UNIVERSITY OF CAPE COAST

EXTENT OF IMPLEMENTATION AND CHALLENGES OF INQUIRY-BASED SCIENCE TEACHING AND LEARNING IN JUNIOR HIGH SCHOOLS IN FOUR GHANAIAN DISTRICTS AND MUNICIPALITIES

BY

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DECLARATION

Candidate's Declaration

I declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: .... Date: 19/09/2018

Name: Salifu Maigari Mohammed

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature: .... Date: 21/09/2018

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ABSTRACT

This study sought to investigate extent of implementation of inquiry-based science teaching and learning in junior high schools and some challenges confronting it. I employed multistage sampling procedure to select 503 students, 308 science teachers, 12 head teachers, four circuit supervisors, three science coordinators, three deputy directors and a director of education from four districts and municipalities in central region of Ghana. I employed the concurrent triangulation mixed methods design, involving surveys and case studies. I used questionnaires, structured observation and semi-structured interview schedules for data collection. Validity, reliability, credibility, and dependability of the instruments were adequate for research. The quantitative data analyses involved calculation of means, standard deviations, frequencies, percentages, factor analyses, Cronbach alphas, ANOVAs, MANOVAs and Two-way MANOVA; while the qualitative data analyses involved thematic analysis. Findings show that there was rare implementation of inquiry-based science teaching and learning in the JHSs. Again, interaction of school location and school type significantly influenced implementation of inquiry teaching and learning in the JHSs. Challenges to implementation of inquiry teaching in the JHSs include teachers' and educational administrators' inadequate conceptions of inquiry; and teachers' low attitudes and weak beliefs and self-efficacy toward inquiry teaching. It is recommended that pre-service and in-service teacher education should emphasize engagement of teachers in inquiry investigations to explicitly promote their conceptions, attitudes, beliefs, and self-efficacy in alignment with the constructivist philosophy of science and science teaching.

KEY WORDS

Attitudes toward science teaching

Beliefs about science teaching

Conceptions of inquiry

English language learners

Inquiry-based science teaching and learning

Self-efficacy toward science teaching

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DEDICATION

To the memory of my late parents, Mallam Mohammed Maigari and Fati Ali Achemfo; my daughter, Fati Mohammed Maigari Salifu; and my wife, Humu-Kulsum Abubakar.

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CHAPTER ONE

INTRODUCTION

Background to the Study

Most people know that Science, Technology, Engineering, and Mathematics (STEM) are important for development of any nation (Anamuah-Mensah, 2012; Anderson, 2006; Asabere-Ameyaw, Dei, & Raheem, 2012; Jegede, 1993; Shumba, 1999; Spencer & Walker, 2011). Therefore, any country that wants to develop and improve the living conditions of its people must take development of STEM seriously. Development of strong foundation in science occurs in junior high school where most students in their formative years come into contact with science. Sufficient exposure of students in their formative years to scientific experiences equips them with knowledge, process skills, and attitudes to become scientific literates (e.g., Garcia, 2003; Kazempour, 2014a). Additionally, sufficient exposure of students to scientific experiences is critical in their later development and progress in science.

Unfortunately, decades of science education has not produced desired scientific literacy in most African countries, including Ghana (Anamuah-Mensah, 2012; Shumba, 1999). African countries continue to struggle with problems of environmental degradation, illegal mining, deforestation, water pollution, waste disposal, flooding, preventable diseases, insufficient food production, and post-harvest losses (Anderson, 2006); and inability to process agricultural products and mineral resources, and industrialize.

The low scientific literacy in Africa is partly due to strong influence of deep-rooted socio-cultural and religious factors on science education (Eminah, 2004; Jegede, 1993; Shumba, 1999). As a result, African students attend science classes with prior knowledge from their cultural beliefs and customs which are at variance with science concepts and principles (e.g., Asabere-Ameyaw et al., 2012; Jegede, 1993; Shumba, 1999). This makes African students combine ideas from their religious beliefs, cultural traditions, and scientific knowledge to interpret natural phenomena during lessons (e.g., Eminah, 2004; Shumba, 1999). For example, most Ghanaian university science students Eminah (2004) studied attributed the causes of HIV/AIDS to supernatural reasons including witchcraft; breaking of taboos; invocation of curses; activities of demons, wizards, and gods; and punishment from God. Most of the students expressed spiritual and supernatural views of HIV/AIDS, showing how strongly they have been influenced by socio-cultural and religious beliefs of their tribal areas. These deep-rooted socio-cultural and religious influences make it difficult for African students to readily apply scientific facts and principles in solving problems in their day-to-day real-life experiences (e.g., Eminah, 2004; Jegede, 1993; Shumba, 1999).

Some researchers argue that Africans have their own cosmological, spiritual, and traditional worldview for explaining natural phenomena, which is distinct from western science (e.g., Asabere-Ameyaw et al., 2012; Jegede, 1993; Shumba, 1999). These researchers agree that it is acceptable for African students to use traditional worldview and superstition to interpret natural phenomena. However, these researchers agree also that science education is important for development of African countries. Therefore, they advocate for mutual coexistence of traditional African and scientific worldviews.

The difficulty for African students to readily apply scientific concepts and principles in solving problems is compounded by predominant use of traditional teaching methods in schools. These methods rely on transmission, rote memorization, and recall of scientific facts and procedures (Anamuah-Mensah, 2012; Asabere-Ameyaw et al., 2012; Jegede, 1993). Jegede (1993) points out that traditional instruction is prevalent in African schools because it is consistent with authoritarianism associated with African culture and customs. Authoritarianism is the traditional belief where older persons are regarded as more knowledgeable and experienced than young individuals. Therefore, young individuals in African societies are expected to accept the views of older persons without questioning. It is frowned upon for young individuals in African societies to question the views of older people. As noted by Jegede, this traditional view gets transferred into classrooms where teachers are seen as authorities in scientific knowledge who transmit the knowledge to students who are expected to accept, memorize, and recall it without questioning. Indeed, past studies in Ghana showed that integrated science teachers relied heavily on traditional teaching methods in basic schools (e.g., Ampiah, 2008).

Unfortunately, traditional instruction is less effective in promoting students' appreciation of relevance of science education and its connections in their everyday real-life experiences; and less effective in developing students' scientific and technological literacy (Chang & Mao, 1999; Simsek & Kabapinar, 2010; Wolf & Fraser, 2008). Again, traditional instruction is less effective in developing students' critical thinking and creativity to investigate and find solutions to problems.

Consequently, most researchers, curriculum developers, and educators advocate for more meaningful science education in Africa through the use of scientific inquiry; indigenous science education; and Science, Technology, and Society (STS) education (Anamuah-Mensah, 2012; Asabere-Ameyaw et al., 2012; Curriculum Research and Development Division [CRDD], 2012; Jegede, 1993). Teaching and learning of science in African schools should emanate from and relate to the natural environment (Jegede, 1993) for it to be meaningful and relevant to students. In view of the benefits of inquiry-based teaching and learning, the current rationale for basic science education in Ghana emphasise the need for all junior high school (JHS) students to be actively engaged in inquiry process (CRDD, 2012, p. iii). A major aim of basic science education in Ghana is to prepare JHS students to develop problem solving skills by engaging in investigations that physically explore natural phenomena in their environments.

Inquiry-based science teaching and learning engages students in real world investigations into problems and phenomena emanating from their experiences. This is the approach being emphasized by contemporary science education reform movements and major policy organizations in many parts of the world (e.g., Anderson, 2002; Chang & Mao, 1999; Chen, 2008; NRC, 1996, 2000, 2012; Sahin, Isiksal, & Ertepinar, 2010; Temiz & Topcu, 2014). Currently, most industrialised and industrialising countries employ inquiry approach as the central strategy to promote students' scientific literacy and technological development. The rationale for inquiry-based teaching and learning is that students learn science effectively when they engage in thinking processes and activities of scientists (Furtak, Seidel, Iverson, & Briggs, 2012; Krajcik, Blumenfeld, Marx, & Soloway, 1994; NRC, 1996, 2000, 2012).

Most empirical evidence show that inquiry-based teaching and learning significantly improves students' conceptual achievements (e.g., Furtak et al., 2012), science process skills (Lati, Supasorn, & Promarak, 2012; Simsek & Kabapinar, 2010; Ornstein, 2006), and attitudes toward science (Akcay & Yager, 2010; Chang & Mao, 1999; Ornstein, 2006); and promotes favourable learning environments (Gillies, 2008; Wolf & Fraser, 2008) and remedy students' misconceptions in science (Simsek & Kabapinar, 2010). Only a few studies reported no significant differences in conceptual achievements (e.g., Akcay & Yager, 2010; Wolf & Fraser, 2008) and attitudes toward science (Simsek & Kabapinar, 2010; Wolf & Fraser, 2008) between students taught using inquiry-based and traditional science instructions.

Despite the reported benefits of inquiry-based science teaching, many pre-service and in-service teachers find it difficult to employ it in their lessons (e.g., Crawford, 2007; Marx et al., 1994; Toolin, 2004). Teachers implementing and those attempting to implement inquiry teaching encounter numerous challenges. Anderson (1996, 2002) categorised the challenges into barriers and dilemmas, and subcategorised them into cultural, technical, and political dimensions. Cultural dilemmas emanate from internal values, beliefs, and dispositions of teachers. They are the most difficult challenges because of their resistance to change. Cultural dilemmas of inquiry teaching include teachers' beliefs (e.g., Abelson, 1979; Crawford, 2007; Mansour, 2009; Pajares, 1992; Pomeroy, 1993; Sampson, Grooms, & Enderle, 2013), self-efficacy (e.g., Bandura, 1977, 1994; Bleicher, 2004; Lardy & Mason, 2011; Riggs & Enochs, 1989; Sahin et al., 2010; Dira-Smolleck, Zembal-Saul, & Yoder, 2006), and attitudes (e.g., Van Aalderen-Smeets & Walma van der Molen, 2013; Kumar & Morris, 2005; Werner, 1996). Pre-service and in-service teachers' willingness to adopt and their effectiveness in implementing inquiry teaching depend on extent to which they hold strong favourable beliefs, self-efficacy, and attitudes toward inquiry teaching.

Technical barriers and dilemmas of inquiry teaching include knowledge and skills teachers require to implement this instructional approach (e.g., Abd-El-Khalick, 2012; Abd-El-Khalick, Bell, & Lederman, 1998; Abell & Smith, 1994; Anderson, 1996, 2002). Thus, teachers' conception and skills in orchestrating inquiry teaching determine their willingness to adopt and effectiveness in implementing this instructional approach (e.g. Blumenfeld et al., 1994; Crawford, 2007; Krajcik et al., 1994; Toolin, 2004; Twigg, 2010).

Political barriers of inquiry teaching involve issues of power, authority, collaboration, and resources (Anderson, 1996, 2002; Grigg et al, 2013; Twigg, 2010). Inquiry teaching flourishes in schools where culture of inquiry exists with support from school administrators, science coordinators, and parents. Inquiry teaching occurs also in schools where there are sufficient teacher collaborations and resources (e.g., Anderson, 1996; Krajcik et al., 1994; Twigg, 2010). In contrast, it is difficult for inquiry teaching to occur in schools where culture of inquiry has not been established, where school authorities and parents do not provide adequate support for science teachers (e.g. Crawford, 2007).

Besides, contextual factors strongly influence effects of barriers and dilemmas confronting teachers in inquiry teaching. Thus, contextual factors strongly influence the formation and development of teachers' conceptions, attitudes, beliefs, and self-efficacy toward inquiry teaching. Consequently, complete understanding of challenges confronting teachers in inquiry-based science teaching can only be achieved by considering the interactions between various elements within a given context (Anderson, 1996, 2002; Toolin, 2004).

Statement of the Problem

While the current rationale for basic science education in Ghana is to actively engage all students in inquiry process (CRDD, 2007, 2012), the existing literature shows little evidence of extent of implementation of inquiry-based science teaching and learning in Ghanaian JHSs.

Again, while a number of research approaches and theoretical frameworks have been used in the past to study science teaching and learning in Ghanaian JHSs (Ampiah, 2006, 2008; Anderson, 2006; Ngman-Wara, 2015; Opoku-Asare, 2004; Osei, 2003; Somuah & Mensah, 2013), there is little evidence in the existing literature of a study that employed an inquiry-based conceptual framework to examine science teaching and learning in Ghanaian JHSs.

While most inquiry-based science teaching and learning studies and meta-analyses have been conducted in the industrialised and industrialising countries (e.g., Anderson, 1996, 2002; Chang & Mao, 1999; Furtak et al., 2012; Gillies, 2008; Lati et al., 2012; Sahin et al., 2010; Smith et al., 2007), the literature shows little evidence of such studies in the Ghanaian (African) context.

Again, while most inquiry-based science teaching and learning studies involved participants and schools in urban centres (e.g., Gillies, 2008; Sahin et al., 2010; Simsek & Kabapinar, 2010; Wolf & Fraser, 2008), the literature provides little evidence of such studies involving schools and participants in rural areas.

While teachers' conceptions, attitudes, beliefs, and self-efficacy toward inquiry teaching strongly influence their decisions and effectiveness in using this instructional approach, the literature shows little evidence of a study that examined Ghanaian JHS teachers conceptions, attitudes, beliefs, and self-efficacy toward inquiry-based science teaching. Similarly, while educational administrators' (head teachers, circuit supervisors, science coordinators, and directors) conceptions of inquiry determine their effectiveness in supervising inquiry teaching and learning in schools, there is little evidence in the literature of a study that examined Ghanaian educational administrators' conceptions of inquiry. These are gaps in research that this study sought to fill.

While most past studies into science inquiry teaching and learning, and teachers' conceptions, attitudes, beliefs, and self-efficacy employed either qualitative (e.g., Abell & Smith, 1994; Abd-El-Khalick et al., 1998; Aguirre, Haggerty, & Linder, 1990; Anderson, 1996; Blumenfeld et al., 1994; Crawford, 2000, 2007; Haefner & Zembal-Saul, 2004; Krajcik et al., 1994; Marx et al., 1994; Oppong-Nuako et al., 2015; Toolin, 2004; Twigg, 2010) or quantitative (e.g., Akcay & Yager, 2010; Arigbabu & Oludipe, 2010; Chang & Mao, 1999; Lucero et al., 2013; Minger & Simpson, 2006; Ornstein, 2006; Riggs & Enochs, 1989; Sampson & Benton, 2006; Sampson, Grooms, & Enderle, 2013; Smith et al., 2007; Van Aalderen-Smeets & Walma van der Molen, 2013) methods, few studies employed mixed methods approaches. Qualitative results alone are insufficient in revealing prevalence (breadth) of inquiry teaching and learning in schools and barriers and dilemmas associated with it. Similarly, quantitative results alone are inadequate in explaining and providing in-depth understanding of issues about inquiry-based science teaching and learning in schools. Therefore, this study employed mixed methods design that combines strengths of both quantitative and qualitative data in a single study (Creswell & Plano-Clark, 2007).

Purpose of the Study

The purpose of this study was to investigate extent of implementation of inquiry-based science teaching and learning in JHSs in four Ghanaian districts and municipalities. The study also investigated extent to which teachers' and educational administrators' conceptions of inquiry, and teachers' attitudes, beliefs, and self-efficacy pose challenges to inquiry-based science teaching in JHSs. The study further investigated extent to which differences in attitudes, beliefs, and self-efficacy of teachers and teacher characteristics pose challenges to inquiry teaching in JHSs. Specific aspects of inquiry teaching and learning examined are the procedural, epistemic, conceptual, social, and guidance domains. Additionally, specific conceptions of inquiry examined are scientific inquiry, inquiry teaching, and inquiry learning.

Research Questions

I used the following questions to guide the study:

1. What is the extent of implementation of inquiry-based science teaching and learning in JHSs in four Ghanaian districts and municipalities?

2. What is the interaction of school location (urban and rural) and school type (public and private) on implementation of inquiry-based science teaching and learning in JHSs in four Ghanaian districts and municipalities?

3. To what extent do teachers' and educational administrators' conceptions of inquiry, and teachers' attitudes, beliefs, and self-efficacy pose challenges to

inquiry-based science teaching in JHSs?

4. To what extent do differences in attitudes, beliefs, and self-efficacy of teachers and teacher characteristics (i.e. school type, school location, gender, and academic qualification) pose challenges to inquiry-based science teaching in JHSs?

Significance of the Study

Findings from this research are intended to add to knowledge (literature) on inquiry-based science teaching and learning; and advocate for the proper use of inquiry teaching and learning in Ghanaian JHSs in order to make science more meaningful to students. Findings from this study are also meant to contribute to the debate on relevance of science education in African countries, including Ghana. This study is also intended to inform and inspire other researchers in Africa to direct their studies toward inquiry-based teaching and learning, in order to expand frontiers of inquiry-based research. Additionally, findings from this study are intended to inform and motivate policy makers, curriculum developers, and science educators to re-examine science education in Ghana and adapt best practices of inquiry teaching and learning from other contexts. It is further hoped that findings from this study will inform school administrators and teachers to establish culture of inquiry teaching and learning in their schools and classrooms to improve students' achievements, process skills, and attitudes toward science.

Delimitations

While there are several features of inquiry-based science teaching and learning (e.g., Crawford, 2000; Grigg et al., 2013; Marx et al., 1996; NRC, 1996, 2000, 2012; Oppong-Nuako et al., 2015; Toolin, 2004), I delimited this study to extent of implementation of the procedural, epistemic, conceptual, social, and guidance aspects (Furtak et al., 2012) in JHSs. Also, while there are many challenges (barriers and dilemmas) to implementation of inquiry-based science teaching (e.g., Anderson, 1996, 2002; Crawford, 2007; Marx et al., 1996; Toolin, 2004), I delimited this study to challenges posed by teachers' and educational administrators' conceptions of inquiry, and teachers' attitudes, beliefs, and self-efficacy toward inquiry teaching.

Moreover, while there are 20 districts and municipalities in central region of Ghana, I delimited this study to two rural districts, one urban and one urban-rural municipalities in the region. This is due to financial and time constraints and volume of work involved in this study. Since schools, teachers, students, and educational administrators in the four districts and municipalities share similar characteristics as those in the remaining districts, results and findings from this study are good representations of extent of implementation of inquiry-based science teaching and learning in the region. Again, results and findings from this study are good representations of attitudes, beliefs, and self-efficacy of science teachers in the region. Findings from this study are also good representations of conceptions of scientific inquiry, and inquiry teaching and learning held by teachers and educational administrators in the region.

I also delimited this study to JHS 2 students and observations of science lessons in JHS 2 classrooms. I did not involve students in JHS 1 and 3 and did not observe science lessons in JHS 1 and 3 classrooms. I sampled JHS 2 students because of assumption that they have had considerable exposure to integrated science lessons at the JHS level, and were in good position to know and accurately report teaching and learning strategies used for science lessons. Again, since JHS 2 students were not preparing for external examinations, it is assumed that integrated science lessons in their classes involve the normal day-to-day teaching and learning strategies.

Furthermore, I delimited this study to participants directly connected with science education in JHSs (students, science teachers, head teachers, circuit supervisors, science coordinators, deputy directors and directors of education). I did not involve parents, district assemblies, educational associations (e.g., NAGRAT and GNAT) and other stakeholders in science education.

Limitations

Due to the inability to examine all features of inquiry teaching and learning (e.g., Crawford, 2000; Marx et al., 1996; NRC, 1996, 2000, 2012; Oppong-Nuako et al., 2015), there may be certain elements of inquiry being implemented in JHSs in the selected districts and municipalities which are not captured in this study. However, given the number of activities constituting each aspect of inquiry investigated (Furtak et al., 2012), this study is a good representation of how to examine inquiry teaching and learning in JHSs. Additionally, due to the inability to investigate all political, technical, and cultural barriers and dilemmas to inquiry teaching (e.g., Anderson, 1996, 2002; Crawford, 2007; Toolin, 2004), there may be certain challenges to inquiry teaching in JHSs in the selected districts and municipalities which are not captured in this study. However, given the fact that teachers' conceptions, attitudes, beliefs, and self-efficacy are internal attributes that pose difficult and resistant challenges to inquiry teaching (e.g. Anderson, 1996, 2002; Pajares, 1992), findings from this study are good representation of challenges that impede implementation of inquiry-based science teaching in the JHSs.

Some JHSs, especially those in remote communities, were inaccessible due to bad or lack of roads. This prevented me from collecting data from such schools. Data from such remote and deprived schools could have enriched results and findings of this study. However, given the large samples of teachers and students selected, and various categories of schools (urban, rural, public, and private) selected for case studies, results and findings from this study are good representation of extent of implementation of inquiry teaching and learning in the selected districts and municipalities. Again, due to interruptions from extra curricula activities (e.g., sports, games, and founders' day celebrations) some teachers could not enact some lessons for observations. Consequently, the observed lessons in some schools were fewer than in schools where there were no such interruptions. A more equitable comparison of lessons across schools could have been done if I had equal number of lesson observations in each school.

Additionally, due to nationwide strike actions by teachers for better conditions of service, there were interruptions in the academic calendar which delayed the data collection considerably and affected early completion of the study. Again, the inability of some students, especially rural and public school students, to read and understand English, might have affected their responses to the questionnaire items. However, I minimized these concerns by reading and translating the items into the students' local language.

Also, due to transfers and conference meetings outside the districts, some directors of education were not available for interviewing. Data from such high-placed educational authorities could have enriched results and findings from this study.

Moreover, due to difficulties in getting assistance for the lesson observations, inter-rater reliability could not be calculated. Estimation of inter-rater reliability could have helped established reliability of the lesson observations. However, consistencies in responses across the questionnaires, interviews, and lesson observations indicate that the lesson observations were valid and reliable.

Organisation of the Study

This thesis consists of five chapters. Chapter one dealt with introduction of the study; which include background to the study, statement of the problem, purpose of the study, research questions, significance of the study, delimitations and limitations of the study. The relevant literature reviewed and conceptual framework for the study are presented in chapter two. The methodology employed for this study is discussed in Chapter three. It consists of the research design; population; sample and sampling procedure; instruments; validity, reliability, credibility, and dependability of the instruments; data collection procedure; and data analyses. The results, findings, and discussion are presented in chapter four. Finally, chapter five presents summary, conclusions, and recommendations of the study; and significant contributions to knowledge and suggestions for further study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The relevant literature reviewed and conceptual framework for this study is presented in this chapter. The literature reviewed is organized under the following sub-headings: Importance of science and scientific literacy; socio-cultural influence on science education; traditional science teaching and learning; inquiry-based science teaching and learning; science instruction for English language learners (ELLs); and effectiveness of inquiry-based science teaching and learning. The literature reviewed also include challenges of inquiry-based science teaching; teachers' and educational administrators' conceptions of the nature of science (NOS), scientific inquiry, and inquiry teaching and learning; teachers' attitudes toward inquiry-based science teaching; teachers' beliefs about inquiry-based science teaching; and teachers' self-efficacy toward inquiry-based science teaching. This chapter ends with conceptual framework for the study.

Importance of Science and Scientific Literacy

Most researchers, educators, curriculum developers, policy makers, teachers, and parents know that Science, Technology, Engineering, and Mathematics (STEM) are important for development of any nation (e.g., Anamuah-Mensah, 2012; Anderson, 2006; Asabere-Ameyaw et al., 2012; Jegede, 1993; Shumba, 1999; Spencer & Walker, 2011). The benefits of science and technology include better medical care, efficient communication services, improved food production and preservation, and faster means of transportation. Therefore, study of science must be taken serious by any country that wants to develop and improve the living standards of its people.

While science and technology has largely improved quality of human life, it has also produced some detrimental effects including ecological imbalances, pollution, global warming, and depletion of natural resources and the ozone layer (Shumba, 1999).

However, due to the overall importance of science for national and economic development, both developed and developing countries, including African countries, have pursued and devoted huge and scarce resources for science education, with the ultimate goal of producing scientifically literate citizens (e.g., Grigg et al., 2013; Jegede, 1993; Shumba, 1999).

Whilst the science education literature contains many definitions of scientific literacy, the NRC (1996) defines it as "knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (p. 22). The NRC goes further to state that a scientifically literate person can ask scientifically-oriented questions about everyday experiences; has ability to describe, explain, and predict natural phenomena; has ability to read articles about science with understanding; has ability to engage in conversation about validity of scientific conclusions; and has ability to identify scientific issues underlying national and local decisions and to express scientifically and technologically informed positions. Again, a scientifically literate person has ability to evaluate quality of scientific information based on the source and methods of its generation; and has ability to initiate and evaluate arguments based on evidence and apply appropriate conclusions from such arguments. The NRC's definition of scientific literacy is consistent with inquiry-based teaching and learning practices. This suggests that students are more likely to develop scientific literacy if they are sufficiently exposed to inquiry-based teaching and learning practices.

Most researchers acknowledge that individuals hold different levels of scientific literacy (e.g., Bybee, 1995, 2008; Koballa et al., 1997; NRC, 1996). Individuals with high levels of scientific literacy exhibit more understandings and abilities to function scientifically, while those with low levels exhibit poor understandings and abilities. The scientific literacy exhibited by an individual grows and deepens over his/her lifetime. However, scientific attitudes and values that learners develop in their formative years influence development of their scientific literacy later in life (NRC, 2000). Therefore, it is important to expose students in their formative years to sufficient and meaningful science experiences that relate to everyday activities in their lives.

The ultimate goal of science education is to equip students with relevant knowledge and skills to exhibit adequate scientific literacy in their day-to-day real-life experiences (e.g., Asabere-Ameyaw et al., 2012; Koballa et al., 1997; NRC, 1996; Shumba, 1999). This is what is expected of students after they have completed science courses required for graduation from high school. Surprisingly, Koballa et al. (1997) have noted that many students in industrialised countries do not exhibit the level of scientific literacy required of them, even though industrialised countries have well established scientific and technological culture. This problem is even worse in Africa and other non-western developing countries. After decades of science education, it is expected that significant number of people in Africa would demonstrate adequate scientific literacy in their everyday life experiences and show concern for their environment. In contrast, African countries continue to grapple with problems of environmental degradation, illegal mining, deforestation, waste disposal, water pollution, flooding, preventable diseases, insufficient food production, post-harvest loses and many more (e.g., Anderson, 2006). Decades of science education has not produced desired scientific literacy in most African countries, including Ghana. The inability of African and other non-Western students to exhibit adequate scientific literacy shows that there are certain difficulties and problems that students encounter in learning science. These problems and difficulties are from multiple sources including socio-cultural environments of the learners.

Socio-cultural Influence on Science Education

Cobern and Aikenhead (1998) assert that in addition to psychological and sociological perspectives, cultural anthropological perspective can provide new understanding of problems and difficulties students encounter in learning science. This view is shared by most researchers into socio-cultural aspect of science education (e.g., Anamuah-Mensah, 2012; Asabere-Ameyaw et al., 2012; Eminah, 2004; Jegede, 1993; Shumba, 1999).

Most researchers agree that scientific rationality is rooted in Western culture (e.g., Asabere-Ameyaw et al., 2012; Cobern & Aikenhead, 1998; Shumba, 1999). Scientific rationality is mechanistic, instrumental, and objective (Asabere-Ameyaw et al., 2012; Jegede, 1993; Shumba, 1999). It is materialistic, individualistic, rejects self-reflection and values consideration, and depends on cause and effect (Shumba, 1999). Science is based on observations and physical experiences (Asabere-Ameyaw et al., 2012; Shumba, 1999), is logical (Asabere-Ameyaw et al., 2012), and is driven by hypotheses testing (Asabere-Ameyaw et al., 2012; Jegede, 1993; Shumba, 1999). Western science is exact; seeks to derive empirical laws, principles, generalisations, and develop theories; and is a public property (Jegede, 1993). Additionally, western scientific knowledge is dynamic, progressive, and tends to have rival competing theories (Shumba, 1999).

In contrast, traditional Africa and other non-Western worldviews are based on spirituality and supernatural forces. Spirituality influences the organization and function of culture in traditional societies, and people's ways of life and history can be understood through their spirituality (e.g., Asabere-Ameyaw et al., 2012; Cobern & Aikenhead, 1998). Indigenous people interpret daily experiences through their spirituality (Asabere-Ameyaw et al., 2012); their everyday activities and social behaviour are guided and regulated by anthropomorphic view of nature (Jegede, 1993) and ancestral system of thought and beliefs (Asabere-Ameyaw et al., 2012). However, the African traditional reasoning process, and gods, spirits, and ancestors used for explaining phenomena are not subject to experimentation (Shumba, 1999).

While some researchers (e.g., Asabere-Ameyaw et al., 2012; Jegede, 1993) acknowledge that Africa and other non-Western societies have their own indigenous science, there is no doubt that significant differences exist between Western scientific and traditional African worldviews. The implication of this is that "... socio-cultural characteristics which children bring into the class from their environment ... create a wedge between what they are taught and what they learn" (Jegede, Fraser, & Okebukola, 1994, p. 139). The strong socio-cultural influences make African students attend science classrooms with prior knowledge that are incompatible with science concepts and principles. This makes them combine ideas from their religious beliefs, cultural traditions, and scientific knowledge to interpret natural phenomena during science lessons.

This is evident in a study by Eminah (2004) who found that most Ghanaian university science students attributed causes of HIV/AIDS to activities of witches, wizards, gods, demons, Satan, breaking of taboos, invocation of curses, and punishment from God. The university students expressed beliefs in supernatural causes of HIV/AIDS, showing how strongly they have been influenced by traditional and religious beliefs of their communities and tribal areas. The fact that university science students viewed HIV/AIDS as a spiritual disease shows how deep traditional conceptions have permeated African societies (Eminah, 2004).

Again, the result of socio-cultural influence is that African students have less positive attitudes toward science (e.g., Eminah, 2004; Shumba, 1999), and are unable to readily apply scientific principles they learn to solve problems in their day-to-day real life experiences. Instead, African students learn science facts, procedures, and techniques necessary to pass examinations after which they resort to their traditional customs and beliefs to solve problems.

In a series of studies to examine socio-cultural influences on science education, Jegede (1993) and his colleagues identified authoritarianism, goal structure, traditional worldview, societal expectation, and sacredness of science as major factors that affect African students' science learning. Authoritarianism is the phenomenon where traditional societies regard older persons as having better abilities to evaluate and correctly judge a given situation or problem, because they have been exposed to more life experiences. Therefore, it is unacceptable for the views of older persons to be challenged or questioned in traditional societies. This makes older persons exercise authority in making decisions for young individuals who are expected to accept the decisions without questioning. This phenomenon gets transferred into classrooms in Africa, where teachers are seen as elders who are more knowledgeable to transmit scientific facts, concepts, and principles for students to receive without questioning (Jegede, 1993; Jegede et al., 1994).

Traditional worldview refers to indigenous beliefs and superstitions used as conceptual models to explain natural phenomena. Supernatural forces are believed to play significant roles in everyday occurrences in traditional societies. Young individuals in these societies are expected to learn and believe these worldviews without questioning. Problems arise when the worldviews students bring into classrooms conflict with what they are taught in science lessons (Jegede, 1993; Jegede et al., 1994).

Sacredness of science is the notion held within traditional societies that science is a special discipline which requires some unusual explanations that are beyond the thinking of persons from non-western societies.

Most researchers agree that the dissonance between Western science and indigenous beliefs, which unable local students to understand and show interest in science, raises the need for new ways of teaching science to local students (Anamuah-Mensah, 2012; Asabere-Ameyaw et al., 2012; Cobern & Aikenhead, 1998; Eminah, 2004; Jegede, 1993; Shumba, 1999). Culturally sensitive instructional approaches and curricula that have been suggested for science education in Africa include the border crossing theory (Cobern & Aikenhead, 1998), collateral learning theory (Jegede as cited in Fakudze, 2004), contiguity learning theory (Ogunniyi as cited in Fakudze, 2004), conceptual eco-cultural paradigm (Jegede, 1993), Science Technology and Society [STS] (Jegede, 1993), Cognitive Border Crossing Learning Model [CBCLM] (Fakudze, 2004), and socio-cultural teaching and learning model (Jegede et al., 1994). Most of these approaches emphasise integration of indigenous knowledge and science in a curriculum or instruction (Eminah, 2004, Jegede, 1993; Jegede et al., 1994; Shumba, 1999).

