of Mathematics, Science and Technology Education, 16(12), em1928.*

Mugabo, L., & Nsengimana, T. (2020). The impediments of inquiry-based learning in Rwanda lower secondary education and ways of overcoming them. *Southern African Association for Research in Mathematics, Science and Technology Education, 257*.

Mugabo, L., Rouleau, D., Odhiambo, J., Nisingizwe, M. P., Amoroso, C., Barebwanuwe, P., & Hedt-Gauthier, B. L. (2015). Approaches and impact of non-academic research capacity strengthening training models in sub-Saharan Africa: a systematic review. *Health researchpolicy and systems*, 13, 1-17.

National Research Council. (2000). *National science education standards*. Washington DC: National Academy Press.

Ng, G. (2006). *Relating classroom teaching to student learning: A critical analysis of why research has failed to bridge the theory-practice gap.* Harvard Educational Review, 74, 273-306.

Ngman-Wara, E. & Acquah, S. (2016). Ghanaian junior high school science teachers' reflection on the use of Tessa secondary science modules. *Journal of Research in Science Teaching*, 3(3), pp. 377-382 DOI:10.12691/education-3-3-317.

Ngman-Wara, E., Tachie, Y.T. & Mawusi, S.K. (2015). Assessing in-service needs of basic school natural science teachers in New Juaben Municipality, Ghana. *American Journal of Educational Research*, *3*(5): 556-563 doi: 1012691 /education-3-5-4

Niyitegeka, D. (2020). Primary school teacher's understanding and Self-efficacy Towards implementation of inquiry-based instruction in primary science curriculum: Case of Kigali City Rwanda. *Unnes Science Education Journal*, *9*(2), 68-83.

Njagi, J. O. A. C. H. I. M. (2016). *Determinants of use of inquiry-based instruction byearlychildhood teachers' in teachings science in Mmeru South Sub-county, Kenya*. Master's Thesis. Kenyatta University.

Nollmeyer, G. E., Morrison, J., & Baldwin, K. A. (2019). Barriers to authentic science inquiry in the elementary classroom. *Educational Research: Theory and Practice*, *30*(1), 1-6

Orton, A. (2004). Learning mathematics: Issues, theory and classroom practice. Germany: Bloomsbury

Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS 9* (7th ed.). London/New York: Routledge, Taylor & Francis Group

Parker S. (2011). *Sampling versus Census: A comparative Analysis*. TNS Employee Insights.

Paulsen, J., & BrckaLorenz, A. (2017). *Internal consistency statistics*. Faculty Survey of Student Engagement.

Piaget, J. (1967). Biology and knowledge. Chicago. University of Chicago Press.

Piaget, J. (1977). *The development of thought. Equilibration of Cognitive Structures.* New York: Viking Press. https://journals.sagepub .com/doi/abs/10.3102 /0013189X007011018

Pozuelos, F. & Gonzaales, G.T. (2014). Inquiry-based teaching: Teachers' conception, ssimpediments and support. *Teaching Education, 22*(2), 131-142.

Ramnarain, U., & Hlatswayo, M. (2018). Teacher beliefs and attitudes about inquiry-based learning in a rural school district in South Africa. *South African Journal of Education*, *38*(1).

Reaume, R. (2011). Pre-service teacher perceptions of and experiences with the implementation of inquiry-based science teaching.

Rosenshine, B. (2012). Principles of instruction: Research-based strategies that all teachers should know. *American educator*, *36*(1), 12.

Ryan, K. & Deci, D. (2000). How do learners in different cultures relate to science and technology? Results and perspectives from the project ROSE (the Relevance of Science Education) *Asia-Pacific Forum on Science Learning and Teaching*, 6, 447-457.

Samuel, D.F., & Ogunkola, B.J. (2013). St. Lucian elementary school teachers´ applicability beliefs and science teaching and learning: Relevance to their level of inquiry-based instructional practices in science. *International Education Studies*, *6*(7):48- 65

Sangsa-ard, R., & Thathong, K. (2014). Examining junior high school science teacher's understanding of the nature of science in Chaiyaphum Province, Thailand. *Social and Behavioral Sciences*. 47854797.

