UNIVERSITY OF EDUCATION, WINNEBA

EFFECTS OF INQUIRY- BASED TUTOR PEDAGOGICAL CONTENT KNOWLEDGE AND PRACTICE ON STUDENTS' CHEMISTRY PERFORMANCE IN NORTHERN COLLEGES OF EDUCATION

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DECLARATION

STUDENT DECLARATION

I **Isaac Azumah Gonyalug** 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: …………………………………….….

SUPERVISOR'S DECLARATION

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

NAME OF SUPERVISOR: ………..……………………..

SIGNATURE: …………………………………..…………

DATE: ……………………………………………..…….

DEDICATION

I dedicate this thesis to my lovely wife, Cynthia and children, Valentina, Emmanuel, Isabella and Caspar.

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ABSTRACT

This study aimed to investigate the effects of tutor pedagogical content knowledge (PCK) and practice on the achievement of pre-service teachers in inquiry-based chemistry instruction. The research employed a quantitative approach, collecting data through questionnaires from 97 respondents out of the total sample of 111, resulting in an 87% response rate. Additionally, an observation checklist was used. The findings indicated that respondents demonstrated a comprehensive understanding of the concept of inquiry-based instruction, as evidenced by high frequencies in 14 out of the 16 constructs examined. However, the study identified significant limitations in real-life study materials, revealing a deficiency in the technological resources required to foster effective inquiry-based instruction. Furthermore, it was noted that the timeframe allotted in the study syllabus did not adequately accommodate the implementation of inquiry-based instruction in a manner that is both efficient and effective. Additionally, the study revealed a positive relationship between inquiry-based instruction and students' performance. The effective implementation of inquiry-based instruction positively influenced students' academic outcomes. Moreover, it was found that pedagogical knowledge moderated the relationship between inquiry-based instruction and students' performance. A thorough grasp of tutor knowledge served as a foundation for understanding and implementing inquiry-based instruction, which, in turn, had a positive impact on students' performance. Based on these findings, the study recommends directing more attention toward improving all aspects of inquiry-based instruction, with a particular focus on enhancing real-life simulators. Furthermore, it suggests revising the study syllabus, especially for science-based subjects, to allocate ample time for effective implementation and practice of inquiry-based instruction. Future research is encouraged to develop a comprehensive research model that considers the broader concept of pedagogical knowledge across various teaching approaches. Additionally, future studies should consider larger sample sizes to further explore the topic.

CHAPTER ONE

INTRODUCTION

1.1 Overview

The background to the study, the problem statement and rationale, the purpose and objectives of the study, the research questions, and the significance of the study are all presented in this chapter. The chapter also covers how the study was organized and its boundaries and restrictions.

1.2 Background to the Study

The poor academic performance of students, particularly in the sciences, is a major problem for Ghanaian colleges of education. The colleges of education in Ghana prepare instructors for the elementary schools. Therefore, it follows that the standard of basic education is significantly influenced by the caliber of instructors Ghana's educational institutions generate. In order to improve the qualification of basic school teachers and ensure quality teaching and learning at the basic school level, Ghana's colleges of education were upgraded in 2005 from certificate-awarding institutions to diploma-awarding institutions. As a result, the entry requirements into colleges of education were adjusted to a minimum of C6 in six relevant subjects (MoE, 2018). 2018 saw the conversion of all Ghanaian colleges of education into degree-granting organizations with a focus on early childhood, primary, and junior high school teaching (MoE, 2019). This was done in order to ensure that a bachelor's degree becomes the requirement for teaching in Ghanaian elementary schools.

Despite these efforts, scientific performance among teacher candidates still presents a problem, particularly in the chemistry-related subjects. The researcher has seen many students put a lot of effort into studying the subject day and night, but a review of their examination scores over time demonstrates that the majority of them have little grasp of the fundamental ideas in science. Despite appearing to work very hard, they do not achieve the desired outcomes.

Some managements at colleges of education have a history of blaming teachers for students' low performance because they feel that the methods used to teach do not adequately satisfy the needs of the students. According to Nayer (2016), the majority of teachers lack professional training and are unable to convey concepts in an engaging manner. These educators suppress curiosity and constantly discourage learning through asking questions since they lack understanding. To some extent, it does imply that a change in teaching methodology is the only important change needed in the classroom. When addressing students' scientific concepts through teaching Lin et al. (2016) states that instructional style is one of the most crucial variables when it comes to conceptual development and is the main issue for science instructors and educators.

Learning is heavily influenced by both the learner's traits and the teacher. Academic achievement of the students and the teacher's material expertise are related (SACE, 2010). Mwenda et al. (2013) assert that, teachers are essential to the successful execution of a program. To effectively administer the program, they must be well trained. According to Spaull (2013), a teacher's quality cannot be surpassed in terms of educational quality. According to research, students who are taught by incompetent teachers or by qualified professors who are unaware of how to teach science effectively achieve subpar results (Lebata & Mudau, 2014).

The first step to implementing inquiry ethics effectively is the understanding of how it works. Since each learner has a unique learning style, it is best for teachers to support their students' learning by putting them in environments like inquiry learning where they can actively create and process knowledge. But how well-versed in inquiry learning are scientific teachers? And how broadly do they use it? The study aims to establish this and, thus, investigate how these affect the chemistry performance of teacher candidates.

Within science curriculum and throughout education, inquiry-based learning (IBL) is a commonly used and highly recommended teaching technique (Aldahmash et al., 2016). While student learning results are frequently the main focus, teachers' understanding and preparation for teaching science should also receive equal priority. This emphasizes how crucial it is for instructors to be prepared in terms of their pedagogical content expertise.

In Ghanaian elementary schools, science instructors rarely or never show IBI in the classroom. The scientific literacy of students in Ghanaian schools has been impacted by their apparent lack of effective pedagogical subject knowledge in this area. The quality of content knowledge possessed by students and the competency of the teacher are some or the factors that impact quality teaching and learning of integrated science (Anamuah-Mensah, Ananga, Wesbrook, & Kankam, 2017). One major factor is inadequate teacher preparation, especially with respect to pedagogical techniques, inconsistent and inappropriate instructional materials (Anamuah-Mensah, Ananga, Wesbrook, & Kankam, 2017).

Poorly supervised and monitored teaching in the classroom is also a significant problem. The current curricula reasoning for basic science education in many African countries emphasizes inquiry-based science teaching and learning (Akuma & Callaghan, 2019; Athuman, 2017; Ssempala, 2017).

As the main teaching strategy in effective science education, inquiry-based instruction has a long history. For instance, the US National Science Education Standards said that science learning revolves around inquiry (NRC 1996). The European Commission demanded in 2007 that school science teaching methodologies shift from being predominately deductive to becoming inquiry-based (Reitinger, Haberfellner, Brewster, & Kraner, 2016). The new National Pre-Tertiary Education Curriculum (NPTEC) in Ghana encourages the use of inquiry-based instructional strategies (Ministry of Education, 2019).

A student-constructed and active educational strategy is inquiry-based learning. Students are involved in the discovery process through inquiry-based learning, which makes science applicable to their everyday problems (Darling-Hammond et al., 2020). The employment of inquiry-science methodologies in higher education is encouraged by a number of factors. According to studies, incorporating inquiry-based learning in scientific classrooms has positive effects (Baker & Robinson, 2018; Schmid & Bogner, 2015; Johnson & Cuevas, 2016). According to research, inquiry-based learning (IBL) can significantly improve students' motivation, academic achievement, and long-term information retention when used in the classroom.

Instead of passively acquiring facts, students can actively generate knowledge in an inquiry-based classroom. It enables pupils to interact with chemical ideas and comprehend how they relate to the outside world. After participating in such events, students are able to relate what they learned to new scientific ideas and everyday life.

1.3 Statement of the Problem

The three science colleges of education in the Northern Region are Bagabaga College of Education, Tamale College of Education, and E.P. College of Education. These universities also prepare teachers of science for Ghana's elementary schools. The small number of optional science students at these colleges of education is typically a reflection of the enrollment in senior high school as well as the number of students who are able to meet the requirements for admission to the colleges of education. In order to increase enrollment in the specialized scientific teacher training program, elective agriculture science and home economics students who have taken at least one or two optional science courses (Biology, Chemistry, or Physics) may occasionally be given consideration. Some students as a result do not perform well in science-based courses.

For greater understanding in science, which is a highly conceptual field, one must be able to work with symbolic representations at all levels. As a result, a teacher's goal and duty are to make a subject as approachable as possible so that the most meaningful learning possible can occur. With its ability to considerably motivate students while also serving as an appropriate educational approach for the acquisition of necessary information and skills, inquiry-based education is gaining popularity. The approach offers the chance for students to be more productively engaged while still having the chance to appreciate science and find it enjoyable. It gives students the chance to check the validity of the evidence, provide arguments, explore for connections between the findings, engage in discussion, and look for alternative interpretations. Additionally, it fosters younger students' enthusiasm in science education, as research has shown that as pupils become older, their interest in science declines (Baram-Tsabari & Yarden, 2009).

According to empirical evidence, inquiry education is widely used in the majority of industrialized and developing nations (Jiang & McComas, 2015; Tairab & Al-Naqbi, 2018), with many of these nations implementing inquiry instruction in elaborate and successful ways (Chang & Wu, 2018; Crawford, 2000). In contrast, there is not much proof that scientific instruction in African schools involves inquiry. Instead, traditional scientific instruction is still used in many African schools (Ramnarain & Hlatswayo, 2018), and the few instances of inquiry practice that have been documented demonstrate low levels of productive inquiry (Akuma & Callaghan, 2018).

There is little evidence of the extent to which inquiry science instruction is being implemented in Ghanaian schools, despite the fact that the current justification for basic science education in Ghana is to involve all students in inquiry investigations into science phenomena in their physical environment (Fredua-Kwarteng, 2015; Ministry of Education, 2019). Additionally, there is minimal evidence of inquiry-based research in Ghana, despite the fact that they are widely used in industrialized and developing nations. The limited studies that are now accessible primarily concentrate on elementary schools, senior high schools, and teachers from these levels (Fredua-Kwarteng, 2015). This study is distinctive because it focuses on the knowledge and use of IBI by college tutors and how this affects the performance of teacher candidates in chemistry at the colleges of education in Ghana's Northern Region.

1.4 Objectives

The objectives of the study were to:

i. Explore the practice of inquiry-based instruction approach among chemistry tutors at the Colleges of Education.

ii. Examine the relationship between the implementation of inquiry-based instruction and the performance of teacher trainees in chemistry.

iii. Investigate the factors influencing the implementation of inquiry-based instruction among chemistry tutors at the Colleges of Education.

iv. Determine the moderating role of tutors' pedagogical content knowledge (PCK) and practice in the relationship between inquiry-based instruction and the performance of teacher trainees in chemistry.

1.5 Research Questions

The following research questions guided the study:

i. To what extent do chemistry tutors understand and Practice Inquiry-Based Instructional Approach?

ii. What is the relationship between Inquiry-Based Instruction and students' performance?

iii. What are the factors influencing the implementation of inquiry-based instruction among chemistry tutors in the colleges of education?

iv. How does tutors' PCK and practice moderate the relationship between Inquiry-Based Instruction and students' performance in chemistry?

1.6 Significance of the Study

The research was designed to explore the relationship between chemistry tutors' PCK and practice with respect to IBI and teacher trainees' performance in chemistry at the Colleges of Education in the Northern Region.

It is hoped that, the outcome of the study would be useful in the following ways:

1. The study would establish the extent to which chemistry tutors' PCK and practice with respect to IBI relate to teacher trainees' performance in chemistry at the Colleges of Education in the Northern Region.

2. It would be beneficial to teacher trainees in that, it would clearly outline inquiry-based chemistry instructional strategies that will enhance understanding of chemical concepts to improve their academic performance in chemistry.

3. The outcome of the study would, by extension, help equip teacher trainees to effectively apply inquiry pedagogy when they join the teaching service after completion of their course.

4. The research will lead to the production of graduates who can engage in life-long learning and apply the knowledge along their career path.

1.7 Delimitation of the Study

The research was conducted at the Three Science Colleges of Education in the Northern Region of Ghana. These include Bagabaga College of Education, Tamale; Tamale College of Education, Tamale and E.P. College of Education, Bimbilla. The study specifically sought to explore the chemistry tutors' knowledge and practice with respect to IBI and how these impacts on teacher trainees' performance in chemistry at the Colleges of Education. The study collected primary data from chemistry tutors and teacher trainees as well as secondary data on trainees' performance in chemistry.

1.8 Limitations of the Study

Although an attempt was made to collect data as objectively as possible and fairly analyse the results, the biases of the investigator and other stakeholders cannot be avoided absolutely since the research was conducted in a familiar environment. This is a potential limitation to data collected and findings of the study. Also, the study was conducted in three Colleges of Education that run science programme in the northern region. Though the outcome is genuine and reliable, it may be difficult to generalise it to all the colleges of education in Ghana considering the size of the sample population.

The research instrument used is a Likert Scale questionnaire. Therefore, the researcher cannot rule out the challenge of respondents:

- Avoiding extreme response categories (***central tendency bias***), especially out of a desire to avoid being perceived as having extremist views on an item(s),
- Agreeing with statements as presented in order to "please" the researcher (***acquiescence bias***),
- Portraying themselves in a more socially favourable light rather than being honest (***social desirability bias***). For example, they may "***fake good***" or "***fake bad***".

1.9 Definition of Terms

1. **Inquiry-Based Instruction (IBI)** – a student-centered pedagogy that encourages the use of scientific processes to actively engage students in

learning by building their own knowledge through hands-on, investigative activities (Thompson, 2006).

2. **Inquiry-Based Learning**- See IBI

3. **Inquiry-Based Chemistry Instruction (IBCI)** – A student–centred approach to teaching chemistry which enables students to actively engage in chemistry activities to construct meaningful knowledge under the guidance of an inspired knowledgeable instructor.

4. **Pedagogical Knowledge (PK)/Pedagogical Content Knowledge (PCK)** - specialised **knowledge** of teachers for creating effective teaching and learning environments for all students.

5. **E.P. College of Education** – Evangelical Presbyterian College of Education

6. **SPSS** – Statistical Package for Social Sciences

7. **Tutor** – A teacher in a College of Education

8. **CPD** – Continuous Professional Development

9. **NRC** – National Research Council

10. **STEM** – Science, Technology, Engineering and Mathematics

11. **WGU** – Western Governors University

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

Review of study-related literature is covered in this chapter. The review considers the theoretical underpinnings, empirical and conceptual aspects inquiry-based learning, the justification for its application at the college level for the preparation of science teachers, and tutor pedagogical expertise.

2.2 Theoretical Underpinning of the Study

The theoretical framework provides insight into the theories that underpin the study. The study is grounded in Constructivist theory.

2.2.1 Theory of Constructivism

Inquiry-based instruction developed from constructivism while constructivism can be traced back to Socrates. The American philosopher and educator John Dewey (1859–1952) advocated teaching through inquiry in the early twentieth century. Other theorists, including Piaget, Vygotsky, and Bruner connected the work of Dewey to ground breaking discoveries on cognitive development and advocated an educational setting where students actively construct their own knowledge while teachers serve as guides or facilitators (Harmon, 2006).

Dewey theory of constructivism is based on the premise that students learn through direct experience and personal reflection (Dewey, 1938). According to Dewey's theory of constructivism, learning happens as an individual meaningfully constructs an interpretation of how things work based on his or her own pre-existing structures. Dewey's primary premise was grounded in personal experience and he encouraged those who doubt how learning happens to consider their own process of inquiry through sustained reflection (1933). Knowing, according to Dewey, happens because of inquiry. While Dewey understood the need for organizing subject matter is an important component of formal education, he repeatedly addressed the need for the learner's personal involvement in exploration, which allows for deeper learning, or "seeking and finding" of one's own solutions (Dewey, 1916, p. 160 cited in Williams, 2017).

According to Harmon (2006), inquiry-based instruction relies on questioning to help students actively seek, analyse, communicate, and reflect on information. Inquiry-based learning in chemistry encourages students to develop multiple perspectives and encourages empathy with the subject. By learning to address chemistry as an inquirer, students learn to problem-solve and think critically. Omokaadejo (2015) pointed out that the responsibility of learning should reside increasingly with the learners where they are actively involved in the learning process-unlike previous educational view point where the responsibility rested with the instructor to teach.

Dewey's theory of constructivism strongly emphasises on identifying, building upon and modifying the existing knowledge (prior knowledge) students bring to classroom, rather than assuming they will automatically absorb and believe what they read in the textbook and are told in the classroom (Carlson, 2003). Traditional teachers tend to be information givers and textbook guided classrooms have failed to bring about the desired outcome of producing thinking students (Carlson, 2003). Dewey's theory emphasizes on active involvement of students, hence knowledge gained last long in their memory. Colburn (2000) attested to the fact that, 'one only knows something if one can explain it. Learners actively take knowledge, connect it to previously assimilated knowledge, and make it theirs by constructing their own interpretation (Colburn, 2000).

The rationale for using this theory to support teacher-trainees' learning using inquiry was based on the fact that the majority of teacher-trainees 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 chemistry classrooms currently. Dewey's constructivism theory was further found relevant to this study because it helped to conceptualize that tutors have to use inquiry-based instruction to enhance their learners' logical and conceptual growth.

The use of inquiry-based approach to teaching and learning of chemistry may help move learners away from the rote memorization of facts to metacognition and self-evaluation and that, tutors' level of training on pedagogy imparts on their ability to implement inquiry teaching and learning. Based on this fact, inquiry-based instruction, which is an activity-based method, will aid better learning in chemistry. Teacher inquiry knowledge is measured using 21 items of inquiry enactments based on National Council Research (2000) and Capps et al. (2016).

According to Pedaste et al. (2015), inquiry in the classroom involves five phases, namely orientation, conceptualization, investigation, conclusion, and discussion. However, in this context of the study, teachers' skills are measured using four phases of inquiry that only involve conceptualization, investigation, conclusion, and discussion in line with the study of Teig et al. (2018) which emphasized the active involvement of students. In Value, Skills and Knowledge (VSK) framework (Chong & Cheah, 2009), pedagogical knowledge and pedagogical skills are interdependent and interconnected in developing education professionals. Based on the VSK framework, this study only emphasizes Skills and Knowledge (SK). When the level of teachers' knowledge in inquiry-based science teaching is high, the level of teachers' skills in implementing them in the process of teaching and learning is also high.

IBI is a pedagogy that allows students to experience the processes of knowledge creation to the best of their ability. Its key components include learning stimulated by inquiry, a student-centered approach, a shift to self-directed learning, and an active approach to learning. It wants to make sure that students become lifelong learners and improve research skills (Sproken-Smith, 2012). IBI is being used throughout the whole range of disciplines at all levels and has strong theoretical backing in education. IBI can improve student engagement, academic performance, and higher order learning outcomes, according to the existing research.

The constructivist theory, which holds that reality is created by human activity, is the foundation of IBI. Constructivism is founded on the notion that people actively create or construct their own knowledge and that your experiences as a learner shape your perception of the world. Basically, students build on their prior knowledge with new information they learn by using it as a foundation (WGU, 2020). Knowledge is made by humans and is constructed (Ernest, 1999). Learning happens through the active creation of meaning (Piaget, 1977). Piaget explains that, when we as learners come across an event or circumstance that is at odds with how we are currently thinking, an unbalanced condition is produced. In order to achieve equilibrium, we must then change the way we think. To put it another way, we interpret new information by connecting it to what we already know or we adapt the new information to our preexisting paradigms by reorganizing our current understanding to a higher level of thought (Driscoll, 1994).