While empirical evidence show that socio-cultural teaching approaches are promising in improving local students' achievements and attitudes toward science (Fakudze, 2004; Jegede et al., 1994), the existing literature does not show widespread usage of these approaches for science learning in African schools. Jegede (1993) suggests that success of STS in many parts of the world makes it an appropriate and widely applicable teaching approach for African schools. The researcher believes that the holistic and problem-solving approach of STS, which enables students to think critically across disciplines about important science, technology, and society issues, makes it suitable to resolve problems about teaching that cannot be solved with mainstream science pedagogies. The researcher acknowledges further that STS connects science students learn in schools to everyday experiences in their lives and addresses students' apparent lack in science process skills.

Likewise, success of inquiry-based approach in many parts of the world makes it a useful alternative for science instruction in Africa and other non-Western developing countries. This view is shared by many researchers (e.g., Ampiah, 2008) who assert that the current constructivist approach of teaching and learning is very suitable for students to develop positive attitudes and process skills through hands-on and minds-on activities. This approach emphasizes contextualisation of science teaching and learning within the local physical environment and is consistent with socio-cultural approaches that have been advanced for science learning of local students.

Traditional Science Teaching and Learning

Traditional science teaching and learning has been the popular approach in Africa and other non-Western developing countries for decades. Most researchers agree that traditional science teaching involves abstract transmission of facts and principles from teachers to students (e.g., Ampiah, 2008; Anderson, 2002; Asabere-Ameyaw et al., 2012; Grigg et al., 2013; Jegede, 1993; Shumba, 1999). It emphasises what students should know rather than how they should know and why they should believe what they know about the natural world (Duschl, 2008). Most traditional instruction occur through carefully designed lectures (Ampiah, 2008; Furtak et al., 2012; Marx et al., 1994; Oppong-Nuako et al., 2015; Toolin, 2004), chalk and talk method (Ampiah, 2008), question and answer sessions (Ampiah, 2008), textbook reading (e.g., Ampiah, 2008; Anderson, 2002; Asabere-Ameyaw et al., 2012; Crawford, 2000), and giving of notes to students (Ampiah, 2008; Oppong-Nuako et al., 2015; Toolin, 2004).

Traditional instruction does not encourage students to ask meaningful authentic questions related to everyday experiences in their lives. Instead, the teacher asks most questions for students to provide responses, after which the teacher provides feedback as to whether the responses are correct or wrong (Ampiah, 2008). Besides, most of the questions are directed toward a few students who are capable of answering them (Ampiah, 2008; Marx et al., 1994). Most students, who are incapable of answering the questions, are left out of the classroom interactions (Ampiah, 2008). Additionally, traditional science instruction involves giving of exercises, assignments, and homework (e.g., Crawford, 2000; Toolin, 2004) and regular testing to determine what students have learnt and understood, and provide feedback on students' strengths and weaknesses (Ampiah, 2008).

Traditional science teaching is a teacher-centred approach (e.g., Anderson, 2002; Marx et al., 1994; Spencer & Walker, 2011; Toolin, 2004); with the sole aim of achieving stated goals (Ampiah, 2008; Marx et al., 1994) within the time allocated for instruction (Ampiah, 2008). This form of instruction seeks to cover broad curriculum content in order to prepare students for and achieve high pass rate in external examinations and tests (Ampiah, 2008; Marx et al., 1994; Toolin, 2004).

Due to the transmission of knowledge associated with traditional instruction, students' learning largely involves reception, memorization, and recall of scientific knowledge (Anderson, 2002; Grigg et al., 2013; Jegede, 1993; Shumba, 1999), and copying of notes written on chalkboard or dictated by the teacher (e.g., Ampiah, 2008). Students' participation in lessons mainly involves answering questions related to science concepts posed by the teacher (Ampiah, 2008; Crawford, 1999). In such situations, few students who are capable of answering questions enjoy better interactions with the teacher. They dominate classroom activities and receive more attention, praise, and constructive feedbacks (Ampiah, 2008). Majority of the students, who are incapable of answering questions, feel that all the answers are in the textbook or have already been provided, so there is nothing more to contribute (Marx et al., 1994). They accept and agree with whatever the most brilliant or outspoken students contribute. In situations where students only respond to questions posed by the teacher, followed by the teacher's evaluation of students' responses, the students' cognitive development is low (Crawford, 1999). Such uncontextualised knowledge sharing about science concepts lead students to provide passive responses (Crawford, 1999).

Hands-on activities that learners experience in traditional science teaching are experiments with predetermined activities, in which questions and procedures to be followed are provided by the teacher, and learners are expected to obtain the same answers (e.g., Alesandrini & Larson, 2002; Crawford, 2000; Garcia, 2003; Marx et al., 1994; Oppong-Nuako et al., 2015; Wolf & Fraser, 2008). Key concepts and principles in the activities are explained to students before they perform the tasks (Ampiah, 2008). Students in a group are assigned roles to perform; they are given detailed directions to follow; and they follow the procedures to carry out the experiments correctly (Marx et al., 1994). In such activities, there is limited movement in class, students listen quietly as the teacher comments on data, identify trends in data, and illustrate trends with information from different areas (Marx et al., 1994). Traditional experiments are designed to verify science concepts, principles, laws, and theories already taught by the teacher in class (e.g., Crawford, 2000; Duschl, 2008; Furtak et al., 2012; Garcia, 2003; Grigg et al., 2013). The sole aim of engaging in these laboratory activities is to enhance students' understanding of science content (Ampiah, 2008; Duschl, 2008) and solve problems in preparation for getting good grades in external examinations (Crawford, 1999; Toolin, 2004).

Traditional hands-on science fails to connect series of activities in the curriculum and link them to relevant meaningful contexts or development of conceptual knowledge (Crawford, 1999, 2000; Duschl, 2008; Krajcik et al., 1998). Additionally, traditional hands-on science lacks dialogic process of knowledge building, which requires students to gather and use evidence and principles to generate explanations and predictions of the natural world (Duschl, 2008). It does not encourage students to derive their own hypotheses and draw conclusions about phenomena (Garcia, 2003); and it does not allow students to discuss purpose of activities, reasons for a procedure, and meaning of data (Marx et al., 1994).

Traditional science teaching and learning is not effective in developing students' higher-order skills such as critical thinking, creativity, innovation, problem-solving, and personal knowledge construction (e.g., Ampiah, 2006, 2008; Crawford, 1999; Duschl, 2008; Jegede, 1993). It does not emanate from or relate to learners' socio-cultural environment, and it fails to consider or explain everyday experiences in learners' world (Jegede, 1993). This form of instruction is not challenging enough and it renders science less meaningful and relevant to students (Ampiah, 2008). Unfortunately, traditional instruction has been the focus of science education in most African countries for decades (Ampiah, 2006; Asabere-Ameyaw et al., 2012; Jegede, 1993; Shumba, 1999).

Inquiry-based Science Teaching and Learning

Contemporary perspectives of science curricula, teaching, and learning, emphasise engagement of learners in inquiry into the natural world. Three major and distinct but related definitions of inquiry frequently used in the science education literature are scientific inquiry, inquiry learning, and inquiry teaching (Anderson, 2002; Furtak et al., 2012). "Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (NRC, 1996, p. 23). This definition shows understanding of processes of science but does not reveal any connection of scientific inquiry to educational processes. However, inquiry learning "refers to the activities of students in which they develop knowledge and understanding of how scientists study the natural world" (NRC, 1996, p. 23). By engaging in inquiry learning students practice the thinking processes and activities of actual scientists and demonstrate understanding of the nature of science. Therefore, inquiry learning reflects the nature of and is related to scientific inquiry (Anderson, 2002). On the hand, inquiry teaching demands teachers to explicitly emphasise scientific inquiry as key content being taught and learning required of students (Anderson, 2002). Therefore, teachers need to understand science as inquiry and learning as inquiry before they can successfully enact this instruction.

While definitions of scientific inquiry and inquiry learning are unambiguous, most researchers agree that inquiry teaching has various names and meaning in the science education literature (Anderson, 2002; Crawford, 2007; Furtak et al., 2012). Consequently, teachers are left to form their own images of inquiry teaching, which results in varied enactments of the instruction (Anderson, 2002; Crawford, 2007; Furtak et al., 2012). However, explicit and detailed description of features of inquiry teaching is helpful in communicating its meaning to teachers who are willing to adopt and practice it, and help researchers in judging extent of implementation of inquiry in classrooms (e.g., Anderson, 2002; Crawford, 2000; Furtak et al., 2012).

Several models, approaches, and descriptions of inquiry teaching and learning have been provided by researchers (e.g., Akcay & Yager, 2010; Blumenfeld et al., 1994; Crawford, 2000; Crawford et al., 1999; Ladewski, Krajcik, & Harvey, 1994; Krajcik et al., 1994; Krajcik et al., 1998; NRC, 1996, 2000, 2012; Marx et al., 1994). One of the most comprehensive and detailed model is provided by Furtak et al. (2012). Furtak et al.'s model consists of two dimensions and five domains. The dimensions are cognitive and social activities of students and guidance provided to students by their teachers, peers, or curriculum materials; while the domains are procedural, epistemic, conceptual, social, and guidance aspects of inquiry. One advantage of this model is that it provides a range of activities within each domain, which allows variations or nuances in each domain to be identified.

The procedural domain involves methods or heuristics of discovery (Furtak et al., 2012). This involves tasks requiring students to ask authentic questions that are feasible, worthwhile, contextualised, and meaningful to drive investigations (e.g., Blumenfeld et al., 1994; Crawford et al., 1999; Krajcik et al., 1994; Ladewski et al., 1994; Marx et al., 1999; NRC, 1996). Authentic driving questions focus on real-world problems similar to that of scientists and related to students' lives, and contain valuable science content. Authentic driving questions are open-ended and give students space to develop strategies for addressing them. They can emanate from students, teachers, or curriculum developers (Krajcik et al., 1994). For instance, the driving question may require students to investigate PH of rain water in their locality. This may lead students to explore concepts of acids, bases, PH, and concentration; and involve students in planning and conducting investigations to measure acidity of rain water and effects of rain water on living and non-living things (Marx et al., 1994). Crawford (2000) found that the authentic nature and unknown outcomes of inquiry motivate students to take ownership of their learning.

The procedural domain also involves students planning and designing science investigations (Anderson, 2002; Furtak et al., 2012; Krajcik et al., 1994; Krajcik et al., 1998; NRC, 1996). This further involves students determining and selecting procedures they will follow; explaining and discussing rationale for their procedures, and variables to control and manipulate (Marx et al., 1994). Planning procedures also involves students generating and revising sub questions from the driving question, and predicting how variables would influence each other (Krajcik et al., 1998). The procedural domain further involves students executing their planned procedures, during which they make measurements, observations, and take notes; and use tools to gather data (Furtak et al., 2012; Krajcik et al., 1994; Krajcik et al., 1998; NRC, 1996).

Data collection includes groups of students going to parks to observe and record various species of flora and fauna; devising means to test PH of solutions, and gathering information from organisations like EPA, wildlife department, and meteorological department (Marx et al., 1994); and going on field trips to rivers, streams, and forests to collect samples of organisms like fishes and praying mantis (Crawford, 2000; Marx et al., 1994).

The epistemic domain involves students knowing how scientific knowledge is produced (Furtak et al., 2012). This further involves students using evidence and data from their investigations to produce scientific knowledge. It also involves students examining and evaluating the quality of data (Duschl, 2008; Furtak et al., 2012; NRC, 1996). Examining the quality of data involves students identifying inconsistencies and anomalies in the data, pointing out lack of precaution that may have resulted in data contamination, and suggesting procedures for resolving inconsistencies in the data (Crawford, 2000). Resolution of inconsistencies and anomalies in data include collection of additional or multiple replications of samples to improve reliability of the data (Crawford, 2000; NRC, 1996).

The epistemic domain also involves students analysing data to identify patterns and generate models (Duschl, 2008; Krajcik et al., 1994); which may involve using computers to draw charts and graphs (Krajcik et al., 1998; Marx et al., 1994), drawing inferences and conclusions, and making predictions and generalisations (Krajcik et al., 1994; Krajcik et al., 1998; NRC, 1996). Students then employ the patterns and models (Duschl, 2008), and inferences and conclusions to interpret/explain scientific phenomena (Anderson, 2002; Duschl, 2008; Furtak et al., 2012; Ladewski et al., 1994) and generate knowledge (NRC, 1996). Students may also apply information from previous investigations and discussions to interpret data in explaining and predicting science phenomena (Marx et al., 1994).

The epistemic domain further involves students learning that their processes of doing science is similar to the way actual scientists work, and learning that scientific knowledge is tentative and subject to change based on new evidence or new interpretation of old evidence (Furtak et al., 2012).

The conceptual domain involves facts, theories, and principles of science. It consists of science as a body of knowledge (Furtak et al., 2012). This involves students learning and applying science concepts and principles in investigations to build artefacts that represent their evolving understanding or explanation of scientific phenomena (Blumenfeld et al., 1994; Krajcik et al., 1994; Krajcik et al., 1998; Marx et al., 1994; NRC, 1996) and solutions to problems (Krajcik et al. 1994). It also involves students drawing on their prior knowledge (Furtak et al., 2012) and looking for information from books, internet, and other sources (Crawford, 2000; Marx et al., 1994; NRC, 1996) to formulate hypotheses, and construct and check reliability of their explanations. In constructing and checking reliability of their explanations students could search for information they have learned from previous investigations; identify various assumptions; use logical and critical thinking; and consider alternative explanations (NRC, 1996). The conceptual domain further involves students learning concepts and principles embedded in contextualised processes of science (Furtak et al., 2012; Krajcik et al., 1994; Krajcik et al., 1998).

The social domain involves students learning collaborative and communicative processes employed in constructing scientific knowledge (Duschl, 2008; Furtak et al., 2012; Krajcik et al., 1994). This entails students making their ideas public through arguments, presentations, and modelling; which helps students to examine and evaluate their evolving understanding of science (Crawford et al., 1999; Duschl, 2008; Furtak et al., 2012). The collaborative and communicative process engages students in group or whole class discussions, to reason together, take collective decisions, and share ideas (Crawford et al., 1999; Furtak et al., 2012; Krajcik et al., 1998; NRC, 1996). The collaborative and communicative process also engages students and teachers with community members, during which experts critique and contribute to students' investigations (Blumenfeld et al., 1994; Krajcik et al., 1994; Krajcik et al., 1998; Ladewski et al., 1994; Marx et al., 1994).

Group and whole class collaborative and communicative presentations occur before investigations, during which students present their initial driving questions, experimental designs and plans, and receive feedback from the teacher and class (Duschl, 2008; Krajcik et al., 1998; NRC, 1996). After investigations students present and describe their data, conceptual models, evidence (Duschl, 2008), findings, and conclusions (Krajcik et al., 1998) to the class. After that the teacher and other students raise questions about the presentations, demand clarifications and explanations, and offer suggestions to improve findings and conclusions of the investigations (Krajcik et al., 1998).

The guidance domain involves continuous exchange of responsibility for learning between the teacher and students (Crawford, 2000; Furtak et al., 2012). There are varying degrees of teacher guidance and involvement in science instruction, with certain things left open for students to define and others provided by the teacher or curriculum materials. The varying levels of teacher guidance and involvement results in different types of inquiry including open inquiry (e.g., Crawford, 2000; Furtak et al., 2012; Oppong-Nuako et al., 2015), teacher-guided inquiry (Crawford, 2000; Furtak et al., 2012; Jeanpierre, 2006; Oppong-Nuako et al., 2015), structured inquiry (Oppong-Nuako et al., 2015), confirmatory inquiry (Oppong-Nuako et al., 2015), full inquiry (Jeanpierre, 2006), partial inquiry (Jeanpierre, 2006), and simple inquiry (Jeanpierre, 2006).

While open inquiry (discovery learning) involves students taking full responsibility for their own learning with minimal guidance from and involvement of the teacher, guided inquiry involves students conducting their own investigations with the teacher acting as a resource person. Similarly, while partial inquiry entails students designing and conducting investigations that enable them to develop abilities and understandings in selected aspects of scientific inquiry, full inquiry entails students designing and conducting investigations that enable them to develop understandings and abilities of most aspects of scientific inquiry. Again, while structured inquiry involves students constructing explanations and understandings for teacher generated questions and procedures, simple inquiry involves students' investigations that proceed linearly without any hitches. Confirmatory inquiry, on the other hand, is the traditional laboratory experiment that involves students in following teacher-designed procedures to verify scientific facts and principles already taught in class. Although open inquiry is the highest level of inquiry (Oppong-Nuako et al., 2015) empirical evidence show that guided inquiry improves students' science learning the most (e.g., Grigg et al., 2013; Furtak et al., 2012). While simple inquiry is appropriately used as a preliminary to full inquiry, simple and partial inquiry are also appropriate for teachers beginning to learn inquiry teaching (Jeanpierre, 2006).

Inquiry-based instruction involves teachers creating environments in which they collaborate with students as active learners (Crawford, 2000; Marx et al., 1994; NRC, 1996). It also involves teachers pondering and selecting initial driving questions and gathering resources necessary to orchestrate the instruction (Blumenfeld et al., 1994; Crawford, 2000; Krajcik et al., 1994; Marx et al., 1994). Inquiry instruction also involves teachers focusing on real-world phenomena related to students' experiences in classroom, outdoors, or in the laboratory (NRC, 1996). It further involves teachers mentoring and guiding students to plan and design investigations, and data collection procedures (Crawford, 2000; NRC, 1996) that are within students' abilities (NRC, 1996). It involves teachers using presentations to provide feedback to students about feasibility and adequacy of students' investigation plans (Krajcik et al., 1998).

Teachers engaged in inquiry instruction offer notebook keeping suggestions for students to learn how to conduct careful, complete, and record observations accurately (Krajcik et al., 1998); they immerse themselves in the field with students to collect samples (Crawford, 2000; Marx et al., 1994); they model for students how to systematically examine and evaluate data quality, and how to analyse and interpret data to develop explanations for scientific phenomena (e.g., Crawford, 2000; Krajcik et al., 1998). Teachers in inquiry instruction pose questions and initiate discussions to elicit students' ideas on lack of precaution that might have led to data contamination. They lead students to figure out and discuss anomalies and inconsistencies in data through identification of extremely high and low data points (Crawford, 2000). They lead students to resolve anomalies and inconsistencies by collecting additional and multiple samples. They guide students to draw graphs and charts (e.g., Crawford, 2000; Marx et al., 1994), identify patterns, draw inferences and conclusions, and apply information from previous investigations and discussions to interpret data (e.g., Crawford, 2000).

Teachers in inquiry instruction promote collaboration, communication, and ensure that all students participate in investigations (Marx et a., 1994; NRC, 1996). They encourage students to share ideas (NRC, 1996); they promote responsibility for students' own learning by listening and soliciting students' ideas, and remain open to new ideas (Crawford, 2000; NRC, 1996); they decide when and why to use whole class and small group interactions and individual work (NRC, 1996); they support written and oral discourse to focus students' attention on how they know what they know and its connection to other ideas; and they hold frequent conversations and give suggestions to students at different stages of investigations (Krajcik et al.. 1998). Teachers delicately balance the provision of explicit guidelines while avoiding too much direction (Crawford et al., 1999; NRC, 1996).

While domains and features of inquiry provided in the literature serve to describe and clarify the meaning of inquiry teaching and learning, they are dependent on each other such that orchestration of activities in one domain results in orchestration of activities in other domains (e.g., Blumenfeld et al., 1994; Duschl, 2008; Furtak et al., 2012; Krajcik et al., 1994; Marx et al., 1994). Inquiry teaching and learning requires teachers and students to assume multiple, complex, and changing roles as the task at hand changes (e.g., Crawford et al., 1999; Crawford, 2000).

Empirical evidence show that most industrialised and industrialising countries have made significant progress in implementing inquiry teaching and learning in their schools. For example, most features of inquiry (84%-100%) were successfully implemented in most classrooms Oppong-Nuako et al. (2015) studied in USA and Canada. Similarly, a significant number of teachers Jeanpierre (2006) studied in USA implemented guided inquiry in their lessons, in which they facilitated student-centred learning experiences, allowed students to formulate their own hypotheses and interpret data, and fostered students' investigations and data analyses. Currently, there are classrooms and schools in industrialised and industrialising countries where inquiry teaching and learning is the norm (Anderson, 2002), and where experienced teachers in inquiry instruction can be found (Crawford et al., 1999; Crawford, 2000). Similarly, there are students in industrialised and industrialising countries who are experienced in inquiry learning and capable of taking responsibility for their own learning (e.g., Crawford, 2000).

Empirical evidence from industrialised and industrialising countries show also that it is possible for teachers who have been using traditional teaching methods to change and adopt inquiry approaches when they are given necessary support (e.g. Blumenfeld et al., 1994; Marx et al., 1994; Toolin, 2004). Likewise, students who are new to inquiry learning are capable of engaging in real-world inquiry experiences and sophisticated thinking (Krajcik et al., 1998; Crawford et al., 1999). Therefore, it is possible to implement inquiry-based science teaching and learning in African schools if the culture of inquiry is established.

However, it must be pointed out that novice students engaged in inquiry learning do encounter certain challenges (Krajcik et al., 1998).

Science Instruction for English Language Learners

English language learners (ELLs) are students learning English as a new language (Lee & Buxton, 2008; Lee & Fradd, 1998). They are students with many different home or local languages (Lee & Fradd, 1998), Non English Language Backgrounds [NELB] (Lee & Fradd, 1998), and Limited English Proficiency [LEP] (Lee, 2005). ELLs need to develop English proficiency in addition to general literacy skills before they participate effectively in mainstream science lessons. While English language learners are minority students in countries like USA (e.g., Lee, 2005; Lee & Buxton, 2008, 2011; Lee & Fradd, 1998; Stoddart, Pinal, Latzke, & Canaday, 2002; Stoddart, Solis, Tolbert, & Bravo, 2010), nearly all junior high school students in Ghana, as in most African countries, are English language or second language learners. Therefore, provision of science education for ELLs or second language learners pose greater challenges for African countries than countries like USA. Unless science learning problems arising from African students' lack of English proficiency is resolved, most JHS students in Africa would not achieve expected outcomes of science education.

Researchers have noted that due to limited English proficiency of ELLs in USA their science achievements persistently fall behind those of native English-speaking student (Lee, 2005; Lee & Buxton, 2011; Stoddart et al., 2002; Stoddart et al., 2010). Researchers agree also that the traditional approach of presenting science content to ELLs with expectation that they will learn and understand is a major contributing factor to underrepresentation and alienation of ELLs in science in USA (e.g., Lee & Fradd, 1998; Stoddart et al., 2002). However, this situation is worse with African students, who persistently perform poorly in international assessments such as TIMSS (e.g. Gonzales, Williams, Jocelyn, Roey, Kastberg, & Brenwald, 2008); and are woefully alienated and underrepresented in science. The traditional approach separates acquisition of English proficiency from science content knowledge, because it is expected that ELLs will master English language as a prerequisite for science instruction (Stoddart et al., 2002). This is problematic because it may take long time for ELLs to develop English proficiency comparable to their native English-speaking peers (Stoddart et al., 2002). In fact, most JHS students in Africa may never attain English proficiency comparable to that of native English-speaking students.

Researchers admit that science has its own linguistic register or norms and patterns of communication (e.g., Lee & Fradd, 1998; Stoddart et al. 2002; Stoddart et al., 2010). This linguistic register uses language functions including hypothesizing, describing, classifying, inferring, interpreting, predicting, and generalizing (Stoddart et al., 2002; Stoddart et al., 2010). These language functions are fundamental and necessary in scientific inquiry. Developing English proficiency require ELLs to learn to speak, read, and write in a second language, and learn vocabulary, syntax, and lexical grammar, and use the language in both social and academic discourse (Stoddart et al., 2002; Stoddart et al., 2010). Similarly, developing scientific literacy require ELLs to acquire ability to read, write, speak, listen, observe, predict, analyse, summarize, and communicate in forms such as oral, written, tabular, graphic, and drawn (Lee & Fradd, 1998).

Code-switching of students' home language and English (e.g., Ampiah, 2008; Launio, 2015; Lee, 2005; NRC, 1996; Pollard, 2002) in the context of inquiry teaching and learning (e.g., Stoddart et al., 2002; Stoddart et al., 2010; Cuevas, Lee, Hart, & Deaktor, 2005) is an approach that can be employed to resolve linguistic processes involved in science teaching and learning of ELLs.

Since development and use of scientific linguistic register is similar to processes in inquiry-based science learning, inquiry science provides real-world contexts for ELLs to use and develop language functions like describing, classifying, hypothesizing, explaining, inferring, predicting, generalizing, reasoning, and reflecting (Lee & Buxton, 2008; Stoddart et al., 2002; Stoddart et al., 2010). Inquiry-based science provides ELLs with meaningful contexts to learn English structure and functions, and English processes provide ELLs with medium to analyse and communicate science content (Stoddart et al., 2002; Stoddart et al., 2010). Science inquiry teaching engages ELLs in investigations of phenomena during which language activities are explicitly connected to objects, hands-on experimentation, processes, and natural events in the environment. As a result, ELLs engage in authentic communicative interactions requiring them to describe, hypothesize, justify, argue, and summarize to foster purposeful language (Stoddart et al., 2002; Stoddart et al., 2010). Contextualised use of English in inquiry-based science promotes ELLs understanding of concepts because it structures how scientific concepts are developed, organized, and communicated (Stoddart et al., 2002; Stoddart et al., 2010).

Besides, the code-switching (alternation or mixing) of ELLs' home language and English allows English language learners to draw on their local language skills in constructing meaning and link science content to their experiences outside the classroom, and connect concrete experiences to abstract concepts (Lee, 2005). Purposeful use of ELLs' home language facilitates their development of English literacy. Researchers acknowledge that instruction that employs code-switching between English and the local language is clearer to ELLs (Lee, 2005) and enables them to understand and participate in science lessons (Ampiah, 2008; Pollard, 2002) than instruction relying solely on English (Ampiah, 2008; Lee, 2005) or the local language (Lee, 2005). Code-switching allows ELLs to effectively communicate their knowledge and understanding of science to teachers and their peers, and elaborate, emphasize, specify, and clarify their ideas and understandings (Pollard, 2002).

Effectiveness of Inquiry-based Science Teaching and Learning

Empirical evidence show that generally, inquiry-based teaching and learning is effective in promoting various learning outcomes of diverse student groups, in various science disciplines, at various grades, in various contexts (countries), and for both sexes. Most studies show that inquiry teaching and learning significantly improves students' cognitive achievements in science (e.g., Anderson, 2002; Furtak et al. 2012; Lati et al., 2012) and is more effective than traditional science instruction (Akcay & Yager, 2010; Chang & Mao, 1999; Lott, 2003; Njoroge, Changeiywo, Ndirangu, 2014; Wolf & Fraser, 2008). It promotes students' conceptual understanding (Anderson, 2002; Balci, Cakiroglu, & Tekkaya, 2006; Ladewski et al., 1994; Simsek & Kabapinar, 2010), content knowledge (Chang & Mao, 1999; Krajcik et al., 1994; Lati et al., 2012), critical and higher-order thinking skills (Anderson, 2002; Gillies, 2008), problem-solving skills (Gillies, 2008), scientific literacy, and vocabulary knowledge in science (Anderson, 2002).

While most studies show that inquiry-based teaching and learning significantly improves students' science achievements and is more effective than traditional science instruction, some studies show otherwise. For instance, Akcay and Yager (2010) found no significant differences in mastery of science concepts between students engaged in student-centred STS instruction and their peers in traditional STS instruction. Similarly, Chang and Mao (1999) found no significant differences in comprehension and application of earth science concepts, and higher-order thinking skills between students taught through inquiry approach and lecture instruction.

Most studies show also that inquiry-based teaching and learning significantly improves students' attitudes toward science (e.g., Anderson, 2002) and is more effective than traditional instruction in doing so (e.g., Akcay & Yager, 2010; Chang & Mao, 1999; Crawford, 2000; Ornstein. 2006). Specifically, inquiry teaching and learning promotes students' involvement in classroom activities and confidence in science (Chang &Mao, 1999), positive interest in science classes and activities in science classes, confidence in their abilities to do science, and interest in science related activities outside school (Ornstein, 2006). Inquiry teaching and learning also promotes students' excitement and curiosity about investigation procedures and apparatus (Krajcik et al., 1998). Studies show further that students' perceptions of inquiry-based science environments are positively and significantly associated with their attitudes toward science. Particularly, students' perceptions of learning environments that are teacher supportive, involving, investigation-oriented, task-orientated, and equitable are positively and significantly associated with their attitudes toward science (Wolf & Fraser, 2008).

Although, most studies show that inquiry teaching and learning improves students' attitudes toward science and is more effective than traditional instruction in doing so, some studies show contrary findings. While Simsek and Kabapinar (2010) found that inquiry teaching is not effective in improving students' attitudes toward science, Chang and Mao (1999), Lott (2003), and Wolf and Fraser (2008) found that there are no significant differences in attitudes toward science between students taught through inquiry and traditional instruction. Particularly, Lott (2003) found that there are no significant differences in enjoyment, leisure interest, and career interest in science between students engaged in inquiry and traditional science teaching. Likewise, Crawford (2000) found that workload involved in inquiry learning promoted negative attitudes toward science among some students.

Most studies show that inquiry teaching and learning significantly improves students' science process skills (Anderson, 2002; Cuevas et al., 2005; Lati et al., 2012; Simsek & Kabapinar, 2010) and is more effective than traditional science instruction in that regard (Akcay & Yager, 2010; Chang & Mao, 1999; Lott, 2003). In particular, inquiry teaching and learning was found to improve students' skills in creativity, proposing answers, and applying science concepts and processes in new situation (Akcay & Yager, 2010). Again, inquiry teaching and learning was found to improve students' skills in formulating hypotheses (Cuevas et al., 2005; Lati et al., 2012; Simsek & Kabapinar, 2010), designing investigation procedures (Cuevas et al., 2005), identifying and controlling variables (Cuevas et al., 2005; Lati et al., 2012), drawing conclusions (Cuevas et al., 2005), recording results (Cuevas et al., 2005), experimenting (Lati et al., 2012), operational definitions (Lati et al., 2012), and measurement and classification (Simsek & Kabapinar, 2010).

However, some studies show that inquiry teaching and learning is not effective in promoting students' process skills. For instance, Cuevas et al. (2005) found that students engaged in inquiry-based science instruction did not demonstrate significant improvement in their abilities to formulate driving questions for investigations.

Inquiry teaching and learning is also effective in remedying students' misconceptions in science. For example, while Simsek and Kabapinar (2010) found that science inquiry instruction remedies most students' misconceptions about "matter", Balci et al. (2006) found that inquiry instruction remedies students' misconceptions about "photosynthesis and respiration".

Studies show further that, inquiry-based teaching and learning is more effective in promoting favourable science learning environment. For example, Wolf and Fraser (2008) found that students engaged in inquiry instruction perceived significantly more cohesive classroom environment than their peers in traditional instruction. Particularly, female students engaged in inquiry perceived higher cohesive classroom environment than their male peers. Additionally, male students engaged in inquiry perceived their learning environment to be significantly higher in task orientation, cooperation, and equitable than male students involved in traditional instruction.

While most findings show that inquiry teaching and learning promotes favourable science learning environment, some findings indicate otherwise. Wolf and Fraser (2008) found that female students engaged in non-inquiry instruction had higher perceptions of equitable classroom environment and similar perceptions of classroom task orientation and cooperation as female students in inquiry instruction.