Saou, K., & Nasri, C. (2023). On Research Methodology in Educational Contexts: FoundationalReviews and Methodological Orientations for Junior Researchers. *Djoussour El-maarefa*, *9*(3).

Seung, E. Park, S. & Jung, J. (2014). Exploring pre-service elementary teachers' understanding of the essential features of inquiry-based science teaching using evidence-based reflections. *Research in Science Education*, 44(4) 507-520, doi:10.1007/s11165-013-9390-x.

Shamsudin, G. Abdullah, M. & Yaamat, B. (2013). *Exploring scientific literacy: How Australia measures up*. Camberwell, Victoria: Australian Council for Educational Research Ltd.

Shamsudin, N. M., Abdullah, N., & Yaamat, N. (2013). Strategies of teaching science using an inquiry-based science education (IBSE) by novice chemistry teachers. *Procedia-Social and Behavioral Sciences*, *90*, 583-592.

Shufutinsky, A. (2020). Employing use of self for transparency, rigor, trustworthiness, and credibility in qualitative organizational research methods. *Organization DevelopmentReview*, *52*(1), 50-58.

Sijali Magar, D. K. (2023). Secondary level EFL teachers' perceptions, practices, and challenges of implementing CAS in public schools in Nepal. A Narrative Inquiry.

Sikko, S. A., Lyngved, R., & Pepin, B. (2012). Working with Mathematics and Science teachers in inquiry-based learning (IBL) approaches: Teacher beliefs. *Visions Conference* 2011: *Teacher Education*. 6 (1) : 17.

Sileyew, K. J. (2019). *Research Design and Methodology*. In E. Abu-Taieh, A. E. Mouatasim, & I. H. A. Hadid (Eds.), Cyberspace. Intech Open.https://doi.org/10.5772/intechopen.85731

Silm, G., Tiitsaar, K., Pedaste, M., Zacharia, Z. C., & Papaevripidou, M. (2017). Teachers' readiness to use inquiry-based learning: An investigation of teachers' sense of efficacy and attitudes toward inquiry-based learning. *Science Education International, 28*(4), 315–325. https://eric.ed.gov/?id=EJ1161535

Sjöström, J., & Eilks, I. (2018). Reconsidering different visions of scientific literacy and science education based on the concept of *Bildung*. In Y. Dori, Z. Mevarech, & D. Baker (Eds.), *Cognition, metacognition, and culture in STEM education* (pp. 65–88). Dordrecht: Springer.

Slavin, K. (1996). *Origins of, and changes in preservice teachers' science teaching self-efficacy*. Paper presented at the annual meeting of National Association for Research in Science Teaching, San Francisco, CA.

Spencer, O. & Walker, G. (2012). Constructing views of science tied to issues of equity and diversity: A study of beginning science teachers. *Journal of Research in Science Teaching, 40*(1), 53-76.

Speziale, H. S., Streubert, H. J., & Carpenter, D. R. (2011). *Qualitative research in nursing: Advancing the humanistic imperative*. Lippincott Williams & Wilkins.

Ssempala, F. (2017). *Science teachers' understanding and practice of inquiry-based instruction in Uganda* (Doctoral dissertation, Syracuse University).

Stufflebeam, D. I. (2002). CIPP evaluation model checklist: A tool for applying the fifth instalment of the CIPP model to access long-term enterprises. Retrieved from http://www.wmich.edu/evalctr/checklist/cippchecklist.htm.on 02/01/2020

Subba, D. (2019). Antecedent and consequences of organizational identification: a study in the tourism sector of Sikkim. *Future Business Journal*, *5*(1), 4.

Sullivan, F. R. (2008). Robotic and science literacy. Thinking skills, science process skills and systems understanding. *Journal of research in science Teaching,45*(3), 373-394.

Sürücü, L., & Maslakçi, A. (2020). Validity and reliability in quantitative research. *Business & Management Studies: An International Journal*, *8*(3), 2694-2726.

Taylor, J. H. & Bilbrey, J. K. (2011). Teacher perceptions of inquiry-based instruction vs. Teacher-based instruction. *International Review of Social Sciences and Humanities*, *2* (1), 152-162.