Constructivism is a significant learning theory that teachers employ to support their students' learning (WGU, 2020). It is predicated on the notion that, humans actively create or construct their own knowledge and that, one's experiences as a learner determines his/her perceived reality. The constructivism components and guiding concepts that define how the theory operates and is applied to pupils are expertly explained by the authors as follows:

- *Students construct their own knowledge* - previous knowledge, experiences, beliefs, and insights are all important foundations for their continued learning.
- *People learn to learn, as they learn* - learning involves constructing meaning and systems of meaning.
- *Learning is an active process* - the learner needs to do something in order to learn. Example, engage in discussions, reading, activities, etc.
- *Learning is a social activity* - learning is directly associated to our connection with other people: our teachers, our family, our peers, our acquaintances etc.
- *Learning is contextual* - we learn in ways connected to things we already know, what we believe, and more.
- *Knowledge is personal* - because constructivism is based on your own experiences and beliefs, knowledge becomes a personal affair. Each person will have their own prior knowledge and experiences to bring to the table. So,

the way and things people learn and gain from education will all be very different.

- *Learning occurs in the mind* - Hands-on experiences and physical actions are necessary for successful learning since these engage the mind.

- *Motivation is key to learning* – devising ways to engage and motivate learners to activate their minds and be excited about what they are learning helps them reach out into their past experience and make connections for new learning.

Elements of the inquiry approach, like constructivist philosophy, have their roots in antiquity and may be found in Confucius' and Socrates' teachings. Since the 17th century, philosophers dating back to Spinoza have argued that knowledge is not transmitted but rather is obtained through the manipulation of ideas. However, John Dewey (1859–1952), an American educator and philosopher, is primarily credited for advancing "learning by doing" (Dewey, 1933). Inquiry-based learning was adopted by many school teachers, including college instructors, in the 1970s as a result of Dewey's thesis. For instance, since its founding in 1970, Hampshire College in the United States has adopted and utilized an inquiry-based curriculum (Weaver, 1989). Additionally, McMaster University in Canada has long used inquiry-based instruction (McMaster University, 2007).

The literature foundation for inquiry-based teaching is still fragmented and dispersed, despite its long history. The majority of the literature appears in pockets among disciplinary and educational journals, typically as an effort by enthusiasts to persuade others to try using the approach. However, there are several recent volumes of research that describe the inquiry approach and give readers a variety of examples (Alford, 1998; Lee, 2004). As a result, it is unclear what exactly an inquiry includes.

Despite this, the evidence that is currently available leads us to believe that inquiry-based science adopts an investigative approach to teaching and learning where students are given opportunities to investigate a problem, look for potential solutions, make observations, ask questions, test out ideas, and think creatively and use their intuition (Gillies, 2020).

In this sense, inquiry-based science refers to the practice of science by students that gives them the chance to investigate potential solutions, formulate hypotheses about the phenomena they are studying, elucidate concepts and procedures, and assess or evaluate their understandings in light of the evidence at hand. This method of instruction depends on instructors realizing how crucial it is to give students with situations that will test their existing conceptual understandings (Vygotsky, 1978), forcing them to make sense of discordant thinking and develop new understandings. According to McMahon (1997), when students formulate their own solutions in this manner, then they are truly learning meaningfully.

2.3 Empirical Review and Hypothesis Development

This section summarizes the research that has been done over the years on the factors being studied, including experiments and findings. They will generate a hypothesis based on the study objectives based on their observations of the correlations between the study's variables. Knowledge is obtained through experience rather than from theory or belief in empirical analysis, which is based on observable and quantifiable phenomena.

2.3.1 Inquiry-Based Instruction and Students' Performance

This section offers a thorough analysis of earlier studies on inquiry-based tuition and student performance. Walsh (2000) used a tool known as the Quality Learning Instrument (QLI) to compare the quality of the learning experiences provided to students in formal (Northern Ireland) and inquiry-based (Denmark) contexts. The study concentrated on nine essential quality indicators: drive, focus, independence, self-assurance, physical health, development of various talents, higher order cognitive abilities, social interaction, and respect. In contrast to the more inquiry-based approach that was able to offer Danish children higher-quality learning experiences, Walsh (2000) came to the conclusion that an overemphasis on the teaching of reading, writing, and mathematics is inappropriate for kids in Northern Ireland. The finding showed that, high quality staff interactions with children, an environment that provided books and written material, and a place where children could choose from a variety of learning activities were the aspects of pedagogy (inquiry-based to be precise) that showed a lasting contribution.

Similarly, a quasi-experimental and action research by Yaw-Baah, Amoah, Anaafo and Asem (2018) on the effect of inquiry-based learning in science on Junior High School pupils in Kumasi found out that, enquiry based teaching allowed students to engage, discover, draw conclusions and report their findings as well as increased their abilities to reason and solved problems. Adjei and Wilson (2020) investigated the impact of inquiry-based method of teaching on general chemistry concepts in the Atebubu College of Education using quasi-experimental and control group design. From the results of the study, the inquiry-based method proved an effective method of teaching, enhancing students' performance than a lecture method.

Effective teachers who can draw children into meaningful experiences both inside and outside of the classroom typically possess the following qualities: a thorough knowledge of their subject; the use of inquiry techniques appropriate to the content; the use of an appropriate language of instruction and a mastery of that language; the creation and maintenance of an effective learning environment; knowledge of and sensitivity to the needs and interests of their learners and communities; reflection on their instruction and the reactions of the students; and the ability to effect change (Craig, Kraft, & Plessis, 1998).

Aforma and Omotuyolle (2013) made the observation that many teachers' actions in Nigeria are indicative of practices that are developmentally inappropriate and that, many Nigerian teachers prefer to teach subjects using dry, theoretical approaches rather than using hands-on. In support of this observation, Osokoya (2002), in A. Mansaray & I.O. Osokoya (Eds) proposed that, teacher education programs should emphasize on the entire student development, which includes allowing for a lengthy period of hands-on instruction and observing kids in their natural habitats. He suggested that persons who want to work in the school should have traits like enjoyment and enthusiasm in dealing with young kids, flexibility in personality, and care for the wellbeing of others regardless of differences in religion or ethnicity.

This was also cited by Keys and Bryan (2001) as a contributing factor to teachers' IBI implementation. Teachers may also be worried about ceding control and handling students' demands for the "correct" responses (Hayes, 2002). (Furtak, 2006). The extent to which these criteria apply to Ghanaian colleges of education was the main focus of this study.

Dewey (1938) viewed the role of an instructor as an exquisite designer in an inquiry-based learning environment. This person is in charge of reviving the links between the students' earlier experiences and the subject matter at hand and providing new connections to learners so that they can subsequently develop additional skills, connections, and factual evidence. Dewey (1938) noted that, there is much more lead time for planning for inquiry-based methods because, the teacher must unquestionably give exposure to and continuously build on the prior experiences of the students. Hence, teachers using the inquiry based approach must be prepared for this so that, their strategies would impact the students' performance. The first study hypothesis was developed as a result of the aforementioned evidence.

H_1: IBI has a positive relationship with Students' performance.

2.3.2 Tutors' Pedagogical Knowledge and Students' Pedagogical Knowledge

Abukari, Bayuo, Alagbela, & Bornaa, (2022) presented a study on the pedagogical content knowledge of science tutors of colleges of education and its impact on the pedagogical content knowledge advancement of teacher trainees in Ghana. The study found that the pedagogical content knowledge demonstrated by the science tutors was dependent on the number of years of teaching experience and qualification. The Pearson's product-moment correlation coefficient (r) was found to be reaching unity suggesting that the science tutors' pedagogical content knowledge has a very strong positive influence on their teacher trainees' pedagogical content knowledge development. About 62.5-87.5% of their pedagogical content was influenced by the pedagogical content knowledge of their tutors.

Owusu-Fordjour et al. (2022) studied the impact of science instructors' Pedagogical Content Knowledge (PCK) on educational practice. The study's goal was to see if there was a link between Ghanaian science instructors' PCK and classroom practices using descriptive survey approach. It was revealed that, subject matter understanding varies depending on a teacher's level of education. Experienced teachers, on the other hand, demonstrated greater pedagogical expertise and were better able to improve academic achievement than inexperienced teachers. According to the findings, teachers' pedagogical and subject-matter knowledge are crucial for effective science instruction and student comprehension.

Based on these empirical evidences, the study raised the hypothesis:

H_2: Tutors' Pedagogical Knowledge has a positive relationship with Students Performance.

2.3.3 Pedagogical Knowledge moderates the relationship between IBI and Students' Performance.

According to Marshall (2010), if the foundation of the instructor knowledge with respect to inquiry based instruction is not properly grounded, inquiry-based training will not be successful, and consequently affect the performance of the students. Conversely, more engaging teachers should aim to develop distinctive educational experiences, but first, as Marshall advised, they must be confident in their pedagogical knowledge and make an effort to foster an environment that is supportive of a constantly evolving global culture (Cornish, 2004).

Furthermore, Hattie (2009) shows through a thorough meta-analysis of the impact of pedagogical knowledge on the adoption and use of inquiry-based learning and its subsequent impact on student achievement, student accomplishment is influenced by a range of instructional and environmental factors. To maximize student achievement, a variety of instructional strategies, including but not limited to IBI, may be required, but only if pedagogical information is thoroughly understood. In their study of pre-service teachers, Ortlieb and Lu (2011) provide additional evidence in favour of the significance of PK on IBI and students' performance. Excellent PK teachers use inquiry-based teaching more effectively and are more persistent in their efforts to support students' acquisition of critical thinking skills. The literature supports the use of well-designed, conceptually-based teaching units for inquiry under the supervision of educators and a solid foundation in PK with the goal of improving students' performance.

Hernandez-Ramos and De La Paz (2009) produced an analysis that contrasted the impact of PK on IBI with teacher-directed instruction in a group of over 700 students in one middle school and a comparable number of students in a middle school located nearby with a similar set of demographics and educator qualifications. In this study, they discovered evidence in favour of higher efficacy for student-centered learning. They discovered that learners who received inquiry-based material presentations and tutors who were well invested in PK outperformed pupils in the control group in terms of both internal motivation and general subject understanding. Additionally, they noted that the pupils' critical thinking skills in the subject area had improved. These data support the second study hypothesis, which is shown below.

H_3: Pedagogical Knowledge moderates the relationship between IBI and Students' performance.

2.3.4 Tutors' Understanding of Inquiry-Based Instruction

Inquiry-based instruction relies on students' use of scientific knowledge to ask questions, collect data, analyse evidence, and develop explanations and then communicate that information to peers (Hudson, 2017). The prior learning or knowledge of some tutors affected their understanding of inquiry-based instruction (Ssempala, 2017). As pointed out by Wang (2016), teachers' understanding of inquiry was influenced by their culture yet at the same time, it is worth noting that there is no shared understanding of inquiry-based instruction between many countries. A study by Mugabo (2015) on Rwandan lower secondary school science teachers' understanding of inquiry-based science teaching (IBST). It was found that participants do not have a common understanding of inquiry. Most teachers associate inquiry teaching with a few of its specific characteristics while others had a very different understanding.

Various studies highlight the difference between conceptions about inquiry science and beliefs about inquiry science. According to Morison (2013), conceptions are defined as ideas, thoughts, and understandings, whereas beliefs hold the connotation of conviction, trust, and faith. Teachers may hold a variety of ideas about inquiry, and the conception they hold about inquiry science may affect how they implement inquiry (Demir & Abell, 2010; Crawford, 2007). It can be said that conception means opinion, views, feelings, or beliefs, hence the need to find out how these affect teachers' implementation of inquiry, which we can call investigation. Teachers' previous learning orientations and previous experiences may also impact their learning about inquiry (Eick & Reed, 2002). This is supported by Luchmann (2007), who stated that, "one of the main challenges in developing a teacher's ideas about reform is to reconcile the teacher's personal prior beliefs about the subject matter as well as learning and teaching developed as the result of their experiences as students in schools with the recommendation made for teaching inquiry science" (p. 823). This assertion implies that a teacher's previous experiences have a direct impact on his/her ability to implement inquiry yet at the same time the world is changing and may require new experiences which are in line with the changing needs of the students. The challenge, therefore, is adjusting to the new environment of implementing inquiry.

According to empirical research, teachers with 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 (Atar, 2011; Avsec & Kocijancic, 2016; Cavas, 2012). Teachers with a more accurate understanding of the nature of science can implement a more problem-based approach to science teaching (Avsec & Kocijancic, 2016). The implementation of proper inquiry is a function of teachers' understanding of the nature of science. Although different from the views of Avsec & Kocijancic (2016), Larrivee (2008) recommended developing 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.

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

The level of effectiveness of teacher education programs enhances inquiry-based instruction (IBI). In support of this assertion, Windschitl and Thompson (2012) studied the effectiveness of teacher education programs designed to enhance prospective teachers' knowledge of inquiry, in particular, their understanding of models and modelling. Participants included 21 prospective secondary science teachers with an undergraduate degree in science, all in a secondary methods course. While prospective teachers could talk about models in a sophisticated way, they had a difficult time creating models themselves. Further, these prospective teachers viewed models as being separate from the process of inquiry, hence taking us back to the view that science teachers have divergent views about what inquiry-based instruction (IBI) is.

In support of the views of Windschitl and Thompson (2012), Kang, Branchini, and Kelly (2013) examined what one cohort of eight pre-service secondary science teachers said, did, and wrote as they conducted a two-part inquiry investigation and designed an inquiry lesson plan. They identified success and struggles in pre-service teachers' attempts to negotiate the cultural border between a veteran student and a novice teacher. They argued that pre-service teachers could benefit from opportunities to navigate the border between learning and teaching science; such opportunities could deepen their conception of inquiry beyond those exclusively fashioned as either student or teacher. So, the key observation highlighted here is lack of deep conception of inquiry beyond which from the previous assertions is tangled with science teachers' divergent views about what inquiry-based instruction (IBI) is. Seung, Park, and Jung (2014) did not deviate much from the views of Windschitl and Thompson (2012), Kang, Branchini, and Kelly (2013) and 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 (Seung et al., 2014).

It is also likely that there is limited understanding of what inquiry-based instruction (IBI) is among the pre-service teachers and mentors. Seung et al. (2014), noted that even though mentors are normally experienced teachers, they have sometimes showed a lack of understanding about each feature of inquiry (Seung et al., 2014). Also, many elementary teachers, including the mentors in their study, do not teach science regularly in their classrooms since science is not included in state student achievement test. Seung et al.'s (2014) study is one of the few studies that have examined inquiry-based teaching and learning focusing directly on the five essential features (Asay & Orgill, 2010). This study is useful in the sense that it calls for more exploration of what IBI is to come up with a common understanding. However, this study was conducted in the US context that is very different from many sub-Saharan African countries.

Kim and King (2012) emphasized the point that even in developed countries like the US; most prospective science teachers misunderstand inquiry. Like the work of Kim and King (2012), Youn et al., (2013) explored 15 Korean prospective elementary teachers' views of inquiry-based instruction (IBI). The study established that prospective teachers changed their views of inquiry teaching from following the process of inquiry or completely unstructured discovery approach to facilitating students' inquiry learning with instructional guidance.

Research on teachers' understanding of inquiry-based instruction (IBI) has led to the conclusion that, different teachers understand the approach differently. As a corollary, differences are notable in the different teachers' implementation of the approach and the outcomes of such application. Some of these differences are noted at the institutional, systemic, or even regional levels. A key inference here is that information on the subject should be disaggregated by institution, and by national and regional context. It is prudent to continue to explore chemistry teachers' understanding of inquiry-based instruction (IBI) at the Colleges of Education and expect that these play a part in tutors' intention and/or ability to successfully carry out inquiry-based instruction (IBI). However, as is clear from the literature, information on the case of the less developed countries is generally limited. This has left an important gap in knowledge and practice; hence, the researcher explores it in this study focusing on the Ghanaian context.

2.3.5. Tutors' Practice of Inquiry-Based Instruction

Although educators often concern themselves with finding the best teaching practices, decades of research have made it clear that no single practice is most effective. Rather, a good instructional program is one that combines different practices to create a rich instructional model that is designed based on an understanding of how students learn. Even with inquiry-based learning, it is essential to combine practices to yield optimal results (Sadik, 2018). Martell (2020) found 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 (Martell, 2020). Various writers have indicated that there are many differences to science teachers' practice of inquiry-based instruction (IBI) including differences in teachers' curricular interpretation (McNeill, 2009). 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 inquiry-based instruction differently.

There is an issue of the relationship between teachers' qualifications and the practice of inquiry-based instruction (IBI). Capps and Crawford (2012) noted that teachers' qualifications were not a guarantee for practicing inquiry-based instruction. What is highlighted as a factor influencing practice of IBI was teachers' work experience and McNeill and Krajcik (2011) asserted that teachers with long teaching experience and students who actively engaged in the investigation greatly benefited from inquiry-based instruction. This was emphasized by other studies done in India (Madhuri et al., 2012) and Taiwan (Chang & Wu, 2015) in which it was re-emphasized that teachers with more years of experience were more likely to embrace inquiry-based instruction than their counterparts with less years of teaching experience.

Science teachers' practice of inquiry-based instruction is also a function of their intentions and actual classroom practices regarding inquiry-based instruction. This is supported by researchers Keys and Kennedy (1999) in which they examined the teaching practice of elementary teachers with an average of 11 years of experience. The intentions included: (a) planned instruction to explore questions that arose in context naturally from science activity, (b) intention to help students take responsibility, (c) supporting children in constructing explanations and concepts from data, and (d) providing opportunities for students to apply scientific knowledge.

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

Nevertheless, Crawford's study provides evidence of how beliefs influence science teachers' practice of inquiry-based instruction. Science teachers' practice of inquiry-based instruction is also a function of the characteristics of the classes in question. Crawford (2000) noted that with different characteristics of classrooms, some being elementary classrooms and others secondary classrooms, and the uniqueness of each teacher's background, particular school setting, and student populations, it is difficult to employ a uniform practice of inquiry-based instruction. The views of Crawford (2000) are important because different contexts may result in different outcomes. More closely related to the views of Crawford (2000), is the quality of science student teachers' practice of inquiry-based instruction. For example, Maskiewicz and Winters (2012) in their longitudinal observations of one elementary teacher's fifth-grade classroom (children ages 11-12 years) found out that students can have a substantive and generative influence on the nature and form of inquiry carried out by the teacher in any given year, underscoring the importance of context. The change in students from one year to the next is a component of the context. What can be learned from the views of Maskiewicz and Winters (2012) is that application of science teachers' practice of inquiry-based instruction should be situational depending on the category of classes and students.

Science teachers' practice of inquiry-based instruction is also dependent on the available curriculum. For example, Fogleman, McNeill, and Krajcik (2011) examined 19 teachers' use of inquiry-oriented middle school science curriculum. Researchers found that two variables significantly predicted students' learning: teacher experience and the amount of student initiation during instruction. Teachers who had taught the inquiry-oriented instruction curriculum previously had a greater student gain. Students who completed investigations had greater learning gains as compared with students whose teachers used demonstration or carried out the inquiry themselves. The research results imply: (a) it takes time for teachers to implement effectively innovative science curriculum, and (b) it is important that students engage actively in inquiry investigation.