Additionally, studies show that inquiry-based teaching and learning is effective in improving students' learning outcomes in various science disciplines and topics; including Science, Technology, and Society [STS] (Akcay & Yager, 2010), photosynthesis and respiration (Balci et al., 2006), earth science (Chang & Mao, 1999), Measurement and matter, and water cycle and weather (Cuevas et al., 2005), classification of non-living things (Gillies, 2008), chemical reaction rates (Lati et al., 2012), chemistry (Lott, 2003), magnetic effect of electric current (Njoroge et al., 2014), matter (Simsek & Kabapinar, 2010), physical science (Wolf & Fraser, 2008), and science courses (Ornstein, 2006).

Inquiry-based teaching and learning is also effective in promoting science outcomes of students at various grades; including elementary school (Balci et al., 2006; Simsek & Kabapinar, 2010), middle school (Ornstein, 2006; Wolf & Fraser, 2008), junior high school (Chang & Mao, 1999; Gillies, 2008), high school (Lati et al., 2012; Ornstein, 2006), secondary school (Lott, 2003; Njoroge et al., 2014), grades 3 and 4 (Cuevas et al., 2005), grade 5 (Simsek & Kabapinar, 2010), grade 6 (Akcay &Yager, 2010), grade 7 (Akcay & Yager, 2010; Wolf & Fraser, 2008), grade 8 (Akcay & Yager, 2010; Balci et al., 2006), grade 9 (Akcay & Yager, 2010; Chang & Mao, 1999; Gillies, 2008), and grade 11 (Lati et al., 2012; Lott, 2003).

Additionally, studies show that inquiry teaching and learning improves students' learning outcomes in various countries and contexts; including Taiwan (Chang & Mao, 1999), USA (Cuevas et al., 2005; Lott, 2003; Ornstein, 2006; Wolf & Fraser, 2008), Australia (Gillies, 2008), Thailand (Lati et al., 2012), Kenya (Njoroge et al., 2014), Turkey (Simsek & Kabapinar, 2010), and in urban area (Balci et al., 2006).

Also, inquiry teaching and learning improves learning outcomes of diverse student groups; including mainstream students (Balci et al., 2006; Chang & Mao, 1999; Gillies, 2008; Lati et al., 2012; Lott, 2003; Njoroge et al., 2014; Ornstein, 2006; Simsek & Kabapinar, 2010; Wolf & Fraser, 2008), low-achieving and high-achieving students, low socio-economic and high socio-economic status students, African American and Hispanic American students, and English-speaking and Hispanic speaking students (Cuevas et al., 2005).

Although inquiry-based teaching and learning is effective in promoting students' achievement in science, some aspects or features of inquiry are more effective in this regard than others. For instance, Furtak et al. (2012) found that engaging students in epistemic and combination of procedural, epistemic, and social activities results in largest improvement in students' science achievements. In contrast, engaging students in epistemic and conceptual, social, or procedural, epistemic, conceptual, and social activities result in moderate improvement in students' science achievements. Similarly, studies show that teacher-guided inquiry is more effective in promoting students' science learning than open inquiry (Furtak et al., 2012; Grigg et al., 2013).

As noted by Wolf and Fraser (2008), if inquiry-based teaching and learning can significantly improve various learning outcomes of diverse student groups, in various science disciplines, at various grades, in various countries and contexts, then similar strategies can work in science teaching and learning of students in Africa, including Ghana.

Challenges of Inquiry-based Science Teaching

Despite the effectiveness of inquiry teaching and possibility for many teachers to initiate it in classrooms, teachers, especially novice teachers, face many challenges in adopting and implementing this innovative instruction. Challenges teachers face arise from contextual and personal factors, and how to enact and orchestrate the features of inquiry (e.g., Crawford, 2007; Krajcik et al., 1994; Marx et al., 1994). Contextual challenges to inquiry teaching emanate from the classroom, school, and district. These include lack of and inadequate resources such as telephone, internet access, and equipment; large class sizes; inadequate teaching time; demands of curriculum (syllabus) coverage and paper-and-pencil assessments (Krajcik et al., 1994; Toolin, 2004); low students' abilities (Crawford, 2007; Marx et al., 1994); teaching beliefs and preferences of school administrators and mentors; and students' resistance to new instructional method (Crawford, 2007).

Personal factors include teachers' knowledge (conceptions), beliefs, experiences, and individual preferences (e.g., Crawford, 2007; Krajcik et al., 1994; Toolin, 2004). Teachers' beliefs about teaching and learning (e.g., Crawford, 2007; Krajcik et al., 1994; Ladewski et al., 1994), schools, and nature of scientific inquiry (Crawford, 2007) influence their willingness to adopt and implement inquiry teaching. Additionally, teachers' content and pedagogical content knowledge, and experiences with different instructional approaches influence their ability to adopt and implement inquiry teaching (Krajcik et al., 1994; Marx et al., 1994). Other challenges teachers encounter include how to enact each feature of inquiry separately and orchestrate the features simultaneously (e.g., Krajcik et al., 1994; Marx et al., 1994).

Anderson (1996, 2002) categorized challenges to inquiry teaching into barriers and dilemmas, which are subcategorised into technical, cultural, and political dimensions. The cultural dimension concerns challenges emanating from teachers' beliefs, attitudes, values, views of assessment, preparation ethics, and commitment to textbook. The cultural dimension is most critical because it involves internal challenges that are difficult to identify and change.

Teachers' and Educational Administrators' Conceptions of the Nature of Science, Scientific Inquiry, Inquiry Teaching, and Inquiry Learning

Teachers' conceptions of the nature of science (NOS), scientific inquiry, inquiry teaching, and inquiry learning are internal factors that challenge or facilitate teachers' adoption and implementation of inquiry teaching. While empirical evidence show that there are multiple factors that prevent teachers from teaching the NOS in classrooms (e.g., Abd-El-Khalick et al., 1998; Lederman, 1999), most researchers agree that both novice and experienced teachers need adequate understandings of the NOS and inquiry teaching as necessary and prerequisite to teach the NOS and engage students in science inquiries (e.g., Abd-El-Khalick, 2012; Haefner & Zembal-Saul, 2004; Ireland, Watters, Brownlee, & Lupton, 2012).

The constructivist perspective of NOS views scientific knowledge is tentative, empirical, subjective, and socially and culturally embedded. It also views development of scientific knowledge as involving human inference, observation, creativity, and imagination; and views differences between observation and inference, and functions and relationships between scientific theories and laws (Abd-El-Khalick, 2012; Abd-El-Khalick et al., 1998; Dudu, 2014; Lederman, 1999). For instance, scientists become creative when they employ intuition to formulate hypotheses and construct workable explanations for natural phenomena. As a social endeavour, science is greatly influenced by cultural traits, worldview, social values, priorities, ideas, skills, ethics, perceptions, and beliefs in a society (Dudu, 2014). As a result, topical issues like HIV/AIDS, global warming, and genetic engineering are given different attention because of their different impacts on different societies.

Contemporary perspective of science holds that a certain degree of subjectivity exists in scientific endeavours, due to social and cultural contexts, and researchers' experiences and expectations. This influence how researchers collect, analyse, interpret, and draw conclusions from data (Dudu, 2014; Lederman, 1999).

Apart from the NOS, pre-service and practicing teachers are expected to develop adequate understandings of constructivist view of scientific inquiry (science processes). While the NOS is different from scientific inquiry, scientific inquiry interact with the NOS in generating and validating scientific knowledge (Abd-El-Khalick et al., 1998). Science processes are activities connected to data collection and interpretation and drawing of conclusions, but the NOS involves epistemological basis underlying activities of science. While understanding science content is an important aspect of scientific inquiry, understanding the nature of science and sources of scientific knowledge is equally important (e.g., Haefner & Zembal-Saul, 2004).

Studies show that most teachers lack adequate understanding of the constructivist perspective of NOS and inquiry teaching. For instance, studies in industrialised and industrialising countries show that many pre-service and in-service teachers hold naïve, realist, inductivist, and positivist understanding of the NOS (e.g., Abell & Smith, 1994; Aguirre et al., 1990; Haefner & Zembal-Saul, 2004). Specifically, many teachers understand science as a process of seeking answers to questions and discovering scientific knowledge (Haefner & Zembal-Saul, 2004) existing out there independent of scientists and free from human imagination and invention (Abell & Smith, 1994). Additionally, many teachers understand science as a process in which experiments are conducted either to prove or disprove theories and hypotheses (Aguirre et al., 1990). Empirical evidence show also that most teachers lack understanding of how scientific theories are developed, accepted, used to organize knowledge and investigations, and predict occurrence of events and phenomena (Abell & Smith, 1994). Many teachers lack understanding of the role of evidence and logic in constructing scientific knowledge, and role of the scientific community in communicating and debating competing theories. Similarly, most teachers hold limited understandings of influence of human elements such as biases, emotions, beliefs, ethical considerations, and mistakes in the generation and validation of scientific knowledge.

Studies in industrialised and industrialising countries show also that many teachers hold inadequate conceptions of inquiry teaching and learning. For example, Aguirre et al. (1990) found that about 50% of the pre-service teachers they studied in Canada understood science teaching as transfer of knowledge from the instructor's head and textbooks to "empty" minds of students. The teachers also understood science teaching to involve modelling, demonstration or illustration of concepts to students. Similarly, Haefner and Zembal-Saul (2004) found that nearly all the teachers they studied in USA initially understood science teaching as provision of hands-on activities to students; where hands-on activities focus on promoting students' involvement and interest in science, rather than developing meaningful and conceptual understandings.

While studies show that many pre-service and practising teachers in industrialised and industrialising countries hold inadequate conceptions of the constructivist views of NOS and inquiry teaching and learning, the situation in

Africa, including Ghana, could be worse. There is little evidence in the science education literature of African teachers with adequate conceptions of the NOS, scientific inquiry, and inquiry teaching and learning.

Researchers agree that teachers hold uninformed conceptions of the NOS, scientific inquiry, and inquiry teaching and learning because of their exposure and experiences with traditional science instruction throughout their schooling (e.g. Abell & Smith, 1994). As a result, the uninformed conceptions held by teachers become stable and resistant to change.

However, empirical evidence show that innovative courses, workshops, seminars, and programmes specifically designed to promote teachers' conceptions of the NOS, scientific inquiry, and inquiry teaching and learning are effective in doing so. For example, Lederman (1999) found that in-service teachers who attended workshops and classes that emphasised both the NOS and teaching of NOS, demonstrated adequate understanding of the NOS in consistent with the constructivist view. Specifically, Lederman found that such teachers are capable of demonstrating adequate understanding of tentativeness, empirical, and subjective nature of science; adequate understanding of the role of imagination, creativity, observation, and inference in constructing scientific knowledge; and understanding the differences between observation and inference. Similarly, Abd-El-Khalick et al. (1998) found that most pre-service teachers who attended science methods and pedagogy courses and field-based internship programmes that emphasize the NOS and its implication for teaching and learning, developed understandings of NOS in consistent with the constructivist views. Specifically, Abd-El-Khalick et al. found that such pre-service teachers are capable of exhibiting adequate conceptions of tentativeness and empirical nature of science, differences between observation and inference, and the role of subjectivity and creativity in development of scientific knowledge. Again, such teachers are capable of understanding the nature of science as being subjective and abandon the notion of science being completely objective and rational.

Similarly, Haefner and Zembal-Saul (2004) found that teachers engaged in authentic science investigations can change their understandings of science and doing science, and hold understandings of scientific inquiry as a process involving asking questions, conducting experiments, collecting and interpreting data, and using evidence to develop explanations. As teachers' understandings shift more toward the processes of science, their interests in students' questions and strategies for helping students' science investigations become a focus of school science.

While studies in most industrialised and industrialising countries (e.g. USA) show that teachers engaged in innovative courses successfully changed their conceptions of NOS, scientific inquiry, and inquiry teaching and learning toward constructivist views, the same cannot be said of teachers in most African countries, including Ghana. There is little evidence in the literature of African teachers who have successfully changed their understandings of the NOS, scientific inquiry, and inquiry teaching and learning toward constructivist views, after engaging in innovative courses. While most industrialised and industrialising countries (e.g. USA, Canada) have developed courses and programmes specifically to promote teachers' conceptions of the NOS, scientific inquiry, and inquiry teaching and learning, teacher preparation programmes in most African countries continue to employ traditional teaching methods.

Teachers' Attitudes toward Inquiry-based Science Teaching

A teacher's attitude toward inquiry-based science teaching is another internal factor that challenge or facilitate his/her adoption and implementation of this instructional approach. Most researchers acknowledge the need for science educators to pay explicit attention to examination and development of pre-service and in-service teachers' attitudes toward inquiry-based science teaching (e.g., Dinauer, 2003; Korur, 2016; Minger & Simpson, 2006; Özdemir & Güngör, 2017; Van Aalderen-Smeets & Walma van der Molen, 2013, 2015; Van Aalderen-Smeets, Walma van der Molen, Asma, 2012). While it is necessary to improve teachers' content and pedagogical content knowledge in science and processes of science, if they are not interested in inquiry-based science teaching or if they are employing inquiry teaching out of necessity, they cannot commit their knowledge and skills in classrooms as expected (Özdemir & Güngör, 2017; Van Aalderen-Smeets & Walma van der Molen, 2013; Van Aalderen-Smeets et al., 2012).

While attitudes toward inquiry-based science teaching is a critical focus of pre-service and in-service teacher education in most industrialised and industrialising countries (e.g., Choi & Ramsey, 2009; Minger & Simposn, 2006; Van Aalderen-Smeets & Walma van der Molen, 2015). there is little evidence in the literature of African countries that pay explicit attention to examination and development of teachers' attitudes toward inquiry-based science teaching during pre-service and in-service teacher education.

Most researchers agree that attitude toward science teaching is a complex or multidimensional concept (e.g., Dinauer, 2003; Moreira, 1992;

Van Aalderen-Smeets & Walma van der Molen, 2015; Van Aalderen-Smeets et al., 2012). It is an association or linkage between science teaching and teachers' affective responses of like or dislike (Dinauer, 2003). Pajares (1992) considers it as a cluster of beliefs that are holistically organised and which predisposes a teacher to teach or not. On the hand, an attitude object is an entity or stimulus about which an attitudinal evaluation is made (Dinauer. 2003; Van Aalderen-Smeets et al., 2012). Attitude objects that are measured in science education include attitude toward science, attitude toward science teaching, and scientific attitudes.

Earlier theories of attitudes toward science teaching were based on affective and tripartite models consisting of cognitive, affective, and behavioural components (Dinauer, 2003; Moreira, 1992; Van Aalderen-Smeets et al., 2012). However, due to ambiguities and constraints identified in the earlier models, Van Aalderen-Smeets et al. (2012) modified the tripartite model and formulated a new theoretical framework that provides enhanced understanding of the structural components underlying teachers' attitudes toward science teaching. The new theoretical framework consists of three components and seven subcomponents that represent different thoughts, beliefs, and feelings (Van Aalderen-Smeets & Walma van der Molen, 2013, 2015; Van Aalderen-Smeets et al., 2012). The three components are cognitive, affective, and perceived control.

The cognitive component involves teachers' beliefs about teaching science and consists of three subcomponents. These are perceived relevance, perceived difficulty, and gender stereotypical beliefs. Teachers' perceived relevance of teaching science involves extent to which they consider science teaching to be important for their personal lives, society, prosperity, or health. Teachers' perceived difficulty about teaching science involves their general beliefs that teaching science is more difficult than teaching other subjects. Teachers' perceived gender stereotypical beliefs about teaching science involves their perceived differences between male and female teachers' abilities to teach science, and perceived differences in male and female teachers' levels of interest and enjoyment in teaching science.

The affective component involves teachers' emotions and feelings about teaching science; which can be positive or negative. The affective component consists of two subcomponents. These are perceived enjoyment and anxiety. Teachers' perceived enjoyment involves positive feelings of pleasure or joy in relation to teaching science, while their perceived anxiety involves negative feelings, fear, or aversion toward the teaching of science. While enjoyment and anxiety in science teaching are independent, they are related.

The perceived control component involves amount of perception of control a teacher has over science teaching. Perceived control reflects subjective beliefs and feelings of teachers about internal and external obstacles likely to prevent the teaching of science and not the real presence of such obstacles. Perceived control has two subcomponents. These are self-efficacy and perceived influence of or dependency on context factors. Self-efficacy is a teacher's beliefs about his/her own ability to teach science based on internal factors such as knowledge, skills, confidence, and experience. Teachers' perceived influence of contextual factors involves beliefs and feelings about existence of external factors that make it easier or harder to teach science.

Perceived influence of context factors is an important component associated with teachers' attitudes toward science teaching (Van Aalderen-Smeets et al., 2012). In situations where teachers perceive certain factors to be essential for teaching science, they feel completely dependent on those factors. While teachers' attitudes strongly predict their teaching intentions, the amount of teachers' perceived dependency on external context factors also strongly predicts their intention to teach (Van Aalderen-Smeets et al., 2012). These contextual factors include collegial support, lack of resources, time allocated for teaching science in the curriculum, time and effort needed to prepare science lessons (investigations or activities), standardized (traditional) teaching methods, and resources (money).

The social cognitive theory (Bandura, 1977, 1994), which contains the original concept of self-efficacy, considers teachers' outcome expectancy and personal efficacy as independent but related components. However, the new theoretical framework (Van Aalderen-Smeets & Walma van der Molen, 2013, 2015; Van Aalderen-Smeets et al., 2012) separates outcome expectancy from self-efficacy and considers self-efficacy as an underlying subcomponent of teachers' professional attitudes toward science, with outcome expectancy not an attitude subcomponent. Again, while Van Aalderen-Smeets et al. (2012) acknowledge that many researchers study teachers' self-efficacy as a sole predictor of teaching science, they propose that teachers' self-efficacy should be studied in conjunction with other components of attitudes. This study examined teachers' self-efficacy separately from their attitudes, in conformity with the social cognitive theory (Bandura, 1977, 1994) and with many studies that examined teachers' self-efficacy separately (e.g., Arigbabu & Oludipe, 2010; Bleicher, 2004; Dira-Smolleck et al., 2006; Lardy & Mason, 2011; Riggs & Enochs, 1989). Again, this study examined outcome expectancy and personal efficacy as independent but related components of teachers' self-efficacy, in line with the social cognitive theory (Bandura, 1977, 1994) and with other studies (e.g., Bleicher, 2004; Dira-Smolleck et al., 2006; Riggs & Enochs, 1989).

Contrary to previous theories, the new theoretical framework considers teachers' behavioural intentions and actual behaviours in classrooms as different from their attitudes toward science teaching, and not a part of the construct of attitude itself. In line with the new theoretical framework, this study considers teachers' behavioural intentions (lesson plans) and classroom behaviours (teaching practices) as different from their attitudes toward science inquiry teaching. This study also considers teachers' attitudes toward science inquiry teaching as prerequisite for their behavioural intentions (lesson plans), which in turn determine their actual classroom behaviours (inquiry teaching practices).

Most empirical evidence show that teachers' attitudes strongly predict their instructional intentions (lesson plans) and actual classroom behaviours (teaching practices). For example, Van Aalderen-Smeets and Walma van der Molen (2013) found that pre-service and in-service teachers' perceived enjoyment, anxiety, and context dependency are indication of their likelihood and frequency of teaching science. Specifically, the researchers found that teachers' with low perceived dependency on contextual factors feel less anxious and are more likely to teach science regularly. Likewise, teachers with low anxiety and perceived dependency on context factors who enjoy teaching science are more likely to teach science regularly. Van Aalderen-Smeets and Walma van der Molen (2013) found further that teachers with high potentials of teaching science experience positive feelings toward and enjoy teaching science, and do not experience any anxiety when doing so.

Theories and empirical evidence show also that teachers can hold contradictory or conflicting attitudes toward inquiry-based science teaching (Dinauer, 2003). For example, while teachers Turkmen (2013) studied in Turkey perceived science teaching to involve guiding students in child-centred lessons, they also perceived science teaching to involve transmission of knowledge to students in a teacher-centred approach. Again, negative attitudes toward inquiry teaching that teachers had formed prior to entering their careers are quite stable and resistant; and can be changed very little with the same traditional instruction they experienced in elementary and secondary schools (e.g., Özdemir & Güngör, 2017).

While empirical evidence show that teachers' attitudes strongly predict their teaching intentions and behaviours, empirical evidence show also that, generally, pre-service and in-service teachers hold negative attitudes toward science teaching, especially inquiry-based science teaching. For example, the elementary teachers Tenaw (2014) studied in Kenya felt dependent on external contextual factors like insufficient time, materials and supply, resources, unstructured curriculum, inadequate collegial support, classroom management, and standardized tests. These negative attitudes led the teachers to avoid regular hands-on activities and rather resort to text-based lessons more frequently. Similarly, Saad and Boujoaude (2012) found that about two-thirds of the teachers they studied in Lebanon had negative attitudes toward scientific inquiry and inquiry teaching. These negative attitudes led most of the teachers to avoid inquiry teaching in their classrooms, while those who practiced inquiry teaching did so for a short period.

Most researchers agree that formation and development of teachers' attitudes toward science teaching is influenced by the kind of teaching and learning they experienced directly as well as instruction they observed when they were students in elementary and secondary schools (Moreira, 1992). Through direct experiences and observations when they were students in elementary and secondary schools, teachers learn and form mental images about the roles of teachers and learners in classroom, and how science instruction should be conducted. As a result, teachers enter their careers already having significant and practical experiences about the teaching process, which have shaped their attitudes toward science teaching (e.g., Özdemir & Güngör, 2017). For example, the lack of exposure and experiences with inquiry instruction prior to an inquiry-based science methods course was responsible for the negative attitudes toward inquiry-based science teaching held by teachers in Choi and Ramsey's (2009) study. Due to their lack of exposure and experiences with inquiry teaching the teachers believed they had little knowledge and skills to teach science and implement inquiry-based science instruction. Thus, teachers teach in the manner in which they were taught when they were students in elementary and secondary schools (e.g. Choi & Ramsey, 2009; Özdemir & Güngör, 2017; Tenaw, 2014; Turkmen, 2013; Van Aalderen-Smeets et al., 2012).

Studies show also that the formation and development of teachers' attitudes toward science teaching is influenced by demographic characteristics such as school location (rural and urban), gender, age, teaching experience, level of education, and school type (private or public). For instance, Turkmen (2013) found that male teachers have more positive attitudes toward teaching science than female teachers. Additionally, the researcher found that teachers with higher levels of education have more positive attitudes toward teaching science than teachers with low levels of education. Korur et al. (2016) also found that while teachers in both Turkey and Spain have little or no perceived anxiety, fear, and gender stereotypical beliefs about teaching science, teachers in Turkey have higher perceptions of depending on context factors in science teaching than teachers in Spain.

Empirical evidence show that explicit attitude-focused pre-service and in-service courses can be employed to change teachers' attitudes and actual classroom practices toward inquiry-based science teaching. For example, Choi and Ramsey (2009) found that while most in-service teachers initially dreaded and were reluctant to employ inquiry teaching in their classrooms, after an inquiry-based course, the teachers no longer dreaded to employ inquiry teaching but rather perceived enjoyment of using science equipment and planning inquiry instruction. Again, Van Aalderen-Smeets and Walma van der Molen (2015) found that attitude-focused professional development courses are effective in improving all components of teachers' professional attitudes toward science teaching, including their cognitive beliefs, affective feelings, and perceived control of teaching science. Particularly, the researchers found that explicit attitude-focused professional intervention is effective in changing teachers' perceived relevance and gender stereotypical beliefs about teaching science; and promoting teachers' perceived enjoyment, feeling in control, and reducing their perceived anxiety and dependency on context factors such as availability of materials, traditional teaching methods, and time for teaching science (Van Aalderen-Smeets & Walma van der Molen, 2015). The researchers found also that positive changes in teachers' professional attitudes toward science reflected in large increases in their actual classroom practices and engagement with science-related activities in their daily lives. Particularly, positive changes in the teachers' attitudes resulted in their use of more inquiry-based, child-oriented, and less pre-structured methods of teaching science.

While most industrialised and industrialising countries are reforming their pre-service and in-service teacher education to embrace explicit attitude-focused science methods courses (e.g., Choi & Ramsey, 2009; Minger & Simpson, 2006; Van Aalderen-Smeets & Walma van der Molen, 2015), the literature shows that most African countries, including Ghana, continue to implement typical traditional teacher education programmes.

Teachers' Beliefs about Inquiry-based Science Teaching

Teachers' beliefs are yet another internal factor that either challenges or facilitates their adoption and implementation of inquiry-based science teaching (e.g., Decker & Rimm-Kaufman, 2008; Karaman & Karaman, 2013; Pajares, 1992; Sahin et al., 2010; Sampson & Benton, 2006). This is because teachers' beliefs are very influential in determining how they plan, organize, and conduct actual science teaching, as well as the effort they employ in doing so. The fact that two teachers with similar knowledge about science and science teaching may teach in different ways suggest that understanding teachers' beliefs is more useful in understanding and predicting their instructional decisions, and shows the powerful effect of teachers' beliefs on their instructional decisions and practices (Pajares, 1992). Researchers call for examination of existing beliefs about science teaching that teachers bring into classroom (e.g. Decker & Rimm-Kaufman, 2008; Pajares, 1992) in order to determine if they are adequately prepared to implement inquiry-based teaching (Karaman & Karaman, 2013; Sahin et al., 2010; Sampson & Benton, 2006).

There is no single and exact definition of beliefs about science teaching (e.g. Mansour, 2009; Pajares, 1992). One needs to understand the nature of beliefs about science teaching in order to understand it. Teachers' beliefs about science teaching have affective (emotional) and evaluative (judgement) components (Crawford, 2007; Mansour, 2009; Pajares, 1992; Sampson & Benton, 2006), have a slender cognitive component (Pajares, 1992), are static and resistant to change (Crawford, 2007; Decker & Rimm-Kaufman, 2008; Mansour, 2009; Pajares, 1992; Sampson & Benton, 2006), are subjective (Crawford, 2007; Mansour, 2009; Pajares, 1992) and episodic in nature (Pajares, 1992). Teachers' beliefs can be personal and shared, are complex, and sometimes contradictory (Mansour, 2009; Pajares, 1992). A teacher's beliefs about science teaching consist of complex and intricate connections of beliefs to one another and to other cognitive and affective structures that collectively form the teacher's beliefs system. Some beliefs within the system are core (central), some are peripheral, some are formed earlier, and others are formed later (Pajares, 1992). Teachers' core beliefs about science teaching that are formed earlier are more stable and difficult to change than their peripheral beliefs that are newly acquired. Apart from teachers' beliefs about science teaching, they hold other educational beliefs and beliefs beyond their profession which influence their classroom practices

(Mansour, 2009; Pajares, 1992).

The affective component of teachers' beliefs work independent of the cognition associated with teachers' knowledge, and it differentiates teachers' feelings and knowledge about science teaching (e.g., Pajares, 1992). The affective and evaluative components are strong and influential. It is these strong emotional, judgemental, and episodic components of beliefs that allow teachers to filter and interpret new instructional experiences, and influence their instructional decisions and practices. It is the emotions attached to teachers' beliefs that contribute to their resistance to change (Mansour, 2009). The emotions attached make it possible for teachers to hold beliefs based on incorrect or incomplete knowledge, even after scientifically correct and valid explanations have been presented to the teachers (e.g., Mansour, 2009; Pajares, 1992). Pajares (1992) went further to assert that a teacher does not require agreement or consensus from others to establish the validity and appropriateness his/her beliefs about science teaching. Due to this subjectivity, a teacher's beliefs are not subject to evaluation and critical examination, and relevance of the beliefs to reality defies logic. It is therefore possible for a teacher to hold contradictory and inconsistent beliefs about science teaching.

Besides, teachers hold several elements of beliefs about science teaching in their belief structures. These include beliefs about "how students learn science", "science lesson design and implementation", "characteristics of science teachers and the learning environment", and "the nature of science curriculum" (e.g., Karaman & Karaman, 2013; Sampson & Benton, 2006). Elements of beliefs held by teachers can broadly be categorised as traditional (behaviourist) or constructivist (inquiry) oriented. Teachers with traditional views of science teaching hold beliefs which reflect in their approaches to science curriculum, the science teaching strategies they adopt, and how they assess students' science learning (Mansour, 2009). Such teachers consider science curriculum as a list of facts that must be presented to students through rigid teaching approaches that emphasize the flow of information from teachers to students (Choi & Ramsery, 2009; Mansour, 2009). They engage in traditional classroom interactions in which teachers ask series of close-ended questions for students to answer; and they engage in evaluation of science learning through summative assessments that determine whether scientific knowledge has been transferred or not. They consider themselves as active transmitters of scientific knowledge and students as passive recipients of scientific knowledge. If teachers believe that science curriculum consists of a body of knowledge to be transmitted, they are not likely to allow students to conduct their own investigations (Krajcik et al., 1994). Therefore, teachers with traditional beliefs about science teaching employ the classical lecture and "chalk-and-talk" methods to impart knowledge to students (Mansour, 2009).

In contrast, teachers with constructivist and inquiry-based beliefs about science teaching value active participation of students in constructing their own scientific knowledge. They consider science learning as practices where students gradually expand their networks of ideas through interaction with peers and materials in the environment (Choi & Ramsey, 2009; Mansour, 2009). They consider science learning as inquiry into students' generated questions, and a process that can proceed in various directions away from the original plans (Kazempour, 2014a). Teachers with inquiry-based beliefs about science teaching provide opportunities and support for students to reflect as students develop conceptual understanding and learn more about scientific inquiry by engaging in investigations (Crawford, 2007; Mansour, 2009). They seek to develop students who think independently and critically; they employ frequent hands-on investigative activities; they create classroom environments that are highly cognitive involving for students; and they employ assessment procedures that activate higher-order thinking skills and processes.

Again, teachers with inquiry-based beliefs about science teaching provide stimulating and motivating experiences that challenge students' existing conceptions (Mansour, 2009); they provide students with science learning experiences that are relevant in their real-world daily lives (Kazempour, 2014a; Mansour, 2009); they foster collaborative learning among students, during which they encourage groups of students to discuss procedures to solve problems or conduct investigations with no or little interference from the teacher (Karaman & Karaman, 2013; Kazempour, 2014a; Mansour, 2009; Pajares, 1992; Pomeroy, 1993). They examine students' understandings of a problem and suitability of students' procedures for investigating the problem.

While empirical evidence show that many pre-service and in-service teachers in countries outside Africa hold traditional (e.g., Crawford, 2007; Saad & Boujaoude, 2012) and conflicting (e.g., Karaman & Karaman, 2013) beliefs about science teaching, many others hold strong beliefs about inquiry-based science teaching (e.g., Pomeroy, 1993; Sahin et al., 2010; Sampson & Benton, 2006). For example, while Saad and Boujaoude found that more than half of the teachers they studied in Lebanon held traditional beliefs about the nature of science and scientific inquiry. Sampson and Benton found that nearly all the teachers they studied in USA held strong inquiry-based beliefs about science teaching. While there is significant and growing population of teachers with strong inquiry-based beliefs about science and science teaching in countries outside Africa, the situation in Ghana and most African countries is different. There is little evidence in the literature of African teachers with strong inquiry-based beliefs about science and science teaching.