Taylor, J., H., Bilbery, J. K. Jr., Anderson B. (2011). *International Review of Social Sciences an Humanities Teacher Perceptions of Inquiry-Based Instruction vs. Teacher-Based Instruction.* Anderson University 316 Boulevard Anderson, SC 29621, USA e-mail: jbilbrey@ Anderson university.edu

Thibaut, L. M., & Connolly, S. R. (2020). Hierarchical modeling strengthens evidence for density dependence in observational time series of population dynamics. *Ecology*, *101*(1), e02893.

Thoman, D. B., Yap, M. J., Herrera, F. A., & Smith, J. L. (2021). Diversity interventions in the classroom: From resistance to action. *CBE—Life Sciences Education*, *20*(4), ar52.

Tortella, G. R., Seabra, A. B., Padrão, J., & Diaz-San Juan, R. (2021). Mindfulness and other simple neuroscience-based proposals to promote the learning performance and mental health of students during the COVID-19 pandemic. *Brain sciences*, *11*(5), 552.

Twahirwa, J. N., Ntivuguruzwa, C., Wizeyimana, E. T., & Nyirahagenimana, J. (2022). Teachers' Perceptions of Inquiry-based Learning in Science Education: A Case of Selected Secondary Schools in Kirehe District, Rwanda. *East Afr. J. Educ. Soc. Sci, 3,29-38.*

Twahirwa, J. N., Ntivuguruzwa, C., Wizeyimana, E. T., & Nyirahagenimana, J. (2022). Teachers' perceptions of inquiry-based learning in science education: A case of selected secondary schools in Kirehe District, Rwanda. *East Afr. J. Educ. Soc. Sci*, *3*, 29-38.

Vu, T. T. N. (2021). Understanding validity and reliability from qualitative and quantitative research traditions. *VNU Journal of Foreign Studies*, *37*(3).

Ward, C. D. (2001). Under construction: on becoming a constructivist in view of the standards. *The Mathematics Teacher*, *94(2), 94-96*

Xie, M., Talin, R., & Sharif, S. (2014). The relationship between teachers' knowledge, attitude and belief with the implementation of inquiry-based learning in Zhengzhou, China. *International Journal of Learning, Teaching and Educational Research*, *8*(1), 149-161 https://www.ijlter.org/index.php/ijlter/article/view/169.

Yamagata, S. (2018). Comparing core-image-based basic verb learning in an EFL junior high school: *Learner-centered and teacher-centered approaches. Language Teaching Research*, *22*(1), 65-93.

Yilmaz, G. (2008). Changing practice by changing practice: Toward more authentic science and science curriculum development. *Journal of Research in Science Teaching*, 36, 521-539.

Yusoff, M. S. B. (2019). ABC of content validation and content validity index calculation. *Education in Medicine Journal*, *11*(2), 49-54.

Zhang, L. (2016). Is inquiry-based science teaching worth the effort? Some thoughts worth considering. *Science & Education*, *25*, 897-915.

APPENDICE

APPENDIX A

QUESTIONNAIRE

QUESTIONNAIRE ON LOWER PRIMARY TEACHERS' KNOWLEDGE AND PRACTICE OF INQUIRY-BASED SCIENCE INSTRUCTION

This questionnaire is designed to investigate ***Lower Primary teachers' perceptions and practices of inquiry-based science instruction*** in the Effutu Municipality in the Central Region of Ghana. The first section of the questionnaire intends to obtain personal information on teachers and the second section contains questions that seek to find out Lower Primary Science teachers' knowledge, practice and challenges in inquiry-based instruction. Please respond honestly to the items and you can be assured that your responses will be kept strictly confidential. Thank you for your cooperation and assistance.

SECTION A: Demographic Information

Instruction: Please thick (√) the appropriate box.