The influence of curriculum on science teachers' practice of inquiry-based instruction is further highlighted by McNeill (2009) who studied the enactment by six middle-level teachers of an eight-week chemistry-based unit. The curriculum focused on students constructing arguments using an adapted version of Toulmin's model of argumentation. Findings revealed a significant teacher effect on students' learning about scientific explanations, evidence, reasoning, and content knowledge. The teacher who defined scientific explanation differently than in the curriculum had the lowest students' gains regarding scientific explanation. The study highlighted that different teachers carry out reform-based curricula in different ways, something curriculum designers need to consider. This study provides evidence that the teacher is a very important factor for the success of any curriculum innovation.

As pointed out earlier, science teachers' practice of inquiry-based instruction is a function of teachers' experience at work. For example, Ozel and Luft (2014) investigated the conceptions and use of inquiry during classroom instruction among beginning secondary science teachers. The study found a consistency between the way new teachers talked about inquiry and the way they practiced it in their classroom. Overall, the study revealed that the beginning secondary science teachers tended to enact a teacher-centred form of inquiry, and could benefit from induction programs focused on inquiry.

Ozel and Luft (2014) found that, experience in the classroom did not change the conception and enactment of inquiry among the beginning teachers. The researchers recommended that pre-service teachers need ample opportunities to build their knowledge and practice about the inquiry, and they need explicit instruction about the different features of inquiry. It is important that new teachers have access to well-designed science induction programs. This study informs the current study of the role of profession development in science teachers' conceptualization of inquiry.

Most teachers use inquiry-based instruction to promote higher-order thinking skills among students. For example, in India, Madhuri et al. (2012) explored how inquiry-based instruction can be used to promote higher-order thinking skills among engineering students taking a chemistry module course in a university located in central India. The aim of the study was to find out how meaningful learning of chemistry can take place using inquiry-based instruction (IBI). The study established that engineering students developed critical thinking, problem-solving ability and integration of knowledge at the end of the chemistry module course taught through an inquiry based approach. They conclude that inquiry based pedagogy has better outcomes compared to a conventional recipe lab approach, and, it motivates engineering students by showing them the relevance of chemistry to engineering discipline. This study is important because it demonstrates the role of inquiry-based instruction in motivating learners to study a largely abstract subject like chemistry, and the relationship between science and engineering.

The need to enhance practical approach to learning can be said to be one of the reasons why teachers use inquiry-based instruction. In Taiwan, Chang and Wu (2015) investigated how experience in learning to teach SI using a practical approach affected teachers' attitudes, evaluation of the use of inquiry, and their actual design of inquiry-based instruction (IBI). The study established that teachers moved progressively from more teacher centred thinking about teaching to student-centred thinking, and actions incorporating SI. The participating teachers also worked together in designing an interdisciplinary inquiry curriculum, providing an effective alternative to traditional rigid standard based curriculum and teacher directed instruction.

Chang and Wu's study contributes to the engineering field by showing that teachers could move progressively from teacher-directed to student-centred actions incorporating inquiry. Also, it provides evidence of the role professional development can play to improve science teachers' ability to practice inquiry, and assess students in inquiry lessons. Since Taiwan is between a developed and developing country, the findings of this study may apply to some developing countries with similar contexts (Ogunniyi & Rollnick, 2015).

It is important to investigate the actual practices of tutors in their classroom over multiple lessons using qualitative methodology in addition to assessing their beliefs and knowledge about the inquiry. Studies discussed illustrate the importance of researchers moving into the classroom to determine what is happening, with all the complexities of individual teacher trainees abilities and predispositions, classroom physical structures, school context, and community. Different classrooms provide different contexts (e.g., urban and rural classrooms, developed and developing country classrooms). Considering that most of the studies discussed were conducted in developed countries, their findings may not apply in most developing countries accordingly. Hence, this research is done in developing country (Ghana) about tutors' practice of inquiry-based instruction to address this knowledge gap in the literature.

2.3.6 Challenges Tutors' Encounter in the Practice of Inquiry-Based Instruction

While inquiry-based instruction continues to be a highly recommended practice for teaching science, research has shown that there are facilitators and obstacles to this practice (Goossen, 2002; Luft, 2001; NRC, 2003). Among the factors affecting tutor's practice of inquiry-based instruction are time, resources, professional development, science topic or content, and mandatory assessments (Gejda & LaRocco, 2006). Time in this context refers to the length of a class period (block versus non-block schedule), semester or school year, such that the teacher makes a decision to practice inquiry based instruction if the tutor feels that there is sufficient time to do so (Gejda & LaRocco, 2006).

The resource factor refers to the equipment or materials, supplemental to a course text, that affect inquiry-based instruction. Resources may include laboratory equipment, online access, etc. The professional development factor refers to the training that tutors receive to inform their practice of inquiry-based instruction and increase their pedagogical knowledge and confidence in this practice (Luft, 2001; NRC, 2003).

The research has shown that certain science content or topic(s) may lend themselves to a more inquiry-based approach and therefore be a factor in a teacher's conscious pedagogical approach (Marlow & Stevens, 1999). Finally, it has been shown that the need to administer high-stakes mandatory assessments may force a teacher to make choices between using an approach that encourages more student inquiry and covering material for an exam (NRC, 2003).

Adofo (2017) also found that, despite the numerous benefits of inquiry-based teaching and learning, there exist challenges that confront tutors in its implementation in science classrooms. Common challenges identified by the two groups include time for implementation of inquiry which usually is restricted by the curriculum, large class size, and tutor's own judgment. Similarly, inadequate resources and equipment were found to be a limitation to an effective implementation of inquiry based learning in science lessons (Adofo, 2017).

Czerniak and Lumpe (2000) observed that, difficulties encountered by tutors when implementing inquiry-based learning include inadequate time, resources and appropriate curriculum materials. Goodenough (2004) maintained that time is of essence as teachers are required to guide students to uncover their critical thinking capabilities required for inquiry-based learning. Like the limitations identified, a study conducted by Reaume (2011) on the topic pre-Service Teacher Perceptions and Experiences with the Implementation of Inquiry Based Science Teaching found inadequate resources as a major problem facing pre-service teachers in the science classroom.

Roehrig and Luft (2004) indicate that there are barriers for the enactment inquiry-based teaching. For instance, as it is often done, detailed information is provided by traditional tutors in the form of lecture, teacher led discussion and lab work aimed at helping students to conceptualise or confirm a given concept. It has also been documented by researchers that many science teachers do not have the requisite knowledge needed to implement inquiry based teaching; and this has become a barrier for them to successfully implement this pedagogy (Crawford 2000; Wallace & Kang 2004; Windschitl 2004). It is always difficult for one to successfully put into practice any method that one has limited or no knowledge about and that science teachers' limited knowledge will impede the implementation of inquiry in their classrooms.

Some challenges that confront tutors when using inquiry have been reported by Anderson and Helms (2002) and Luera and Otto (2005) to include: large class size, interest and abilities of students, inadequate time, weak comprehension of nature of science on the part of the tutor, inadequate skills in pedagogy, the inappropriateness of curricula, existence of tensions between emerging roles to be played by tutor during inquiry lessons, views held by teachers on inquiry and the culture of the school. They also mention the conflict that exists between model standards and true revelations in science classes. Amrein and Berliner (2002) emphasised that test preparation may improve test scores in the short term; however, they do little to improve student learning. The student must be developed holistically to be able to acquire the needed skill to be able to contribute meaningfully to solving problems confronting the society. These skills are acquired through active participation of the student in scientific processes.

In a European Commission supported project dubbed 'Mathematics and Science for Life' (MASCIL), Doorman, Fechner, Jonker, & Wijers (2014) conducted a large-scale survey on the use of inquiry based learning across 14 European Union countries. The study identified three categories of factors which affect the implementation of inquiry-based learning, namely: System restrictions, classroom management, and resources. It is reported that these three factors hinder the smooth implementation of inquiry-based learning. System restrictions were found to be most desirable for predicting the use of inquiry-based learning whereas classroom management was most preferable for predicting attitude towards inquiry-based learning (p. 26). Some authors have also questioned the effectiveness of inquiry. To them, many of the minimally led inquiry learning experiences 'do not work' (Kirschner et al., 2006).

Bevins and Price (2016) postulate that 'models of inquiry are too limited, revolve around extensive practical work and omit the wealth, power and complexity of the scientific endeavour' (p. 19). On his part, Anderson (1996) argues that teaching through inquiry is hindered by three dimensional limitations: technical problems, political limitations, and cultural issues. He further explains the technical challenge constitute teacher's inability to fully teach due to inadequate teaching skill development. The political dimension encompasses frictions resulting from inadequate supply of resources as well as limitation on time. The cultural problem is associated with the perception that students must be prepared for promotion to A, B, C school levels.

According to Yoon, Joung and Kim (2012), six challenges are usually encountered by pre-service teachers on the use of inquiry based teaching. These are: (a) helping students to develop ideas on their own as well as their curiosity, (b) assisting students to design an experiment to suit hypotheses they have set, (c) scaffolding students' interpretation of data as well as their discussion, (d) friction emanating from guided inquiry and open inquiry, (e) partial insight into hypothesis (f) lost confidence in the content knowledge of science.

To them, a, b and c are experienced when the lesson is ongoing therefore are referred to as 'on the lesson' difficulties. The last three difficulties: d, e, and f are difficulties in the minds of pre-service teachers called 'under the lesson' difficulties.

The researchers opine that under the lesson difficulties are likely to impact negatively and create difficulties that appeared 'on the lesson' in class. These difficulties were intertwined and featured in the decision-making process pre-service teachers' and affected their inquiry teaching based on hypothesis. Thus, this current study intends to find out the challenges tutor encounter in the practice of inquiry-based instruction at the Colleges of Education in the Northern Region.

2.4 Conceptual Review

A spoken or visual description of the anticipated relationship between two variables is known as a conceptual review. The conceptual review is frequently created using a literature review on the subject. This section reviews the ideas of performance, pedagogical knowledge, and inquiry-based instruction.

2.4.1 Inquiry-Based Instruction

The last two decades have seen growing calls for inquiry to play an important role in science education (Rocard et al., 2007). This call for inquiry-based learning is based on the recognition that science is essentially a question-driven, open-ended process of constructing coherent conceptual frameworks with predictive capabilities and that students must have personal experience with scientific inquiry and engage in its practices, in order to be enculturated in these fundamental aspects of science (Linn, Songer, & Eylon, 1996; NRC, 1996).

However, one difficulty for efforts to promote inquiry is the lack of specificity of what it can mean in classroom terms. Other researchers (Anderson, 2002; Minner et al., 2010) have discussed this problem of ambiguity in the term "inquiry" and described three distinct meanings of the term as: (1) *scientific inquiry*, referring to the diverse ways in which scientists practice to generate and validate knowledge; (2)

inquiry learning, referring to the active learning processes in which students are inevitably engaged; and (3) *inquiry teaching*, which is the main focus of literature around inquiry, for which there is no clear operational definition. What is worth mentioning is that the educational process by itself consists of two major actors: the teacher and the learner(s). Hence, it involves two processes, namely, teaching and learning, which may rely on different methods, strategies and principles.

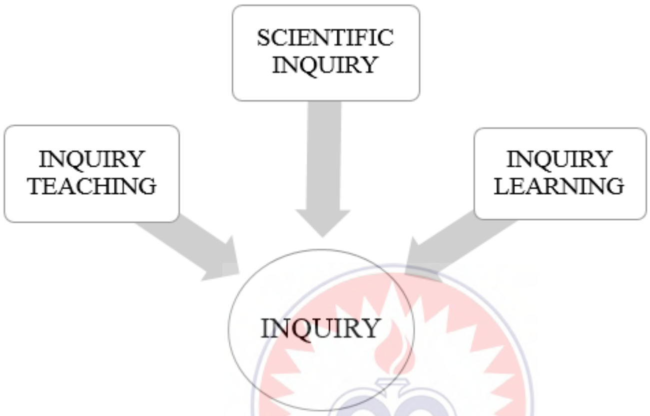


Fig.1: Three perspectives of "inquiry" (Minner, et al., 2010)

Falling in with Anderson and Minner et al., Marshall & Smart (2013) identified various contexts of inquiry as *scientific inquiry*, *inquiry-based learning* and *inquiry-based teaching*. Lederman (2004) saw inquiry as the process by which scientific knowledge is developed while Hassard (2005) said inquiry is a term use in science teaching that refers to a way of questioning, seeking knowledge or information or finding out about phenomena. In-arguably, inquiry as a classroom enterprise is a process, it does not matter which angle one views it.

The effective use of scientific inquiry is one hallmark of outstanding science teachers. Science teachers who use this approach develop within their students an understanding that science is both a product and a process (Akben, 2015; Miranda &

Damico, 2015). Often, students of these teachers learn the rudimentary knowledge and skills used by scientists. Many science teachers within the profession are unable to teach science by inquiry for some obvious reasons: lack of competence, lack of strong knowledge of scientific inquiry and the inability to use experimental skills and misconception about scientific inquiry among others. Thus, they are not able to teach authentic inquiry (Crawford & Capps, 2012).

These shortfalls stem from the nature of science teaching at the College or University level that largely uses didactic-teaching-by-telling approach (Miranda & Damico, 2015). In many teacher education programs, little attention is given to how the processes of scientific inquiry should be taught (Meyer et al., 2013). It is often assumed that, once teacher candidates graduate from an institution of higher learning, they understand how to conduct scientific inquiry and effectively pass on appropriate knowledge and skills to their students. This brings to fore the critical need to formulate clear framework for the most effective promotion of inquiry processes among students at all levels.

According to the U.S. National Research Council (2000), the following are essentially observable in an inquiry-based science classroom:

- Learners are engaged by scientifically oriented questions;
- Learners give priority to evidence;
- Learners formulate explanations from evidence to address scientifically oriented questions;
- Learners evaluate their explanation in light of alternative explanation; and
- Learners communicate and justify their proposed explanation (p.35).

Research suggests that inquiry-based science instruction enhances students' understanding of concepts in science and increases students' interest in the field (Hoftsein, & Mamlok-Naaman 2007). Inquiry-based learning experiences help students develop critical thinking skills and give them a sense of accomplishment. To ensure effective engagement of students in scientific inquiry, the 5Es Inquiry-Based Instructional Model was recommended during the design and implementation of STEM instruction in the United States (Northern, 2019).

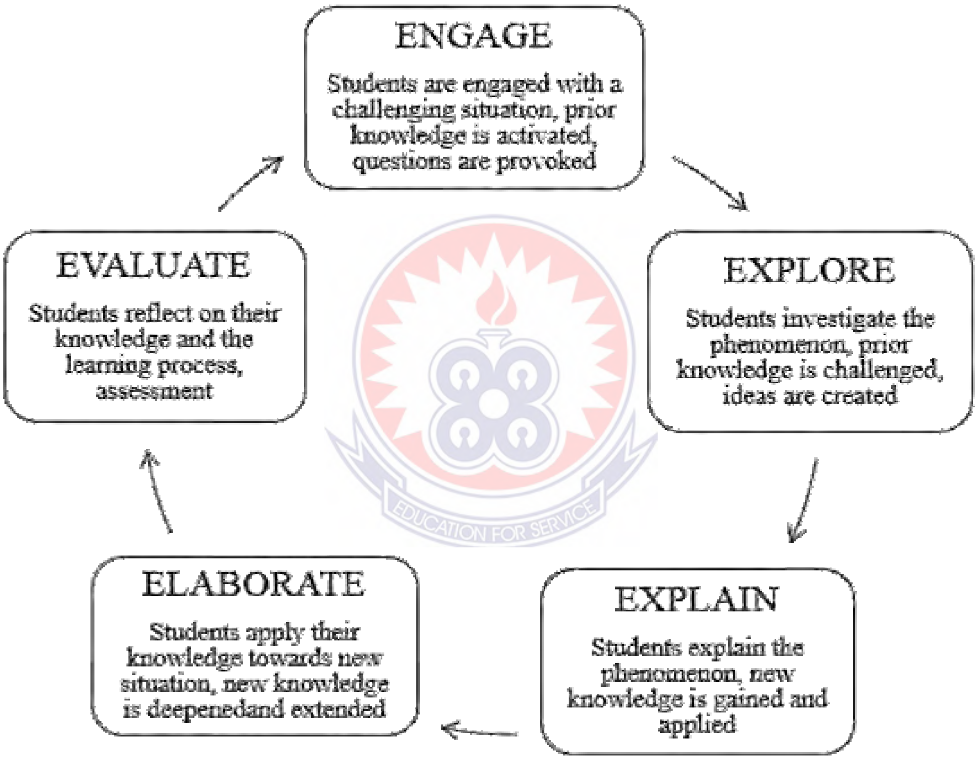


Fig. 2: 5E Inquiry-Based Instructional Model (Northern, 2019)

The 5E Inquiry-Based Instructional Model is a novelty based upon cognitive psychology, constructivist theory to learning, and best practices in STEM instruction (Bybee and Landes 1990). The 5E learning cycle leads students through five phases: Engage, Explore, Explain, Elaborate, and Evaluate. The 5E Instructional Model brings coherence to different teaching strategies, provides connections among educational activities, and helps science teachers make decisions about interactions with students (BSCS 2019). Compared to traditional teaching models, the 5E learning cycle results in greater benefits concerning students' ability for scientific inquiry (Bybee 2009). According to Williams (2019), a focus on content at the expense of process in science education will inhibit student learning, because the important learning occurs through the activities of the process. When the learning of content is necessary so it can be applied, through an activity to a situation, such content is perceived as relevant and so will be learnt more effectively and efficiently. (p. 3). The 5E Inquiry-Based Instructional Model serves as a flexible learning cycle that assists curriculum developers, classroom teachers, and school librarians with the creation of science lessons that illustrate constructivist, reform-based, best teaching practices.

In the view of Thompson (2006), inquiry-based activities involve the use of manipulatives or hands-on materials incorporating inquiry, discovery, and problem-solving approaches and applying mathematics and science concepts to real-world context. Moreover, inquiry-based methods for learning associates the activities in the classroom to distinct careers and involves the original data analysis. It also inspires both collaboration and communications by the students (Thompson, 2006).

Thompson found support for the idea that there is effectiveness for inquiry-based presentations for improving the achievement of the students as well as the satisfaction of the instructors when development occasions that are appropriate are made available. In a wide variety of perspectives and in a broad number of methods in the seventy years since Dewey (1938) hedged education as a progressive movement, there is still a strong predisposition toward using teacher directed methods of instruction. With respect to the instruction of math which was considered previously, although many believe memorization of basic operations and computational facts must be accomplished using teacher directed methods (Codding et al., 2009), proponents of inquiry-based methods suggest that there needs to be some sort of declaration of real-world mathematics concepts before any elementary skill sets are committed to memory (Thompson, 2006).

Dewey (1938) provided the following foundation for the progressive academic movement that is founded on the academic underpinnings of inquiry-based education: A clearly stated rule of the most recent school is that learning should begin with experience that students have previously acquired. The starting benchmark for future learning should be provided by this experience along with the aptitudes that were already formed during its participation.