Most researchers agree that formation and development of teachers' beliefs about science teaching occur throughout their lifetime, especially from vivid episodic memories of science instruction they experienced when they were students in elementary and high schools (e.g. Choi & Ramsey, 2009; Crawford, 2007; Decker & Rimm-Kaufman, 2008; Mansour, 2009; Pajares, 1992; Sampson & Benton, 2006). Pajares (1992) went further to explain that the richly, detailed, episodic memory of science instruction that teachers have from some influential teaching practices when they were students strongly influenced the formation of their beliefs about science teaching, and serve as an inspiration and template that determine their own science teaching practices. These vivid experiences influenced the teachers to form strong beliefs about certain practices that occur during science instruction. These experiences also influenced the teachers to form strong beliefs about the roles of teachers and students in science classrooms. Therefore, teachers who passed through elementary and high school educational system that was based on traditional foundations of education (Karaman & Karaman, 2013), and who had science learning experiences that involved teacher-centred and occasional confirmatory laboratory activities (Kazempour, 2014a), formed and developed traditional beliefs about science teaching. These prior beliefs are then reinforced and shaped by pre-service and in-service teacher education that places heavy emphasis on science content at the expense of reflections about the processes and philosophy of science (Pomeroy, 1993; Saad & Boujaoude, 2012).

Again, the formation, development, and translation of teachers' beliefs about science teaching into classroom practices are strongly influenced by the context in which the teachers are situated. These contextual factors include constraints, opportunities, and external influences posed by the individual classroom, school, principal, community, curriculum, and physical setting in which teachers are situated (Mansour, 2009). In situations where teachers are unable to implement teaching strategies in consistent with their beliefs about science teaching, it results in mismatch between their beliefs and classroom practices (e.g., Crawford, 2007; Mansour, 2009; Pajares, 1992; Saad & Boujaoude, 2012). Therefore, researchers agree that it is important to consider the socio-cultural context within which teachers are situated in order to understand the formation and development of their beliefs about science teaching, and the instructional decisions and practices they employ in classrooms.

Additionally, the formation, development, and translation of teachers' beliefs about science teaching into classroom practices are influenced by demographic characteristics. Empirical evidence show that demographic characteristics that influence teachers' beliefs about science teaching include age (Decker & Rimm-Kaufman, 2008; Neuhaus & Vogt, 2013), gender (Decker & Rimm-Kaufman, 2008; Karaman & Karaman, 2013; Neuhaus & Vogt, 2013; Pomeroy, 1993), level of education (number of course taken)

(Decker & Rimm-Kauman, 2008; Macugay & Bernardo, 2013), majors (area of specialisation) (Karaman & Karaman, 2013; Macugay & Bernardo, 2013; Pomeroy, 1993), teaching experience (Decker & Rimm-Kaufman, 2008; Sahin et al., 2010), and ethnicity (Decker & Rimm-Kaufman, 2008).

Empirical evidence show that teachers with traditional beliefs and practices about science teaching, can change and adopt inquiry-based beliefs and practices when they are engaged in appropriate pre-service and in-service teacher education courses and programmes (e.g. Choi & Ramsey, 2009; Kazempour, 2014a; Krajcik et al. 1994; Toolin, 2004). For example, Choi and Ramsey found that most teachers in their study who initially held traditional beliefs and engaged in traditional teaching practices, were able to change and adopt inquiry-based beliefs and teaching practices after they were engaged in an inquiry-based science methods course. Similarly, the pre-service teacher that Kazempour studied initially held traditional beliefs about science teaching and engaged in traditional teaching practices. However, the teacher was able to change and adopt inquiry-based beliefs and successfully enacted inquiry-based science lessons, after being engaged in an inquiry-oriented science methods course.

While significant successes have been made in changing teachers' beliefs and practices in alignment with inquiry-based teaching approaches in most industrialised and industrialising countries, the literature shows little evidence of such changes in science teachers' beliefs and practices within the African context, including Ghana. Again, while pre-service and in-service teacher education programmes in most industrialised and industrialising countries have been reformed to emphasize constructivist approaches, the science education literature shows little evidence of such reforms in most African countries, including Ghana.

Teachers' Self-efficacy toward Inquiry-based Science Teaching

Most researchers agree that in addition to examining teachers' attitudes, conceptions, and beliefs about science inquiry teaching, examining their self-efficacy is important in having a more complete understanding of their instructional behaviours (e.g., Bleicher, 2004; Kazempour, 2014a; Lardy & Mason, 2011; Otieno, Leonard, Charagu, & Mogire, 2016; Riggs & Enochs, 1989). Teachers' self-efficacy is a significant contributor to the lack of priority given to science teaching in schools, and for teaching in ways that promote little students' achievements in science (Riggs & Enochs, 1989). Otieno, Leonard, Charagu, and Mogire (2016) argue that teachers are key agents in implementation of teaching reforms, and their own perceptions of their abilities to employ innovative approaches (e.g., inquiry teaching) significantly contribute to the success or failure of reforms. Therefore, researchers advocate for goals of science teacher education to include examination and development of pre-service and in-service teachers' self-efficacy in order to enable them confidently teach science in classrooms (e.g., Bleicher, 2004; Lardy & Mason, 2011).

Researchers admit that there are different theories and frameworks about the nature and origins of self-efficacy and processes by which self-efficacy influence human behaviour. These include the social cognitive learning theory (Bandura, 1977, 1994) and theoretical framework for primary teachers' attitudes toward science (Van Aalderen-Smeets & Walma van der Molen, 2013, 2015; Van Aalderen-Smeets et al., 2012). While self-efficacy is a core construct of the social learning theory (Bandura, 1977; Bleicher, 2004; Brown, Malouff, & Schutte, 2013; Dira-Smolleck et al., 2006; Kazempour, 2014a; Lardy & Mason, 2011; Riggs & Enochs, 1989), it is a subcomponent of attitude in the new theoretical framework (Van Aalderen-Smeets et al., 2012). Self-efficacy is even considered to be a theory on its own (e.g., Brown et al., 2013). Again, while the social learning theory considers efficacy expectations and outcome expectancy as independent but related components of self-efficacy, the new theoretical framework (Van Aalderen-Smeets et al., 2012) separates self-efficacy from outcome expectancy and considers self-efficacy as part of the construct of attitude with outcome expectancy not being a part. As noted by Bandura (1977), the different theoretical perspectives give rise to different approaches for examining teachers' efficacy expectations and their influence on teaching practices.

While Van Aalderen-Smeets et al. (2012) recommend examination of teachers' self-efficacy in conjunction with other components of their attitudes, the researchers admit that many studies investigate self-efficacy as a sole predictor of teachers' instructional practices. Again, many studies examine teachers' outcome expectancy and efficacy expectations as independent but related components. In line with the social cognitive learning theory (Bandura, 1977, 1994) and with many studies (e.g., Bleicher, 2004; Dira-Smolleck, 2006; Kazempour, 2014a; Lardy & Mason, 2011; Riggs & Enochs, 1989), the present study examined teachers' self-efficacy as a sole predictor of their instructional practices, and teachers' outcome expectancy and efficacy expectations as independent but related components.

Efficacy expectation is a teacher's conviction that he/she has the ability to successfully implement innovative teaching approach, while outcome expectancy is a teacher's expectation that innovative approach can improve students' learning (Bandura, 1977). Therefore, teachers' self-efficacy is defined as levels of confidence in their abilities to impact students' learning through teaching practices (Lardy & Mason, 2011). Personal efficacy is distinct from outcome expectancy in that a teacher may avoid innovative teaching because he/she lack the personal efficacy required, or the teacher may have the required efficacy expectations but is convinced that the teaching practices will not lead to effective students' learning.

The social cognitive learning theory has been widely applied in studies and design of instruments to examine science teaching self-efficacy of pre-service and in-service teachers. In line with the social learning theory, science teaching self-efficacy has two independent but related components. These are Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) (e.g., Bleicher, 2004; Dira-Smolleck, 2006; Lardy & Mason, 2011; Riggs & Enochs, 1989). Science teachers' behaviours in classrooms depend on both components, in that science teachers act in classrooms with the expectation that their practices will produce desirable learning (outcome expectation), and with the beliefs that they have capabilities to perform those practices (personal efficacy) (Riggs & Enochs, 1989). Generally, science teachers' self-efficacy can either align with constructivist (inquiry-based) philosophy of science and science teaching or with positivist (traditional/behaviourist) method of science and science teaching. As such, teachers need to have confidence in their own abilities to employ inquiry teaching before they can implement it in classrooms (Dira-Smolleck, 2006;

Kazempour, 2014a; Sahin et al., 2010). Kazempour (2014a) agrees that availability of teachers with strong self-efficacy toward inquiry-based science teaching is critical for success of constructivist science teaching reforms. She is of the view that teachers may avoid using inquiry-based strategies due to low confidence in their abilities to teach science in a manner that align with constructivist philosophy.

Teachers with strong self-efficacy toward inquiry-based science teaching have strong confidence, feel comfortable, and do not fear science as inquiry-based and hands-on endeavour; they conceptualize science teaching as student-centred, authentic, and enjoyable experiences; they foster meaningful learning, and facilitate and guide students' learning while simultaneously assuming the role of learners and exploring ideas with students (e.g., Kazempour, 2014a). Such teachers have capabilities to adopt and implement inquiry teaching and exert great effort in doing so; and they persist over a long period when they encounter challenges and problems (e.g., Bandura, 1977, 1994). Teachers with strong personal efficacy and outcome expectations adopt and implement inquiry strategies in an assured and decided manner. However, teachers with weak outcome expectancy and strong personal efficacy initially intensify their efforts but become frustrated when they encounter difficulties, while teachers with both weak outcome expectancy and personal efficacy either do not attempt inquiry teaching at all or easily abandon it when they encounter challenges (e.g. Riggs & Enochs, 1989). While teachers with strong self-efficacy believe that students' learning can be promoted by inquiry-based science teaching and have confidence in their abilities to implement it, teachers with weak self-efficacy are not certain whether students' learning can be promoted with inquiry teaching and are not confident in their abilities to implement it. Besides, teachers with weak sense of self-efficacy hold students entirely responsible for learning and do not have much expectation for students' success (Lardy & Mason, 2011).

Teachers with strong self-efficacy about inquiry teaching are open to new ideas; employ activities that demand students to use higher-order thinking and problem-solving skills; seek to develop students' critical thinking and decision making skills; pay attention to students' prior knowledge and experiences; and teach science content that is worthwhile, embedded in real-world experiences, and developmentally appropriate. They exhibit favourable attitudes toward science teaching reforms (e.g., Lardy & Mason, 2011).

In contrast, teachers with weak self-efficacy adopt traditional teaching that involve transmission, memorization, and recall of scientific facts (Kazempour, 2014a); and assess success of lessons by their ability to control students' behaviours and keep students quiet and orderly in classrooms (Lardy & Mason, 2011). They are highly dependent on external contextual factors; do not exhibit adequate confidence of being in control of instructional practices (Van Aalderen-Smeets et al., 2012); doubt their own abilities to employ inquiry teaching; avoid tasks and strategies that appear challenging (Brown et al., 2013; Kazempour, 2014a); and consider difficult tasks and strategies as problematic (Brown et al., 2013). Teachers with weak self-efficacy toward inquiry-based science teaching exhibit increased fears, anxiety, stress, and vulnerability in adopting demanding tasks and instructional strategies (Brown et al., 2013).

While teachers can hold strong self-efficacy based on adequate conceptions of inquiry teaching, teachers can also hold strong self-efficacy based on misconceptions of inquiry teaching. For instance, the varying meanings of "hands-on" science teaching held by teachers Lardy and Mason (2011) studied, had large influence on the teachers' self-efficacy and unintended effect on their teaching practices. Strong self-efficacy based on misconception of inquiry involves understanding of science teaching which is different from the constructivist view. In situations where teachers' strong self-efficacy are based on conceptions of science teaching which are different from the constructivist view, the teachers' strong self-efficacy cannot be translated into successful inquiry teaching in classrooms (Lardy & Mason, 2011). Besides, in situations where teachers with strong self-efficacy based on misconceptions of inquiry believe that they are teaching science effectively, they feel little need to critically examine their teaching practices and they have no doubt about their sense of self-efficacy.

Again, teachers' efficacy beliefs about science teaching are stable and resistant to change (e.g., Bandura, 1977, 1994). It is also possible for teachers to hold contradictory self-efficacy toward science teaching, and act on any one of them based on the context in which they find it appropriate.

Researchers agree that formation and development of teachers' self-efficacy toward science teaching arise from mastery experiences (performance accomplishments), vicarious experiences, verbal persuasion, and emotional arousal (physiological states) (Bandura, 1977, 1994; Brown et al., 2013; Otieno et al., 2016; Page, Pendergraft, & Wilson, 2014). Besides, the four sources can interact in various ways to collectively form and shape teachers' efficacy expectations (e.g., Bandura, 1977).

Formation and development of teachers' self-efficacy from mastery experiences occur when they attempt science teaching and are able to do and master it successfully (Brown et al., 2013). The persistence of teachers to overcome problems, challenges, and difficulties during the teaching lead to mastery experiences which promotes their self-efficacy. Additionally, feedback information teachers receive from their actions and practices during instruction enable them to distinguish appropriate behaviours from inappropriate ones (Bandura, 1977). Mastery experiences are the most effective way for the formation and development of teachers' self-efficacy toward science teaching, because teachers are more likely to believe that they can adopt and implement an instructional approach if it is similar to the one they have already accomplished successfully (Bandura, 1977, 1994; Brown et al., 2013). Empirical evidence from studies (e.g., Kazempour, 2014a; Otieno et al., 2016) confirms this proposition.

While prolong exposure and experiences with scientific inquiry and inquiry teaching lead to the formation and development of inquiry-based self-efficacy, continuous exposure and experiences with traditional science and science instruction results in the formation and development of traditional science teaching self-efficacy. For example, the pre-service teacher Kazempour (2014a) studied initially held traditional science teaching self-efficacy because of the teacher's prior experiences with traditional science teaching and learning as a student in elementary and high schools.

Vicarious experiences or observation of instructional successes and failures of others involved in science teaching is another way for the formation and development of teachers' self-efficacy toward science teaching (Bandura, 1977; Brown et al., 2013). When teachers observe others engaged in science teaching, it increases their expectations (self-efficacy) that they too can enact science teaching if they persist and intensify their efforts (Bandura, 1977). The observation of other teachers or resource persons engaged in science teaching enable teachers to form conceptions of the instruction which later guides them in their own teaching in classrooms. Teachers then refine the teaching practices they learned by using self-corrective feedback information from their own performances.

While vicarious experiences promote formation and development of teachers' self-efficacy, observing successful science teaching enacted by others who are similar to oneself promote better formation and development of one's self-efficacy than observing successful science teaching enacted by others who are different from oneself (Bandura, 1977, 1994; Brown et al., 2013). Again, observation of successful science teaching which has clearly stated learning outcomes promote better formation and development of teachers' self-efficacy than observing successful science teaching which has no clearly stated goals. Similarly, observation of multiple teachers engaged in successful separate science teaching promote better formation and development of one's self-efficacy than observation of multiple science teaching enacted by the same person. This happens because one becomes convinced that if teachers with different characteristics can successfully enact science teaching, then he/she can also do it.

Verbal persuasion is another, easy, and readily available source for the formation and development of teachers' self-efficacy toward science teaching (Bandura, 1977; Brown et al., 2013). When teachers are verbally persuaded that they have the ability to accomplish science teaching strategies, they develop confidence in their own capabilities (self-efficacy) and are more likely to attempt implementation of the science teaching (Brown et al., 2013). Similarly, when others verbally describe their successful accomplishments and mastery experiences in science teaching, it promotes confidence in teachers' abilities to adopt and implement the instructional approach. Empirical evidence from studies (e.g., Kazempour, 2014a; Marx et al., 1994; Van Aalderen-Smeets & Walma van der Molen, 2015) confirm that discussions and reflections that occur during collaborative inquiry-based methods courses, enable others to communicate ideas, and share successes and strategies, which promote confidence in abilities of teachers to initiate inquiry teaching. However, when others describe their failures and dissuade teachers from adopting and implementing inquiry teaching, it is likely to diminish and weaken teachers' self-efficacy.

While verbal persuasion promote formation and development of teachers' self-efficacy, perceptions of teachers about the credibility, prestige, trustworthiness, expertise, and assuredness of others persuading them significantly influence the formation and development of teachers' self-efficacy (Bandura, 1977). If teachers believe the credibility of others persuading them to adopt and implement inquiry-based science teaching, it is more likely to enhance the formation and development of teachers' self-efficacy.

Emotional arousal or physiological state is another source for the formation and development of teachers' self-efficacy (Bandura, 1977; Brown et al., 2013) about science teaching. Emotional states of teachers when they contemplate the adoption and implementation of science teaching influence their perceptions of success or failure, which subsequently influence the formation and development of their self-efficacy. As noted by Brown et al. (2013) when teachers feel stressful, anxious, fearful, vulnerable, disinterest, and discomfort about adoption and implementation of science teaching, it leads to perception of failure and creates doubt in the teachers' abilities to adopt science teaching, which weakens the formation and development of their efficacy expectations. However, if teachers feel excited, interested, and comfortable about adoption and implementation of science teaching, it leads to perception of success and provide assurance in the teachers' abilities to adopt science teaching, which enhance the formation and development of their self-efficacy. Empirical evidence from studies confirm that teachers who perceive science teaching to be relevant, enjoyable (Van Aalderen-Smeets & Walma van der Molen, 2013), comfortable, and interesting (Kazempour, 2014a) develop strong self-efficacy toward it.

Again, formation and development of teachers' efficacy beliefs are influenced by a number of contextual factors such as the social, situational, and temporal conditions under which teaching occurs (e.g., Bandura, 1977; Dira-Smolleck, 2006; Lardy & Mason, 2011; Riggs & Enochs, 1989; Van Aalderen-Smeets & Walma van der Molen, 2015). Similarly, teachers with established self-efficacy may not be able to translate it into successful teaching in classrooms because of prevailing contextual factors such as perceived lack of time and teaching materials (Van Aalderen-Smeets & Walma van der Molen, 2015).

Additionally, the formation and development of teachers' self-efficacy are influenced by demographic characteristics such as gender (Bleicher, 2004; Otieno et al., 2016; Riggs & Enochs, 1989), undergraduate science courses taken (Bleicher, 2004; Lardy & Mason, 2011; Otieno et al., 2016), years of teaching experience (Lardy & Mason, 2011; Otieno et al., 2016), grade level teaching (Lardy & Mason, 2011), age (Bleicher, 2004; Otieno et al., 2016), number of college courses taken (Bleicher, 2004), school type (Sahin et al., 2010), and school location (Page et al., 2014).

While most industrialised and industrialising countries have significant and growing population of pre-service and in-service teachers with strong efficacy expectations about inquiry-based science teaching (e.g., Lardy & Mason, 2011; Sahin et al., 2010; Van Aalderen-Smeets & Walma van der Molen, 2013, 2015) and are able to translate their self-efficacy into successful inquiry teaching in classrooms (e.g., Kazempour, 2014a; Lardy & Mason, 2011), there is little evidence in the literature of African teachers with strong self-efficacy toward inquiry-based science teaching (e.g., Arigbabu & Oludipe, 2010; Otieno et al., 2016).

Conceptual Framework for the Study

The conceptual framework developed from the literature reviewed, which is applied to the study and interpretation of science inquiry teaching and learning and challenges of inquiry teaching in selected Ghanaian districts and municipalities is presented next. Key variables or constructs that come together to form the conceptual framework are presented in Figure 1. The conceptual framework highlights key variables and relationships among the variables I investigated and considered in this study. Variables in the conceptual framework are linked by solid and broken arrow lines.

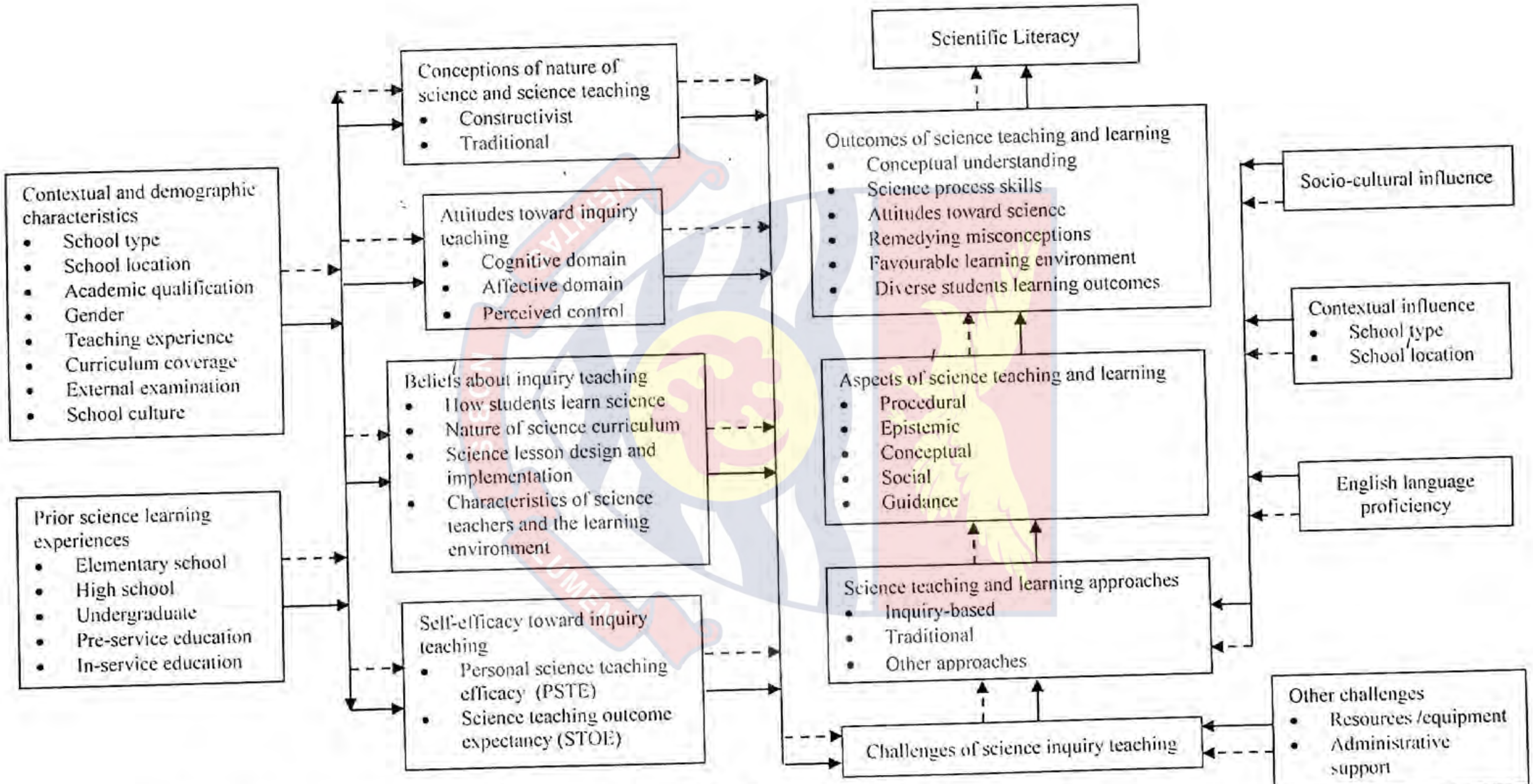

Figure 1: Conceptual framework for science inquiry teaching and learning and challenges of inquiry teaching
Source: Author's construct, Mohammed (2015)

The solid arrow lines represent inquiry-based relationships and their effects, while the broken arrow lines represent traditional relationships and their effects. This conceptual framework posits that inquiry-based activities, events, phenomena, and relationships are more effective than traditional ones. Basically, the conceptual framework includes 15 key variables which are categorised into three.

The first category includes "scientific literacy" and "outcomes of science teaching and learning". The second category includes "aspects of science teaching and learning", "science teaching and learning approaches", "socio-cultural influence", "contextual influence", and "English language proficiency". The third category includes "challenges of science inquiry teaching", "other challenges", "conceptions of nature of science and science teaching", "attitudes toward inquiry teaching", "beliefs about inquiry teaching", "self-efficacy toward inquiry teaching", "contextual and demographic characteristics", and "prior science learning experiences".

Variables in the first category represent the goal, aims, and objectives of science teaching and learning (science education); which involves students' development of scientific literacy (e.g., Grigg et al., 2013; Jegede, 1993; Shumba, 1999) and achievements of science learning outcomes. Students' achievements of science learning outcomes include development of conceptual understanding, science content knowledge, higher-order thinking and problem-solving skills, science process skills, creativity, positive attitudes toward science, dispelling science misconceptions and superstitious beliefs. This conceptual framework holds that students who are taught with inquiry-based approaches develop high levels of scientific literacy, demonstrate greater understandings and abilities to function scientifically, and achieve higher levels of science learning outcomes. In contrast, students who are taught with traditional methods develop low levels of scientific literacy, exhibit poor scientific understandings and abilities, and achieve low levels of science learning outcomes.

The second category of variables in this framework represents science teaching and learning processes, and socio-cultural and contextual factors that either facilitate or impede science teaching and learning. For students to achieve desirable learning outcomes and be scientifically literate, they need to be engaged in effective science teaching and learning experiences in favourable socio-cultural and contextual environments. Effective science teaching and learning experiences involve engagement of students in certain aspects of science; including the procedural, epistemic, conceptual, social, and guidance domains (e.g., Duschl, 2008; Furtak et al., 2012; NRC, 1996, 2000). In this study, I investigated extent of implementation of the procedural, epistemic, conceptual, social, and guidance aspects of inquiry teaching and learning in JHSs in four Ghanaian districts and municipalities. These aspects of science teaching and learning can be implemented in classrooms or lessons using certain instructional approaches, including traditional methods and inquiry-based strategies. However, this conceptual framework holds that inquiry-based strategies are more effective for implementing these aspects of science instruction than traditional methods.

The instructional approach (type of teaching and learning) employed for science lessons in a school or classroom is influenced by socio-cultural factors in the school or classroom environment; including the prevailing worldview (e.g., Anamuah-Mensah, 2012; Asabere-Ameyaw et al., 2012; Cobern & Aikenhead, 1998; Jegede, 1993; Shumba, 1999). Students in Western societies attend science classes with prior knowledge and experiences from the scientific worldview which aligns with school science experiences and facilitates the students' learning. In contrast, students in African and other non-Western societies attend science classes with prior knowledge and experiences from the traditional worldview which does not align with school science experiences and impede the students' learning. This prevents African students from developing scientific literacy (e.g., Shumba, 1999). This conceptual framework holds that employment of inquiry-based strategies is more effective for promoting meaningful learning and development of scientific literacy of African and other non-Western students than traditional methods.

Again, the instructional approach employed for science teaching and learning is influenced by contextual characteristics of the school; including the school location and school type. In this study, I investigated the interaction of school location (urban versus rural) and school type (public versus private) on implementation of inquiry-based science teaching and learning in JHSs in four Ghanaian districts and municipalities. Science teaching and learning that occurs in rural areas is different from that which occurs in urban centres. Similarly, teaching and learning that occurs in private schools is different from that which occurs in public schools (e.g. Addy, 2013; Somuah & Mensah, 2013). These contextual differences bring about differences in science achievements and learning outcomes of students in urban and rural areas, and public and private schools. However, this conceptual framework holds that inquiry-based science teaching and learning is more effective in promoting learning outcomes of and reducing the achievement gaps among diverse student groups (e.g., Balci et al., 2006; Gillies, 2008; Wolf & Fraser, 2008).

Additionally, the instructional approach (type of teaching and learning) employed for science lessons in a classroom or school is influenced by English (language) proficiency of students. While native English-speaking students have high proficiency in English language; can speak, read, and write English correctly; and participate actively in science lessons, most African students and other English Language Learners (ELLs) are not proficient in English; cannot speak, read, and write English correctly; and do not take active part in science lessons (Lee & Buxton. 2008; Stoddart et al., 2002; Stoddart et al., 2010). This impedes science learning of African students and retards their development of scientific literacy. However, this conceptual framework posits that the code-switching (mixing or alternation) of English and students' home language in the context of inquiry-based teaching and learning, can promote ELLs' science learning and development of scientific literacy, and reduce the achievement gaps between students who are fluent in English and those who are not.

The third category of variables in this conceptual framework represents challenges of inquiry-based science teaching and contextual and demographic characteristics that foster or reduce those challenges. Teachers' conceptions of the nature of science (NOS), scientific inquiry, and inquiry teaching and learning represent a factor that pose major challenges or facilitate their adoption and implementation of inquiry-based teaching in JHSs (e.g. Abd-El-Khalick, 2012; Abell & Smith, 1994; Lederman, 1999). In this study, I examined extent to which teachers' and educational administrators' conceptions of scientific inquiry, inquiry teaching and learning pose challenges to implementation of inquiry teaching in JHSs in four Ghanaian districts and municipalities. This conceptual framework holds that adequate constructivist conceptions of the nature of science, scientific inquiry, and inquiry teaching and learning is a prerequisite and facilitates effective inquiry teaching in JHSs. In contrast, uninformed conceptions of the nature of science and scientific inquiry, and traditional conceptions of science teaching and learning pose major challenges and dilemmas for inquiry-based teaching in JHSs.

Teachers' attitudes toward science and science teaching represent another factor which pose major challenges or facilitate their adoption and implementation of inquiry-based science teaching in JHSs (e.g. Van Aalderen-Smeets et al., 2012; Van Aalderen-Smeets & Walma van der Molen, 2013, 2015). Teachers' attitudes toward science teaching consist of a number of underlying components; including the teachers' perceived relevance, anxiety, difficulty, and interest in inquiry teaching. In this study I examined extent to which teachers' attitudes (anxiety, relevance, interest, and difficulty) pose challenges to implementation of inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities. This conceptual framework holds that teachers with high attitudes toward inquiry-based science teaching readily adopt and implement this instructional approach. In contrast, teachers with low inquiry-based but high traditional attitudes toward science teaching readily adopt and implement traditional science teaching.

Teachers' beliefs about science and science teaching represent another factor which pose major challenges or facilitate their adoption and implementation of inquiry-based science teaching in JHSs. A number of underlying components or constructs come together to form teachers' beliefs about science teaching. These include teachers' beliefs about "how students learn science", "nature of science curriculum", "science lesson design and implementation", and "characteristics of science teachers and the lesson environment". In this study, I examined extent to which these four components of teachers' beliefs pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities. This conceptual framework posits that teachers with strong inquiry-based beliefs about science teaching readily adopt and implement it in JHSs. In contrast, teachers with weak inquiry-based but strong traditional beliefs about science teaching readily adopt and implement traditional science teaching in JHSs.

Teachers' self-efficacy toward science teaching represents another factor which poses major challenges or facilitates the implementation of inquiry-based science teaching in JHSs. According to the theory of self-efficacy (e.g., Bandura, 1977; Riggs & Enochs, 1989) there are two underlying components of teachers' self-efficacy toward science teaching. These are Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectance (STOE). In this study, I investigated extent to which teachers' PSTE and STOE pose challenges to the adoption and implementation of inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities. This conceptual framework holds that teachers with strong self-efficacy toward inquiry-based science teaching readily adopt and implement it in JHSs. In contrast, teachers with weak inquiry-based but strong traditional self-efficacy toward science teaching readily adopt and implement traditional science teaching.

The formation and development of teachers' conceptions, attitudes, beliefs, and self-efficacy toward inquiry-based science teaching is influenced by a number of contextual and demographic characteristics; including teachers' school location, school type, academic qualification, gender, teaching experience, ethnicity, and grade level taught. In this study, I investigated how school location, school type, and academic qualification influence the formation and development of teachers' attitudes, beliefs, and self-efficacy toward science teaching. I also investigated extent to which differences in teachers' attitudes, beliefs, and self-efficacy and teacher characteristics (school location, school type, academic qualification) pose challenges to implementation of inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities.

Again, the formation and development of teachers' conceptions, attitudes, beliefs, and self-efficacy toward science teaching is influenced by the prior science learning experiences they had when they were students in elementary and secondary schools, and in teacher training and tertiary institutions. In this study, I examined how prior science learning experiences influenced the formation and development of teachers' attitudes, beliefs, and self-efficacy toward science teaching; and influenced the formation and development of teachers' and educational administrators' conceptions of scientific inquiry, and inquiry teaching and learning.