1.Gender

Male [ ] Female [ ]

2. Age Range

20-25 years [ ] 26-30 years [ ] 31-35 years [ ]

36-40 years [ ] 41 years and above [ ]

3. Years of Experience

0-3 [ ] 4-5 [ ] 6-9 [ ] 10 and above [ ]

4. Educational Level

Diploma [ ] Degree [ ] Master's [ ]

Other [ ] please specify …………………………………

5. Academic Background

Science [ ] Non-Science [ ]

SECTION B: Lower primary teachers' perception of inquiry-based science instruction

Instruction: Please, read each of the following statements carefully and provide the appropriate response to each of them. For each of the items, please answer using the following scales for each statements: **1=Strongly Disagree (SA)** **2=Disagree (D)** **3= Agree (A)** **4= Strongly Agree (SA)**

S/N	Items	SD	D	A	SA
1	Inquiry-based science instruction deals with learners investigating and finding solutions to topics or problems as a way of constructing knowledge for themselves.				
2	There are different types of inquiry-based instruction				
3	The main focus of inquiry-based science learning is to demonstrate how it is done rather than to excite learners' interest in the topic				
4	Learners are to be engaged in scientifically oriented questions and give priority to evidence in responding to these questions.				
5	In the inquiry-based science process, learners are to formulate explanations from evidence and connect it to scientific knowledge.				
6	Learners are provided opportunities to communicate and justify their explanations during the injury-based process.				
7	In the inquiry-based science process, the teacher is a facilitator whiles learners become researchers.				
8	Inquiry learning in science is usually a result of collaborative effort between students.				
9	Inquiry-based learning takes place only in the classroom				
10	In the inquiry process the teachers becomes the researcher who provides information to the learners.				

SECTION C: Lower primary teachers' practices of inquiry-based science instruction.

Instruction: Please, read each of the following statements carefully and provide the appropriate response to each of them. For each of the items, please answer using the following scales for each statement: **1= Never (N)** **2= Once in a while (OW)** **3= Quite Frequently (QF)** **4= Regularly (R)** **5= Always (A)**

S/N	Items	N	OW	QF	R	A
1	I always plan lessons to actively involve learners.					
2	I always begin my lessons with a question to allow learners explore the topic under study on their own					
3	I use experimentation to help learners ask questions.					
4	I use group work to enable learners exchange ideas and thoughts to understand lessons better.					
5	I ensure that learners are presented with real world problems for them to investigate.					
6	I deliver lessons in a way that enable learners to ask questions and explore their natural curiosities					
7	I provide learners with resources to ensure hands-o Science learning.					
8	I mostly adopt the lecture method in my lesson delivery					
9	I do not provide opportunities for learners to do research outside the classroom in order to complete various tasks.					
10	I do not use projects as part of my teaching approaches in Science.					

SECTION D: Lower primary teachers challenge in the implementation of inquiry-based science instruction.

Instruction: Please, read each of the following statements carefully and provide the appropriate response for them. For each of the items, please answer using the following scales for the various statements: **1=Strongly Disagree (SA) 2=Disagree (D) 3= Agree (A) 4= Strongly Agree (SA)**

S/N	Items	SD	D	A	SA
	Teacher Based Challenges				
1	Motivating students poses a challenge to my implementation of inquiry-based instruction				
2	My level of knowledge of inquiry-based science instruction poses a challenge to its implementation				
3	I am not familiar with the contents of the Science curriculum and this influences my implementation.				
4	I face difficulties in implementing IBSI because I do not have a Science background				
5	I am not encouraged to implement IBSI based on my working conditions				
	Pupils Based Challenges				
1	Learners attitude during inquiry-based science instruction challenges my implementation of it.				
2	Learners difficulty in collaboration and team work relatively affects the implementation of inquiry-based science instruction				
3	The low academic abilities of my learners discourage me from implementing IBSI				
	Classroom Based Challenges				
1	Lack of resources poses a challenge to my implementation of inquiry-based science instruction.				
2	Inadequate time allotted for the teaching of Science in the classroom affects the implementation of inquiry-based science instruction.				
3	The large class size affects my ability to implement inquiry-based science instruction.				
4	I am unable to implement IBST due to lack of support from school authorities.				
10	Absence of regular in-service training impedes my ability to implement IBSI				

APPENDIX B

SEMI-STRUCTURED INTERVIEW

This semi-structured interview is on the topic "***Lower Primary Teachers' Perceptions and Practices of Inquiry-based Scie***nce ***Instruction***. Please answer each question frankly as possible. The answers to these questions will be kept completely confidential. This interview consists of set of questions that I will ask you to reflect, recall and share your experiences. You are free to ask for clarification where necessary during the interview. On occasions, I may ask related follow up questions to the original scripted question. Thank you for your cooperation and assistance.