IBI-related issues that Dewey (1938) raised are of the utmost importance to those who support this methodology. The question is, "What does freedom entail, and under what circumstances can it be realised?" Papanikolaou and Grigoriadou (2009) conducted a pilot study on an educational science capable of guiding students while they consciously choose their own personalised learning paths to provide a singular educational outcome. They outlined a distinction between the old media and the new media that focuses on the design of educational procedures and materials as well as the outcome objects that are targeted, and methods of assessment that determine whether or not students have retained the right levels, whereas the constructivist approach centers on in context learning structured around specific assignments.

2.4.2 Inquiry-Learning Tools

Clearly, the contemporary view of how students learn implies content that is deeper than facts and information, a curriculum that is richer than reading and teaching that is more than telling (Bybee, 2002). In line with this view, inquiry material should contain the content knowledge that a teacher wants to impart, but leaves space to explore the content. This can be done with the help of questions raised during engagement with the material. A student needs to find a satisfactory answer to such questions, by using his or her motivation und curiosity. This is in line with the claim of Novak (1988) that, most students are not aware that learning is a responsibility they must accept. Teachers have a responsibility to select meaningful material and seek to share his meaning with students, but only the student can choose to learn. They can choose to learn by rote or to learn meaningfully. The questions raised in the material should have a connection with the everyday life of students and, therefore, connect school contents with relevant scientific problems that might occur throughout a student‘s life.

Consequently, Bransford, Brown and Cocking (2000) are of the view that, ideas are best introduced when students see a need or a reason for their use. This helps them see relevant uses of knowledge to make sense of what they are learning‖. In the strategy of inquiry-based science learning, students are the main actors during a lesson. Hands-on working is an important part of inquiry-learning that helps to facilitate the understanding of theoretical knowledge and ideas. However, the researcher agrees with the opinion of Mayer (2004) that, activity may help promote meaningful learning, but the kind of activity that really promotes meaningful learning is cognitive activity (such as selecting, organizing, and integrating knowledge). Instead of depending solely on learning by doing, the most genuine approach to constructivist learning is learning by thinking‖. This is what is meant by higher level inquiry.

According to Furtak et al. (2009), the procedural facet of inquiry-based science does not involve students proceeding mindlessly through scripted laboratory procedures. While active learning suggests students are physically participating in the lesson, inquiry-learning requires that they are also mentally participating in it (Lord & Orkwiszewski, 2006).

The duo invented a structured inquiry lesson designed to turn the responsibility for learning to the students, by centrally involving them in the thinking process about what the given experiments where for and in linking their observations to the theory provided. The lesson topic was the human ear and acoustics. Students were expected to learn how sound is created, how it is transferred to our ears as well as about the ear‘s anatomy, including the organization and function of the *Ossicles* and the organ of *Corti*. As they also learned about the characteristic of sound waves, they were expected to use this newly acquired knowledge when learning about the function of the organ of *Corti* and the *Basilar Membrane*, as well as incorporating this knowledge to derive causes why noise is dangerous for our ears or the natural limitation of human hearing to a certain range of frequencies. In summary, the main learning goal of our inquiry-based lesson was the learning of science, defined as, acquiring and developing conceptual and theoretical knowledge (Hodson, 2014).

2.4.2.1 Inquiry as a Motivation to Learning

The "Zone of Proximal Development" (ZPD), which Vygotsky defined as "the distance between the actual developmental level and that determined through problem solving under adult guidance or in collaboration with more capable peers," is a significant theoretical concept that has been frequently used in pedagogical research in science (Vygotsky, 1978). According to ZPD, a youngster will be able to perform independently tomorrow what they can do in conjunction with others today.

According to Von Glasersfeld (1989), a learner's belief in his or her capacity for learning plays a critical role in maintaining motivation to study. These feelings of competence and confidence in one's ability to solve new challenges come from first-hand knowledge of solving problems in the past, and they are significantly stronger than any external recognition and motivation (Prawat & Floden, 1994). This is connected to Vygotsky's concept of the "zone of proximal development," where learners are given challenges that are both close to and just above their existing levels of development. Learners acquire confidence and drive to take on more complex problems when they successfully complete challenging activities.

One of the main arguments in favour of an inquiry-based approach is that, it is believed to more effectively encourage students. Bransford et al. (2000) claim that, motivation has an impact on how much time and effort people are prepared to put into learning. They believe that work must be difficult but not too difficult in order to remain motivated. Students will feel bored if they are too simple or frustrated if they are too challenging.

Ciardello (2003) suggested that, through piqueing students' curiosity, learning will be better stimulated and motivated. Students are therefore urged to look for questions and information that will assist them answer the discrepancy or dilemma by presenting them with a condition of confusion. When students can see the value and applicability of what they are studying, particularly in their own community, they become more motivated (Bransford et al., 2003). The implications for IBI are obvious, namely that students might be highly motivated by challenging, individualized inquiries.

2.4.2.2 Inquiry as Contextual Teaching in Science

Contextual teaching is supported by cognitive psychology theory, stating that "cognition is contextually dependent and must be described in that context before the material is understood". There are two complementary usages of word context Tweney (1992) cited in R N Giere (Ed) (Cognitive models of science vol. XV). First, context used to denote domain specificity which relates to the disciplinary knowledge that the learners wish to acquire, while the later used to denote signal task that contains true-to-life problems for the learners in the process of acquiring or applying the knowledge (Baker, O'Neil, & Linn, 1994; Ebenezer, & Gaskell, 1995).

Contextual learning occurs when a student processes new information or knowledge in a way that makes sense to him/her within his/her own memory, experience, and response frame (Crawford, 2001). To achieve this, teachers need to design learning environment with appropriable and desirable contexts which fit students' new knowledge. Five strategies called Relating-Experiencing-Applying-Cooperating-Transferring (REACT) applies to contextual teaching (Crawford, 2001).

- *Relating* - learning within context of learners or learners' prior knowledge. *Experiencing* - refers to learning by doing, including exploration, investigation, discovery, and invention.
- *Applying* - the activities in which the concepts are used or implemented.
- *Cooperating* - involvement of other learners during the learning process, including sharing, responding, communicating.

- *Transferring* - the use of classroom-acquired knowledge in new context or new situation.

There are seven components of contextual teaching and learning: 1) constructivism; 2) modelling; 3) questioning; 4) learning community; 5) inquiry; 6) authentic assessment; and 7) reflection.

In constructivism, students build their own knowledge by testing ideas based on prior knowledge or experience, applying these ideas to a new situation, and integrating the new knowledge gained with pre-existing knowledge (Berns, & Erickson, 2001). In constructivist classroom, students are actively engaged in hands-on activities and encouraged to gain knowledge through exploration (Crawford, 2001). Inquiry has its origins in the practices of scientific inquiry, emphasizing students to pose questions, gather and analyse data, and construct problem-solving or conclusion based on evidence (Hmelo-Silver, Duncan, & Chinn, 2007).

Modelling in contextual teaching can be performed by teacher himself/herself or even involving students to give example to other students relating to the material taught. Questioning aims to stimulate and foster students thinking skills; this can be conducted by encouraging students to as questions to be answered by other students or whole classroom or simply asking the students about what they have not understood or they want to know. Learning community refers to increase the use of group work and help low-achieving students to learn with the assistance of high-achieving students.

Authentic assessment utilized tasks that are real example of extended criteria performances of actual learning goals (Sears, 2003). This kind of assessment also used rubrics and other criteria checklists as standards to improve learning and teaching, providing multiple opportunities for students to learn and practice the desired outcomes as well receiving feedback and reflection. Last component, reflection, engages students and teachers to review, think, and evaluate their learning process and what they have just learned.

In science, contextual teaching can be conducted by illuminating theoretical practices and providing an opportunity for hands-on investigation. The contextual hands-on investigation should increase the degree of openness, for instance by posing the problem, but methods and answers are left open; offering students to discover relations he doesn't already know; and confronting students with raw phenomena with open problems, answers, and methods (Roth, & Roychoudhury, 1993).

Contextualized science should be taught like scientists' science or open-ended research in which 1) the task is simplified, 2) students' motivation and engagement are enhanced by the perception that their practical work is authentic. Essentially, contextual teaching in science should also present concepts in familiar contexts and tangible examples or experiences compared to abstract conceptual models (Klassen, 2006).

2.4.3 Inquiry-Based Instruction in Science Teacher Training

A revived interest in inquiry-based learning has emerged, with a focus on the development of scientific literacy. In the twenty-first century, the inquiry approach is largely regarded as being crucial for teaching scientific literacy (Yakar & Baykara, 2014). This strategy for teaching science considers;

(1) the diverse ways in which scientists conduct their work

(2) the power of students' observations

(3) students' ability to ask testable questions

(4) students' ability to make hypotheses

(5) students' ability to properly use various forms of data to identify patterns.

By focusing their attention, organizing their experiences, and encouraging their learning efforts, teachers help youngsters develop their curiosity and perseverance. Students must engage in carefully planned activities, receive instructional support from teachers, and have opportunity to do so for several weeks, months, or even years in order to succeed in science (Duschl, Schweingruber, & Shouse, 2007).

Because the way science is taught depends on the teacher, professional development and training for teachers are crucial. Experience has shown that unless science instructors receive systematic and ongoing professional development to support the changes necessary in the curriculum, no innovation will be sustained (Osborne & Dillon, 2008). According to Pajares (1992), instructors' conceptions are a result of their educational experiences as students. According to Shulman (1987), pedagogical content knowledge (PCK) of teachers develops over a long period of time and in a complicated manner; for this reason, it is essential to begin preparing science instructors for inquiry application in pre-service training and continue in in-service training.

It might be difficult for teachers to plan and carry out inquiry-based instruction with their students. It's possible that improper application of inquiry activities in science instruction won't yield the desired results. Teachers must develop their professional competencies in using inquiry activities in the classroom in order for inquiry learning to be successful. The teacher education program and ongoing professional development must consequently incorporate this competency of inquiry approach (CPD).

The inquiry approach to teaching science is an effective strategy that represents a change in how science is taught to and understood by teacher students at the college. Enhancing higher order thinking abilities to confirm or reject hypotheses, build and support a model or argument, take into account alternative explanations, and comprehend the provisional nature of science (Crawford, 2007). By using inquiry-based learning, teachers can help students learn the techniques and methods that scientists use to discover new information about the world while also assisting them in putting those techniques into practice. Through conducting problem-centered investigations created for learning particular science concepts, students learn and apply these procedures (McBride, Bhatti, Hannan & Feinberg, 2004). Science instructors try to get their pupils to grasp how the process of scientific inquiry is dynamic and ever-evolving (Khishfe & Abd-El-Khalick, 2002).

Both the dissemination of knowledge about scientific principles and practices and the development of abilities are recognized as being important by researchers and proponents of teaching science by inquiry. A variety of methods can be used to teach via inquiry:

- Laboratory experiments
- Reading and analysis of articles
- Case studies from the history of science
- Making observations in the field

It is necessary to teach students inquiry-related skills, aptitudes, and behaviors so that they acquire and internalize the scientific ways of thinking critically and objectively in order to solve challenges that advance both science and society (Lazarowitz, 2000). Students have the chance to personally experience science when they learn science through inquiry-based learning. This strategy also encourages conversation and supports curiosity, originality, innovation, tenacity, experience with failure, and ingenuity. As kids grow into future citizens, inquiry helps them develop a realistic perception of science (Tamir, 1983). As a result, the teacher's job is to guide the students as they digest the information and/or data gathered throughout their investigation (Anderson, 1996).

Researchers observed that high school students who studied biology through inquiry demonstrated a deep awareness of the relationships between the many elements of scientific investigation (Tamir, Stavy & Ratner, 1998). Despite the significance of this, studies about teachers' knowledge, attitudes, and practices in the classroom are still scant and dispersed (Saad & BouJaoude, 2012).

According to the constructivist viewpoint, one instructional strategy that has the potential to assist students in creating knowledge through a process of discovery that promotes continuous learning is inquiry-based learning (lifelong learning). It can meaningfully include pupils in both solitary and group activities. According to Driver et al. (1994), meaningful activities can help students understand scientific notions and the scientific method's procedures.

Inquiry-based learning (IBL) is a key thrust in school science education, and has for decades been the prominent and central theme of science curriculum improvement (Aldahmash, Mansour, Alshamrani & Almohi, 2016; Dunne, Mahdi &

O'Reilly 2013; Wang, Zhang, Clarke & Wang, 2014). In fact, according to Crawford (2014) most conversations about reform-based science teaching include the word 'inquiry.' Inquiry has also been used to characterise good science teaching and learning (Anderson, 2007).

However, despite the strong advocacy for IBL, multiple meanings and interpretations have been put forward. Nevertheless, there is consensus that IBL is based on the epistemology of scientific research, and this suggests that learners should acquire theoretical content, thinking skills (Haug, 2014) and process skills (Breslyn & McGinnis, 2012; Rocard, Csermely, Jorde, Lenzen, Walwerg-Heriksson & Hemmo, 2007; Wang et al., 2014). This holistic approach to science has led to it being termed 'authentic' science, because learners may make their own decisions in terms of the content with which they engage, the manner of presenting the acquired knowledge, their own topic of research, and the methodology used (Hubber, Darby & Tytler, 2010). The essence of inquiry is thus the active involvement of learners, focusing on the 'why' and 'how' and less on the 'what' and it is suggested this helps learners to gain a better perception of what science is and how it is practiced (Rooney, 2012; Zion, 2007).

Inquiry-based learning is also key in preparing a workforce that is adaptable in its thinking and able to operate with greater autonomy. Whereas skills in set routines were desired attributes in the past, today each worker is expected to think critically, solve abstract problems and generate new ideas for improvement (Castells, 2005). Economic growth and competitiveness is dependent on continuous technological improvement and innovation. We live in a knowledge-based economy where knowledge is a driver of productivity and economic growth (Organisation for

Economic Co-operation and Development, 1996), and this leads to a new focus on education. In the knowledge-based economy, "learning-by-doing" is paramount, and inquiry-based learning activities could encapsulate experiences that develop thinking skills demanded by the workplace in this economy. These new demands from the workplace and the technological advancements of the world in which we live have served to stimulate much change in national curricula throughout the world.

In "A Framework for K-12 Science Education" for the United States, it is emphasised that students should experience inquiry-based practices and not merely learning about them (NRC, 2012). Instead of 'inquiry skills,' the term 'inquiry practices' is used to highlight that the process of inquiry requires the coordination of both knowledge and skills simultaneously. The following 'practices' are identified: asking questions (for science); defining problems (for engineering); developing and using models; planning and carrying out investigations; analysing and interpreting data; using mathematics and computational thinking; constructing explanations (for science); designing solutions (for engineering); engaging in argument from evidence; and obtaining, evaluating and communicating information (NRC, 2012:42).

This concept of inquiry is now reaffirmed in the Next Generation Science Standards (NGSS Lead States, 2013), where scientific inquiry is now synonymous with a vision of scientific literacy that encompasses skills and knowledge related to Scientific and Engineering Practices (Lederman, Bartos, Bartels, Meyer & Schwartz, 2014). In South Africa, IBL is prescribed in the latest national curriculum document called the Curriculum and Assessment Policy Statement (CAPS). This focus of IBL in CAPS is reflected in Specific Aim 2 where the intent is to develop in learners "scientific skills and ways of thinking scientifically at level of academic and scientific literacy that enables them to read, talk about, write and think about biological processes, concepts and investigations" (Department of Basic Education, Republic of South Africa, 2011:16–17).

The benefits of IBL are well-established from empirical research studies. Affectively, doing inquiry is motivational, and stimulates interest in science learning (Osborne, 2010; Piburn & Baker, 1993). IBL has also been shown to contribute to the development of conceptual understanding in science (Leonor, 2015). Scientific inquiry may lead to the development of higher-order thinking skills such as analysis, synthesis, critical thinking and evaluation (Conklin, 2012). Inquiry is also an important means to understanding the nature of science (Abd-El-Khalick, et al., 2004; Gaigher, Lederman & Lederman, 2014; Lederman, & Lederman, 2012) and provides an insight into the world of the scientist (Breslyn & McGinnis, 2012).

Despite growing consensus regarding the value of inquiry-based teaching and learning, research has found that the implementation of such a pedagogical practice continues to be a challenge for many teachers (Smolleck & Mongan, 2011; Trautmann, MaKinster & Avery, 2004). IBL signals a paradigm shift from the traditional teacher-dominated to a learner-centred approach. Here, the role of the teacher as one who acts as a 'sage-on-the-stage' in a traditional passive learning environment, is redefined into multiple roles that include those of "motivator, diagnostician, guide, innovator, experimenter, researcher, modeller, mentor, collaborator, and learner" (Crawford, 2014). In South Africa, the advent of IBL as a curriculum imperative has been a recent development, and hence only limited research has been done in this regard (Dudu & Vhurumuku, 2012; Ramnarain, Nampota & Schuster, 2016). The research reported in this article is on the interaction between Grade 10 Physical Sciences teachers' beliefs about IBL, and their practice of IBL in their classrooms.

In particular, the study centres on the beliefs of Physical Sciences teachers in a rural district in the province of Mpumalanga. Mpumalanga is a province that lies in eastern South Africa, bordering Swaziland and Mozambique. It is pre-dominantly rural. In South Africa, the advent of the new democratic political order since 1994, has resulted in a major overhaul of the apartheid education system. One national and nine provincial departments have been created out of 18 fragmented departments that were based on race and ethnicity.

This restructuring of the education system has resulted in major gains in post-apartheid South Africa. These include improved access to education, as reflected in school enrolment figures, accelerated provisioning of school infrastructure, more equitable distribution of resources, improved learner-educator ratios, and the introduction of school nutrition programmes (Statistics South Africa, 2010). However, rural education is out of step with educational development in other parts of the country. This is despite the fact that the vast majority of school-going children in South Africa live in rural areas. Correspondingly, factors that mitigate against curriculum reform such as the introduction of IBL appear to be more pronounced in rural districts. A particular focus of this research was therefore on the teachers who were teaching at rural schools.

2.4.4 Limitations to Instructional-Based Inquiry

When attempting to use a constructivist approach to learning, limitations do occur. Influences have an impact on IBI and learning, but they can be mitigated with the correct assistance and supervision. Lack of resources or diverse perspectives, insufficient time to plan and properly implement inquiry lessons and assessments, the simplicity of direct instruction over inquiry instruction, limiting disruptions in the classroom, and teacher and student attitudes toward the inquiry process can all be difficulties. It is impossible for inquiry-based learning to succeed without access to a textbook. Students' ability to historically reflect about material as learned is hampered by the restricted resources available to them and the limited perspectives they can view. This historical thinking includes the related aspects of historical comprehension, chronological reasoning, historical analysis and interpretation, historical research skills, and historical problem-solving and issue-analysis (NCHS, 1996). Students must look at historical records, notebooks, diaries, artifacts, historic places, works of art, quantitative data, and other historical evidence in addition to the information in the course textbook (Prokes, 2009). In classrooms that emphasize communication, critical thinking, and skills for lifelong learning, it is crucial to employ a variety of resources and viewpoints (Scott, 2015).