CHAPTER THREE

RESEARCH METHODS

Discussion of the research method employed for this study is presented in this chapter. This involves the research design, population, sampling procedure, and data collection instruments. The discussion also includes validity, reliability, credibility, and dependability of the instruments; as well as the data collection and analyses procedures.

Research Design

Research design is a plan that guides the investigator in collecting, analysing, interpreting, and reporting research data (e.g., Creswell, 2009, 2013; Creswell & Plano-Clark, 2007). Logical decisions taken in selecting a research design for a rigorous, high quality study include the philosophical perspective adopted by the researcher.

The Positivist Research Perspective

Traditionally, research in social science and education has been done from the positivist and interpretive perspectives (e.g., Mensah, 2012). The positivist worldview assumes that social phenomena are caused by certain circumstances; relationships between social phenomena and circumstances causing them can be discovered and understood; social phenomena and circumstances causing them are regular in nature; and that universal laws and theories can be formulated to account for and accurately predict and control social phenomena (e.g., Cohen, Manion, & Morrison, 2007; Creswell, 2003; 2009, 2013; Kusi, 2012). Positivism further assumes that social phenomena are objective realities existing out there; direct observations and experiences with social phenomena are the means for verifying hypotheses and obtaining valid and reliable knowledge; and that empirical testing of hypotheses involves collection of data through quantitative methods and measurements to produce numerical data. The numerical data are then employed in strongly confirming or refuting the hypotheses. Positivism relies on deductive and inductive reasoning to generalise observations from particular samples to populations from which the samples are drawn.

Therefore, positivist researchers proceed on studies with the purpose of discovering objective social phenomena existing out there; determining relationships between variables; and testing existing universal laws and theories independent of the researcher (Cohen et al., 2007; Creswell, 2003, 2009, 2013; Kusi, 2012). They formulate hypotheses and research questions; employ methods, instruments, and measurements to produce numerical data; analyse the data using quantitative and statistical procedures; and generalise findings from representative samples to populations from which the samples are drawn.

Criticisms levelled against positivism include ineffectiveness of its quantitative methods to generate in-depth understanding and complexity of social phenomena; and reducing human behaviours and social phenomena to mechanical occurrences governed by universal laws and theories which can be objectively studied independent of the researcher (Cohen et al., 2007; Kusi, 2012).

Part of the data collected in this study was quantitative in nature. I used quantitative methods (surveys and structured observations) and instruments (questionnaires and structured observation guides) to collect numerical data; analysed the data using descriptive and inferential statistics; determined relationships and differences between variables and groups; and generalised findings from the samples to populations from which they were drawn. However, given the limitations associated with quantitative methods and data, I complemented them with qualitative methods and data, as described in the next section.

The Interpretive/Constructivist Research Perspective

The interpretive or constructivist worldview assumes that human behaviour and social phenomena are not mechanically regular and not governed by universal laws and theories. It assumes that human beings are autonomous, with feelings, values, attitudes, beliefs, emotions, and experiences (Cohen et al., 2007; Creswell, 2003, 2009, 2013; Kusi, 2012); meanings and understandings of social phenomena are constructed by individuals in particular contexts; meanings and understandings of social phenomena are varied and can be shared; complex social phenomena and lived experiences of individuals can best be explained and understood from the point of views of those in that setting; and that social reality is subjective and not objectively independent of the knower.

As a result, interpretive researchers embark on studies with open-ended research questions; with the purpose of exploring, explaining, and obtaining in-depth understanding and varied perspectives of complex social phenomena and lived experiences. They interact directly with participants and phenomena in their natural settings; adopt qualitative methods to collect verbal and visually rich data in the form of texts, pictures, audios, and audiovisuals; and analyse the data to identify emergent themes, patterns, and categories (Cohen et al., 2007; Creswell, 2003, 2009, 2013; Kusi, 2012). As they try to identify commonalities among contexts and cases, they also strive to identify features that are peculiar to particular contexts and cases.

Criticisms levelled against interpretivism include the likelihood of researchers to introduce their personal values, emotions, attitudes, experiences, and biases into studies; difficulties in generalising findings of research from one context to another; and the small sample sizes and low statistical power associated with qualitative data.

Another part of the data collected in this study is qualitative in nature. I used qualitative methods (multiple case studies) and data collection strategies (semi-structured interviews) to gather data in the form of texts, audios, and pictures. I analysed the data to identify emergent themes, patterns, and categories; identified commonalities among the various contexts and cases, and identified unique characteristics associated with particular contexts and cases. However, given the limitations associated with qualitative methods and data, I complemented them with quantitative methods and data, as stated in the previous section.

Mixed Methods Research

Mixed methods research involves the collection of both quantitative and qualitative data in a single study (Creswell, Plano-Clark, Gutmann, & Hanson, 2003). This approach operates under the pragmatic research perspective (e.g., Creswell, 2003; 2009; 2013; Creswell & Plano-Clark, 2007; Hall, 2013). Considerations made in selecting a mixed methods design include the timing (implementation), weighting (priority), and mixing (integration) of the data (Creswell, 2003, 2009, 2013; Creswell & Plano-Clark, 2007; Creswell et al., 2003). Concurrent triangulation mixed methods design is one of the several designs available for researchers to choose (Creswell, 2003, 2009; Creswell, 2013; Creswell et al., 2003; Creswell & Plano-Clark, 2007). This design involves the collection of quantitative and qualitative data in a single phase; given of equal priority to both types of data; and integration of the data types during interpretation of the results. This design also involves the use of quantitative and qualitative data to corroborate, confirm. or cross-validate findings in a single study and to better understand the research problem. Apart from triangulating data from different methods, concurrent triangulation design allows the researcher to triangulate data from different participants, investigators, and theories (Yeasmin & Rahman, 2012).

The most notable drawbacks of concurrent triangulation mixed methods design are difficulties and efforts required to compare results from two different methods and resolve inconsistencies that may arise; and the length of time needed to collect data using two different approaches (Creswell. 2003; Creswell & Plano-Clark, 2007; Creswell et al., 2003).

In light of its strengths over its weaknesses. I employed the concurrent triangulation mixed methods design in this study. I addressed most of the research questions using both quantitative and qualitative data, and addressed one research question using only qualitative data. I collected both quantitative and qualitative data from science teachers; qualitative data from head teachers, circuit supervisors, science coordinators, deputy directors and a director of education: and quantitative data from students and classroom observations. The quantitative methods employed in this study are surveys (involving questionnaires) and structured observations. and the qualitative method is multiple case studies involving semi-structured interviews.

The collection and analyses of both types of data occurred in one phase (concurrently) but in two parts. The first part involved survey of JHS teachers' attitudes, beliefs, and self-efficacy toward science teaching. This resulted in the collection of quantitative data. The second part involved survey of JHS 2 students' ratings of inquiry teaching and learning in schools; structured observations of integrated science lessons in classrooms; and multiple case studies of 18 science teachers. 12 head teachers, four circuit supervisors, three science coordinators. three deputy directors and one director of education on issues about science teaching and learning in JHSs. The survey of students and lesson observations resulted in the collection of quantitative data. The multiple case studies resulted in the collection of qualitative data on extent of inquiry teaching and learning in JHSs: teachers' attitudes, beliefs. and self-efficacy toward inquiry teaching; teachers' and educational administrators' conceptions of scientific inquiry. inquiry teaching. and inquiry learning; and other issues connected with integrated science education in JHSs.

I gave equal priority to both types of data in addressing most of the research questions. Integration of the data occurred during presentation of the results and discussion of the findings.

The surveys enabled me to collect standardized data from large samples of teachers and students. This allowed me to determine the breadth of issues investigated in this study and facilitated the use of descriptive and inferential statistics, as well as meaningful generalizations of the findings (Ampiah, 2004; Ornstein, 2006; Wolf & Fraser, 2008). Triangulation of the quantitative results with qualitative results allowed me to empirically validate findings from the study, and gained insight, explanation, understanding, and varied perspectives into the quantitative results. The qualitative data also helped me to unravel issues I did not consider initially. The use of qualitative data to empirically validate results and findings, and provide in-depth understanding and interpretation of quantitative results has been shown to be very effective and comprehensive in many studies (e.g., Ampiah, 2004; Creswell, 2003; Drits, 2011; Grigg et al., 2013; Jeanpierre, 2006; Lardy & Mason, 2011; Wolf & Fraser, 2008).

Population

The target population consisted of all JHS 2 students, integrated science teachers, JHS head teachers, circuit supervisors, science coordinators, deputy directors and directors of education in the central region of Ghana.

Sampling Procedure

I used multistage sampling procedure in selecting the participants. In the first stage, I purposively sampled two rural districts (Ajumako-Enyan-Essiam and Ekumfi), one urban (Awutu-Senya East, Kasoa) and one urban-rural (Agona west) municipalities in the central region of Ghana. The capital town of Agona west municipality, Agona Swedru, is urban whereas other towns and villages in the municipality are rural. Therefore, I categorised data from Agona Swedru and Awutu-Senya East municipality (Kasoa) as urban data; and data from other towns and villages in Agona West municipality as well as Ajumako-Enyan-Essiam and Ekumfi districts as rural data.

In the second stage, I purposively sampled all integrated science teachers in the selected districts and municipalities. However, an actual sample of 308 teachers participated in the study. This is a large sample size comparable to those used in similar studies (Arigbabu & Oludipe, 2010; Bleicher, 2004; Sahin et al., 2010; Smith et al., 2007; Wenner, 1996). The second stage also involved purposive sampling of three science co-ordinators (SC1-SC3), four circuit supervisors (CS1-CS4), three deputy directors (DD1-DD3) and one director (D4) of education. The three deputy directors replaced directors who were not available for interviewing. One science coordinator was also not available for interviewing.

In the third stage, I randomly sampled four JHSs (two public and two private) from each district and municipality for case studies. In all, a total of 16 JHSs (eight public and eight private) participated in the study. I used MS Excel for sampling the JHSs. I sampled rural and urban schools because rural schools are characterised by low enrolment and high dropout rate; lack of/or poor science equipment; lack of and inability to attract and retain qualified science teachers; poor management and supervision of science activities; low performance in examinations; as well as lack of and poor school infrastructure (Addy, 2013). Again, most parents in rural areas are unaware of their roles in the education of their children; and they find it difficult to provide the requisite teaching and learning materials for their children. Such parents do not show much concern in the schooling of their children (Somuah & Mensah, 2013). In contrast, urban schools attract and retain qualified science teachers, have sufficient and good science equipment, have good infrastructure, and perform better in examinations. Additionally, science activities in urban schools are generally well managed and supervised. In view of the differences outlined, I expected to find differences between rural and urban JHSs and rural and urban participants in this study.

Again, I sampled private and public schools because private JHS students usually outperform their public school counterparts in external examinations; which makes people to consider private schools as better than public schools (Ampiah, 2008). Also, students in private JHSs are fluent in English and have their own textbooks for studies in and outside the school, whilst most students in public JHSs cannot express themselves fluently in English and lack textbooks for studies, especially outside the school premises (Ampiah, 2008). Due to their fluency in English and ability to read and understand texts, private school students participate actively in classroom interactions. Besides, parents who send their children to private schools appreciate the importance of education, have the means to finance their children's education, and provide adequate resources needed for the progress of the students (Sassenrath, Croce, & Penaloza, 1984). As a result of the differences outlined, I expected to find differences between public and private JHSs and participants in public and private schools in this study.

The third stage in the sampling procedure also involved purposive selection of all JHS 2 students in the case study schools. A total of 503 students participated in the study (Table 1). The sample size (503 students) is large enough and comparable to those used in similar studies (e.g., Ornstein, 2006; Wolf & Fraser, 2008). I sampled JHS 2 students because of the assumption that they had spent more than one year studying integrated science at the JHS level and were capable of distinguishing "exemplary from non-exemplary" learning environments (Wolf & Fraser, 2008, p.24), and to accurately report the extent of inquiry teaching and learning in their schools. Additionally, inquiry approach requires students to be actively involved in the teaching and learning process, and so they can accurately report whether they are given opportunities to play their roles or not. Again, students in JHS 2 were not preparing for any external examination, hence teachers employ the normal day-to-day instructional strategies in teaching these students. Therefore, observation of science lessons in JHS 2 classrooms had the potential to produce more valid results of strategies teachers normally employ in lessons.

Table 1: *Sample of JHS 2 students*

District/municipality	Public JHS 2 Students	Private JHS 2 Students	Total
Ajumako-Enyan-Essiam	49	33	82
Agona West	95	18	113
Awutu-Senya East	112	76	188
Ekumfi	82	38	120
Total	338	165	503

Source: Field data, Mohammed (2015)

The third stage further involved purposive sampling of all head teachers in the case study schools, and science teachers whose lessons were observed. A total of 18 integrated science teachers and 12 head teachers participated in this study. Four head teachers were not available for interviewing, while two additional integrated science teachers volunteered to be interviewed. I included integrated science teachers and key administrators (head teachers, circuit supervisors, science coordinators, deputy directors and director of education) directly connected with science education in JHSs because they have acquired "legitimate insider" knowledge, values, beliefs, attitudes, and dispositions from their practices as professionals (Twigg, 2010, p.42), which I could elicit to better understand issues concerned with science instruction in Ghanaian JHSs.

Instruments

I used six instruments for data collection in this study. These are:

1. Teachers' Questionnaire
2. Students' Questionnaire
3. Lesson observation Schedules A and B
4. Interview Schedule for Science Teachers
5. Interview Schedule for Head Teachers
6. Interview Schedule for Directors, Science Coordinators, and Circuit Supervisors

Teachers' Questionnaire

The teachers' questionnaire (Appendix G) is a 79-item instrument, consisting of a section on background information and three sub-instrument sections. The sub-instruments are: attitudes toward science inquiry teaching, beliefs about science inquiry teaching, and self-efficacy toward science inquiry teaching. The background section required respondents to provide information such as teacher's age, gender, qualification, years of teaching experience, type of school (public and private), school location (urban and rural), and school district.

Attitudes toward Science inquiry teaching instrument

I designed and developed this sub-instrument to rate JHS teachers' attitudes toward inquiry-based science teaching. I drew on the design and validation of attitude instruments used in past studies (e.g., Ampiah, 2004;

Buaraphan, 2011; Faulkner-Schneider, 1980; Moore & Foy, 1997; Salta & Tzougraki, 2004; Sunger, 2007; Van Aalderen-Smeets & Walma van der Molen, 2013, 2015). I designed this sub-instrument based on a priori hypothesis that teachers' attitude toward science inquiry teaching is multidimensional. Therefore, I identified components (scales) and features consistent with the literature on teachers' attitudes toward inquiry teaching. I took the design and development of this sub-instrument through stages (conceptualisation, item formulation, content validation, and construct validation) of questionnaire development outlined by Ampiah (2004).

Stage 1: Conceptualisation. In this study, teachers' attitudes toward inquiry-based science teaching is conceptualised as their perceived interest, anxiety, difficulty, and relevance of engaging students in inquiry activities (Van Aalderen-Smeets & Van der Molen, 2013, 2015). Inquiry-based activities that teachers and students experience during science lessons include procedural, epistemic, conceptual, social, and guidance tasks (Furtak et al., 2012).

Procedural tasks engage students in asking scientifically-oriented questions; planning, designing, and performing their own experiments; making measurements and observations; and manipulating materials and collecting data. Epistemic tasks engage students in examining and evaluating the quality of data; explaining and predicting scientific phenomena based on data; and learning that their own processes of science is similar to the way actual scientists work. Conceptual tasks engage students in drawing on their prior knowledge to formulate hypotheses; explaining and predicting scientific phenomena from their existing knowledge; checking their explanations to see if they are consistent with scientific knowledge; and learning science content during the process of investigations. Social tasks engage students in group work to reason and reach scientific decisions together; communicating and sharing scientific ideas with their peers; and making their ideas public through presentations, modelling, and argumentations. Guidance tasks engage teachers in facilitating students' investigations; observing and listening to students as they work; and anticipating difficulties students might encounter and devising contingency plans to deal with them.

Perceived interest involves how teachers feel excited, comfortable, and find it easy and enjoyable to engage students in inquiry-based science activities. Perceived anxiety involves how teachers feel bored, nervous, and uneasy to engage students in inquiry-based science activities. Perceived difficulty involves how teachers find it difficult to engage students in inquiry activities. Perceived relevance involves how teachers find it important and appropriate to engage students in inquiry activities.

Stage 2: Item formulation. Items formulation for this sub-instrument involved the combination of attitudinal characteristics and inquiry activities outlined in stage 1. The items are modelled along those of Attitude toward Science Teaching Questionnaire [ASTQ] (Buaraphan, 2011), revised Science Teaching Attitude Scale [rSTAS] (Sunger, 2007), and Computer Algebra System (CAS) attitude scale (Leng, 2003). Initially, I formulated 75 items to ensure availability of a large pool of items. Criteria used to guide the items construction are:

1. Avoidance of leading questions that give clues to respondents.
2. Utilisation of simple and short words that match vocabulary of

respondents, especially in the Ghanaian context.

3. Utilisation of specific items.
4. Avoidance of ambiguous words with multiple meanings.
5. Avoidance of sensitive and irritating questions.
6. Avoidance of indirect question.
7. Avoidance of words that might not be understood by respondents.
8. Construction of statements thought to cover the entire range of a scale.
9. Construction of statements that refer to the present rather than the past or future.
10. Avoidance of statements likely to be endorsed by all or none of the respondents.

The items are constructed on a 5-point Likert scale ranging from strongly disagree = 1, disagree = 2, uncertain = 3, agree = 4, to strongly agree = 5; with 1 indicating a low score and 5 indicating a high score on a scale. The statements require respondents to rate their agreements or disagreements with each item.

Stage 3: Content validation. I used extensive literature to determine content validity of the items. Additionally, I employed expert judgements from the two supervising professors to establish content validity of the items. They examined the items to check if the statements are consistent with inquiry activities and attitudinal characteristics outlined in stage 1. Furthermore, the experts examined appropriateness of wording of the items. Additionally, other lecturers and PhD students in DSME offered suggestions to improve content validity of the items, during regular presentation sessions.

After examination of the items, the supervising professors agreed on

40 items for pilot testing. I removed a total of 35 items from the initial pool for being similar to others and appeared to be measuring the same thing; and to reduce the length of the sub-instrument. I constructed three parallel forms of this sub-instrument for pilot testing in order to determine its reliability. This strategy sought to minimise fake responses from respondents (Salta & Tzougraki, 2004). The first parallel form contained statements such as: "I am interested in teaching integrated science when JHS students plan, design, and perform scientific experiments on their own". The second parallel form contained statements such as "I am interested in making JHS students plan, design, and perform scientific experiments on their own". The third parallel form contained statements such as "It is interesting to make JHS students plan, design, and perform scientific experiments on their own".

I pilot-tested the first parallel form using 39 teachers from Cape Coast metropolis and Komenda-Edina-Eguafo-Abirem (KEEA) municipality of the central region. I pilot-tested the second parallel form using 52 teachers from Mfantsiman municipality of the central region; and pilot-tested the third parallel form using 108 teachers from Sekondi-Takoradi metropolis of the western region. I purposively sampled all the teachers involved in the pilot test. I gave the questionnaires to the teachers and requested them to complete the questionnaires within three days. I went round on the third days to collect the completed questionnaires. Participants involved in the pilot test did not take part in the main study.

Stage 4: Item analyses. There was item analysis to estimate reliability of each parallel form of the sub-instrument. The analysis allowed items with low corrected item-total correlations to be identified. Removal of such items increased internal consistencies of the questionnaires.

Results of the analysis showed that each parallel form had Cronbach alpha value above the conventional reliability estimate (0.70) (Smith et al., 2007). The first parallel form had the highest reliability (0.93) with only seven items below 0.30 corrected Item-total correlations. The third form had the next high (0.78) reliability with 18 items below 0.30 corrected item-total correlations. The second parallel form had a reliability of 0.74 with 23 items below 0.30 corrected item-total correlations. Items with corrected item-total correlations above 0.3 are considered to be good for research (Van Aalderen-Smeets & Walma van der Molen, 2013). I therefore adopted the first parallel form of the sub-instrument for the main study. I retained six of the seven items with low item-total correlations because they were measuring important concepts. In all, I retained a total of 39 items for the main data collection and further refinement through factor analysis. There was slight modification in wording of the items to reduce their lengths.

Due to inadequate sample sizes of the pilot subjects for factor analysis (e.g. Field, 2005; Van Aalderen-Smeets & Walma van der Molen, 2013), there was no factor analysis prior to the main study.

Factor analysis. After the main data collection, there was confirmatory Principal Component Analysis (PCA) with varimax rotation to further refine the components and entire instrument. Like any factor analysis, PCA is an important step in establishing support for the validity of a questionnaire (e.g., Moore & Foy, 1997; Van Aalderen-Smeets & Walma van der Molen, 2013). PCA is one of the most widely used techniques in published research (e.g., Hair, Black, Babin, & Anderson, 2010; Karaman & Karaman, 2013; Salta &

Tzougraki, 2004; Sampson & Benton, 2006; Sampson et al., 2013; Van Aalderen-Smeets & Walma van der Molen, 2013; Williams, Brown, & Onsman, 2010). It leads to extraction of maximum variance from data (Yong & Pearce, 2013), and its results are comparable to those from similar techniques (e.g., Field, 2005).

The sample size (308 teachers) from the main study satisfy several criteria outlined for factor analysis (e.g. Costello & Osborne, 2005; Field, 2005; Hair et al., 2010; Williams et al., 2010). There was prior data screening to remove outliers and cases with missing values. Prior data testing also show that assumptions of normality, multicollinearity, and singularity have not been violated. There was reverse scoring of negative worded items and items reflecting traditional teaching perspectives. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (0.793) is above 0.50 and Bartlett's test of sphericity $\chi^2[(741) = 4398, p < .001]$ is significant. These confirm suitability of the data for component analysis. The six criteria relied upon to determine the number of components to rotate are: a priori hypothesis that attitudes toward science inquiry teaching is multidimensional, the number of eigenvalues greater than 1, scree plot, parallel analysis, percentage of total variance explained, and interpretability of the factor solution.

The results show 11 items with eigenvalues greater than 1. The scree plot (Figure 2) and Monte Carlo parallel analysis suggest that five and seven components respectively can be extracted for rotation. However, no proper interpretation can be given to the component solutions. Therefore, there was rotation of four interpretable principal components using varimax procedure.

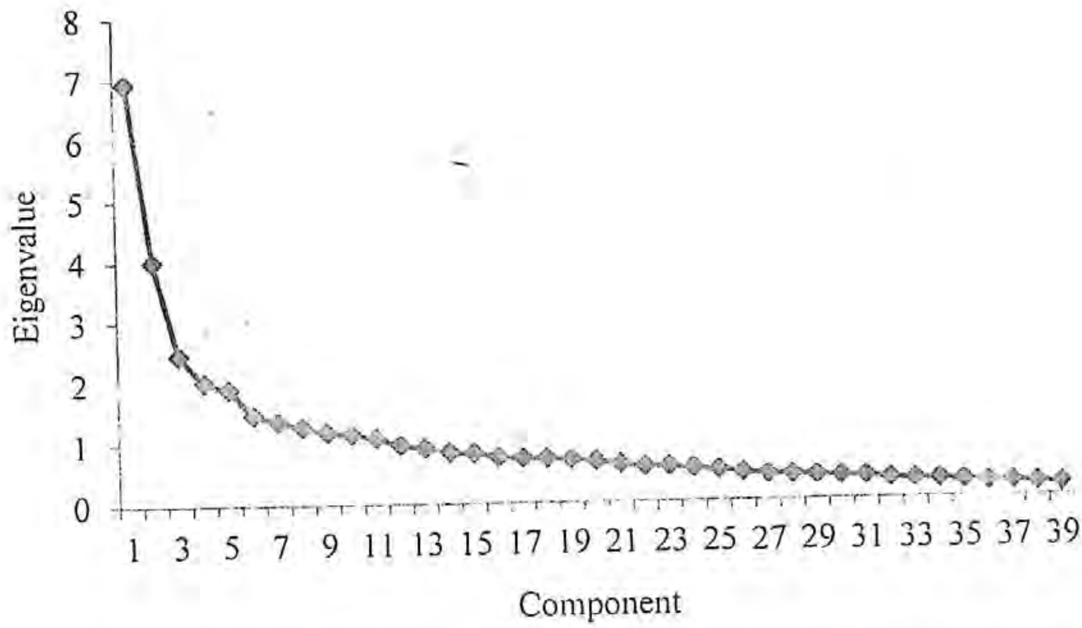

Figure 2: Scree plot of eigenvalues of attitudes toward science inquiry teaching instrument
Source: Field data, Mohammed (2015).

Table 2 shows the four rotated interpretable components. I removed twenty items (8, 9, 10, 11, 18, 19, 20, 22, 23, 24, 25, 30, 31, 32, 33, 36, 38, 40, 43 and 46) because they either exhibit cross-loadings or load onto the wrong component. I adopted the remaining 19 items which yielded four interpretable components as final version of the attitude instrument, for data analyses to answer some research questions in the main study. Item loadings on the components (0.556 - 0.840) are above 0.30, suggesting that each item contribute significantly to the total variance explained. The percentage of total variance (52.07%) explained by the four components is satisfactory for research (e.g., Hair et al., 2010) and comparable to those in similar instruments (Ampiah, 2004; Race, 2001; Salta & Tzougraki, 2004; Van Aalderen-Smeets & Walma van Molen, 2013). Results of the analysis support the a priori hypothesis that attitude toward science inquiry teaching is multivariate.

Table 2: *Rotated component matrix of final version of attitudes toward science inquiry teaching instrument*

Item number	Component 1	Component 2	Component 3	Component 4
13	.703			
29	.687			
14	.679			
37	.635			
21	.595			
26	.556			
35		.786		
34		.669		
27		.662		
28		.653		
12		.566		
16			.840	
15			.806	
39			.728	
17			.707	
42				.789
41				.766
45				.665
44				.664
% of variance explained	13.97	13.11	13.07	11.93
Eigenvalues	2.65	2.49	2.48	2.27

N = 308

1 = anxiety toward inquiry teaching, 2 = perceived relevance of inquiry teaching, 3 = interest in inquiry teaching, 4 = perceived difficulty of inquiry teaching.

Source: Field data, Mohammed (2015).

The results indicate that a large part (52.07%) of teachers' attitudes toward inquiry teaching can be explained in terms of their perceived anxiety.

relevance, difficulty, and interest in inquiry teaching. The 1st, 2nd, 3rd, and 4th, components account for 13.97%, 13.11%, 13.07%, and 11.93% of the total variance respectively. This shows that teachers' perceived anxiety, relevance, interest, and difficulty toward inquiry teaching are critical in their decisions and effectiveness in using this teaching approach. This result is consistent with the findings of Van Aalderen-Smeets and Walma van der Molen (2013, 2015) that perceived relevance, anxiety, difficulty, and enjoyment are components of teachers' attitudes toward science teaching.

Table 3 shows the four components (scales), their descriptions, and Cronbach alpha values.

Table 3: *Components, descriptions, and Cronbach alpha values of attitudes toward science inquiry teaching instrument*

Component	Description	Cronbach alpha
Anxiety	Extent to which teachers are afraid, nervous, and feel uneasy and bored in using inquiry teaching in science lessons.	0.73
Relevance	Extent to which teachers find it relevant and appropriate to use inquiry teaching in science lessons.	0.74
Interest	Extent to which teachers feel excited and find it easy and enjoyable to use inquiry teaching in science lessons.	0.78
Difficulty	Extent to which teachers find it difficult to use inquiry teaching in science lessons.	0.71
Total	Teachers' attitudes toward science inquiry teaching.	0.72

Source: Field data, Mohammed (2015). N = 308

The interest component has the highest (0.78) reliability while perceived difficulty has the lowest (0.71). All the components have alpha values above the conventional reliability (0.70) recommended by Nunnally (as cited in

Hafiz & Shaari, 2013). These indicate that the components and entire instrument have high internal consistencies and are valid and reliable for measuring teachers' attitudes toward science inquiry teaching within the Ghanaian context. This is an extension of the literature on instruments about attitudes toward science inquiry teaching.

Beliefs about science inquiry teaching instrument

I designed and developed this sub-instrument (Appendix G) to rate teachers' beliefs about inquiry-based science teaching in JHSs. This sub-instrument is designed and developed to rate extent to which teachers' beliefs align with constructivist philosophy of science teaching. The design and development of this sub-instrument is modelled along the Beliefs About Reformed Science Teaching and Learning (BARSTL) questionnaire (Karaman & Karaman, 2013; Sahin et al., 2010; Sampson & Benton, 2006; Sampson et al., 2013). Again, development of this sub-instrument is based on assumption that teachers with inquiry-based and traditional beliefs about science teaching will respond differently to items on the questionnaire.

In this study, belief about inquiry teaching is conceptualised as multidimensional and consists of four components (scales). These are beliefs about "science lesson design and implementation", "characteristics of science teachers and the learning environment", "how students learn science", and "nature of science curriculum" (e.g., Karaman & Karaman, 2013; Sahin et al., 2010; Sampson & Benton, 2006; Sampson et al., 2013). Teachers with inquiry-based beliefs about science teaching view students' prior knowledge as important and believe learning takes place through modification of students' prior knowledge. In contrast, teachers with traditional beliefs about science teaching view students' minds as tabular rasa to be filled with knowledge. They believe that learning occurs through accumulation of scientific facts and concepts. Similarly, teachers with inquiry-based beliefs consider design and implementation of science lessons as student-centred activities; with students actively planning, designing, and performing their own investigations. In contrast, teachers with traditional beliefs consider design and implementation of science lessons as teacher-centred activities; with teachers using lectures to deliver science facts and concepts students need to know. Again, teachers with inquiry-based beliefs about characteristics of science teachers consider their roles as facilitating, listening, and coaching students to construct their own knowledge. In contrast, teachers with traditional beliefs about characteristics of science teachers consider their roles as transmitting knowledge to students who are required to memorize and reproduce it when required. Again, teachers with inquiry-based beliefs about science curriculum believe that science curriculum should emphasize the development of conceptual understanding, application of knowledge, in-depth investigation of scientific phenomena, and flexibility to cater for students' questions and interests. In contrast, teachers with traditional beliefs about science curriculum believe that science curriculum should emphasize the accumulation of vast amount of fixed scientific concepts and principles.

This sub-instrument is designed and developed to rate the four components outlined. I initially constructed 48 items to cover the four components (scales). The design and development of this sub-instrument went through the same stages and processes used for the attitude instrument mentioned earlier. The two supervising professors agreed on twenty items for pilot testing. I pilot tested three parallel forms of this sub-instrument using the same samples as used for pilot testing the attitude instrument. After collecting the completed questionnaires I subjected the data to item analysis. Cronbach alpha values of the 1st, 2nd, and 3rd parallel forms were 0.64, 0.75 and 0.71 respectively. However, removal of one item from the first parallel form increased its alpha value to 0.85; showing that the first parallel form with 19 items had the highest internal consistency. I therefore adopted the first parallel form for the main data collection and further refinement through component analysis.

Factor analysis. After the main data collection, there was confirmatory PCA with varimax rotation to further refine the components (scales) and entire instrument. There was prior data screening to remove outliers and cases with missing values. Again, prior data testing shows that assumptions of normality, multicollinearity, and singularity have not been violated. There was reverse scoring of negative worded items and items reflecting traditional teaching perspectives. The KMO value (0.82) is above 0.5, and Bartlett's test of sphericity $\chi^2[(171) = 1657, p < 0.001]$ is significant; indicating that the data is suitable for component analysis.