SECTION A: Lower primary teacher's perceptions about inquiry-based science instruction

1. How would you explain the term inquiry-based instruction?
2. Are there types of inquiry-based instruction? if yes, briefly highlight on them.
3. What are some of the models of IBSI you have used in your science lessons as a way of implementing inquiry-based instruction?

SECTION B: Lower primary teacher's practice of inquiry-based science instruction

1. Have you used inquiry-based instruction as a teaching approach?
2. If yes, how do you practice inquiry-based instruction during your science lessons?
3. If no, are there any reasons why you would not want to use inquiry in your Science lesson?

SECTION C: Lower primary teachers challenge in the implementation of inquiry-based science instruction.

1. Do the perceptions of teachers pose a challenge in the implementation of inquiry-based instruction? If Yes, how.

2. Do your pupils pose as a challenge to your ability to implement IBSI? If Yes, how?
3. Does resources and materials pose as a threat to your ability to implement IBSI? If yes, how?
4. Are there any other factors that hinder your implementation of IBSI?

APPENDIX C

OBSERVATIONAL FRAMEWORK ON LOWER PRIMARY TEACHERS' PERCEPTIONS AND PRACTICES OF INQUIRY-BASED SCIENCE INSTRUCTION

Engagement	Explore	Explain	Elaborate	Evaluate
Begin the lesson with probing questions	Observe students' interaction	Ask students to explain concepts	Encourages students to apply concepts	Assess students' knowledge
Ask students for information	Ask probing questions to redirect students	Ask students to justify their thinking	Encourage students to apply skills	Observe students applying new concepts
	Act as consultant for students	Draw on students' previous experiences	Encourage students to extend concepts	Observe students applying new skills
	Create opportunities for students to work together	Ask students to clarify their thinking	Encourage students to extend skills.	Provide students with feedback to enhance thinking
		Ask students to explain definitions	Refer students to existing evidence	Ask open ended questions
		Provide directions for students	Remind students of alternative explanations	Look for evidence of changed behaviour
		Provide explanation for students		Look for evidence of changed thinking
				Allow students to assess their own learning
				Allow students to assess their group skills

APPENDIX D

LETTER OF INTRODUCTION

GHANA EDUCATION SERVICE

In case of reply the number and Date of this letter should be Quoted

REPUBLIC OF GHANA

MUNICIPAL EDUCATION OFFICE
POST OFFICE BOX 54
WINNEBA
TEL: 03323 22075
Email.geseffutu@gmail.com

My Ref. No. GES/CR/EMEOW/LC.80/VOL.7/20
Your Ref. No:..........................

DATE: 11TH JULY, 2023

LETTER OF INTRODUCTION

We acknowledge receipt of your letter dated 30th May, 2023 seeking permission to conduct research in the municipality.

Permission has therefore been granted to Mr. Isaac Kwakye, an M.Phil student of the Department of Basic Education, University of Education, Winneba to conduct a research in the municipality form July to September, 2023.

Mr. Isaac Kwakye is carrying out a research on the topic: ***"Lower Primary Teachers' Perceptions and Practices of Inquiry-Based Science Instruction in the Effutu Municipality".***

You are to ensure that your visit to the school would not disrupt teaching and learning in the schools.

Headteachers should assist the student gather relevant data for his research while ensuring that he abides by the ethics of the teaching profession.

MABEL JUDITH MICAH (MRS)
MUNICIPAL DIRECTOR OF EDUCATION
EFFUTU-WINNEBA

THE HEAD OF DEPARTMENT
DEPARTMENT OF BASIC EDUCATION
UNIVERSITY OF EDUCATION
WINNEBA

MR. ISAAC KWAKYE
DEPARTMENT OF BASIC EDUCATION
UNIVERSITY OF EDUCATION
WINNEBA

HEADTEACHERS
CONCERNED SCHOOLS
WINNEBA

cc: All SISOs
Effutu Municipality
Winneba