One key limitation of education is that students must actively create knowledge for themselves rather than passively receiving it from teachers (Olusegun, 2015). Direct transfer of information is regrettably all too often in school, especially in the social studies topic, due to the accountability of testing and its time limits (Au, 2013). Since it can be challenging to strike the correct balance, teachers frequently employ direct instruction to accelerate the learning of the material before state-mandated tests. Teachers can, however, strike the correct mix to provide the rich set of inquiry skills and tactics to their classrooms and beyond (Selwyn, 2014). Teachers must formulate effective inquiry questions that are both broad and specific enough to promote depth and complexity in inquiry-based learning (Selwyn, 2014). Effective questioning gives teachers the chance to link ideas and provide students the information they need to perform at a high level of mastery (Mathis, 2015).

Students must be given the chance to instruct and learn from one another in order to develop high levels of mastery in the inquiry-based learning approach (Pahomov, 2014). Since most schools are set up with desks facing front in rows, collaboration is essential to the success of inquiry. However, when students collaborate, they can speak openly with one another, which could provide difficulties for the teaching of inquiry. Even throughout the inquiry process, there might be disruptions in the learning environment. One student's dominance over the group, pressure to adhere to majority opinion, and group members failing to complete their fair portion of the work are some of the disruptions in this method of learning (Burke, 2011).

By using peer evaluations, grading students individually and in groups, assigning students to specific roles, creating team contracts with roles, rules, and expectations for the task, supporting groups in appropriate communication, providing feedback to groups as they work, and allowing inquiry time to occur, teachers can overcome these obstacles to the inquiry process (Barkley, 2017; Pahomov, 2014).

The effect of instructor and student attitudes on the inquiry process presents another difficulty. Due to rigid curricula, unsupportive administrators, and insufficient preservice and in-service training opportunities, teachers who have never used a constructivist approach to teaching feel that they have never become open to the learning theory (Brooks & Brooks, 2001). Contrarily, students have more frequently experienced teacher-centered instruction and have little to no experience with inquiry (Pahomov, 2014). Brooks and Brooks (2001) suggested these steps to implement instructional shift to inquiry learning in order to counteract instructors' and students' unfavorable views regarding inquiry.

According to Brooks and Brooks (2001), resources and educational investment should be devoted to teacher professional development. These programs should center on constructivist techniques in preservice education as well as ongoing education for teachers. When the subject matter is relevant to their everyday lives and the learning environment is supportive, encourages individual progress, and isn't dependent on comparing one student to another, students' attitudes can change toward inquiry (Pahomov, 2014).

2.5 The Teacher's Pedagogical Content Knowledge

In recent years, the teaching profession has advanced to the point where it is now viewed as a producer of specialized knowledge. Currently, the teacher is viewed as an intellectual actor, a professional with a "knowledge base," and a set of abilities that he develops while engaging in instructional activities (Fernandez, 2014). A concept known as "Pedagogical Content Knowledge" (PCK) has been used frequently in the literature on teachers' knowledge and aims to represent the professional knowledge of teachers (Fernandez, 2014). This has been a successful approach for studies intended to record the knowledge that constitutes good teaching.

Every discipline has an educational component that cannot be separated from its contents, according to Acevedo (2009). As a result, it seems essential to move away from more general approaches and toward more specific ones when training teachers. This entails placing a strong emphasis on the value of particular teaching courses (such as Methods / Instrumentation for the Teaching of Chemistry).

Gess-Newsome (1999) presented the Integrative Model (IM) and Transformative Model(TM) as two theoretical frameworks to explain the emergence and growth of PCK. According to Gess-Newsome, the Transformative Model views PCK as the outcome of a transformation of pedagogical knowledge, subject matter knowledge, and context knowledge whereas the Integrative Model views PCK as the junction between pedagogical, subject matter, and contextual information. This research looks at the PCK in the context of IM (Figure 2.1).

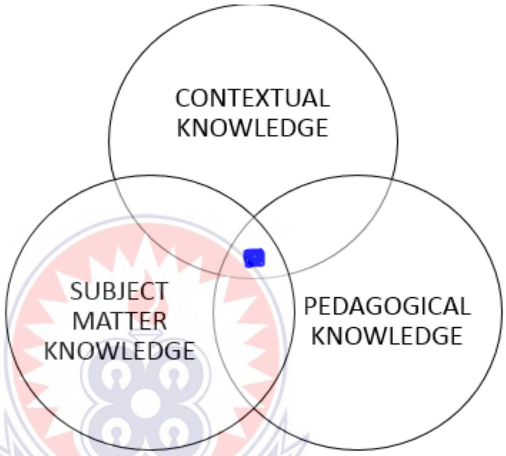


Fig 3: Model of Teacher Knowledge (Integrative Model). ■ = PCK = Knowledge Needed for Classroom Teaching (Gess-Newsome, 1999).

The knowledge of teachers is explained by the intersection of three constructs—subject matter knowledge, pedagogical knowledge, and context knowledge—in the Integrative Model because PCK does not exist as a domain of knowledge (Gess-Newsome, 1999). According to Abell (2008, 1107), the context considers the students, the school, the community, and the district while the subject matter knowledge examines the skills, concepts, applications, etc. The pedagogical knowledge focuses on learners and learning, classroom management, curriculum instruction, and educational goals. According to this perspective, teaching would be the act of fusing information from these three disciplines. Knowledge may develop separately in the Integrative Model before integrating during the teaching action. Gess-Newsome compared the IM to "a combination," where the separate components are still chemically distinct but have a visually seamless integration. The IM has effects on the teacher education curriculum. The more traditional teacher training programs, divided into content, pedagogy, and practice disciplines, frequently adhere to an integrative model of teachers' knowledge.

The IM, whether they are seasoned instructors or new teachers with some experience, is a useful starting point for examining the curricula of teacher education, according to Nilsson (2009). This PCK building model can assist teacher educators in developing a curriculum that is focused on providing comprehensive training. Abell (2008) thought that in order to facilitate learning for new teachers, science teachers' instructors should pay special attention to the individual components of PCK. According to Barnett and Hodson (2001), experienced teachers have information that is more easily accessible, applicable, and organized than that of less experienced teachers. He noted that whereas experienced teachers employ the most pertinent information in an integrated manner, beginners "access" knowledge of concepts, procedures, and tactics one at a time.

As a result, engaging in group discussions where more and less experienced participants discuss their own personal practices and beliefs as well as the practices and beliefs of the other participants would help each participant better understand the unique qualities of the contexts in which they operate. According to Nilsson (2008), the pre-service teacher's perspective on professional development fosters self-awareness of one's own learning. Undergraduates gain experiences through practice, but they also need to reflect on those experiences through class discussion.

The importance of including teaching practice in the training process, along with discussion of articles on educational work, as alternative conceptions of students and how they reason, is reaffirmed by De Jong, Veal, and Van Driel in their 2002 article. They do this by referring to the formative elements that would help build the PCK of undergraduates. According to Rollnick et al. (2008), PCK should be incorporated into teacher education since it might be passed to inexperienced teachers, aiding them in their training, provided you can access the PCK and describe the professional practice of instructors.

The difference between an experienced teacher and a novice teacher, according to Talanquer (2004), is that the novice teacher chooses a book and follows the suggested sequence when picking an activity. The experienced teacher, on the other hand, has an entirely new "look" for the text. The task, according to the author, requires teachers to assess the level of intellectual development, prior knowledge, interest, and motivations of their pupils while examining the aims, reasons, and philosophy of what to accomplish in chemistry in a certain environment.

According to Talanquer (2004), teacher preparation programs ought to work together to develop the future teachers' PCK. Openings for the main teaching points of the subject matter are analyzed, and didactic and pedagogical issues are discussed. Developing their PCK as well as the critical thinking and analytical abilities that enable them to organize the classroom as an environment for ongoing study would be aided by this kind of reflection for student teachers.

Like other academic fields, chemistry has unique characteristics that the instructor must take into account. Science educators have identified a variety of curriculum areas where pupils struggle. When preparing their lesson plans, an experienced chemistry teacher must take these challenges into account and tailor the chemical content to the pupils' needs in the particular situation. The experienced teacher will choose problems carefully so that his or her sequence presents examples of combinations of chemicals that exist in atomic and molecular form, problems where there is an exchange of polyatomic ions, for example working balance of mass and charge, etc.

The novice teacher, for example, pays little attention to the type of problem used when balancing a chemical equation. In order to help pupils grasp why the number of atoms but not the molecules is conserved during a chemical reaction, an experienced instructor will be aware of this challenge and will use examples that put those concepts in conflict (Talanquer, 2004). Such a teacher has a strong PCK foundation that is rooted in subject-matter expertise. Therefore, introducing inquiry learning into teacher training programs would equip instructors with strong PCK to provide instruction effectively in the classroom.

2.6 Teacher Beliefs and IBI

Teachers faced with new pedagogical approaches to education face a number of dilemmas, many of which are rooted in their beliefs and values (Anderson, 2007). Philip refers to beliefs as “psychologically held understandings, premises or propositions about the world that are thought to be true” (Philip, 2007). Within the context of education, Kagan (1992) refers to teacher beliefs as “implicit assumptions about students, learning, classroom, and the subject matter to be taught” (p. 66).

Binns and Popp (2013) underline the significance of teacher beliefs by arguing that it is not educational background alone that determines whether a teacher will use an inquiry-based pedagogy, but also teachers’ beliefs, values and views regarding knowledge and how it is acquired that are significant. Teachers' beliefs about science, beliefs about the nature of science, beliefs about teaching and learning, and beliefs about inquiry-based approaches influence science teachers' decisions and choices of pedagogical strategies (Sikko, Lyngved & Pepin, 2012). If teachers' core beliefs are in conflict with inquiry practices, they act as a hindrance to teachers in choosing inquiry as a pedagogical strategy (Binns & Popp, 2013).

Beliefs held by teachers influence their perceptions and judgement, which in turn affects their choices of teaching strategies and their behaviour in the classroom (Pajares, 1992). Harwood, Hansen and Lotter (2006) argue that while the factors that influence teachers' practices are complex and numerous, teachers' beliefs have been found to influence teachers' teaching practices, how they believe content should be taught, and how they think learners learn. Beliefs are therefore likely to play an important role in whether teachers intend to and/or actually carry out the practice of teaching science as inquiry (Crawford, 2014). Saad and BouJaoude (2012) also assert strongly that one of the major barriers to implementing inquiry practices in science class-rooms is teachers' beliefs about teaching, learning and classroom management.

Research that has been conducted outside South Africa has investigated the interconnection between teacher beliefs on IBL and their teaching practice. Studies have reported on how teachers' practice of inquiry has been related to their beliefs about inquiry. In a quantitative study, Haney, Czerniak and Lumpe (1996) reported that teacher beliefs were a strong predictor of their intentions to implement a reform-based pedagogy such as IBL. In a case study of six experienced high school teachers, Wallace and Kang (2004) found that teachers having a belief in inquiry to lead to successful science learning, especially in conceptual understanding, were willing to integrate IBL activities into their teaching. However, research has also reported on an apparent dis-connect between teacher belief in IBL and its enactment. It has been found that when a teacher holds an inquiry-driven belief, those beliefs do not necessarily translate into correlated practice.

In a study of primary school teachers in Hong Kong conducted by Chan (2010), it was found that while teachers have positive beliefs about inquiry-based teaching and learning, such beliefs have not developed into influencing their choice of pedagogical strategies, and the teachers were seldom found to use inquiry-based teaching and learning approaches in their classrooms. In a study conducted across European countries, it was found that while there is a positive orientation towards inquiry-based teaching and learning, there are significant differences in the actual use of inquiry-based teaching and learning approaches in classrooms (PRIMAS, 2011).

Saad and BouJaoude (2012) state that in a study conducted in Lebanon, teachers found that while 85% of the teachers had positive attitudes and favourable beliefs towards scientific inquiry, classroom practices of the teachers indicated that there is no consistent relationship between attitudes and beliefs, and knowledge about inquiry and practices. The research reported in this article sought to establish whether the developments worldwide were similarly exhibited in South Africa.

2.7 Teachers' Skills in Implementing Inquiry-Based Teaching

Aside from knowledge, teachers' skills also serve as an important aspect in determining the effectiveness of implementing inquiry-based science teaching. Basically, skill means efficiency (Zakaria, 2015). Teachers' efficiency is needed to make sure students are able to engage actively in a meaningful learning environment by exploring and constructing their own scientific understanding (Hogan & Berkowitz, 2000).

According to Suchman's Inquiry Model, skills in implementing an inquiry approach that had been emphasized in this model is the efficiency of teachers to provide objectives, ask questions, conduct experiments, guide students in making hypotheses, and analyze the inquiry processes during the learning process (Taridi, 2007). Meanwhile, teachers' skills in the phase of the inquiry approach, according to Pedaste et al. (2015) involved five phases, which are orientation, conceptualization, investigation, conclusion, and discussion.

Then, the inquiry phase was further developed by Uum et al. (2016) into seven phases: (a) introduction, (b) exploration, (c) investigation planning, (d) conducting investigation, (e) conclusion, (f) communication, and (g) deepening. In this research, teachers' skills in implementing inquiry-based science teaching focus on four phases, which are conceptualization, investigation, conclusion, and discussion that are in line with the study of Teig et al. (2018).

Findings from previous studies showed that teachers are less skilled in implementing inquiry-based science teaching, where teachers only teach science implicitly without proper explanation and guidance for their students (Taridi, 2007). Thus, students only learn indirectly without knowing the real characteristics of an inquiry-based science learning approach resulting in the ineffective implementation of inquiry in the process of teaching and learning (Capps et al., 2016). Teachers tend to use the traditional approach compared to the inquiry-based approach, which is more based on teacher-centered and memorization of the facts (Hanri, 2013) because they are less skilled at implementing them. When the level of teachers' skills to implement a teaching pedagogy is low, then the process of teaching and learning is bound to fail (Ishak & Iksan, 2015; Razak et al., 2009). This is because, the implementation of inquiry approach needs skills and critical thinking to facilitate students in problem-solving of their investigation and exploration (Mahalingam & Hamzah, 2016). According to Hakim and Iksan (2018), mastering a pedagogical approach is a must for all teachers to ensure that students gain knowledge and develop their interest toward science in achieving the country's goal of producing experts in science and technology.

2.8 Students' Performance

In teachers' point of view, we find students' performance in different form, for example suppose some a teacher beginning is good but his presentation is not good or some other teacher's voice is slow but his explanation and presentation power is good. Therefore, evaluation of teacher's performance is a critical task.

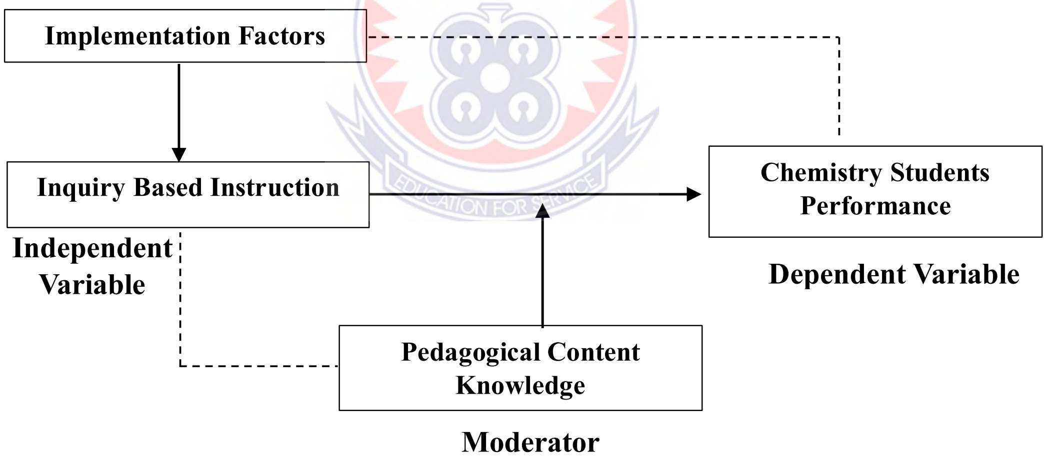
Evaluating the performance of a student is necessary due to many reasons for betterment of students and teachers –

- Improvement of the student's performance
- Monitoring of the students
- Betterment of the students
- Increase motivation to further improve performance
- Increase self-respect and ambition

Researchers and decision-makers have recently given teachers' performance evaluation incentives a lot of attention and support as the foundation for educational improvements. Although evaluating instructors' effectiveness is a challenging endeavor, pedagogical surveys have been used for years to do so. The most common type of educational survey consists of merely a few closed-ended questions with a set of multiple options that are arranged in some way. Each student completes a pedagogical survey separately to evaluate their teacher, and the mean score is used to determine how well the teacher is doing. Despite the popularity of such tools, to our knowledge, no research has been done on the subject of using surveys to automatically predict teachers' performance.

2.9 Conceptual Framework

This section provides the conceptual framework for the study, depicting the direct and indirect relationship between the study's variables as highlighted in the hypothesis development.



Source: Researcher's Construct

Figure 4: Conceptual framework of the Study

In this conceptual framework diagram, "Inquiry Based Instruction (IBI)" is depicted as the independent variable. It represents the extent to which tutors implement and utilize inquiry-based instructional strategies in their teaching. Also, factors influencing the implementation of IBI are present in the framework.

The "Pedagogical Content Knowledge (PCK)" of tutors is presented as the moderator, which influences the relationship between inquiry-based instruction and student performance. PCK refers to the knowledge and understanding that tutors possess in integrating pedagogical approaches with subject-specific content, in this case, chemistry.

Finally, the "Performance of Students" is the dependent variable, which reflects the academic outcomes or achievements of students in the context of chemistry education. It is influenced by the interplay between inquiry-based instruction and the pedagogical content knowledge of tutors.

This conceptual framework provides a visual representation of the relationships and interactions between the variables in the study, highlighting the potential role of inquiry-based instruction and the moderating effect of tutors' pedagogical content knowledge on student performance. Broken lines in the framework depict a relationship between the variables involved however, unrelated to the study. It is seen in the framework that Influencing factors have a direct relationship with Student's Performance however, this proposition is not within the scope of the study. Also in general terms, IBI is seen as a sub entity of PCK thus having a direct relationship nevertheless, this study views them as two separate entities, making IBI the independent variable whereas PCK is the moderator of the study.

In this regard, the striking difference between Inquiry-Based Instruction (IBI) and Pedagogical Content Knowledge (PK) lies in their distinct focuses and areas of expertise within the context of education. IBI primarily refers to an instructional approach that emphasizes active learning, critical thinking, and problem-solving through the process of inquiry (Bayram et al., 2013). It involves engaging students in posing questions, investigating phenomena, and constructing knowledge through firsthand experiences, experiments, and research. IBI focuses on student-centered learning, where students take an active role in their learning process by formulating hypotheses, designing investigations, and drawing conclusions.

On the other hand, PCK refers to the specialized knowledge and understanding that teachers possess in integrating pedagogical approaches with subject-specific content (Shulman, 1986). It encompasses teachers' knowledge of how to effectively teach particular content areas and the ability to represent that knowledge to students in a way that promotes meaningful learning. PCK includes an understanding of the subject matter itself, as well as the pedagogical strategies and methods that best facilitate student understanding and engagement with that content.

2.10 Chapter Summary

The discussion so far has shown that Inquiry-Based Instruction and Learning are effective in science education. Nonetheless, the literature has also indicated that, teachers' understanding of the approach remains diffused. What is observed is that, the approach is being understood in the context of science practices with the mind that teachers will be able to teach science more successfully. This is the case even in the most developed countries like the US, where the approach has been conceived and used for a very long time.