The six criteria used to determine the number of components to extract are: a priori hypothesis that teachers' beliefs about science inquiry teaching is multidimensional, the number of eigenvalues greater than 1, scree plot, parallel analysis, percentage of total variance explained, and interpretability of the factor solution. The results show six items with eigenvalues greater than 1. The scree plot (Figure 3) and Monte Carlo parallel analysis confirm that four interpretable components can be extracted for rotation.

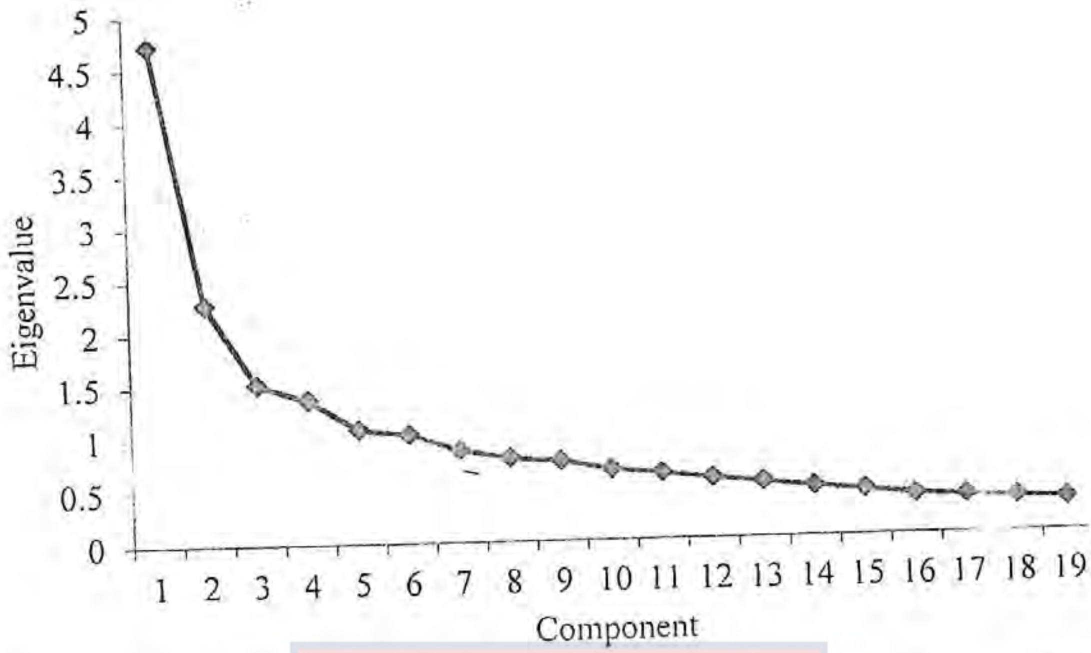

Figure 3: Scree plot of eigenvalues of beliefs about science inquiry teaching instrument
Source: Field data, Mohammed (2015).

Table 4 shows the four rotated interpretable components. I removed six items (47, 48, 50, 54, 56 and 58) from the sub-instrument either because they exhibit cross-loadings or load onto the wrong component. I adopted the remaining 13 items which produced four interpretable components as final version of the teachers' beliefs about science inquiry teaching instrument. for data analysis to answer some research questions in the main study. The extracted components are consistent with those obtained in similar studies (Karaman & Karaman, 2013; Sahin et al., 2010; Sampson & Benton. 2006; Sampson et al., 2013). This result confirms the a priori hypothesis that belief about science inquiry teaching is multidimensional. Item loadings (0.682-0.846) on the components are above 0.30 indicating that all items contribute significantly to the total explained variance.

The four components account for 66.45% of total variance in the teachers' beliefs about inquiry teaching. This is satisfactory for an educational research (Hair et al., 2010). and is consistent with variances obtained in similar studies (e.g., Sampson & Benton, 2006; Sampson et al., 2013).

Table 4: *Rotated component matrix of final version of beliefs about science inquiry teaching instrument*

Item number	Component			
	1	2	3	4
63	.832			
64	.782			
62	.692			
65	.682			
49		.831		
57		.831		
52		.819		
55			.846	
51			.800	
53			.755	
60				.826
59				.793
61				.710
% of explained variance	17.46	17.37	16.17	15.43
Eigenvalues	2.27	2.59	2.10	2.01

N = 308

1 = Beliefs about characteristics of science teachers and the learning environment, 2 = Beliefs about the nature of science curriculum, 3 = Beliefs about how students learn science, 4 = Beliefs about science lesson design and implementation.

Source: Field data. Mohammed (2015).

This result indicates that a large part of teachers' beliefs about science inquiry teaching can be explained in terms of these four components. The first, second, third, and fourth components account for 17.46%, 17.37%. 16.17%. and 15.43% of the total variance respectively. This shows that teachers' decisions and effectiveness in using inquiry teaching is critically influenced by their beliefs about "characteristics of science teachers and the learning environment", "nature of science curriculum", "how students learn science", and "science lesson design and implementation".

Table 5 shows the four components (scales), their descriptions, and Cronbach alpha values.

Table 5: *Components, descriptions, and Cronbach alpha values of beliefs about science inquiry teaching instrument*

Component	Description	Cronbach alpha
Characteristics of science teachers and the learning environment.	Inquiry-oriented teachers facilitate, listen and coach students working collectively in groups; while traditional-oriented teachers transmit knowledge to students working independently and learning by rote.	0.74
Nature of science curriculum.	Inquiry-oriented curricula concentrate on conceptual understanding and application, are flexible and change with students' questions and interests; while traditional curricula concentrate on accumulation of vast amount of fixed knowledge.	0.82
How students learn science	Inquiry learning is influenced by students' prior knowledge and learning and leads to modification of existing ideas; while traditional learning leads to accumulation of knowledge in the minds of students viewed as "blank slates".	0.77
Science lesson design and implementation	Inquiry lessons result in student-centred activities in which students manipulate materials to collect data and interpret data to explain scientific phenomena; while traditional lesson lead to transmission of facts and concepts by teachers relying heavily on textbooks.	0.74
Total	Teachers' beliefs about science inquiry teaching.	0.66

Source: Field data, Mohammed (2015). N =308.

"Nature of science curriculum" component has the highest reliability (0.82) while the entire instrument has the lowest reliability (0.66). These reliabilities are acceptable in educational research (Little et al., 1999; Kline, 2011; Suhr, 2005, 2006), indicating that items on the components and entire instrument exhibit high internal consistencies. The values further indicate that the components and entire instrument are valid and reliable for measuring teachers' beliefs about science inquiry teaching in a typical African context. This is an extension of the literature on instruments on beliefs about science inquiry teaching.

Self-efficacy toward science inquiry teaching instrument

I designed and developed this sub-instrument (Appendix G) to rate self-efficacy toward inquiry-based science teaching in JHSs. The design and development of this sub-instrument drew on the Science Teaching Efficacy Belief Instruments (STEBI A and B) (e.g., Bleicher, 2004; Dira-Smolleck, 2004; Lardy & Mason, 2011; Riggs & Enochs, 1989, 1990). However, unlike the STEBI this sub-instrument is similar to the Teaching Science as Inquiry (TSI) instrument (Dira-Smolleck et al., 2006) because of its emphasis on measuring inquiry-based teaching self-efficacy. As with the STEBI and TSI, the design and development of this sub-instrument is based on Bandura's (1977) theory of self-efficacy, which states that people are encouraged to perform an activity if they are convinced they can perform that activity (efficacy expectation) and that activity will lead to a desirable result (outcome expectancy). Hence, self-efficacy toward science teaching consists of two components (scales) – Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). Like the STEBI and TSI, this sub-instrument is designed and developed to measure these two components

(Appendix G).

Initially, I constructed thirty items to cover these two components. The construction and wording of items on this sub-instrument was guided by the same criteria as used for the construction and wording of items on the attitude and beliefs sub-instruments. Similarly, validation of items on this sub-instrument went through the same stages and processes as used for the attitude and beliefs sub-instruments. After the validation process the two professors agreed on 18 items for pilot testing. I pilot tested three parallel forms of this sub-instrument using the same samples as used for pilot testing the attitudes and beliefs sub-instruments. The first, second, and third parallel forms of this sub-instrument had Cronbach alpha values of 0.77, 0.70 and 0.64 respectively. After deleting four items with low corrected item-total correlations from the first parallel form, its Cronbach alpha value increased to 0.78. Therefore, the first parallel form had the highest reliability and exhibited the highest internal consistency. I therefore adopted it for the main data collection and further refinement through factor analysis.

Factor analysis. After the main study, there was confirmatory PCA with varimax rotation to further refine the components (scales) and entire instrument. There was prior data screening to remove outliers and cases with missing values. Prior data test also indicate that assumptions of normality, multicollinearity, and singularity have not been violated. There was reverse scoring of negative worded items and items reflecting traditional teaching perspectives. The KMO (0.759) value is above 0.5 and Bartlett's test of sphericity $\chi^2[(91) = 1028, p < 0.001]$ is significant; confirming suitability of the data for component analysis.

The six criteria used to determine the number of components to extract are: a priori hypothesis that science teaching self-efficacy is multidimensional, the number of eigenvalues greater than 1, scree plot, parallel analysis, percentage of total variance explained, and interpretability of the components solution. The results show three items with eigenvalues greater than 1. The scree plot (see Figure 4) and parallel analysis confirm that three components can be extracted for rotation. However, no proper interpretation can be given to the three-factor solution. I therefore extracted two interpretable components for rotation. I removed two items (75 and 78) from the sub-instrument because they do not load onto any component due to low communalities (.099 and .273), while removal of items 66 and 68 increased the total explained variance from 44.61% to 50.73%.

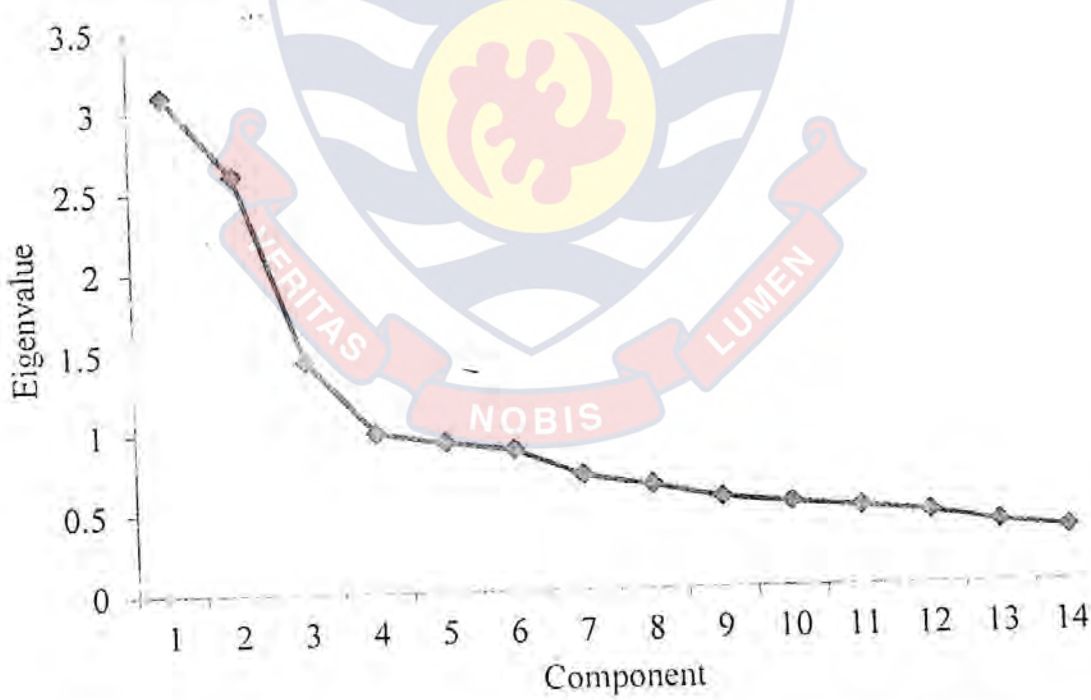

Figure 4: Scree plot of eigenvalues of self-efficacy toward science inquiry teaching instrument
Source: Field data, Mohammed (2015).

I adopted the remaining 10 items as final version of the self-efficacy toward science inquiry teaching instrument, for data analysis to answer some research questions in the main study.

Table 6 shows the two rotated interpretable components and factor loadings of items on the components.

Table 6: *Rotated component matrix of final version of self-efficacy toward science inquiry teaching instrument*

Item number	Component 1	Component 2
67	.750	
77	.708	
79	.668	
70	.647	
74	.607	
76	.481	
72		.813
71		.805
73		.765
69		.746
% of explained variance	25.44	25.29
Eigenvalues	2.54	2.53
		N = 308

1 = Science Teaching Outcome Expectancy (STOE), 2 = Personal Science Teaching Efficacy (PSTE).

Source: Field data, Mohammed (2015).

Results of the analysis confirm the a priori hypothesis that teachers' self-efficacy toward science inquiry teaching is two dimensional (PSTE and STOE). This is consistent with results found in other studies (Bleicher, 2004;

Dira-Smolleck, 2004; Dira-Smolleck et al., 2006; Lardy & Mason, 2011; Riggs & Enoch, 1989, 1990). Loadings of items on the two components (0.481-0.813) are above 0.30, suggesting that all the items contribute significantly to the total variance explained. The two components account for 50.73% of variance in the teachers' self-efficacy. This is considered to be satisfactory in educational research (e.g., Hair et al., 2010). This result indicates that a large percentage of self-efficacy toward inquiry-based science teaching can be explained in terms of teachers' PSTE and STOE. The results show also that teachers' PSTE and STOE are critical in their decisions and effectiveness in using inquiry teaching.

Table 7 shows components (scales), descriptions, and Cronbach alpha values of the self-efficacy toward science inquiry teaching instrument.

Table 7: Components, *descriptions, and Cronbach alpha values of self-efficacy toward science inquiry teaching instrument*

Component (scale)	Description	Cronbach alpha
Personal Science Teaching Efficacy (PSTE)	Teachers' beliefs in their ability to use inquiry teaching in integrated science lessons.	0.79
Science Teaching Outcome Expectancy (STOE)	Teachers' beliefs that the use of inquiry teaching in integrated science lessons can improve students' achievements and produce desirable outcomes.	0.72
Total	Teachers' self-efficacy beliefs in science inquiry teaching.	0.66

Source: Field data, Mohammed (2015). N = 308.

The Cronbach alpha values are 0.79, 0.72 and 0.66 for the PSTE, STOE, and entire instrument respectively. These reliabilities are acceptable in educational research (Kline, 2011; Little et al., 1999; Suhr, 2005, 2006) and are comparable to those in other studies (Agyei & Voogt, 2010; Ampiah, 2004; Karaman & Karaman, 2013). Reliability of the PSTE scale is higher than that of the STOE scale. This is consistent with reliability values obtained in the original STEBI (Riggs & Enochs, 1989). Compared to the STOE scale, the higher reliability associated with the PSTE scale is attributed to the fact that teachers tend to respond consistently on items affecting them personally than items on external factors over which they have little control. The alpha values show that the components and entire instrument have high internal consistencies and are valid and reliable for measuring teachers' self-efficacy toward science inquiry teaching in a typical African context. This is an extension of the literature on self-efficacy toward science inquiry teaching instruments.

Students' Questionnaire

I designed and developed this instrument to rate extent of inquiry-based science teaching and learning in JHSs. This questionnaire consists of two sections, A and B (Appendix H). Section A required students to provide their background information such as age, sex, school type (public and private), school location (rural and urban), and school district. Section B consisted of items that required JHS students to rate extent to which their teachers engage in inquiry-based science activities during lessons. Section B also required students to rate extent to which they are actively involved in inquiry-based science activities during lessons. Items on this instrument are consistent with those used in other contexts to measure inquiry teaching and learning in schools (Campbell, Abd-Hamid, & Chapman, 2010; Jeanpierre, 2006; Llewellyn, 2004; Oppong-Nuako et al., 2015; Saunders-Stewart, Gyles, & Shore, 2012; Shore, Chichekian, Syer, Aulls, & Frederiksen, 2012).

I designed and developed this instrument based on the conceptual model of inquiry teaching and learning posited by Furtak et al. (2012). This model posits that inquiry-based science teaching and learning consists of many essential and distinct but related features (Furtak et al., 2012; NRC, 1996, 2000, 2012). Furtak et al. postulated that inquiry-based science teaching and learning consist of the procedural, epistemic, conceptual, social, and guidance domains (aspects). I therefore considered inquiry-based science teaching and learning as multidimensional with five aspects (scales). I initially constructed 34 items to cover the five aspects. Design of the students' questionnaire is on a 5-point Likert scale (1 = never, 2 = a few lessons, 3 = half the lessons, 4 = most lessons, and 5 = all the lessons). The items required students to rate how often inquiry-based science activities occurred during teaching and learning in JHSs. The criteria used to guide construction and wording of items on this instrument are the same as that used for construction and wording of items on the attitudes, beliefs, and self-efficacy instruments mentioned earlier. Additionally, I shortened the length of items on this instrument and simplified the language for students' understanding.

I used extensive literature and expert judgements from the two supervising professors to establish content validity of the items. Other lecturers and PhD students in DSME of UCC also offered suggestions, during regular presentation sessions, to improve content validity of the items. I pilot tested this instrument using 152 JHS 2 students from eight public and private

JHSs in urban and rural areas of KEEA municipality. Students involved in the pilot test did not take part in the main study. I administered the questionnaires to students with assistance from some science teachers. I seated all the sampled students in their classrooms and gave them the questionnaires to complete. After completing the questionnaires I collected them for item analysis using SPSS (version 16).

Cronbach alpha values for the procedural, conceptual, epistemic, social and guidance components and the entire instrument were 0.67, 0.77, 0.76, 0.73, 0.90, and 0.80 respectively. All the reliability values were adequate and acceptable for educational research (e.g., Kline, 2011; Little et al., 1999). This indicated that items constituting the components (scales) and entire instrument were highly internally consistent. This further indicated that the scales and entire instrument were valid and reliable for rating inquiry-based science teaching and learning in JHSs. I therefore adopted the instrument for the main data collection and further refinement through component analysis.

Component analysis. After the main study, there was confirmatory PCA with varimax rotation to further refine the components (scales) and entire instrument. The sample size (503 students) is adequate for component analysis (e.g., Field, 2005; Williams et al., 2010). There was prior data screening to remove outliers and cases with missing values. Prior data test also indicate that assumptions of normality, multicollinearity, and singularity have not been violated. There was reverse scoring of negative worded items and items reflecting traditional teaching perspectives.

The KMO (0.869) value is above 0.5 and Bartlett's test of sphericity $\chi^2[(561) = 5515, p < 0.001]$ is significant, confirming suitability of the data for component analysis. The six criteria used to decide the number of components to extract are: a priori hypothesis that inquiry-based science teaching and learning is multivariate, the number of eigenvalues greater than 1, scree plot, parallel analysis, percentage of total variance explained, and interpretability of the rotated solution. The results show nine components with eigenvalues greater than 1. The scree plot (Figure 5) suggests that either five or seven components can be retained, while parallel analysis suggests that six components can be retained. However, no proper interpretation can be given to the six and seven component solutions. Therefore, I retained five interpretable components (scales).

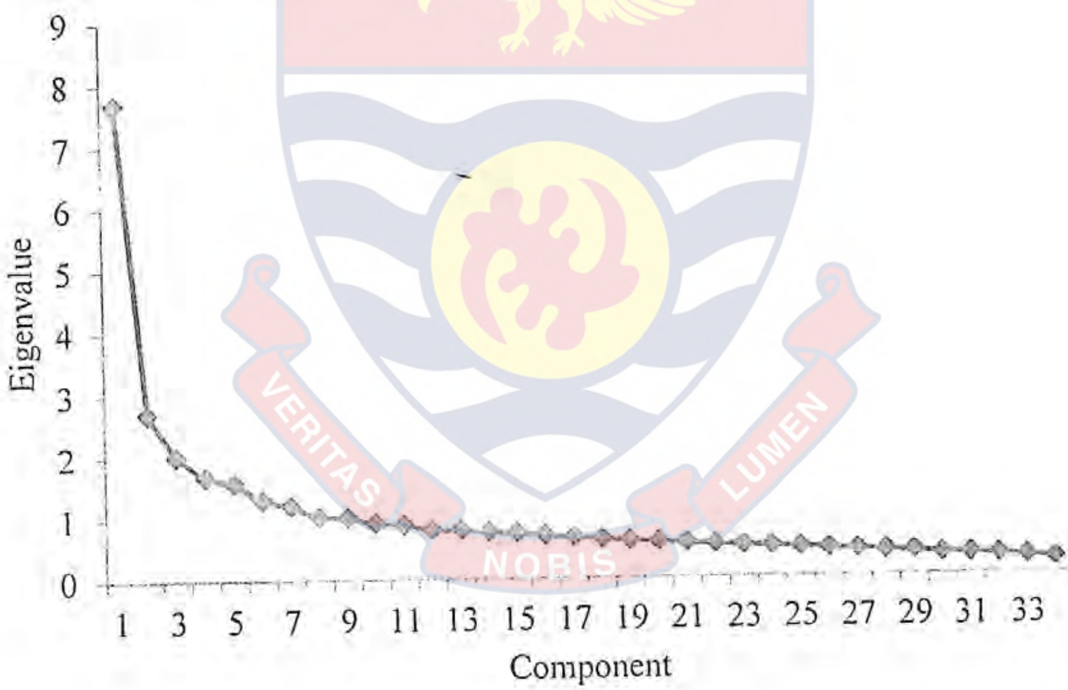

Figure 5: Scree plot of eigenvalues of components of students' questionnaire
Source: Field data. Mohammed (2015).

Table 8 shows the five rotated interpretable components. I removed item 34 from the instrument because it does not load onto any component. I also removed items 8, 11, 14, 15, 18, 19, 20, 21, 24, 30, 36, 37, and 39 either because they exhibit cross-loadings or load onto the wrong component.

Table 8: *Rotated component matrix of final version of students' questionnaire*

Item number	Component				
	1	2	3	4	5
25	.764				
28	.718				
26	.698				
27	.641				
29	.597				
33		.774			
35		.732			
32		.680			
31		.639			
38		.638			
7			.774		
9			.737		
10			.722		
6			.686		
13				.819	
12				.800	
17				.799	
22					.865
16					.843
23					.698
% of explained variance	13.38	12.64	11.86	11.70	10.40
Eigenvalues	2.67	2.53	2.37	2.34	2.08

N = 503

1 = social domain, 2 = guidance domain, 3 = procedural domain, 4=conceptual domain, 5 = epistemic domain.

Source: Field data, Mohammed (2015).

I adopted the remaining 20 items as final version of the students' questionnaire, for data analysis to answer some research questions in the main study. Results of the PCA confirm the conceptual model posited by Furtak et al. (2012) that there are five aspects of inquiry-based science teaching and learning. These are: social, guidance, procedural, conceptual, and epistemic domains. Item loadings (0.597-0.865) on the components are above 0.30, suggesting that all the items contribute significantly to the total variance explained. The five components account for 59.95% of total variance inquiry teaching and learning activities. This is considered to be a large variance in educational research (e.g., Hair et al., 2010). This shows that inquiry-based science teaching and learning can largely be assessed in terms of the five domains.

The 1st, 2nd, 3rd, 4th, and 5th components account for 13.36%, 12.64%, 11.86%, 11.70% and 10.40% respectively. This shows that the social interactions among students working in groups, guidance provided by teachers, procedures students follow, conceptual understandings exhibited by students, and epistemic activities of students during investigations are critical aspects of inquiry-based science teaching and learning.

Table 9 shows the five components (scales), their descriptions and Cronbach alpha values. All the Cronbach alpha values are above the conventional reliability estimate (0.7), indicating that items on the scales and entire instrument exhibit high internal consistencies. This further shows that the components and instrument are valid and reliable for rating extent of inquiry teaching and learning in a typical African context. This is an extension of the literature on instruments for assessing science inquiry teaching and learning.

Table 9: Components, *descriptions, and Cronbach alpha values of final version of students' questionnaire*

Scale	Description	Cronbach alpha
Social domain	Students working collectively in groups to construct, share, and communicate scientific ideas and understandings.	0.78
Guidance domain	Teachers facilitating, coaching, and listening as students undertake scientific investigations.	0.74
Procedural domain	Students asking scientifically-oriented questions; and planning and performing experiments to collect and record data.	0.74
Conceptual domain	Students formulating hypotheses, giving and considering alternative explanations to science phenomena based on their prior knowledge.	0.83
Epistemic domain	Students examining and evaluating the quality of data, and explaining science phenomena based on data (evidence).	0.76
Total	Extent of science inquiry teaching and learning	0.73

Source: Field data, Mohammed (2015). N = 503.

Lesson Observation Schedules A and B

I designed and developed these instruments to observe and rate inquiry-based science teaching and learning in JHS classrooms. The design and development of these instruments (Appendices I and J) drew on the Reformed Teaching Observation Protocol (RTOP) (e.g., Cianciolo et al., 2006; Sawada, Piburn, Falconer, Turley, Benford, & Bloom, 2000; Temiz & Topcu, 2014). The RTOP has been used widely in studies to observe and assess science teaching and learning in schools (e.g., Lardy & Mason, 2011).

The RTOP is multidimensional consisting of three components (scales). These are: lesson design and implementation, content, and classroom culture. Examination of components of the RTOP shows that they are consistent with the five aspects (domains) of inquiry posited by Furtak et al.

(2012). Therefore, the design and development of the lesson observation schedules is based on the conceptual model posited by Furtak et al. I constructed 28 items to cover the five scales. Both observation schedules A and B consist of two sections and contain the same kind of items. Section A is designed to elicit demographic information while section B is designed to observe and rate inquiry-based science teaching and learning in classrooms. Demographic information elicited include school location (rural and urban), school type (public and private), classroom enrolment (boys and girls), teachers' gender, teaching experiences of teachers, teachers' qualifications, topic observed, class observed, date of observation, and period (length) of lesson observed.

Observation schedule A is designed on a momentary event sampling format while observation schedule B is designed on a 5-point Likert scale format. Observation schedule A is designed for recording specific activities that occur at 1 minute intervals over the entire period of a lesson. Only activities observed from teachers and students are recorded. Results from observation schedule A are then used to complete observation schedule B. Ratings on observation schedule B range from 1 = never, 2 = rarely, 3 = sometimes, 4 = often, to 5 = very often; with 1 indicating complete absence of an activity and 5 indicating very frequent occurrence of an activity during lesson. The criteria used to guide construction and wording of items on the observation schedules are the same as that used for construction and wording of items on the attitudes, beliefs, self-efficacy, and students' questionnaires mentioned earlier. Additionally, the processes used for establishing content validity of the observation schedules are the same as that used for establishing content validity of the attitudes, beliefs, self-efficacy, and students' questionnaires.

I pilot tested the instruments through the observations of 10 science lessons in four JHS 2 classrooms in KEEA municipality. The Cronbach alpha (0.61) was acceptable for educational research (e.g., Little et al., 1999; Suhr, 2005, 2006). This suggested that items on the observation schedules are internally consistent and the instrument is valid and reliable for observing and rating science lessons. I therefore adopted the observation schedules for data collection in the main study.

There were 31 lesson observations in 16 JHS 2 classrooms during the main study (Appendix N). Analysis after the main study show that item 27 has low corrected item-total correlation. Its removal increased the Cronbach alpha to 0.74. This further shows that lesson observation schedule B has high internal consistency and is valid and reliable (e.g., Kline, 2011). I therefore adopted the remaining 27 items as final version of lesson observation schedule B, for data analysis to answer some research questions in the main study.

Interview Schedules for Science Teachers, Head Teachers, Circuit Supervisors, Science Coordinators, and Directors of Education

I designed three separate semi-structured interview schedules for data collection in the study. These are: Interview schedule for science teachers; Interview schedule for head teachers; and Interview schedule for directors, science coordinators, and circuit supervisors. Each interview schedule has two sections, A and B. Section A is designed to elicit demographic information such as respondent's age, gender, qualification, school type (public and private), school location (rural and urban), school district, and working experience. Section B contain items to elicit extent of science inquiry teaching and learning in JHSs; teachers' and educational administrators' conceptions of inquiry teaching and learning; and teachers' attitudes, beliefs, and self-efficacy toward inquiry-based science teaching. Section B also contains items to elicit respondents' educational and professional development experiences. Each interview schedule is designed to elicit information on the same general issues and themes from particular group of respondents. However, the interview schedules are flexible to allow for issues and themes initially not considered to emerge from interviews (Jacob & Furgerson, 2012; Kajornboon, n.d; Turner, 2010).

Most of the items on the interview schedules are open-ended, which allow respondents to fully express their view points and experiences and to provide detailed information. The items also contain potential probes, prompts, and follow-ups, which allow the interviewer to explore issues from various perspectives. Flexibility in the interview schedules also allow the order of questions to be changed, based on responses from respondents.

I pilot tested the interview schedules using six science teachers, three head teachers, one circuit supervisor, one science coordinator, and one deputy director of education from the KEEA municipality. The pilot testing allowed questions that could elicit credible and dependable responses to be identified. The pilot test also enabled me to identify effective probes, prompts, and follow-up questions that could make respondents elaborate and clarify their responses; and to explore new paths initially not considered. The pilot test further enabled me to check the working conditions of my audio recording equipment, and identified potential problems that could arise during the interviewing process. This made me developed contingency plans to handle problems in the main study. After the pilot test I made modifications in wording of some of the questions to remove ambiguities, and removed redundant questions that were eliciting the same responses as others. I then adopted the modified schedules as final versions of instruments for interviews in the main study. The modified interview schedules are shown in appendices K, L, and M respectively.

Data Collection Procedure

I obtained an introductory letter (Appendix A) from DSME of UCC and made many copies of it. I attached copies of the introductory letter to copies of an application letter and consent form (Appendix B). to seek approval from directors of education in the four districts and municipalities to conduct the study in schools under their jurisdiction. I collected lists of all JHSs in the districts and municipalities after getting permissions from the directors of education (see Table 10).

Table 10: *Number of JHSs in selected districts and municipalities*

District/Municipality	Type	Public JHSs	Private JHSs	Total
Ajumako-Enyan-Essiam	Rural	76	12	88
Agona West	Urban-rural	59	37	96
Awutu-Senya East	Urban	26	213	239
Ekumfi	Rural	72	11	83
Total		233	273	506

Source: Field data, Mohammed (2015)

Again, I contacted science coordinators and some circuit supervisors in the districts and municipalities to inform them about my study, and sought their cooperation and participation in the study. I attached copies of the introductory letter to copies of another application letter and consent form (Appendix C) and signed permission letters from the directors to seek further permission from head teachers of the selected JHSs. After giving me permissions, the head teachers introduced me to science teachers and JHS 2 students in their schools, and asked them to give me their cooperation. I established rapport with the participants, which facilitated the conduct of this study.

The data collection occurred in one phase but two parts. The first part involved administration of questionnaires to JHS science teachers in the four districts and municipalities. I distributed the questionnaires to the teachers and asked them to complete the questionnaires within three days. On the third days I went round to collect the completed questionnaires. Out of the 352 distributed questionnaires, the teachers completed and returned 308 to me. This represent 87.50% return rate. I made several attempts to retrieve the uncompleted questionnaires before I finally abandoned them. The first part of the data collection started from early September to late December, 2014.

The second part of the data collection involved multiple case studies in 16 JHSs. This involved questionnaires administration to JHS 2 students, science lesson observations, and semi-structured interviews with science teachers and head teachers. With the help of some science teachers, I administered questionnaires to all JHS 2 students who were present in the schools. I seated all the students in their classrooms and gave out the questionnaires to them. I then gave them instructions on how to complete the questionnaires. I read the items aloud to the students, with translation into the local language where necessary. I then allowed the students to respond to the items on their own. I collected the questionnaires after the students had completed them. I administered a total of 503 questionnaires to students. Reports from the teachers indicated that few students were absent in the schools during the questionnaire administration. This indicates a high participation of students in the study.

Additionally, I observed and rated science lessons in one JHS 2 classroom for a period of one week in each school. Most of the observed lessons lasted about 70 minutes. I fully observed and rated a total of 31 lessons (Appendix N).

I also conducted individual face-to-face semi-structured interviews with the sixteen (T1-T16) science teachers I observed their lessons. I conducted additional interviews with two other science teachers (T17-T18) who volunteered to be interviewed. Besides, I interviewed 12 head teachers (HT1-HT12) of the case study schools. Four head teachers were not available for interviewing. The second part of the data collection also involved individual face-to-face semi-structured interviews with four circuit supervisors (CS1-CS4), three science coordinators (SC1-SC3), three deputy directors (DD1-DD3) and one director (D4) of education. I sought the consent of each interviewee prior to the interview. We agreed on convenient dates, times, and places for the interviews. I gave consent forms (Appendices D, E, F) to the respondents before the interviews started. The consent forms contained explanation of the purpose of the interviews and assurance of respondents' anonymity, confidentiality, privacy, and rights to refuse or withdraw from the interviews. I established sufficient rapports and trust with the respondents prior to the interviews. These enhanced the conversations and enabled participants to talk freely and gave out credible and dependable information. The interviews started with simple background questions which were meant to warm-up and build further trust with the interviewees. The interview questions were open-ended. This allowed the respondents to fully express their views and experiences in detail.

Interviews with each group of participants covered the same general issues and themes. This facilitated fair comparisons of the case studies. However, the use of probes, prompts, and follow-up questions allowed issues that emerge from the interviews to be explored further. The use of probes, prompts, and follow-up questions also allowed the interviewees to clarify and elaborate on their responses. Flexibility in the interviews allowed me to change the order of the questions, based on responses from the participants. I remained neutral throughout the interviews to avoid influencing responses from the participants. I conducted, recorded, and transcribed all the interviews alone. Most of the interviews lasted about 1 hour, with a few lasting more or less than an hour. The second part of the data collection started from early January to the end of February, 2015.

Data Processing and Analysis

Analyses of the quantitative data began with data entry into SPSS (version 16) software, followed by prior screening to remove outliers and cases with missing values; while analysis of the qualitative data started with transcription of audio recordings of all the interviews, followed by auditing and editing of the interview transcripts. I then imported all the interview transcripts into Nvivo (version 8) software for coding. The coding occurred through an inductive process. This allowed all the codes to emerge from the data itself. The coding process also involved reading of each transcript several times. This enabled every relevant piece of information, idea, issue, theme, and category in the data to be identified.

Providing answers to research question one involved analysis of extent of implementation of inquiry-based science teaching and learning in JHSs. This also involved calculation of average item means, average item standard deviations, frequencies, and percentages of items constituting the five aspects of inquiry. Average item mean is the scale (domain/aspect) mean divided by the number of items in a scale (domain/aspect), while average item standard deviation is the scale standard deviation divided by the number of items in a scale (Wolf & Fraser, 2008). Quantitative data for calculating the descriptive statistics are from the students' ratings of inquiry teaching and learning in JHSs, and my ratings from classroom observations of inquiry teaching and learning in JHSs. The analysis also involved triangulation of descriptive statistics from the quantitative data with emergent themes, patterns, and sample quotes from thematic analysis of interview responses on extent of inquiry teaching and learning in JHSs. Qualitative data for the thematic analysis are from interview responses of science teachers, head teachers, circuit supervisors, science coordinators, deputy directors and a director of education.

Providing answers to research question two involved analysis of the interaction of school location and school type on implementation of inquiry-based science teaching and learning in JHSs. This also involved conducting Two-way Multivariate Analysis of Variance (MANOVA) with school type (public and private) and school location (rural and urban) as independent variables and aspects (components) of inquiry (social, procedural, epistemic, conceptual, and guidance) as dependent variables. It also involved calculating means and standard deviations of items constituting the aspects of inquiry for public and private JHSs in urban and rural areas. Quantitative data for the two-way MANOVA are from the students' ratings of inquiry teaching and learning in JHSs. The analysis also involved triangulation of results from the Two-way MANOVA with results from classroom lesson observations and interview responses of teachers and educational administrators. Prior analysis to the two-way MANOVA show that assumptions of normality, multicollinearity, linearity, equality of variance and covariance have not been violated.

Providing answers to research question three involved analysis of extent to which teachers' and educational administrators' conceptions of inquiry pose challenges to inquiry-based science teaching in JHSs. This also involved determination of extent to which the interviewees held uninformed, partially informed, or fully informed constructivist conceptions of inquiry that impede or facilitate inquiry teaching. This further involved using emergent themes, patterns, categories, and sample quotes from the interviewees' responses to determine their conceptions of scientific inquiry, inquiry teaching, and inquiry learning. Comparison of the emergent themes, patterns, and categories with literature on the constructivist philosophy of scientific inquiry and inquiry teaching and learning allowed determination of extent to which the participants' held uninformed, partially informed, or fully informed constructivist conceptions of inquiry.

Providing answers to research question three also involved analyses of extent to which teachers' attitudes, beliefs, and self-efficacy pose challenges to inquiry-based science teaching in JHSs. This also involved calculation of average item means, average item standard deviations, frequencies, and percentages of items constituting components of attitudes, beliefs, and self-efficacy toward inquiry teaching. Quantitative data for calculating the descriptive statistics are from the teachers' ratings of their attitudes, beliefs, and self-efficacy. The analyses also involved triangulation of results from the descriptive statistics with qualitative themes, patterns, and sample quotes from interview responses on attitudes, beliefs, and self-efficacy toward inquiry teaching, collected from a subsample of the teachers.

Providing answers to research question four involved analysis of extent to which differences in attitudes, beliefs, and self-efficacy of teachers and teacher characteristics pose challenges to inquiry teaching in JHSs. This also involved conducting One-way Multivariate Analysis of Variance (MANOVAs) with gender, school location, school type, and teaching qualification as independent variables and components of attitudes, beliefs, and self-efficacy as dependent variables respectively. Prior analyses to the MANOVAs show that assumptions of normality, multicollinearity, linearity, equality of variance and covariance have not been violated. The analyses further involved calculation of means and standard deviations of items constituting the components of attitudes, beliefs, and self-efficacy for teachers with different demographic characteristics. Quantitative data for conducting the MANOVAs and calculating descriptive statistics are from the teachers' ratings of their attitudes, beliefs, and self-efficacy toward inquiry teaching. The analyses also involved triangulation of results from the One-way

MANOVAs and descriptive statistics with qualitative themes, patterns, and sample quotations from interview responses on attitudes, beliefs, and self-efficacy, collected from a subsample of the teachers.

CHAPTER FOUR

RESULTS AND DISCUSSION

The purpose of this study was to investigate extent of implementation of inquiry-based science teaching and learning in JHSs in four Ghanaian districts and municipalities; and extent to which teachers' and educational administrators' conceptions of inquiry and teachers' attitudes, beliefs, and self-efficacy pose challenges to inquiry-based science teaching in JHSs. This study also investigated extent to which differences in attitudes, beliefs, and self-efficacy of teachers and teacher characteristics pose challenges to inquiry-based science teaching in JHSs.

I used the concurrent triangulation mixed methods design to collect both quantitative and qualitative data. The quantitative data from large samples of students and teachers allowed me to explore the extent of implementation of inquiry teaching and learning in JHSs, and the extent to which teachers' attitudes, beliefs, and self-efficacy pose challenges to inquiry teaching. Part of the qualitative data allowed me to empirically corroborate results and findings from the quantitative data, gained insight and offer valid interpretations of the findings, and identified emergent issues initially not considered. Other part of the qualitative data allowed me to explore conceptions of teachers and educational administrators that pose challenges to the implementation of inquiry teaching in JHSs. Apart from science teachers and JHS students, I collected data from head teachers, circuit supervisors, science coordinators, deputy directors and a director of education in four districts and municipalities in the central region of Ghana. The results and findings, and their discussion are presented in this chapter. The presentation is ordered according to the four research questions used to guide the study. Presentation of the results and discussion begins with demographic characteristics of the respondents.

Demographic Characteristics of Respondents

A. Teachers' Demographics

Table 11 shows demographic characteristics of science teachers in this study.

Table 11: *Demographic characteristics of science teachers*

Demographics	Private JHSs n(%)	Public JHSs n(%)	Total n(%)
Gender			
Male	125(45.13)	152(54.87)	277(100.00)
Female	7(22.58)	24(77.42)	31(100.00)
Qualification			
Certificate	106(53.00)	94(47.00)	200(100.00)
Graduate	25(23.81)	80(76.19)	105(100.00)
Post-graduate	1(33.33)	2(66.67)	3(100.00)
Teaching experience			
1 – 5 years	95(53.37)	83(46.63)	178(100.00)
6 – 10 years	30(37.98)	49(62.03)	79(100.00)
11 – 15 years	7(15.91)	37(84.09)	44(100.00)
16+ years	0(0.00)	7(100.00)	7(100.00)
School location			
Urban	114(69.94)	49(30.06)	163(100.00)
Rural	18(12.41)	127(87.59)	145(100.00)

Source: Field data, Mohammed (2015) N = 308

Most of them were males 277(89.94%) with just a few females 31(10.07%). This confirms the assertion that science education and science-related careers are male dominated (e.g., Patrick, 2012). Most of the teachers 200(64.94%) were certificate holders with Diploma in Basic Education (DBE), Teachers'

Certificate “A”, SSCE, WASSCE, and the like. More than half of the certificate teachers 106(53.00%) were in private JHSs, suggesting that private school proprietors do not usually recruit teachers with higher qualifications. Only 3(0.97%) post graduate teachers with MED, MSC, and MA certificates were teaching in JHSs. More than half of the teachers 178(57.79%) were novices with between 1 to 5 years of teaching experience; and only 7(2.27%) had more than 15 years teaching experience, with all of them working in public schools. Most of the private school teachers 114(86.36%) were in urban centres, with 88 of them in Awutu-Senya East municipality (Kasoa) alone. Mean age of the science teachers was 28.73 (SD = 6.54) years, with males (M = 28.90, SD = 6.56 years) being older than females (M = 27.16, SD = 6.17 years). While public school teachers (M = 31.36, SD = 6.12 years) were older than private school teachers (M = 25.22, SD = 5.33 years), rural school teachers (M = 29.64, SD = 5.57 years) were older than urban school teachers (M = 27.91, SD = 7.21years).

B. Students' Demographics

Table 12 shows demographic characteristics of JHS 2 students in the study. More than half of them 261(51.89%) were females, confirming the claim that there is gender parity in enrolment at the basic education level in Ghana (MoE, 2012). This large number of girls being exposed to science education at an early stage is consistent with the finding that more females are currently opting to enrol in science disciplines in secondary schools (e.g., Patrick, 2012). Most of the students 301(59.84%) were in urban centres, confirming the statement that urban schools usually record high enrolments (e.g., Addy, 2013).

Table 12: *Demographic characteristics of JHS 2 students*

Demographics	Private JHSs	Public JHSs	Total
	n(%)	n(%)	n(%)
Gender			
Male	92(38.02)	150(61.98)	242(100.00)
Female	73(27.97)	188(72.03)	261(100.00)
School location			
Urban	94(31.23)	207(68.77)	301(100.00)
Rural	71(35.15)	131(64.85)	202(100.00)

Source: Field data, Mohammed (2015) N = 503

C. Educational Administrators' Demographics

Key educational administrators involved in this study were one director and three deputy directors of education, four circuit supervisors, three science coordinators, and 12 head teachers. The director and three deputy directors were males. Their ages ranged 49-57 years. They had 28-34 years of working experiences in the Ghana Education Service (GES). Two deputy directors had BSC and BED qualifications, the other deputy director had MPhil qualification, while the director had MED qualification. Two deputy directors were from rural districts, the other was from an urban municipality, and the director was from an urban-rural municipality.

Two circuit supervisors were females (50.00%) and the other two were males (50.00%). Ages of the circuit supervisors ranged 46-50 years and they all had BED qualifications. They had 26-28 years of working experiences in the GES.

Two science coordinators were males (66.67%) and one was a female

(33.33%). Two had BED (66.67%) and one had MSC (33.33%) qualifications. They had 5-15 years of working experiences in the GES. Their ages ranged 35-46 years.

Most of the head teachers were males 8(66.67%) with 4(33.33%) being females. Eight (66.67%) were from public and 4(40.00%) from private JHSs. Ages of the head teachers ranged 24-58 years. Public JHS head teachers (M = 46.57 years) were older than private JHS head teachers (M = 41.00 years). Most public school head teachers had BED qualifications with two having BCOM and BMGT. All head teachers in public JHSs were professionally trained. Only one private JHS head teacher had BED qualification and was professionally trained; the remaining three had no professional training and were holders of MSLC, WASSCE, and O' Level, qualifications. Most of the head teachers had 9-36 years of working experiences in education, with one having three years and another having four years working experiences.

Research Question 1: What is the extent of implementation of inquiry-based science teaching and learning in JHSs in four Ghanaian districts and municipalities?

Answering this research question involved determining extent of implementation of five aspects of inquiry-based science teaching and learning (procedural, epistemic, conceptual, social, and guidance domains) in JHSs in the four districts and municipalities; using quantitative data from students' ratings of procedural, epistemic, conceptual, social, and guidance activities during lessons. I then triangulated the quantitative results with quantitative results from my ratings of classroom observations of procedural, epistemic, conceptual, social, and guidance activities in the JHSs; and qualitative results from teachers' and educational administrators' interview responses on science teaching and learning in JHSs.

Table 13 shows average item means and average item standard deviations of students' ratings of science procedural, epistemic, conceptual, social, and guidance activities in the JHSs.

Table 13: *Average item means and average item standard deviations of students' ratings of science procedural, epistemic, conceptual, social, and guidance activities in JHSs*

Aspect/domain of inquiry teaching and learning	No of items	Min	Max	Average item mean	Average item standard deviation
Social	5	1	5	2.48	1.03
Guidance	5	1	5	1.99	0.87
Epistemic	3	1	5	1.97	0.92
Conceptual	3	1	5	1.91	0.99
Procedural	4	1	5	1.46	0.60
Overall inquiry	20	1	5	1.99	0.48

Note: high mean is inquiry-based, low mean is traditional-oriented N = 503

Source: Field data, Mohammed (2015)

Overall, the students' ratings show that implementation of inquiry-based science teaching and learning in the JHSs occurred in only a few lessons per term (M = 1.99, SD = 0.48). While inquiry-based guidance (M = 1.99, SD = 0.87), epistemic (M = 1.97, 0.92), and conceptual (M = 1.91, SD = 0.99) activities were implemented in a few lessons per term, there appeared to be no implementation of inquiry-based procedural activities (M = 1.46, SD = 0.66) in the JHSs. Again, while there was considerable implementation of inquiry-based social activities (M = 2.48, SD = 1.03), it was largely traditional science social activities that were implemented in the JHSs.

Most of the students' ratings show that they never engaged in inquiry-based procedural activities such as planning and designing their own experiments 401(79.7%), performing their own experiments 357(71.0%), and collecting and recording their own data 333(66.2%) during science lessons (Table 14). Only 79(15.7%) students' ratings show that they planned and designed experiments in a few lessons, while 119(23.7%) ratings show that the students performed experiments in a few lessons.

Table 14: *Frequencies and percentages of students' ratings of science procedural, epistemic, conceptual, social, and guidance activities in JHSs*

Activities	Responses per tem				
	Never	In a few lessons	In half the lessons	In most lessons	In all lessons
	n(%)	n(%)	n(%)	n(%)	n(%)
Procedural					
Student plans and designs experiments.	401(79.7)	79(15.7)	15(3.0)	5(1.0)	3(0.6)
Student Performs experiments.	357(71.0)	119(23.7)	18(3.6)	2(0.4)	7(1.4)
Student handles and uses science equipment and materials.	284(56.5)	157(31.2)	29(5.8)	19(3.8)	14(2.8)
Student collect and record data.	333(66.2)	116(23.1)	23(4.6)	24(4.8)	7(1.4)
Epistemic					
Student explains phenomena based on data.	251(49.9)	139(27.6)	51(10.1)	31(6.2)	31(6.2)
Student learns science concepts through experimentation.	135(26.8)	228(45.3)	56(11.1)	42(8.3)	42(8.3)
Student change old understanding based on data.	262(52.1)	160(31.8)	40(8.0)	32(6.4)	9(1.8)

(Table 14,continued).

Conceptual					
Student formulates hypotheses for science phenomena.	279(55.5)	124(24.7)	58(11.5)	24(4.8)	18(3.6)
Student explains phenomena based on prior knowledge.	262(52.1)	136(27.0)	48(9.5)	26(5.2)	31(6.2)
Student learns concepts in the processes of science.	193(38.4)	184(36.6)	45(8.9)	47(9.3)	34(6.8)
Social					
Student engages in class discussions.	133(26.4)	94(18.7)	61(12.1)	79(15.7)	136(27.0)
Student communicates and share scientific ideas with class mates.	180(35.8)	114(22.7)	85(16.9)	66(13.1)	58(11.5)
Student reasons and take collective decisions with mates.	205(40.8)	121(24.1)	71(14.1)	64(12.7)	42(8.3)
Student collaborates with classmates to understand science knowledge and processes.	193(38.4)	129(25.6)	81(16.1)	50(9.9)	50(9.9)
Student Work in groups.	163(32.4)	131(26.0)	81(16.1)	54(10.7)	74(14.7)
Guidance					
Teacher leads discussions.	50(9.9)	55(10.9)	50(9.9)	134(26.6)	214(42.5)
Teacher defines and states concepts.	35(7.0)	39(7.8)	36(7.2)	77(15.3)	316(62.8)
Teacher tells expected answers.	39(7.8)	50(9.9)	66(13.1)	128(25.4)	220(43.7)
Student work individually.	30(6.0)	55(10.9)	38(7.6)	111(22.1)	269(53.5)
Teacher does most talking in class.	15(3.0)	34(6.8)	48(9.5)	178(35.4)	228(45.3)

Source: Field data, Mohammed (2015) N = 503

Again, more than half of the students' ratings indicate that they never engaged in inquiry-based epistemic activities such as changing their old understandings of science concepts based on data 262(52.1%), while half of the ratings indicate that they never explain science phenomena based on data 251(49.9%) (Table 14). Only 139(27.6%) students' ratings show that they used data to explain science phenomena in a few lessons, while 160(31.8%) ratings show that the students employed data to change their old understandings of science concepts in a few lessons.

Additionally, more than half of the students' ratings show that they never engaged in inquiry-based conceptual activities such as formulating hypotheses for science phenomena 279(55.5%), and explaining science phenomena based on their prior knowledge 262(52.1%) (Table 14). Only 124(24.7%) students' ratings show that they formulated hypotheses for science phenomena in a few lessons, while 136(27.0%) ratings show that the students employed their prior knowledge to explain science phenomena in a few lessons.

Moreover, most of the students' ratings show that there was no implementation of inquiry-based guidance activities in the JHSs (Table 14). Instead, there was implementation of traditional science guidance activities in all or most of the lessons, with the students sitting individually or in pairs 380(75.6%) behind desks in classrooms, and their teachers doing most of the talking 406(80.7%), through definition and statement of science concepts and principles 393(78.1%).

Again, while a significant proportion of the students' ratings indicate that they engaged in some inquiry-based social activities, a large proportion of the ratings show that either they never engaged in class discussions 133(26.4%), group work 163(32.4%), and communication and sharing of scientific ideas and understandings with their mates 180(35.8%) or they engaged in class discussions 94(18.7%), group work 131(26.0%), and communication and sharing of scientific ideas and understanding with their mates in a few lessons 114(22.7%) per term (Table 14).

While the students' ratings show that implementation of inquiry-based teaching and learning occurred in a few lessons, overall rating from the classroom observations appear to show that inquiry-based teaching and learning was never implemented in JHSs in the four selected districts and municipalities (M = 1.47, SD = 0.17) (Table 15). While the lesson observations appear to show that inquiry-based conceptual (M = 1.00, SD = 0.00), epistemic (M = 1.01, SD = 0.04), social (M = 1.05, SD = 0.19), and procedural (M = 1.23, SD = 0.16) activities were never implemented in the JHSs, the observations show that there was rare implementation of inquiry-based guidance activities (M =2.46, SD = 0.50).

Table 15: *Average item means and average item standard deviations of ratings from classroom observations of science procedural, epistemic, conceptual, social, and guidance activities in JHSs*

Activities	No of items	Min.	Max.	Average item mean	Average item standard deviation
Guidance	8	1	5	2.46	0.50
Procedural	4	1	5	1.23	0.16
Social	4	1	5	1.05	0.19
Epistemic	5	1	5	1.01	0.04
Conceptual	6	1	5	1.00	0.00
Overall inquiry	27	1	5	1.47	0.17

Note: high mean is inquiry-based, low mean is traditional-oriented N = 31
Source: Field data, Mohammed (2015)

Ratings from all the lessons observed show that the students never engaged in inquiry-based conceptual activities such as formulating hypotheses for science phenomena 31(100.0%), considering alternative explanations for science phenomena 31(100.0%), and learning content embedded in the processes of science 31(100.0%) (Table 16).

Again, ratings from all the lessons observed show that the students never engaged in inquiry-based epistemic activities such as changing their old understandings of science concepts based on data 31(100.0%), and explaining science phenomena based on data 31(100.0%). Only ratings from one (3.2%) lesson observed show that the students engaged in rare examination and evaluation of the quality of science data (Table 16).

Table 16: *Frequencies and percentages of ratings from classroom observations of science procedural, epistemic, conceptual, social, and guidance activities in JHSs*

Activities	Classroom observation				
	Never	Rarely	Sometimes	Often	Very often
	n(%)	n(%)	n(%)	n(%)	n(%)
Procedural					
Students ask scientifically oriented questions.	10(32.3)	18(58.1)	3(9.7)	0(0.0)	0(0.0)
Students plan and design experiments.	31(100.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Students manipulate materials and equipment.	28(90.3)	3(9.7)	0(0.0)	0(0.0)	0(0.0)
Students collect and record data.	30(96.8)	1(3.2)	0(0.0)	0(0.0)	0(0.0)
Epistemic					
Students interpret phenomena based on data.	31(100.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Students examine and evaluate quality of data.	30(96.8)	1(3.2)	0(0.0)	0(0.0)	0(0.0)
Students change understanding based on data.	31(100.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Students learn that their processes are similar to work of actual scientists.	31(100.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)

(Table 16, continued).

Activities	Classroom observation				
	Never	Rarely	Sometimes	Often	Very often
	n(%)	n(%)	n(%)	n(%)	n(%)
Conceptual					
Students formulate hypotheses based on prior knowledge.	31(100.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Students check explanations against established scientific knowledge.	31(100.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Students consider alternative explanations for phenomena.	31(100.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Students learn content embedded in processes of science.	31(100.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Social					
Students communicate to peers and teachers and make their ideas public.	29(93.5)	2(6.5)	0(0.0)	0(0.0)	0(0.0)
Students collaborate to construct scientific knowledge.	29(93.5)	2(6.5)	0(0.0)	0(0.0)	0(0.0)
Students work in groups to reach collective scientific decisions.	29(93.5)	2(6.5)	0(0.0)	0(0.0)	0(0.0)
Guidance					
Teachers elicit students' prior knowledge.	0(0.0)	2(6.5)	6(19.4)	22(71.0)	1(3.2)
Teachers observe and listen to students' interactions.	30(96.8)	1(3.2)	0(0.0)	0(0.0)	0(0.0)
Teachers deliver content through lectures and discussions.	0(0.0)	1(3.2)	6(19.4)	14(45.2)	10(32.3)
Teachers write facts and concepts on chalkboard.	0(0.0)	2(6.5)	11(35.5)	15(48.4)	3(9.7)
Teacher reads scientific facts from textbooks.	11(35.5)	4(12.9)	15(48.4)	0(0.0)	1(3.2)
Teachers define and explain science concepts and principles.	1(3.2)	2(6.5)	6(19.4)	14(45.2)	8(25.8)
Students answer questions posed by teachers.	1(3.2)	4(12.9)	11(35.5)	12(38.7)	3(9.7)

Source: Field data, Mohammed (2015) N = 31

Additionally, ratings from most of the lessons observed show that the JHS students never engaged in inquiry-based social activities such as working in groups to reach collective scientific decisions 29(93.5%), collaborating with their peers to construct scientific knowledge 29(93.5%), and communicating with their peers to make their ideas public 29(93.5%). Only ratings from a few lessons show that the students rarely worked in groups to take collective scientific decisions 2(6.5%), collaborated with their peers to construct scientific knowledge 2(6.5%), and communicated with their peers to make their ideas public 2(6.5%) (Table 16).

Moreover, ratings from most of the lessons observed show that the students never engaged in inquiry-based procedural activities such as planning and designing their own experiments 31(100.0%), collecting and recording their own data 30(96.8%), and manipulating science equipment and materials 28(90.3%) (Table 16). Only ratings from a few lesson observations show that the students rarely manipulated science equipment and materials 3(9.7%), and collected and recorded data on their own 1(3.2%).

Furthermore, while ratings from some classroom observations reveal that the JHS teachers engaged in some inquiry-based guidance activities, most of the observations show that they never engaged in inquiry-based guidance activities such as observing and listening to students' interactions 30(96.8%) (Table 16). Instead, the teachers often engaged in traditional guidance activities such as delivering science content through lectures 24(77.5%), definition and explanation of science concepts and principles 22(71.0%), and writing science facts and concepts on the blackboard for students to copy 18(58.1%).

While the students' ratings and ratings from the classroom observations show that there was no or rare implementation of inquiry-based science teaching and learning in the JHSs, emergent themes and patterns from interview responses of science teachers, head teachers, circuit supervisors, science coordinators, deputy directors and a director of education also show that there was rare implementation of inquiry-based science teaching and learning in JHSs in the four districts and municipalities (Figure 6). Out of the 41 teachers and educational administrators interviewed, only a few of them 6(14.63%) said that inquiry-based Science, Technology, Mathematics, Innovation, and Education (STMIE) clinics were implemented in JHSs.

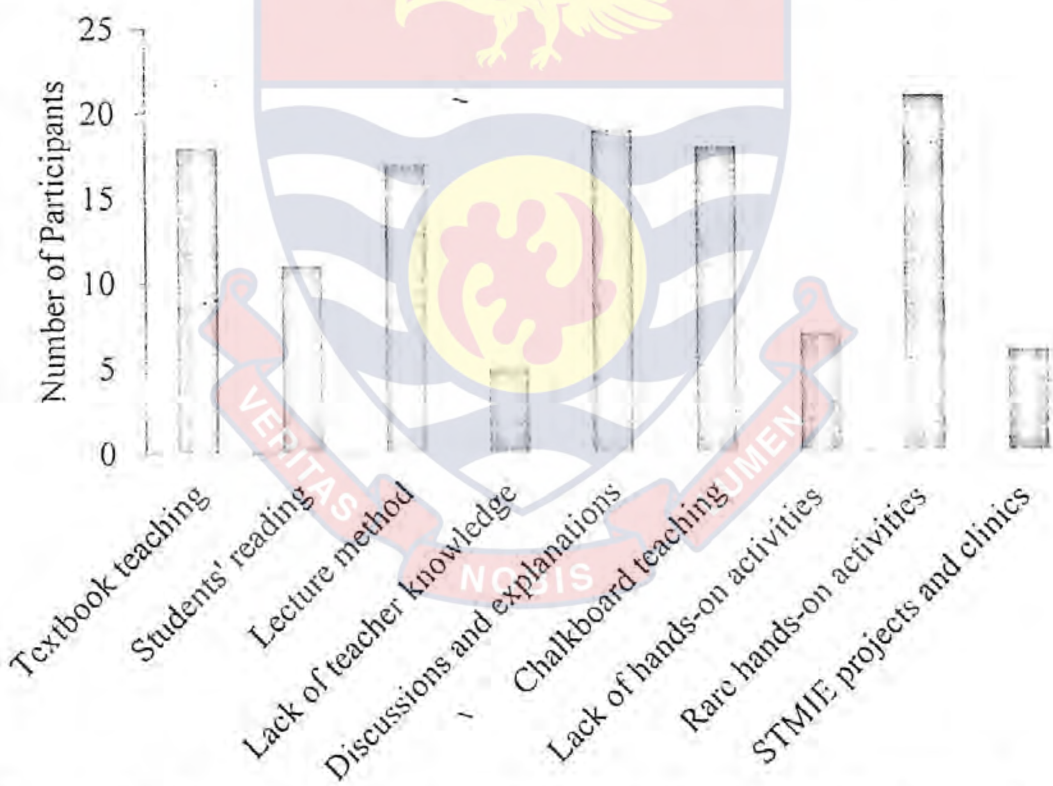

Figure 6: Emergent themes about science teaching and learning from interview responses of science teachers and educational administrators
Source: Field data, Mohammed (2015)

The STMIE is a programme introduced in JHSs for groups of students to come up with their own projects under the guidance of their teachers. This programme requires students to use local and other materials to make products and models for exhibition to the public at science fairs or clinics; where students and members of the public discuss and share scientific ideas. However, responses from the interviewees indicate that there was rare implementation of the STMIE in JHSs. For example, a head teacher and a science coordinator stated:

> *There have been two science clinics for children since I came to this school. That is about three or four years ago.* (HT1)

> *These days it (the STMIE) has not been functional. At the end of last term for example, we should have had it but it didn't come on. So it seems it is going down. It has not been functional lately.* (SC3)

Interview responses from the teachers and educational administrators show that there was no implementation of inquiry-based procedural activities in the JHSs. While a few of them said hands-on activities never occurred in the JHSs 7(17.1%), more than half of them said hands-on activities rarely occurred in the JHSs 21(51.2%) (Figure 6). Examples of quotes from a deputy director and a science teacher expressing these experiences are:

> *Teachers don't organise any experiment in the schools for students. I will say everything (teaching) is done by theory, the theoretical aspect of teaching.* (DD2)

> *I don't allow the students to plan and perform their own science experiments ... because we don't have many of the basic instruments that we need in this school.* (ST9)

On rare occasions where students were engaged in hands-on activities, all of them were given the same sets of equipment and materials, and followed the same step-by-step procedures to arrive at the same answers. For example, a teacher said:

> *Allowing the children to perform experiment with guidance is good. By guidance I mean students should be given the instructions and steps necessary to perform experiments.* (ST3)

Additionally, interview responses from the teachers and educational administrators indicate that there was rare implementation of inquiry-based conceptual activities in the JHSs (Figure 6). Rather, the responses show that JHS students engaged in textbook readings to answer questions and contribute to discussions in traditional class activities. For example, a head teacher and a science teacher stated:

> *What the integrated science teacher in this school does is, if he has a lesson next week he will ask the pupils to read ahead.* (HT10)

> *Prior to the next lesson I tell the students the next topic we are going to talk about. They do their own reading about the topic so that the next time we have integrated science lesson, they can have some foreknowledge about it.* (ST7)

Moreover, interview responses from the teachers and educational administrators show that there was no implementation of inquiry-based guidance activities in the JHSs, but frequent implementation of traditional guidance activities (Figure 6). The responses show that science instruction in JHSs mostly involves textbook teaching 18(43.9%), lecturing 17(41.5%), discussions and explanations 19(46.3%), and chalkboard teaching 18(43.9%).