But the question is, "how do science teachers in the less developed countries like Ghana understand and practice inquiry based instruction?" The significance of this question is from the background that, science is hoped to accelerate the development of these countries when taught/learned using effective approaches, of which the inquiry pedagogy is one.

Incidentally, review of available literature on the topic leads to the conclusion that, studies on the subject has focused primarily on the experience of the most developed countries. Literature on teachers' knowledge and practice of inquiry science instruction in Africa is very scanty. The few studies sighted focused on the elementary and secondary science education. There is no study on science tutors' knowledge and practice with respect to inquiry instruction at the college level where the elementary teachers are trained. Therefore, this study seeks to bridge this knowledge gap by assessing chemistry tutors' understanding and practice of inquiry-based instruction in the context of chemistry education at the Colleges of Education in Ghana.

The literature on teachers' understanding of IBI leads to the conclusion that, different teachers may understand the approach differently as these are notable in the different teachers' implementation of the approach and the outcomes of such application. Some of these differences are noted at the institutional, systemic or even regional levels. Nonetheless, it is prudent to continue to explore science teachers' understanding of IBI and expect that these play a part in teachers' intention and/or ability to successfully carry out IBI, especially in chemistry classrooms.

The various studies discussed make it clear that, investigating the knowledge and actual practices of teachers in their classrooms, with respect to inquiry-based instruction is a right move since this would ensure that the gaps are identified for redress and effective implementation of the pedagogical approach. The studies illustrate the importance of researchers moving into the classroom to determine what is happening, with all the complexities of individual student abilities and predispositions, classroom physical structures, school context, and community. These factors influence teachers' approach to IBI implementation since different classrooms provide different contexts. Considering that most of the studies discussed were conducted in developed countries, their findings may not apply in most developing countries including Ghana. Hence, the need to research into science teachers' understanding and practice of inquiry to address this knowledge gap in the literature in the Ghanaian context.

The literature discussion has also shown that, a number of external and internal factors affect science teachers' ability to implement IBI. Although most of the studies have focused on general science prospective teachers in developed countries, few studies have focused on discipline specific in-service science teachers such as biology, chemistry, and physics. There is no published study in literature that has explored chemistry tutors' knowledge and practice of inquiry-based instruction at the colleges of education in Ghana. Since no context is the same in any two countries (Englen et al., 2013; Pozueloso et al., 2014), studies done elsewhere may not apply fully to developing countries like Ghana, hence, the need to carry out studies in other countries to reflect their culture and context.

The review of the available literature leads to the conclusion that, although inquiry-based approach to the teaching and learning of science is effective and recommended, literature on the pedagogy is budding. Conceptions of the IBI differ and relatively little is known about the ways in which it is understood and implemented by teachers. The experiences of the less developed countries, like Ghana, are typically underreported in the scanty literature that has been published on the subject. As a result, information on the factors influencing implementation of the approach in these countries is scanty and this affects the efforts being made by teachers and researchers to improve on the effectiveness with which science education is delivered. This makes it imperative to investigate science teachers' understanding and practice of IBI, with specific reference to chemistry tutors at the colleges of education in the Northern Region of Ghana.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter explains the research methodology used in the study. It begins with the description of the research design, followed by population, sample size and sampling techniques and the research instruments. Also, validity and reliability of the instruments, data collection procedure, data analysis as well as ethical considerations are discussed.

3.2 Research Design

The study was quantitative research which employed descriptive survey approach. A comprehensive descriptive research design involving cross sectional survey was used to investigate the determinants of chemistry tutors' pedagogical knowledge and practice with respect to inquiry-based learning approach at the Colleges of Education in the Northern Region of Ghana. This approach was considered appropriate for the study because, in-depth information concerning tutor pedagogical knowledge and practice with regards to inquiry-instruction as well as impact of these on the achievement of teacher trainees in chemistry at the colleges of education in the Northern Region were obtained. Data were collected from both chemistry tutors and students using questionnaires and observation. The collection of data from different sources and with different instruments was to allow for triangulation of the data to ensure quality and validity of the research findings.

3.3 Population of the Study

The population of interest for the study comprises of the individuals, dyads, groups, organizations, or other entities one seeks to understand and to whom or to which the study results may be generalised or transferred (Alex & Nancy, 2021). It is the principal group about which the research is concerned. A population may refer to an entire group of people, objects or events (Alex & Nancy, 2021). In this study, the population of interest comprises the chemistry students and tutors in the Science Colleges of Education in Ghana. The accessible population included all the chemistry tutors and students in the selected three Science Colleges of Education (Bagabaga, Tamale and E.P.) in the Northern Region.

3.4 Sample Size and Sampling Procedure

Eleven (11) chemistry tutors and one hundred (100) third year chemistry students, given a total of one hundred and eleven (111) respondents formed the sample size for the study. These were drawn from the three Science Colleges of Education in the Northern Region: Bagabaga, Tamale, and E.P. Colleges of Education.

A multi-stage sampling procedure was used for this study. In multistage sampling, or multistage cluster sampling, you draw a sample from a population using smaller and smaller groups (units) at each stage (Bhandari, 2023). It's often used to collect data from a large, geographically spread group of people in surveys (Bhandari, 2023). It is a method of obtaining a sample from a population by splitting a population into smaller and smaller groups and taking samples of individuals from the smallest resulting groups (ZACH, 2021). The approach was chosen because of its effectiveness in primary data collection, cost and time effectiveness as well as its high level of flexibility (Dudovskiy, 2018).

First, the population was divided into two strata:

Stratum 1: Chemistry teachers

Stratum 2: Chemistry students

Second, the chemistry students were further divided into three strata:

Stratum 1: Chemistry students in Bagabaga College of Education

Stratum 2: Chemistry students in E.P. College of Education

Stratum 3: Chemistry students in Tamale College of Education

Thirdly, all chemistry teachers in the three colleges of education were purposively sampled. Also known as judgmental sampling, purposive sampling is a strategy in which particular settings, persons or events are selected deliberately in order to provide important information that cannot be obtained from other choices (Maxwell, 1996). It is where the researcher includes cases or participants in the sample because she or he believes they warrant inclusion.

Next, the chemistry students were proportionally sampled using the percentage figure of chemistry students in each college. Samples of 11 chemistry tutors and 100 chemistry students were obtained given a total sample size of 111 subjects for the study.

Table 3.1 Sampling Frame

College of Education	Chemistry Tutors(CT)	Chemistry Students(CS)	% of CS
Bagabaga College of Education	3	85	28
E.P. College of Education	4	120	40
Tamale College of Education	4	98	32
Total	**11**	303	**100**

Total Sample Size = **11 + 100** = **111**

Then, haven obtained the proportional samples (28, 40 and 32) of the students from each of the three Colleges of Education (Bagabaga, E.P. and Tamale), simple random sampling technique was used to select individual students for the study. Simple YES and NO were written on papers and folded into a bowl for students to pick. Those who picked YES were included in the study.

3.5 Research Instruments

Two main types of instruments were used for data collection. These include questionnaires (one for tutors and one for students) and observation checklist. The questionnaire for the tutors consisted of thirty (30) items designed in a five-point Likert style and used to examine chemistry tutors' pedagogical knowledge and practice with respect to classroom IBI. Also, a fifteen (15) item questionnaire was developed and administered to the students to measure their experiences and complement the responses of the tutors. Again, a 25-item observation checklist was designed and used to observe chemistry tutors' practice of inquiry instruction in the classroom.

The questionnaires were called Inquiry-Based Tutor Questionnaire (IBTQ) and Inquiry-Based Student Questionnaire (IBSQ) respectively, while the observation checklist was called Inquiry-Based Tutor Classroom Observation (IBTCO). The instruments were developed by the researcher. See Appendices A, B and C.

3.5.1 Questionnaire

Questionnaires provide relatively cheaper, faster and efficient way of obtaining large amount of information from a large sample of a population (McLeod, 2018). The use of questionnaire is economical since it can provide large amount of research data for relatively low cost. Another good thing is that, the respondent provided information which was easily converted into quantitative (numerical) data, allowing statistical analysis of the responses, and made it suitable for quantitative research such as this study. The questions were standardized. Respondents were asked exactly the same questions in the same order. This means a questionnaire can be replicated easily to check for reliability. Thus, a second researcher can use the questionnaire to check that the results are consistent.

3.6 Data Collection Procedure

Prior to the data collection process, the researcher, who resides and teaches in Bagabaga College of Education, Tamale, visited E.P. College of Education, Bimbilla and Tamale College of Education, Tamale to meet the chemistry tutors and the student teachers who study chemistry as an elective subject. The visits by the researcher were meant to establish rapport with all the respondents. This familiarisation visits were used to explain the purpose of the study to the respondents as well as ask for their consent and maximum co-operation so that, the objectives of the study could be achieved just as was done to those at the Bagabaga College of Education. The classroom teaching observations were also scheduled with the tutors concerned.

During the data collection process, the two questionnaires (IBTQ and IBSQ) were administered to the respondents by the researcher with the support of colleague science tutors. The IBTQ was administered to the chemistry tutors whilst the IBSQ was administered to the sampled chemistry students in the three science colleges in the north. Using the IBTCO tool, six chemistry tutors' classroom teaching (two from each of the three Colleges) were observed. The questionnaires were completed and returned to the researcher.

3.7 Data Analysis

Data analysis is the process of examining, cleaning, manipulating, and modelling data to extract usable information, make conclusions, and aid in decision-making. The researcher used IBM SPSS version 26 to descriptively analyse the data. The descriptive statistics included Mean, Minimum, Maximum, and Standard Deviation. These were used to describe the IBIs, Pedagogical Content Knowledge and Practice and Students' Performance. Inferential statistics included correlational analyses, Cronbach Alpha, Exploratory factor analysis, and regression analyses.

Correlational analyses are conducted to examine the relationship between two or more variables. These tests provide information about the strength and direction of the relationship, indicating whether variables are positively or negatively correlated. Pearson's correlation coefficient is used to quantify the degree of association. Correlational analyses ease the understand of the extent to which variables are related and can be used to make predictions or draw conclusions about their associations.

Cronbach Alpha is a reliability analysis used to assess the internal consistency of a scale or a set of items. It measures the extent to which items within a scale are measuring the same construct. Cronbach Alpha calculates a reliability coefficient, ranging from 0 to 1, with higher values indicating greater internal consistency. Cronbach Alpha is used to determine the reliability and consistency of measures, such as questionnaires or surveys, ensuring that the items are reliable indicators of the construct they intend to measure.

Exploratory Factor Analysis (EFA) is a statistical technique used to identify the underlying factor structure of a set of observed variables. It helps uncover the latent variables that best explain the relationships among the observed variables. EFA is used to explore the underlying structure of their data and understand the underlying dimensions or constructs that influence the observed variables.

Finally, Regression analyses are conducted to examine the relationship between a dependent variable and one or more independent variables. It makes easy the understanding of how changes in one variable are associated with changes in another variable. Regression analyses provide insights into the strength, direction, and significance of relationships, as well as enable prediction and estimation.

The inferential statistics were used to test the data for reliability and validity, test the relationship between the variables and test the study's hypotheses.

3.8 Reliability Test

Research work is a whole scientific process that must be tested and proven, by using established standards to arrive at results. According to Heale and Twycross (2015), in quantitative research, reliability measurements are used to test the rigour and quality of a research. Reliability is the accuracy of the instrument or data collection tools used, and their ability to produce the same results when used repeatedly. The degree to which a research instrument produces consistent results after repeated use is called its reliability (Cronbach, 1953). Cronbach's Alpha was utilized to determine the internal consistency of the data collected. As established earlier, Cronbach's alpha is a measure of internal consistency reliability used to assess the reliability or consistency of a scale or a set of items in a research study. It quantifies the extent to which the items within a scale are measuring the same underlying construct or attribute. The Cronbach's alpha coefficient ranges from 0 to 1. Higher values of Cronbach's alpha indicate greater internal consistency, suggesting that the items within the scale are more closely related and reliably measuring the intended construct. A Cronbach's alpha value closer to 1 indicates a higher degree of internal consistency, implying that the items consistently measure the same construct.

When a scale or set of items has a high Cronbach's alpha value, it suggests that the items are consistently measuring the targeted construct, and the scale is reliable. Reliability is crucial in research because it ensures that the measure is consistent and stable over time or across different situations. A reliable measure reduces measurement error and increases the precision and accuracy of the results. A high Cronbach's alpha value implies that the items within the scale are highly correlated with each other and share a common underlying construct. It suggests that the scale provides a consistent and dependable measure of the construct of interest. Researchers can have greater confidence in the results obtained from a reliable measure, as it indicates that the observed scores are less likely to be influenced by random error or measurement inconsistencies.

Reliability is the quality of a measure's general consistency. A measure is said to have high dependability if it continuously yields the same outcomes under the same circumstances. Weiner et al. (2008) contend that attaining validated results depends on assuring the content validity of the instrument utilized since it ensures that the questions posed are appropriate for measuring the construct under investigation. Scores that are highly dependable are precise, reproducible, and constant across testing occasions. Cronbach Alpha was utilized by the researcher to evaluate the reliability of the variables in this investigation.

Table 3.2 Reliability Measurement

Variables	No. of items	Alpha (α)
Inquiry-Based Instruction	14	.723
Pedagogical Knowledge and Practice	14	.774
Students' Performance	5	.827

Source: Field study (2022)

The dependability of the instruments is displayed in table (4.5) above. According to Hair et al. (2011), trustworthy constructs in a reliability test have a Cronbach's Alpha score of 0.70 or higher (Taber, 2018). All of the variables' Cronbach's Alphas were above 0.70 (IBI, .723, pedagogical knowledge, .774, and tutors' performance, .827), demonstrating the validity of the instrument utilized in this study for the data collection of the variables.

3.9 Validity Test

Joppe (2000) claimed that, validity is a critical factor to consider while collecting data for research. The validity of a research instrument is referring to capabilities of the instrument to measure a construct or variable to be measured (Creswell, 2014). An instrument has a high validity if its degree of ability to measure what is supposed to be measured is high (Majid, 1990). Two types of validity were addressed: face validity and content validity of the instruments. The content validity or face validity refers to the ability of the instrument to collect data that will meet the objectives of the study (Noah, 2002). According to Stoner et al. (2011), the face validity meant that the instrument was assessed at a glance by the expert and found it suitable and appropriate, in terms of readability, feasibility, layout and style, and clarity of wording, to apply in measuring the predetermined domain in a study without looking in more detail.

The face validity of the instruments in this study was achieved through inspection by the researcher's supervisor and the Head of Science Department of Bagabaga College of Education, Tamale. The validators determined the suitability of the content material, clarity of the items and the instructions.

The content validity of the instrument was achieved through Exploratory Factor Analysis.

3.10 Ethical Considerations

Key ethical consideration in social science research is potential distress or harm to participants (Liamputtong, 2009). This research was conducted with the level 300 chemistry students and their tutors in three science teacher training colleges in the Northern Region of Ghana. In order to pose an extremely low risk to all participants, the study did not involve sensitive or intrusive actions. Also, all personal information of participants was protected and all documents were kept private. The researcher knew the identities of some participants and so, names were removed and replaced with Identity Document Number (ID code). Once the data collection was complete, survey scores of participants were matched and stored in a data base. ID codes were used during the whole process and pseudonyms were used in the reports unless where the participants requested disclosure of their genuine identity. In such case, participants' identities were only known and available to the researcher. Confidentiality and anonymity were guaranteed to colleges and individuals.

Also, participating tutors and students participated voluntarily and were well informed about the study. In addition, participants had the right to withdraw from the study at will and data collected from participants who withdrew were not included. In fact, the highest standard of ethical consideration was ensured in the study. Colleges and participants were assured of high level of confidentiality and these were duly adhered to.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Overview

This chapter presents the analyses of data and the discussion of results. The response rate, descriptive statistics, test of validity and reliability, inferential statistics, and discussion of results according to the research questions (RQs) set by the study.

4.2 Response Rate

The respondents were given access to a total of 111 questionnaires via various social media channels. In all, 97 responses were received, given 87% response rate.

4.3 Descriptive Statistics

This section describes the extent of Inquiry-Based Tuition, Pedagogical Content Knowledge and Student's performance using Mean, Minimum, Maximum and Standard Deviation.

4.3.1 Demographic Characteristics of Respondents

The profile of the ninety-seven respondents in terms of Gender and Age Group are analysed in this section (Table 4.1).

Table 4.1 Demographic profile of Respondents

Constructs		Frequency	Percentage (%)
Gender	Male	66	68
	Female	31	32
Age Group	18 to 30	68	70
	31 to 40	23	24
	41 to 50	6	6
Chemistry Tutors	3 CoE	11	11
Chemistry Students	3 CoE	86	89

Source: Field study (2022)

The respondents' demographic profiles are described in Table 4.1. On the whole, 68% of responders were males whilst 32% were Females. According to the age distribution, 70% of the respondents were within the ages of 18 to 30; 24% were within the ages of 31 to 40 while 6% were within the ages of 41 to 50. It was revealed that, 11% of respondents were tutors teaching chemistry in the three science colleges of education in the northern region while 89% were students (trainee teachers) in the three science colleges who are learning elective chemistry as part of their training.

4.3.2 Inquiry-Based Instruction

IBI was the predictor variable for the study, and fourteen items were developed to measure IBI. Inquiries on this section were based on discussion in the literature review, and respondents were required to respond on a scale of 1 to 5, where 1 is very low and 5 is very high. Descriptive statistics on IBI are provided in Table 4.2

Table 4.2 Descriptive Statistics – IBI

Constructs	Min	Max	Mean	SD
The IBL training I got at University, Workshops and PD Sessions is …	1	5	4.64	1.284
My understanding of the constructivist theory is …	2	5	4.28	1.382
My ability to conceive inquiry in the context of constructivism is...	2	5	4.2	1.52
My understanding of Social Learning is …	1	5	4.74	1.738
My understanding of contextual learning is …	2	5	4.08	1.516
My understanding of hands-on learning is …	2	5	4.34	1.242
My understanding of inquiry as a motivation to learning is	1	5	4.94	1.125
My understanding of inquiry in the context of scientific method of learning is …	1	5	4.49	1.259
My ability to conceive inquiry in the context of discovery method of learning is …	2	5	4.22	1.288
My understanding of the various contexts of inquiry learning is …	2	5	4.32	0.994
My understanding of the 5E IBI model is ...	1	5	4.83	1.172
My appreciation of the challenges affecting chemistry teachers' practice of IBI is …	2	5	4.21	1.672
My appreciation of IBL as a Pedagogical Approach in the classroom is …	1	5	4.11	1.728
My students' involvement anytime I teach by inquiry is …	1	5	4.01	1.093
My students' collaboration in inquiry-group discussions in class is …	1	5	3.98	1.007
The required technologies and equipment are available to enhance IBI	1	4	2.332	1.329
The teaching syllabus and timeline are favourable to the implementation of IBI	1	3	2.481	1.282
Total Score	1.6	5	4.092	1.03138

Source: Field Study (2022)

Table 4.2 presents the descriptive statistics on the IBI. With a mean of 4.092 and a standard deviation of 1.031, the study reveals a high understanding and practice of the IBI by the majority of respondents, however, lack of technologies and equipment as well as timeline proposed by the teacher's syllabus were hindrances to the practice of IBI. The mean, also known as the average, is a measure of central tendency. It is calculated by summing up all the individual responses and then dividing that sum by the total number of responses. The mean represents the average value or the typical score of the responses. Since respondents were required to answer from a scale of 1 to 5 where 1 depicts “Strongly Disagree” and 5 depicts “Strongly Agree”, any mean value between 1 – 2.9 is considered low and 3 – 5 is considered high. With this synopsis, it could be said that the practice of IBI is impressively high (4.092).

On this variable, the researcher personally performed a physical observation on the understanding and practice of IBI in the natural teaching and learning environment. The observation process was guided by an observation checklist which had ratings between 1 to 5 where 1 = Poor, 2 = Weak, 3 = Satisfactory, 4 = Good, 5 = Outstanding. The results are displayed in Table 4.3:

Table 4.3 Descriptive Statistics – (IBI Observation Check List)

Section	Item	Frequency	Percentage %
Tutor Practice of Inquiry-Based Instruction in the Classroom	Lessons involved hands-on activities	3	60
	Activities are mostly student-initiated	2	40
	Activities are mostly teacher-initiated	4	80
	Tutor uses group activities	4	80
	Questioning is mostly teacher-led	5	100
	Questioning is mostly student-led	2	40
	Lesson allows teacher trainees to use technology in search of information	3	60
	Lesson involves laboratory practice	5	100
	Tutor uses inquiry to teach chemistry	3	60
	Tutor teaches chemistry by inquiry with confidence	3	60
	Teacher Trainees are actively involved in hands-on activities	4	80
Factors Influencing the Implementation of IBI	Time	1	20
	Resources	1	20
	Professional Development	4	80
	Science topic or Content	5	100
	Mandatory Assessments	4	80
	Teacher Trainees set tasks for learning	5	100
Teacher trainees Learning Chemistry by Inquiry in the Classroom	Teacher Trainees collaborate in classroom activities	5	100
	Teacher Trainees perform activities individually	3	60
	Teacher Trainees discuss inquiry findings with colleagues	4	80
	Teacher Trainees relate their enquiry findings with real-life context	4	80
	Teacher trainees peer-assess their learning	3	60
	Teacher trainees self-assess their learning	5	100

	Teacher trainees engage in open-ended exploration	4	80
	Teacher trainees engage in play-based learning	4	80
	Teacher trainees conduct internet-based research	5	100
	Teacher trainees perform experiment in the laboratory	3	60
	Teacher trainees make artefacts	5	100
	Teacher trainees take part in field trips	3	60
	Teacher trainees participate in group discussions	4	80

Source: Field Study (2022)

Based on the observation checklist, the following findings are discussed:

4.3.2.1 Tutor Practice of Inquiry-Based Instruction in the Classroom

Lessons involved in hands-on activities scored 60%. This indicates that the tutor incorporated practical, experiential learning opportunities for the teacher trainees. However, it also suggests that a significant portion of the lessons did not include hands-on activities, which may limit the trainees' engagement and active participation. The lesson allows teacher trainees to use technology in search of information also scored 60%, implying that the tutor recognized the importance of incorporating technology into the learning process. However, a considerable proportion of the lessons did not leverage technology, potentially missing out on opportunities for trainees to develop digital literacy skills and access a wider range of resources. Again, 60% of the observed lessons involved the use of inquiry-based teaching methods. This demonstrates that the tutor recognized the value of inquiry in promoting active learning and critical thinking skills. Nevertheless, it also suggests that a significant portion of the lessons did not employ inquiry-based approaches, potentially limiting the trainees' exposure to this effective instructional strategy.

Moving forward, group activities were included in 80% of the observed lessons. This suggests that the instructor valued collaborative learning and gave students the chance to collaborate. Activities with others can improve interpersonal relationships, teamwork, and peer-learning. This result implies that the tutors successfully implemented cooperative learning techniques into their lesson plans. Initiated by the teacher, 80% of the observed activities, including teacher trainees' active participation in practical exercises, the trainees appeared to be actively involved in the learning process and had opportunities to put their newfound knowledge and abilities to use in real-world situations, which shows that the tutor played a more significant role in leading and guiding the learning experiences. A higher percentage of student-initiated activities would provide greater student autonomy and ownership of the learning process, even while some teacher initiation is expected.

Lessons included student-led questioning - only 40% of the observed activities were initiated by the students themselves. This shows that there is room for improvement in encouraging student-generated questions because the trainees had few opportunities to take the lead in creating their queries or customizing their learning experiences. Active participation, critical thinking, and curiosity can all be sparked through student-led questions.

While teacher-led questioning can be valuable for guiding and scaffolding learning, incorporating more student-led questioning can empower trainees to take ownership of their learning and develop higher-order thinking skill. Also, 100% of the observed lessons involved laboratory practice. This finding indicates that the tutor recognized the importance of providing hands-on experiences in a laboratory setting for learning chemistry. Laboratory practice allows trainees to apply theoretical knowledge, develop practical skills, and foster a deeper understanding of scientific concepts.

4.3.2.2 Factors Influencing the Implementation of IBI

Time factor suggests that the amount of time allocated to implementing inquiry-based instruction in the classroom is relatively low. It implies that teachers may not have sufficient time to fully engage students in inquiry-based activities, which could potentially limit the effectiveness of this instructional approach. Teachers might need to find ways to manage their time effectively to allow for more inquiry-based learning experiences. The high percentage allocated to resources indicates that the availability and access to materials, tools, and other resources for inquiry-based instruction is limited. Inadequate resources could hinder the implementation of inquiry-based instruction, as students may not have the necessary materials or equipment to conduct investigations or explore topics in depth. Tutors and colleges should consider investing in appropriate resources to support inquiry-based learning effectively.

The knowledge factor stands out suggesting that teachers' knowledge and expertise in the field of inquiry-based instruction greatly influence its implementation. This finding highlights the importance of professional development and continuous learning for teachers to enhance their understanding of inquiry-based strategies, teaching methods, and effective facilitation of student-centered learning experiences.

Strengthening teachers' knowledge in this area is crucial for successful implementation.

The topic factor implies that the specific subject matter or content being taught may have a minimal impact on the implementation of inquiry-based instruction. It suggests that inquiry-based approaches can be applied across various topics and subjects, and its effectiveness is not significantly dependent on the specific content being taught. This finding reinforces the idea that inquiry-based instruction is a flexible approach applicable to a wide range of subjects.

4.3.2.3 Teacher trainees Learning Chemistry by Inquiry in the Classroom

The findings indicate that all teacher trainees were able to effectively set tasks for learning chemistry through inquiry in the classroom. It suggests that they understand the importance of planning and organizing learning activities to promote inquiry-based learning. In addition, the fact that all teacher trainees participated in collaborative classroom activities is encouraging. Collaboration fosters active engagement, critical thinking, and problem-solving skills among trainees. It also suggests that the trainees value working together and understand the benefits of collaboration in the context of chemistry learning. Although a majority of teacher trainees engaged in discussing their inquiry findings with colleagues, there is room for improvement. Peer discussion and sharing of findings contribute to a deeper understanding of concepts and encourage reflection. Encouraging the remaining 20% to participate in such discussions could enhance their learning experience.

Self-assessment is a crucial skill for lifelong learning. The fact that all trainees self-assessed their learning indicates their awareness of the importance of reflecting on their progress and identifying areas for improvement. This practice can enhance metacognitive skills and empower trainees to take ownership of their learning. Internet-based research is a valuable skill in the modern age. The fact that all trainees conducted research using online resources suggests their ability to locate and utilize relevant information effectively. Integrating technology and digital literacy skills into chemistry learning prepares trainees to adapt to the evolving educational landscape.

Finally, field trips provide real-world experiences and help bridge the gap between theory and practice. This it indicates that some trainees may have missed out on this opportunity. Field trips can offer hands-on experiences, stimulate curiosity, and provide context to theoretical concepts. Encouraging more trainees to participate in field trips could enrich their learning experience.

4.3.3 Pedagogical Content Knowledge

Pedagogical Content Knowledge was the moderator variable for the study, and fourteen items were developed to measure this variable. Inquiries on this section were based on discussion in the literature review, and respondents were required to respond on a scale of 1 to 5 where 1 is very low and 5 is very high. Descriptive statistics on Pedagogical Content Knowledge are provided in Table 4.3.

Table 4.4 Descriptive Statistics – Pedagogical Content Knowledge of Tutors

Constructs	Min	Max	Mean	SD
How much can you do to motivate students who show low interest in school work?	2	5	4.22	1.279
How much can you do to get students to believe they can do well in school work?	2	5	4.76	1.133
How much can you do to help your students value learning?	2	5	4.16	1.066
To what extent can you craft good questions for your students?	1	5	4.39	1.652
How much can you use a variety of assessment strategies?	1	5	4.47	1.647
To what extent can you provide an alternative explanation for example when students are confused?	1	5	3.61	2.088
How well can you implement alternative strategies in your classroom?	2	5	4.43	1.332
How much can you do to control disruptive behaviour in the classroom?	1	5	4.10	1.427
How much can you do to get children to follow classroom rules?	1	5	3.89	1.020
How much can you do to calm a student who is disruptive or noisy?	2	5	4.31	0.978
How well can you establish a classroom management system with each group of students?	1	5	4.62	1.215
I have the qualities of a good teacher.	1	5	4.09	1.032
I am interested in teaching	1	5	4.22	1.074
Teaching (will allow) allows me to influence the next generation.	1	5	3.98	1.113
Total Score	1.36	5	4.23	1.12227

Source: Field study (2022)

Table 4.4 presents the descriptive statistics on pedagogical content knowledge. All constructs developed under this variable are positive implication of PCK and practice. As such, positive responses in this section indicate positive PCK and practice while negative responses imply negative PCK. With a mean of 4.23 and a standard deviation of 1.12, the study reveals high Pedagogical Content Knowledge among respondents.

4.3.4 Students' Performance

Students' Performance was the outcome variable for the study, and ten items were developed to measure students' performance. Here, the five main areas geared towards the betterment of students and teachers, as earlier stated in the literature review as the main matrix of evaluating tutors' performance developed by Pont et al., (2008), is used to measure students' performance. These areas are Improvement of the student's performance, monitoring of the students, betterment of the students and increase motivation to further improve performance. Descriptive statistics on tutors' performance are provided in Table 4.5

Table 4.5 Descriptive statistics – Tutors' measure on their Students' Performance

Constructs	Min	Max	Mean	SD
General Performance	1	5	4.63	1.186
Attentiveness	3	5	4.12	1.014
Improvement from previous year	3	5	4.18	0.91
Increase motivation	4	5	4.06	0.876
Increase self-respect and ambition	3	5	4.76	1.064
Confidence	1	5	3.21	1.242
Independence	1	5	3.49	1.351
Multiple skill acquisition	1	5	2.62	0.942
Higher order thinking skills	1	5	2.98	0.628
Social Interaction	1	5	3.28	1.212
Overall Score	3.71	5	3.62	0.86342

Source: Field study (2022)

Table 4.5 presents the descriptive statistics on Students' Performance. This section was met with mixed responses as the first 5 constructs recorded relatively high means. Physical well-being, multiple skill acquisition and High order thinking skills recorded low means, indicating flaws in these fields. A low mean in physical well-being could suggest that students' physical well-being, such as their health, fitness, or overall physical development, may be lacking. It could indicate a need for improvement in areas like physical education, sports, or health promotion within the educational setting. Also, a low mean in multiple skill acquisition suggests that students may not be acquiring or demonstrating a wide range of skills beyond the core academic subjects. It could indicate a potential gap in areas such as creativity, problem-solving, critical thinking, communication, teamwork, or other essential skills needed for holistic development. Again, a low mean in high order thinking indicates that students may struggle with advanced cognitive abilities such as critical thinking, analytical reasoning, synthesis, or evaluation. This finding suggests a need for enhancing higher-order thinking skills, which are crucial for academic success and real-world problem-solving.

4.4 Normality Test

The main variables' normality tests are displayed in Table 4.6. Generally, a variable is considered to be regularly distributed if $p > 0.05$ (Hazra & Gogtay, 2016). From the table, it can be seen that all of the variables produced by the Kolmogorov-Smirnov and Shapiro-Wilk tests have significance values (p) that are less than 0.05 ($p < 0.05$). This shows that the variables are not normally distributed.

Table 4.6 Test of Normality

Variables	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	p	Statistic	df	p
Inquiry-Based Instruction	.067	252	.000	.984	252	.000
Pedagogical Knowledge	.115	252	.000	.969	252	.000
Tutors' Performance	.070	252	.000	.986	252	.000

a. Lilliefors Significance Correction

Source: Field study (2022)

The Kolmogorov-Smirnov normality test is a statistical test used to determine if a given sample follows a normal distribution. In this case, the test was conducted on three variables: IBI (Inquiry-Based Instruction), Pedagogical Content Knowledge (PCK), and Students' Performance.

The statistics value (0.67) represents the maximum discrepancy between the empirical distribution of the sample and the expected normal distribution. In the case of IBI, this value indicates that there is a moderate discrepancy between the observed distribution and the expected normal distribution. The larger the statistics value, the greater the discrepancy. The degrees of freedom (df) value (97) represent the number of independent pieces of information used in the calculation of the test statistic. In this case, it suggests that the sample size for the IBI variable was 97. A variable with a low p-value ($p < 0.05$) in a normality test does suggest evidence against the null hypothesis of normality (Hazra & Gogtay, 2016). Therefore, it can be concluded that the IBI variable does follow a normal distribution.

The statistics value (0.115) for Pedagogical Knowledge represents a relatively smaller discrepancy between the observed distribution and the expected normal distribution compared to the IBI variable. It indicates a slight deviation from normality. The degrees of freedom (df) value (97) suggests that the sample size for the Pedagogical Knowledge variable was 97. The significance value (0.00) suggests that, the Pedagogical Knowledge variable follows a normal distribution.

The statistics value (0.070) for Students' Performance indicates an even smaller discrepancy between the observed distribution and the expected normal distribution compared to both IBI and Pedagogical Knowledge variables. It suggests that the Students' Performance variable is relatively closer to a normal distribution. The degrees of freedom (df) value (97) represent the sample size for the Students' Performance variable. The significance value (0.00) once again indicates strong evidence suggesting that the Students' Performance variable follows a normal distribution.

The results for the Shapiro-Wilk test on the three variables also follow a normal distribution. The results suggest that, the distribution of the IBI data is significantly in line with the normal. In other words, the data follows the normal pattern. Similarly, the Shapiro-Wilk test results indicate that, both the Pedagogical Knowledge and Students' Performance data significantly follow a normal distribution pattern ($p < 0.05$).

4.5 Exploratory Factor Analysis

All of the study's items were subjected to principal components analysis (PCA) for factor analysis using SPSS version 26. The adequacy of the data for factor analysis was evaluated prior to doing PCA. Bartlett's Test of Sphericity (Bartlett, 1954) achieved statistical significance (approximately: Chi-square= 15860.878, df. 496, p .000) because the Kaiser-Meyer-Olkin (KMO) value of 0.912 was above the advised base value of 0.6 (Kaiser, 1970). This suggests that the variables had a meaningful link and that factor analysis was necessary. The results of the KMO and

Bartlett's Test of the various constructs, as collected from the respondents, are shown in Table 4.7.

Table 4.7 KMO and Bartlett's Tests

KMO Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.912
Bartlett's Test of Sphericity	Approx. Chi-Square	15860.878
	Df	496
	Sig.	.000

Source: Field study (2022)

Based on the results provided from the Exponential Factor Analysis test that was conducted, here is a discussion of the outcomes.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy: The recorded value of 0.912 suggests that the dataset used in the analysis is suitable for factor analysis. Typically, a value above 0.6 is considered acceptable.

Bartlett's Test of Sphericity: The approximate chi-square value recorded as 15860.878 indicates that there is significant evidence to reject the null hypothesis that the correlation matrix is an identity matrix (indicating no underlying factors). In other words, the variables in the dataset are significantly correlated, making it appropriate to proceed with factor analysis.

Degrees of Freedom (df): The recorded value of 97 represents the number of variables or items being analysed in the factor analysis.

Significance: The recorded significance value of 0.00 indicates that the observed chi-square statistic is statistically significant. This suggests that there are underlying factors in the data and supports the decision to proceed with factor analysis.

4.6 Inferential Statistics

Correlation analysis, linear regression, and mediated regression are all covered in this section. The link between the variables was examined using the correlation analysis. The research's theories were put to the test using linear and mediated regression.

4.6.1 Correlation Analysis

The relationship between the IBI, Pedagogical Knowledge and Students' Performance is tested using Pearson's Correlation.

Table 4.8 Correlation Analysis

Correlations

		IBI	**PK**	**TP**
IBI	Pearson Correlation	1	.715**	.592**
	Sig. (2-tailed)		.000	.000
	N	97	97	97
PK	Pearson Correlation	.715**	1	.498**
	Sig. (2-tailed)	.000		.000
	N	97	97	97
TP	Pearson Correlation	.592**	.498**	1
	Sig. (2-tailed)	.000	.000	
	N	97	97	97

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field study (2022) Notes: Inquiry-Based Instruction (IBI); Pedagogical Knowledge (PK); Students' Performance (SP)

Table 4.8 presents the results of the Pearson correlation as follows:

IBI and Pedagogical Knowledge: The correlation coefficient of 0.715 suggests a strong positive relationship between IBI and Pedagogical Knowledge. This means that higher levels of Pedagogical Knowledge are associated with higher implementation of the IBI teaching method. The p-value of less than 0.01 indicates that this correlation is statistically significant, suggesting that it is unlikely to have occurred by chance.

IBI and Students' Performance: The correlation coefficient of 0.592 indicates a positive relationship between IBI and Students' performance. This suggests that higher levels of IBI implementation are associated with better academic performance among students. The p-value of less than 0.01 indicates that this correlation is statistically significant, further supporting the notion that the relationship is not due to chance.

Pedagogical Knowledge and Students' Performance: The correlation coefficient of 0.498 suggests a positive relationship between Pedagogical Knowledge and Students' performance. This means that higher levels of Pedagogical Knowledge are associated with better academic performance. The p-value of less than 0.01 indicates that this correlation is statistically significant, indicating that it is unlikely to have occurred by chance.

4.6.2 Regression Analysis

Hypotheses one and two of the study were tested in this section using linear regression and Hayes Process Macro regression to test the effects and of variables on each other.

4.6.2.1 Inquiry-Based Instruction and Students' Performance

The first hypothesis examines the relationship between the IBI and Students' Performance. The regression results for H1 are discussed below.

Table 4.9 Model Summary

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.592[a]	.526	.520	.65156

Source: Field study (2022)

According to Table 4.9, an R^2 of 0.526 indicates that IBI account for 52.6% of the variation in Students' Performance. Also, an adjusted R^2 of 0.520 indicates that IBI account for an additional 52% of the variation in students' performance.

Table 4.10 Analysis of Variance Between IBI and Students' Performance

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	35.635	1	35.635	71.086	.000[b]
	Residual	43.478	95	.516		
	Total	61.131	96			

Source: Field study (2022)

Table 4.10 shows that IBI could accurately explain the variation in students' performance considering $p < 0.01$. In other words, Table 4.10 highlights that the variations in students' performance are a direct result of the IBI.

Table 4.11 Coefficient of Variation

Coefficients[a]						
Model		**Unstandardised Coefficients**		**Standardised Coefficients**	**t**	**Sig.**
		β	**Std. Error**	**Beta**		
1	(Constant)	3.737	.473		8.310	.000
	IBI	.543	.080	.592[a]	8.836	.000

Source: Field study (2022)

According to Table 4.11, for every unit of IBI increase, there is a 0.543 increase in students' performance. The path coefficient results β =.543, t = 8.836, p < .01. lends significant support for H1, which states: *IBI has a positive relationship with Students' performance.*

4.6.2.2 The moderation analysis of Pedagogical Knowledge in the relationship between Inquiry-Based Instruction and students' performance (Research Question 4)

This hypothesis of the study was tested using the bootstrapping method suggested by Hayes (2009) moderation analysis (model 1) (Hayes 2009).

Table 4.12: The Relationship between IBI and Students' Performance

	Coeff	Se	T	P	LLCI	ULCI
Constant	2.3672	.0399	59.2821	.0000	2.2885	2.4458
IBI	1.2087	.0628	19.2405	.2158	1.0849	1.3324
PK	-.1715	.0347	-4.9421	.0000	-.2399	-.1032
Int_1	.1457	.0342	4.2622	.0026	.0784	.2130

Source: Field study (2022)

The results (β = 0.1457, p < 0.01), 95% CI (0.0784, .2130) of the table (4.12) show that Pedagogical Knowledge will moderate the relationship between IBI and students' performance, and the relationship is significant because the confidence interval contains no zero in the pair CI (0.0784, 0.2130). The value β = 0.1457 shows that a change of one unit in IBI will lead to a change of 0.1457 units in students' performance. Therefore, Hypothesis H2 is supported; *'Pedagogical knowledge will moderate the relationship between IBI and students' performance'*.

4.7 Discussion of Findings

Further discussion of findings in relation to the literature review is discussed in this section.

Research Question 1: To what extent do Chemistry Tutors Understand and Practice Inquiry-Based Instructional Approach?

The first research question sought to investigate how well the IBI Approach, the study's independent variable, is known and used. The degree of IBI is quantified as an independent variable, and its impact on other factors is investigated. A variable that is independent is precisely what it sounds like. It is a stand-alone variable that is unaffected by the other variables you are attempting to assess.

Fourteen questions were responsible for measuring IBI among the respondents. All of the constructs developed on this variable were met with positive response, recording a mean of 4.03 out of 5 thus emphasizing on the positivity of the response. Statistically, the figures are excellent but there is more to achieve if constructs that recorded low means are attended to. Walsh (2000) expanded on the significance of IBI by contrasting the standard of the educational opportunities provided to pupils in formal education setting in Northern Ireland and play-based education setting in Denmark. The study concentrated on nine essential quality indicators: drive, focus, independence, self-assurance, physical health, development of various talents, higher order cognitive abilities, social interaction, and respect. In contrast to the more inquiry-based approach that was able to offer the children in Denmark greater quality learning experiences, Walsh (2000) came to the conclusion that an overemphasis on the teaching of reading, writing, and math is inappropriate for young children in Northern Ireland.

IBI received favorable reviews from other authors in their studies. According to Siraj-Blatchford and Sylva (2004), high-quality staff interactions with children, an environment that provides books and written materials, and a place where kids could choose from a variety of learning activities were the aspects of pedagogy that included IBI that made a lasting contribution. They observed that IBI is crucial, and that the best preschool environments strike a balance between giving kids the chance to learn from teacher-initiated group work and offering them the chance to engage in freely chosen yet potentially educational play activities in terms of intellectual, social, and attitudinal outcomes.

Additionally, they contended that the finest teachers employ a variety of methods, including scaffolding, extending, discussing, monitoring, and direct instruction (under both IBI and Play-based approaches), to fit the concept or skill and the children's developmental stage. Effective teachers who can involve students in worthwhile activities both inside and outside of the classroom typically have a solid understanding of their subject, use pedagogical knowledge and skills appropriate for the subject, use an appropriate language of instruction and are fluent in that language, establish and maintain an effective learning environment, identify and address the needs and interests of their students and communities, and reflect on their own teaching and the responses of the students (Craig, Kraft, & Plessis, 1998).

Research findings for this variable are in line with findings made by the reviewed authors above, the importance of IBI with regard to students' performance will be discussed later in this section.

Research question 2: What is the Relationship between Inquiry-Based Instruction and Students' Performance?

Understanding the connection between IBI and students' performance was the goal of this segment. Hmelo-Silver, Duncan, & Chin (2007) used the following factors to analyze the performance of the sampled students, which were previously described in the literature. In a nutshell, a student's performance or improvement affects how well a tutor performs. The results of this field's research were related to IBI using linear regression. The findings showed that IBI and student performance have a positive and significant association, emphasizing that an increase in one of these two variables will lead to an increase in the other. Some researchers have argued that inquiry-based teaching is most effective when it involves higher levels of guidance (Hmelo-Silver, Duncan, & Chin, 2007), implying that positive outcomes of IBI are only achieved when a tutor performs his duty well in archiving positive students' outcomes.

Several authors have found a positive relationship between IBI and students' performance. Ronnebeck et al. (2016) highlighted two dimensions of inquiry in the literature: (1) tasks completed by students and, (2) level of guidance, to show how having guided inquiry is conceptually relevant. Therefore, guided inquiry keeps the focus on learning indirectly through student-led inquiries (the activities component), but it also improves the level of direction offered by the teacher (the guidance dimension). Even the original supporters of this methodology acknowledged that there might be variances in how much of the inquiry was guided, despite the fact that this plainly marks a change from pure inquiry-based teaching (Schwab, 1962).

The rationale for guided inquiry is derived from cognitive load theory (CLT) (Martin, 2016). According to CLT, students must organize new material in their working memory, however, working memory has a finite capacity, and if it becomes overloaded, learning would be hampered. Intrinsic load is the amount of cognitive strain that is inherent to the knowledge being learnt, and extraneous load is the amount of cognitive load that depends on the instructional strategies used to gain the knowledge (Sweller, Ayres, & Kalyuga, 2011). Therefore, guided inquiry seeks to minimize unnecessary load (Martin, 2016), either by imposing restrictions on the inquiry being done or by giving students cues and prompts to assist them in the inquiry process (De Jong & Lalonde, 2014). These results just present the correlation between IBI and students' achievement as measured by the output of instructors. The results of this study therefore agree with those of the aforementioned authors.

Research Question 3: What are the Factors Influencing the Implementation of Inquiry-Based Instruction among Chemistry Tutors in the Colleges of Education?

The study discovered that time, resources, and science topic or content are factors influencing the implementation of Inquiry-Based Instruction (IBI), and these align with existing literature in the field. Several studies have explored these factors and their impact on the successful adoption and implementation of IBI. Let's discuss each factor and its relationship to IBI implementation based on relevant empirical literature.

Time is often cited as a critical factor influencing the implementation of IBI. Teachers need sufficient time to plan, design, and facilitate inquiry-based activities effectively. Research has shown that time constraints can limit teachers' ability to fully engage students in the inquiry process, provide adequate feedback, and allow for in-depth exploration of scientific concepts (Chinn, 2011; Friedrichsen et al., 2016). When teachers feel rushed and constrained by time, they may resort to more traditional instructional methods, compromising the implementation of IBI. To address the time challenge, studies have suggested the need for extended instructional periods, dedicated time for collaborative planning among teachers, and flexible scheduling that allows for extended and uninterrupted inquiry experiences (Loucks-Horsley et al., 2010; Quigley et al., 2011). Additionally, providing teachers with support in lesson planning and curriculum design can help them allocate appropriate time for engaging inquiry activities (Windschitl et al., 2012).

The availability and accessibility of resources play a crucial role in implementing IBI effectively. Resources include laboratory equipment, materials, technology tools, and quality curricular resources that support inquiry-based learning experiences. Empirical studies have highlighted that limited access to resources can hinder teachers from implementing IBI in their classrooms (Windschitl et al., 2012; Friedrichsen et al., 2016). Insufficient resources can impede students' ability to engage in hands-on investigations, conduct experiments, and analyze data, which are fundamental aspects of IBI. Research emphasizes the importance of providing teachers with adequate resources, including funding for materials and access to well-equipped science laboratories, to enhance the implementation of IBI (Windschitl et al., 2012; Friedrichsen et al., 2016).

The nature of the science topic or content being taught can influence the implementation of IBI. Some topics may be inherently more conducive to inquiry-based approaches, while others may present challenges. Empirical studies have shown that teachers may be more hesitant to implement IBI in certain complex or abstract scientific concepts (Akerson et al., 2011; Friedrichsen et al., 2016). Difficult topics, such as molecular structures or abstract scientific theories, may require additional support, scaffolding, or alternative instructional strategies to effectively engage students in inquiry. Research suggests the importance of providing teachers with targeted professional development and resources specifically designed to address the challenges associated with teaching specific science topics (Windschitl et al., 2012; Friedrichsen et al., 2016).

Research question 4: How does Tutors' PCK and Practice Moderate the Relationship between Inquiry-Based Instruction and Students' Performance in Chemistry?

The bootstrapping method proposed by Hayes (2009) for moderation analysis was used to assess the moderating influence of PCK on the relationship between the independent and dependent variables (model 1). The findings demonstrate that PCK has a favorable moderating influence on IBI and student performance. According to studies, PK is a foundation for carrying out an IBI properly (Horvathova, 2010; Salama, 2010). To be effective in a certain field of jurisdiction, it is only logical to understand the wide base of a concept. IBI is a subfield of PCK, and as such, in order to fully comprehend and practice IBI, one must be well-versed in PCK (Horvathova, 2016). As stated in previous sections, IBI positively correlates with students' performance, implying that an IBI incident has an effect on students' performance. If IBI is negative, students' performance will be negative; if it is positive, students' performance will be positive. The findings of this study appear to be a carbon replica of the findings of these researchers.

CHAPTER FIVE

SUMMARY FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Overview

This part of the research focuses heavily on the study's important findings based on the research's main purpose. The study also discovered the key results and offers critical recommendations for enhancing student performance using Inquiry-Based Instruction. The first chapter contains an introduction to the study, followed by a review of the literature and discussions in chapter two, which formed the basis for the analysis and interpretation of the research findings. The suitable approaches used to address the study's objectives were outlined in Chapter three. Chapter four provided an overall picture of the data presented, while Chapter five provided a discussion of the findings. Finally, chapter five drew the research to a close by delivering a vivid summary that fulfilled the research's aims and objectives.

5.2 Summary of Findings

The key findings from the study are summarized in this section.

5.2.1 The understanding and practice of Inquiry-Based Instruction Approach

The study revealed that all 14 constructs of the understanding and practice of IBI approach which were provided in the study questionnaire were affirmed by respondents as most attained responses higher than average, 3.0.

Respondents' feedback on the most understood aspect of IBI: In order of importance, the most understood and practiced aspects of IBI include:

- High understanding of inquiry as a motivation to learning;

- High understanding of the 5E inquiry-based instructional model;
- High understanding of Social Learning;
- High training at Universities, Workshops and PD Sessions; and,
- High understanding of inquiry in the context of scientific method of learning.

However, constructs which inquired on the sufficiency technologies and equipment as well as accommodation of IBI in the study syllabus due to timeframe is a drawback to the practice of IBI.

5.2.2 Inquiry-Based Instruction and Students' Performance

The findings of the study revealed a positive and significant relationship between IBI and Students' performance through results from linear regression with coefficient results $\beta = .543$, $t = 8.836$, $p < .01$.

5.2.3 Moderating Role of Pedagogical Knowledge

The findings of the study suggest that PCK significantly moderates the relationship between IBI and Students' Performance($p < 0.05$). This finding was derived from Hayes moderation analysis and produced the following figures; ($\beta = .1457$, $p < 0.01$), 95% CI (.0784, .2130) indicating a significant moderator role by PCK.

5.3 Conclusion

In conclusion, this thesis aimed to investigate the effects of tutor knowledge and practice of inquiry-based instruction on teacher trainees' chemistry performance at the Colleges of Education. Through the analysis of the research questions, several important findings emerged.

Firstly, the study explored the extent to which chemistry tutors understand and practice inquiry-based instructional approaches. The results revealed that tutors have a high level of understanding and practice in various aspects of inquiry-based instruction, such as inquiry as a motivation to learning, the 5E inquiry-based instructional model, social learning, and the scientific method of learning.

Secondly, the relationship between inquiry-based instruction and students' performance was examined. The findings indicated a positive and significant relationship between inquiry-based instruction and students' performance. The results from the linear regression analysis demonstrated a strong association between IBI and improved student performance.

Thirdly, the factors influencing the implementation of inquiry-based instruction among chemistry tutors in the colleges of education were investigated. The study identified time, resources, and science topic or content as significant factors influencing the successful implementation of IBI. Limited time availability, inadequate resources, and challenges associated with specific science topics were found to impede the effective adoption of inquiry-based instruction.

Lastly, the study explored how tutors' pedagogical content knowledge (PCK) and practice moderate the relationship between inquiry-based instruction and students' performance in chemistry. The findings indicated that PCK plays a significant moderating role in this relationship. The analysis using Hayes moderation analysis showed that PCK significantly influences the relationship between IBI and students' performance, emphasizing the importance of tutors' pedagogical content knowledge in facilitating successful implementation and positive outcomes of inquiry-based instruction.

5.4 Recommendations

First, the study revealed strong understanding and practice of IBI and a strong relationship between IBI and Students' performance but a shortfall was discovered in the availability of modern equipment to foster IBI approach. It is recommended that, the college of education should channel more attention to improving all aspects of IBI, most especially real-life simulators. This initiative will improve on the IBI approach and foster students' performance.

Again, the current findings should be considered by colleges of education to review the study syllabus and practices, especially for science-based subjects, in such a way that, ample time be allocated these subjects in order to accommodate effective implementation and practice of IBI. Classes hours can either be extended, vacation weeks shortened or some public holidays ignored to facilitate quality education through IBI.

Also, the study discovered a significant moderator role of Pedagogical Knowledge in the relationship between IBI and Students' Performance. It is further recommended that, tutors of colleges of education take tutor knowledge very high in order to adequately carryout IBI and consequently achieve student performance.

5.5 Suggestions for Further Studies

Future studies are encouraged to develop a research model that considers the broad concept of Pedagogical Knowledge across various teaching approaches. Furthermore, future studies are also encouraged to consider a large sample size in relation to the topic.

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APPENDIX A

This survey is part of a graduate student's M.Phil. in Science Education research at the University of Education, Winneba on the topic: ***EFFECTS OF INQUIRY- BASED TUTOR PEDAGOGICAL CONTENT KNOWLEDGE AND PRACTICE ON STUDENTS' CHEMISTRY PERFORMANCE IN NORTHERN COLLEGES OF EDUCATION.*** It consists mostly of tick-the-box questions which will take between 10 and 15min. to fill in. Your views and responses which will contribute valuable insights into the field of inquiry-based learning pedagogy would remain entirely anonymous, and will only be used for the purpose it is been collected. Thanks for being part of this noble academic exercise.

Likert Scale: 1 = Very Low, 2 = Low, 3 = Moderate, 4 = High, 5 = Very High

INQUIRY-BASED INSTRUCTION

		ITEM	RESPONSE SCALE				
			1	**2**	**3**	**4**	**5**
Tutor Knowledge about Inquiry-Based Learning (TK).	TK_1	My experience in inquiry pedagogy is ……..					
	TK_2	IBL training I got at University, Workshops and PD Sessions is …..					
	TK_3	My understanding of the constructivist theory is ….					
	TK_4	My ability to conceive inquiry in the context of constructivism is.....					
	TK_5	My understanding of Social Learning is …….					
	TK_6	My understanding of contextual learning is ……….					
	TK_7	My understanding of hands-on learning is …..					
	TK_8	My understanding of inquiry as a motivation to learning is …..					
	TK_9	My understanding of inquiry in the context of scientific method of learning is ……					
	TK_{10}	My ability to conceive inquiry in the context of discovery method of learning is …….					
	TK_{11}	My understanding of the various contexts of inquiry learning is …..					
	TK_{12}	My understanding of the 5E inquiry-based instructional model is					
	TK_{13}	My appreciation of the challenges affecting chemistry teachers' practice of IBI is ……					

	TK_{14}	My appreciation of IBL as a Pedagogical Approach in the classroom is ………					
	TK_{15}	My students' involvement anytime I teach by inquiry is ……					
	IP_1	My students' collaboration in inquiry-group discussions in class is ……					
	IP_2	My students' engagement in individual inquiries is …..					
	IP_3	My students' engagement in play-based learning is …..					
	IP_4	The rate at which my students conduct internet-based research is ……					
	IP_5	The rate at which my students take part in field trips is ……					
	IP_6	The rate at which my students conduct interviews is …..					
Inquiry-Based Practice in the Classroom (IP).	IP_7	The rate at which my students lead in questioning is ………					
	IP_8	My students' engagement in open-ended exploration is ………					
	IP_9	The rate at which my students carry out laboratory-based experiment is ……					
	IP_{10}	The rate at which my students determine activities of the class is …….					
	IP_{11}	The rate at which my students are able to connect their inquiries to real-life context is ……….					
	IP_{12}	The rate at which my students present inquiry findings to colleagues is ……					
	IP_{13}	My students' reflection on their inquiry journeys is ……					
	IP_{14}	The opportunity for students to self-assess their inquiry learning is ……					
	IP_{15}	The opportunity for students to peer-assess their inquiry learning is …….					

APPENDIX B

PEDAGOGICAL CONTENT KNOWLEDGE

ITEM	RESPONSE SCALE				
	1	2	3	4	5
How much can you do to motivate students who show low interest in school work?					
How much can you do to get students to believe they can do well in school work?					
How much can you do to help your students value learning?					
To what extent can you craft good questions for your students?					
How much can you use a variety of assessment strategies?					
To what extent can you provide an alternative explanation or example when students are confused?					
How well can you implement alternative strategies in your classroom?					
How much can you do to control disruptive behaviour in the classroom?					
How much can you do to get children to follow classroom rules?					
How much can you do to calm a student who is disruptive or noisy?					
How well can you establish a classroom management system with each group of students?					
I have the qualities of a good teacher.					
I am interested in teaching					
Teaching (will allow) allows me to influence the next generation.					
How much can you do to motivate students who show low interest in school work?					
How much can you do to get students to believe they can do well in school work?					
How much can you do to help your students value learning?					
To what extent can you craft good questions for your students?					
How much can you use a variety of assessment strategies?					

To what extent can you provide an alternative explanation or example when students are confused?					
How well can you implement alternative strategies in your classroom?					
How much can you do to control disruptive behaviour in the classroom?					
How much can you do to get children to follow classroom rules?					
How much can you do to calm a student who is disruptive or noisy?					
How well can you establish a classroom management system with each group of students?					
I have the qualities of a good teacher.					
I am interested in teaching					
Teaching (will allow) allows me to influence the next generation.					
How much can you do to motivate students who show low interest in school work?					

APPENDIX C

STUDENTS' PERFORMANCE

ITEM	RESPONSE SCALE				
	1	**2**	**3**	**4**	**5**
General Performance					
Attentiveness					
Improvement from previous year					
Increase motivation					
Increase self-respect and ambition					
Confidence					
Independence					
Physical well-being					
Multiple skill acquisition					
Higher order thinking skills					
Social Interaction					