Examples of a circuit supervisor's and a deputy director's quotes expressing these experiences are:

Some teachers refer to what is written in the textbooks and write it on the blackboard. (CS2)

What I saw was that some teachers were just reading, giving notes, and explaining science concepts to students. (DD 2)

However, interview responses from the teachers and educational administrators indicate that there was some implementation of inquiry-based social activities in the JHSs (Figure 6). An example of respondents' quotes expressing these experiences is:

Considering the materials available, I put the students into groups. I then give them guidelines and allow them to perform (the experiments). After that we come together (as a class) to discuss (the results). (ST6)

Discussion

In summary, triangulation of results from the students' ratings, classroom lesson observations, and interview responses from science teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education show that there was rare implementation of inquiry-based science teaching and learning in JHSs in the four Ghanaian districts and municipalities. Instead, there was frequent implementation of traditional science teaching and learning in the schools. This finding is similar to what Ampiah (2008) and Opoku-Asare (2004) found in some Ghanaian schools some years ago, but contradicts many findings in the industrialised and industrialising countries (e.g., Crawford, 2000; Jeanpierre, 2006; Oppong-

Nuako et al., 2015).

Like the present finding, the main approaches for science instruction in the basic schools Ampiah (2008) studied were traditional methods involving "chalk and talk", questions and answers, demonstrations, and lectures. Similarly, the most frequently used instructional resources in the schools Opoku-Asare (2004) studied were blackboard and textbook illustrations. In contrast, the most prevalent strategy for science instruction in the elementary schools Jeanpierre (2006) studied in USA was guided inquiry. Many researchers and educators have complained about the prevalence of traditional science teaching in African schools in the past (e.g. Ampiah, 2008; Anamuah-Mensah, 2012; Asabere-Ameyaw. et al., 2012; Jegede, 1993; Shumba, 1999). However, this study shows that implementation of traditional science instruction persists in JHSs in the four districts and municipalities, despite the rationale for all Ghanaian students to be actively engaged in science inquiry investigations (CRDD. 2007; 2012).

This finding confirms the claim that socio-cultural influence, in this case authoritarianism, promotes implementation of traditional science instruction in African schools (e.g., Cobern & Aikenhead, 1998; Jegede, 1993; Jegede et al., 1994). Authoritarianism refers to socio-cultural belief in African societies where older persons are regarded as being more experienced and knowledgeable than the young ones, and therefore, assert their authority in making decisions for the young ones who are expected to accept the decisions without questioning (Jegede, 1993). The strong influence of authoritarianism in implementation of traditional science instruction in JHSs in the Ghanaian districts and municipalities is evident in this study, to the extent that teachers defined, stated, and wrote science content on blackboards for students who only copied the notes into their books without questioning the credibility of the knowledge delivered to them.

It is, however, noteworthy that this study found some implementation of inquiry-based Science, Technology, Mathematics, Innovation, and Education (STMIE) clinics in JHSs in the districts and municipalities. This finding was not reported in Ampiah's (2008) study and in most of the available literature.

Again, this study found that while there was considerable implementation of the social aspect of inquiry teaching and learning in the JHSs, important aspects of inquiry (procedural, epistemic, conceptual, and guidance activities) were rarely implemented. This differs from many findings in industrialised and industrialising countries (e.g., Crawford, 2000; Jeanpierre, 2006; Oppong-Nuako et al., 2015). For example, Oppong-Nuako et al. found that most features of inquiry (84% and100%) were successfully implemented in most of the classrooms they studied in Canada and USA. Again, more than two-thirds of the teachers Jeanpierre studied in USA facilitated students' learning; provided opportunities for students to formulate their own hypotheses and interpret data from investigations; and provided sufficient opportunities for students to engage in authentic inquiry activities. While industrialised and industrialising countries have made significant successes in shifting away from traditional science instruction toward the implementation of inquiry-based teaching and learning in schools, this study shows that implementation of inquiry teaching and learning in JHSs in the four Ghanaian districts and municipalities is far from successful.

While empirical evidence show that inquiry-based science teaching and learning is more effective than traditional instruction in promoting students' achievements (e.g., Furtak et al., 2012), content knowledge (e.g., Chang & Mao, 1999), critical and higher-order thinking skills (Anderson, 2002; Gillies, 2008), problem-solving skills (Gillies, 2008), attitudes (e.g., Akcay & Yager, 2010), and scientific literacy (e.g., Anderson, 2002), the current finding shows that JHSs in the four Ghanaian districts and municipalities continue to implement instructional method which is ineffective in promoting students' scientific literacy. The consistent poor performance of Ghanaian students in international assessments such as TIMSS could be due to their experiences mainly with traditional instruction.

Again, empirical evidence show that students taught through traditional instruction exhibit low science process skills (e.g., Lati, et al., 2012; Simsek & Kabapinar, 2010). Therefore, the prevalence of traditional instruction in JHSs in the four districts and municipalities, is a significant contributor to the inability of students from these schools to readily apply science process skills in solving problems in their day-to-day real-life experiences.

Research Question 2: What is the interaction of school location (urban and rural) and school type (public and private) on implementation of inquiry-based science teaching and learning in JHSs in four Ghanaian districts and municipalities?

Answering this research question involved conducting two-way MANOVA to examine the interaction of school location (urban and rural) and school type (public and private) on implementation of inquiry-based procedural, epistemic, conceptual, social, and guidance activities in JHSs in the districts and municipalities; using data from students' ratings of inquiry activities in JHSs. I then triangulated results from the two-way MANOVA with results from my ratings of observations of inquiry teaching and learning in JHSs, and results from interview responses of teachers and educational administrators on inquiry teaching and learning in JHSs.

The two-way MANOVA shows that there was statistically significant main effect of school location (rural and urban) on implementation of inquiry teaching and learning in JHSs in the four districts and municipalities, Pillai's Trace = .033, F(5, 495) = 3.373, $p < .05$, partial $\eta^2 = .033$. Additionally, there was statistically significant main effect of school type (private and public) on implementation of inquiry teaching and learning in the JHSs, Pillai's Trace = .046, F(5, 495) = 4.808, $p < .05$, partial $\eta^2 = .046$; and a statistically significant interaction between school location and school type on implementation of inquiry teaching and learning in the JHSs, Pillai's Trace = .106, F(5, 495) = 11.690, $p < .05$, partial $\eta^2 = .106$. These results permitted the conduct of separate one-way ANOVAs for each aspect of inquiry as follow up tests, with each ANOVA being evaluated at a Bonferroni adjusted alpha level of .01.

Table 17 shows two-way MANOVA results for interaction of school location and school type on implementation of procedural, epistemic, social, conceptual, and guidance activities in JHSs in the four Ghanaian districts and municipalities.

Table 17: *Two-way MANOVA results (F and eta²) for school location and school type on students' ratings of science procedural, epistemic, conceptual, social, and guidance activities in JHSs*

Aspect of inquiry teaching and learning	Two-way ANOVA results					
	School location		School type		School location × school type	
	F	Eta^2	*F*	Eta^2	*F*	Eta^2
Social domain	1.020	0.002	18.385*	0.036	44.724*	0.082
Conceptual domain	10.827*	0.021	0.643	0.001	17.219*	0.033
Guidance domain	3.859**	0.008	0.000	0.000	2.039	0.004
Procedural domain	0.179	0.000	6.523**	0.013	4.824**	0.010
Epistemic domain	0.824	0.002	2.814	0.006	0.696	0.001

Source: Field data, Mohammed (2015) **P*< .01, ***P*< .05, N = 503

Interaction of school location (urban and rural) and school type (public and private) on implementation of inquiry-based social activities in JHSs in four Ghanaian districts and municipalities

Table 17 shows that there was statistically significant interaction between school location and school type on implementation of inquiry-based social activities in the JHSs $F(1, 499) = 44.724$, $p < .01$, partial $\eta^2 = .082$. Post hoc analysis shows that while urban private JHSs in the districts and municipalities implemented inquiry-based social activities in half of their science lessons per term (M = 3.05, SD = 0.97), rural private JHSs implemented inquiry-based social activities in only a few lessons per term (M = 2.53, SD = 1.15) (Figure 7).

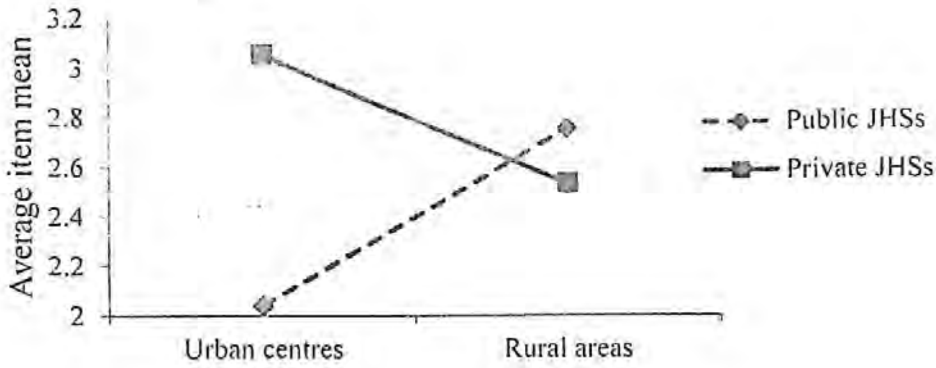

Figure 7: school location (urban and rural) by school type (public and private) interaction on students' ratings of inquiry-based social activities in JHSs
Source: Field data, Mohammed (2015)

While students in the urban private JHSs engaged in group work, class discussions, collaborations, and sharing of scientific ideas in half of their science lessons per term, students in the rural private JHSs engaged in group work, class discussions, and sharing of scientific ideas in only a few of their science lessons per term (Table 18).

Table 18: *Means and standard deviations of students' ratings of items on science social activities for public and private JHSs in rural and urban areas*

Item statement	Mean (Standard deviation)			
	Urban JHS		Rural JHS	
	Public	Private	Public	Private
How often student engages in discussion with mates in a term.	2.71(1.62)	3.37(1.43)	3.21(1.50)	2.86(1.63)
How often student shares scientific ideas and understandings with mates in a term.	2.01(1.32)	2.95(1.32)	2.59(1.29)	2.61(1.50)
How often student reason and take collective scientific decisions with mates in a term.	1.88(1.16)	2.93(1.33)	2.23(1.33)	2.38(1.40)
How often student collaborates with mates to understand scientific knowledge and processes in a term.	1.80(1.15)	2.96(1.37)	2.51(1.32)	2.32(1.30)
How often student works in groups in a term.	1.81(1.18)	3.03(1.19)	3.20(1.32)	2.47(1.57)

N = 207(Urban public); N = 94(Urban private); N = 131(Rural public);
N = 71(Rural private); Average score = 2.50
Source: Field data, Mohammed (2015)

While quantitative results from the students' ratings show that there were differences in implementation of inquiry-based social activities between urban private and rural private JHSs in the districts and municipalities, interview responses from science teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education offer interesting insights into these differences. Responses from many interviewees reveal that urban private school students in the districts and municipalities often went on excursions and field trips; where they asked questions about science phenomena, engaged in discussions, shared scientific ideas, and collaborated to construct their own understandings of scientific knowledge and principles. This is illustrated by the statement of an urban private JHS head teacher who said:

> *The school has a programme where every term the children go on excursions and field trips. Last term they went to "Apostle Kojo Sarfo's" car manufacturing site. They asked a lot of questions.* (HT12)

Additionally, responses from the interviewees reveal that the urban private JHS students were often tasked to do their own readings on lesson topics at home. Therefore, the students got well prepared before lessons in school. As a result, they took active part in class discussions, and shared scientific ideas and understandings with their class mates. For example, a teacher in an urban private JHS said:

> *I recently went to class and told the students that there is a new technology called genetically modified food. I told them to read from several sources on their own and bring their "findings" to school for*

discussion. (ST3)

In contrast, responses from the interviewees indicate that most rural private JHS students in the four districts and municipalities could not afford to go on excursions and field trips to engage in such social interactions. Many rural students found it difficult to even pay their fees and buy textbooks. This is illustrated by the statement of a rural private JHS teacher who said:

> *Paying examination fees of children is a problem in the rural area here. Teachers have to sack children to go home and bring their school and examination fees.* (ST4)

Again, Figure 7 shows that while rural public JHSs in the districts and municipalities implemented inquiry-based social activities in nearly half of their science lessons per term (M = 2.75, SD = 0.95), the urban public JHSs implemented inquiry-based social activities in only a few science lessons per term (2.04, SD = 0.86). While the rural public school students engaged in group work, class discussions, collaborations, and sharing of scientific ideas in nearly half of their science lessons per term, the urban public school students engaged in group work, class discussions, collaborations, and sharing of scientific ideas in only a few science lessons per term.

While quantitative results from the students' ratings show that there were differences in the implementation of inquiry-based social activities between rural public and urban public JHSs, interview responses from science teachers and head teachers offer in-depth understanding into these differences. Responses from the interviewees indicate that most rural public JHS students in the districts and municipalities cannot read and understand English well. Therefore, their teachers combined English and the local language as media for science instruction. In such cases the students understood the lessons and took active part in class discussions, and shared ideas with their mates. For example, two science teachers said:

> *If we are using "Fante" as the medium of instruction for science, the students perform very well because they understand the language.* (ST18)

> *English language is a major barrier in teaching science in our rural area here. We (the teachers) bring in the local language before the students understand the lessons.* (ST10)

Interaction of school location (urban and rural) and school type (public and private) on implementation of inquiry-based conceptual activities in JHSs in four Ghanaian districts and municipalities

Results from the students' ratings (Table 17) show that there was statistically significant interaction between school location and school type on implementation of inquiry-based conceptual activities in JHSs in the districts and municipalities $F(1, 499) = 17.219$, $p < .01$, partial $\eta^2 = .033$. Post hoc analysis show that urban public JHSs in the districts and municipalities implemented inquiry-based conceptual activities in fewer lessons per term (M = 1.59, SD = 0.81) than rural public JHSs (M = 2.28, SD = 1.12), however, both urban private (M = 2.05, SD = 0.93) and rural private (M = 1.97, SD = 1.03) JHSs implemented inquiry-based conceptual activities in only a few lessons per term (Figure 8).

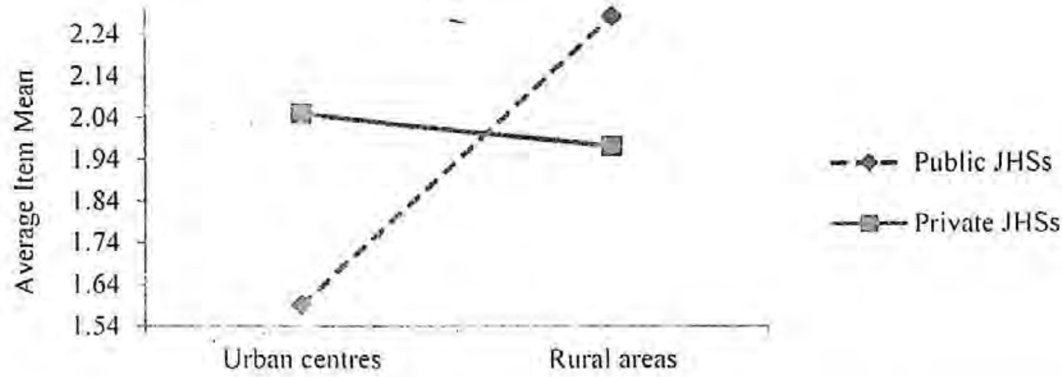

Figure 8: school location (urban and rural) by school type (public and private) interaction on students' ratings of inquiry-based conceptual activities in JHSs
Source: Field data, Mohammed (2015)

Table 19 shows that urban public JHS students engaged in formulation of hypotheses, explanation of science phenomena based on prior knowledge, and learning of content embedded in the processes of science in fewer lessons per term than rural public JHS students.

Table 19: *Means and standard deviations of students' ratings of items on science conceptual activities for public and private JHSs in rural and urban areas*

Item statement	Mean (Standard deviation)			
	Urban JHS		Rural JHS	
	Public	Private	Public	Private
How often student formulates hypothesizes for science phenomena in a term.	1.36(0.73)	1.82(0.97)	2.37(1.30)	1.73(0.99)
How often student explains science phenomena based on prior knowledge in a term.	1.62(1.08)	1.94(1.19)	2.08(1.21)	2.07(1.21)
How often student learns content embedded in science processes in a term.	1.79(1.03)	2.38(1.09)	2.37(1.35)	2.10(1.34)

N = 207(Urban public); N = 94(Urban private); N = 131(Rural public);
N = 71(Rural private); Average score = 2.50
Source: Field data, Mohammed (2015)

While quantitative results from the students' ratings show that there were differences in implementation of conceptual activities between rural public and urban public JHSs. interview responses from the science teachers and educational administrators offer insights into these differences. The responses reveal that inability and refusal of urban public JHS students in the districts and municipalities to read about lesson topics at home in preparation for science lessons at school is a reason for the lower implementation of inquiry-based conceptual activities in the schools. For example, an urban public JHS teacher said:

> *I ask the students to read ahead and find out more information about the topic we are going to treat in the next lesson. When they come back to school, I make effort to find out what they read at home. I become disappointed to find out that they did not do any reading.* (ST 18)

Responses from the interviewees reveal also that the inability and refusal of urban public JHS students to do homework and assignments given to them is another reason for the lower implementation of inquiry-based conceptual activities in the schools. For example, one urban public JHS teacher stated:

> *Some parents give their children too much household chores to the extent that the children do not get enough time to do or complete the homework given to them by the teacher. So, the students return to school the next day without the completed assignment or homework.* (ST17)

In contrast, responses from the interviewees show that the ability of some rural public JHS students to read ahead of lessons is a reason for the slightly higher implementation of inquiry-based conceptual activities in the schools. For example, a rural public school head teacher said:

What the integrated science teacher in this school does is, he asks the pupils to read ahead. So, students who have the textbooks go through the topics themselves before the teacher comes to class. This helps in the teaching and learning a lot. (HT10)

Interaction of school location (urban and rural) and school type (public and private) on implementation of inquiry-based procedural activities in JHSs in four Ghanaian districts and municipalities

Results from the students' ratings show that there was statistically significant interaction between school location and school type on the implementation of inquiry-based procedural activities in JHSs in the four districts and municipalities $F(1, 499) = 4.824$, $p < .05$, partial $\eta^2 = .010$ (Table 17). Post hoc analysis shows that urban public JHSs in the districts and municipalities implemented inquiry-based procedural activities in fewer science lessons per term (M = 1.36, SD = .62) than urban private JHSs (M = 1.63, SD = .49), however, both rural public (M = 1.46, SD = .53) and rural private (M = 1.48, SD = .76) JHSs implemented inquiry-based procedural activities in only a few lessons per term (Figure 9).

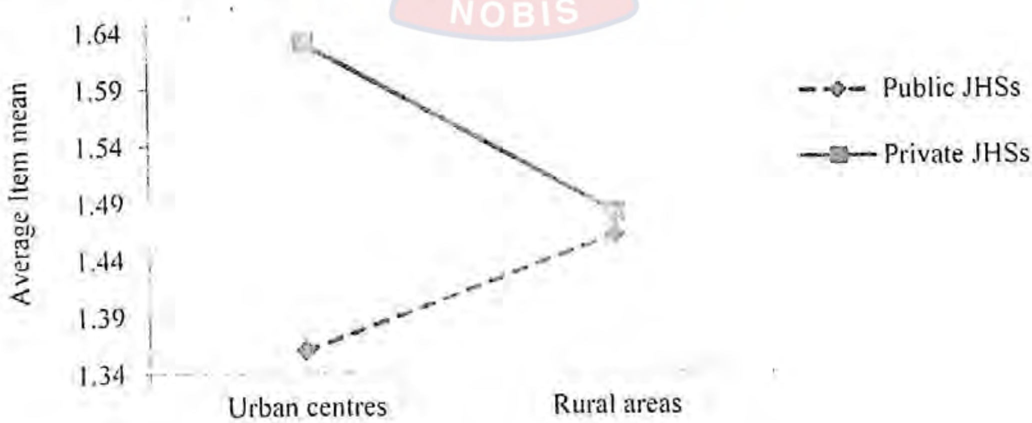

Figure 9: school location (urban and rural) by school type (public and private) interaction on students' ratings of inquiry-based procedural activities in JHSs
Source: Field data, Mohammed (2015)

Urban public JHS students engaged in planning and designing of science experiments, handling and manipulation of science equipment and materials, performance of science experiments, and collection and recording of science data in fewer lessons per term than urban private JHS students (Table 20).

Table 20: *Means and standard deviations of students' ratings of items on science procedural activities for public and private JHSs in rural and urban areas*

Item statement	Mean (Standard deviation)			
	Urban JHS		Rural JHS	
	Public	Private	Public	Private
How often student performs science experiments in a term.	1.27(0.71)	1.62(0.53)	1.34(0.71)	1.44(0.82)
How often student plans and designs experiments in a term.	1.14(0.49)	1.51(0.68)	1.28(0.64)	1.31(0.77)
How often student handles and uses science equipment and materials in a term.	1.57(1.02)	1.78(0.82)	1.79(0.95)	1.47(0.86)
How often student collects and records data in a term.	1.46(0.90)	1.63(0.83)	1.44(0.69)	1.72(1.20)

N = 207(Urban public); N = 94(Urban private); N = 131(Rural public); N = 71(Rural private); Average score = 2.50

Note: high mean is inquiry-based, low mean is traditional-oriented

Source: Field data, Mohammed (2015)

While quantitative results from the students' ratings show that there were significant differences in the implementation of inquiry-based procedural activities between urban private and urban public JHSs, results from the classroom observations also reveal similar differences between the school types. In an observed lesson in one urban private JHS (School M) (Appendix N), the teacher gave step-by-step hands-on procedures to students to prepare dilute, concentrated, saturated, and supersaturated solutions of sugar, salt, and hair and food dyes. However, there was no observation of even a single hands-on activity in the urban public JHSs.

Discussion

In summary, triangulation of results from the students' ratings, classroom lesson observations, and interview responses from the science teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education show that there was significant interaction between school location (urban and rural) and school type (public and private) on the implementation of inquiry-based science teaching and learning in JHSs in the four Ghanaian districts and municipalities. Specifically, this study found that while urban private JHSs in the districts and municipalities implemented inquiry-based social activities in half of the science lessons per term, the rural private JHSs implemented inquiry-based social activities in only a few lessons per term. In contrast, while the rural public JHSs implemented inquiry-based social activities in half of the science lessons per term, the urban public JHSs implemented inquiry-based social activities in only a few lessons per term. This finding has not been reported in the available literature searched.

Additionally, this study found that while the urban public JHSs implemented inquiry-based procedural activities in fewer lessons per term than the urban private JHSs, both the rural public and rural private JHSs implemented inquiry-based procedural activities in a few lessons per term. This shows that there was lesser implementation of hands-on activities in the urban public JHSs than in the urban private JHSs.

Differences between urban private JHSs and urban public and rural private JHSs in the districts and municipalities are not surprising. This is because many urban private JHS students come from parents with formal education, gainful employment, and high income levels. Therefore, the parents are able to provide sufficient educational materials, funding, and extra tuition and show deep interest in their children's education. In contrast, most rural and public JHS students come from parents with no or little formal education. Most of these parents are subsistence farmers, petty traders, and low income workers. Therefore, they cannot provide sufficient educational materials, funding, and extra tuition and they do not show deep interest in their children's education.

Differences in teaching and learning activities between urban private JHSs and public and rural JHSs in the districts and municipalities largely explain gaps in science achievements that may be present between students in the urban private JHSs and those in the public and rural JHSs.

Empirical evidence show that sufficient exposure of students from diverse backgrounds to inquiry-based science experiences lead to considerable reduction in achievement gaps between them (e.g., Bredderman, 1983; Palincsar, Magnusson, Collins, & Cutter, 2001). Studies show also that inquiry-based experiences promote greater development of disadvantaged students' science process skills, content knowledge, creativity, logic, intelligence, and language proficiency (Bredderman, 1983). Therefore, the aforementioned findings suggest that increased implementation of inquiry-based science teaching and learning in JHSs in the four districts and municipalities would reduce gaps in science achievements that may be present between the urban private JHS students and their counterparts in the rural and public JHSs, and promote scientific literacy of the rural and public school students.

This study found also that urban public JHSs in the four districts and municipalities implemented inquiry-based conceptual activities in fewer science lessons per term than the rural public schools, while both urban private and rural private JHSs implemented inquiry-based conceptual activities in a few lessons per term. Additionally, this study found that rural public JHSs implemented inquiry-based social activities more than urban public JHSs because of the code-switching (mixing) of English and the local language in rural JHSs. This finding is similar to those of Ampiah (2008) and Launio (2015). Ampiah found that the mixing (code-switching) of English and the Ghanaian language in rural schools helped pupils to understand the lesson taught, while the predominant use of English for communication in urban public schools prevented some pupils from asking questions in class. Similarly, Launio found that the mathematics achievements of students taught using code-switching between Hiligaynon and English improved more than the achievements of students taught using only English. While inquiry-based teaching and learning is effective (e.g. Ackay & Yager, 2010; Anderson, 2002; Furtak et al., 2012; Gillies, 2008; Lati et al., 2012) and the central strategy for science instruction in most industrialised and industrialising countries (e.g., NRC, 1996, 2000, 2012), this finding suggests that implementation of inquiry-based teaching and learning in the Ghanaian JHSs (as in most Ghanaian African schools) is feasible only if there is code-switching of English (second language) and the students' local language. The integration of code-switching and inquiry-based teaching and learning is an effective approach that has been used in many countries to develop ELLs' science understanding and English proficiency simultaneously (e.g., Lee, 2005; Lee & Buxton, 2008; Lee & Fradd, 1998).

The higher implementation of some aspects of inquiry teaching and learning in the rural public JHSs is both surprising and encouraging, given that rural school students in Ghana have always lagged behind their urban counterparts in science achievements, as evidenced in BECE results for decades. Code-switching of English and the local language created an opportunity for the rural students to draw on their skills in constructing meaning in their home language to link content of science lessons to their experiences outside the school, and link abstract experiences with concrete experiences (Lee, 2005).

Research Question 3: To what extent do teachers' and educational administrators' conceptions of inquiry, and teachers' attitudes, beliefs, and self-efficacy pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities?

Results and discussions that provide answers to this research question are presented in four separate sections. These are: Extent to which teachers' and educational administrators' conceptions of inquiry pose challenges to inquiry-based science teaching in JHSs, extent to which teachers' attitudes pose challenges to inquiry-based science teaching in JHSs, extent to which teachers' beliefs pose challenges to inquiry-based science teaching in JHSs, and extent to which teachers' self-efficacy pose challenges to inquiry-based science teaching in JHSs.

Extent to which teachers' and educational administrators' conceptions of inquiry pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities

Determining extent to which teachers' and educational administrators' conceptions of inquiry pose challenges to inquiry-based science teaching in JHSs in the four districts and municipalities involved examination of the participants' conceptions of scientific inquiry, inquiry teaching, and inquiry learning to determine whether the conceptions are uninformed, partially informed, or fully informed to facilitate or impede inquiry teaching. This involved examination of emergent themes, patterns, categories, and sample quotations from interview responses of the teachers and educational administrators to determine whether or not they are consistent with the constructivist philosophy of science and science teaching and learning.

Table 21 shows frequencies of emergent terms and phrases used by science teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education to describe their conceptions of scientific inquiry, inquiry teaching, and inquiry learning.

Table 21: *Frequencies of emergent terms and phrases used by science teachers and educational administrators to describe scientific inquiry, inquiry teaching, and inquiry learning*

Term/phrase	Frequency of emergent terms and phrases related to:		
	Scientific inquiry	Inquiry teaching	Inquiry learning
Activities/Practical	8	6	10
Asking questions	-	6	9
Coaching	-	1	-
Contextualised teaching	-	1	-
Demonstration lesson	-	7	-
Directing	-	6	-

(Table 21,continued).

Term/phrase	Frequency of emergent terms and phrases related to:		
	Scientific inquiry	Inquiry teaching	Inquiry learning
Don't know	2	1	-
Elicit/contribute prior knowledge and ideas	2	10	7
Facilitating learning	1	7	-
Feedbacks	-	4	-
Field trips	-	2	-
Students' involvement and autonomy	-	13	17
Give/receive support	-	4	-
Give/follow instructions	-	14	7
Group students/work	-	4	4
Guiding	-	18	-
Problem identification and solution	5	7	5
Identification of students' abilities	-	1	-
Investigation	5	2	2
Knowledge of subject area	-	14	-
Leading	-	2	-
Lecturing/delivering information	1	8	-
Lesson notes preparation	-	2	-
Moderating	-	1	-
Monitoring	-	2	-
Motivating	-	1	-
Removing misconception	-	2	-
Supervision	-	6	-
Bring out difficulties	-	-	1
Discipline	-	-	1
Data collection	-	-	4
Demand explanations	-	-	1
Discovery	1	-	2
Experimenting	4	-	4
Exploration	-	-	4
Hypothesizing	-	-	1
Imitation	-	-	1
Manipulate materials	2	-	8
Observation	3	-	1
Pay attention	-	-	9
Plan and design experiment	-	-	1
Present results and findings	-	-	8

(Table 21, continued)

Term/phrase	Frequency of emergent terms and phrases related to:		
	Scientific inquiry	Inquiry teaching	Inquiry learning
Research	8	-	10
Responsibility for learning	-	-	3
Student-centred	2	-	9
Critical thinking	-	-	3
Inductive teaching	1	-	-

Source: Field data, Mohammed (2015) N = 41

Table 21 shows that while the interviewees used more terms and phrases to describe their conceptions of inquiry teaching (28) and learning (26), they used relatively few terms and phrases to describe their conceptions of scientific inquiry (14).

Additionally, while most of the interviewees used two or more terms to describe their conceptions of inquiry teaching 35(85.4%) and learning 30(73.2%), a number of them used only single terms and phrases to describe their conceptions of scientific inquiry 15(36.6%) (Table 22). These results suggest that the teachers and educational administrators appeared to have better conceptions of science teaching and learning than scientific inquiry.

Table 22: *Frequencies of single and multiple terms and phrases used by science teachers and educational administrators to describe scientific inquiry, inquiry teaching, and inquiry learning*

No of terms and phrases	Frequency of terms and phrases related to:		
	Scientific inquiry	Inquiry teaching	Inquiry learning
1	15	4	7
2	11	5	6
3	2	6	8
4	2	11	3
5	-	7	7
6	-	2	1
7	-	3	2
8	-	-	1
9	-	-	1
10	-	-	1
11	-	-	-
12	-	1	-

Source: Field data, Mohammed (2015) N = 41

Based on their interview responses, I grouped the teachers and educational administrators into two broad categories. These are participants holding "Uninformed/Traditional" and "Partially informed" conceptions of inquiry. Table 23 shows frequencies of science teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education holding "Uninformed/Traditional" and "Partially informed" conceptions of scientific inquiry, inquiry teaching, and inquiry learning.

Table 23: *Frequencies of science teachers and educational administrators holding "Uninformed/Traditional" and "Partially informed" conceptions of scientific inquiry, inquiry teaching, and inquiry learning*

Participants	"Uninformed/Traditional" conception (n)	"Partially informed" Conception (n)
Science teachers	14	4
Head teachers	10	2
Circuit supervisors	3	1
Science coordinators	1	2
Directors	3	1
Total	31	10

Source: Field data, Mohammed (2015) N = 41

Conceptions of scientific inquiry (nature of science)

Interview responses of teachers and educational administrators from the four districts and municipalities show that they held "Uninformed/Traditional" and "Partially informed" conceptions of scientific inquiry, with none of them holding fully informed conception of inquiry.

"Uninformed/Traditional" conceptions. Over three-quarters 31(75.6%)

of the interviewed teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education held uninformed conceptions of scientific inquiry (Table 23). Interviewees in this category consist of 14 science teachers (ST1, ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9, ST11, ST12, ST13, ST14, ST15), 10 head teachers (HT2, HT4, HT5, HT6, HT7, HT8, HT9, HT10, HT11, HT12), 3 circuit supervisors (CS2, CS3, CS4), 1 science coordinator (SC1), 2 deputy directors (DD2, DD3) and 1 director of education (D4). When they were asked to describe their conceptions of scientific inquiry most of them said, it is a practical subject involving students in step-by-step activities to understand science concepts (Table 21). For example, a deputy director said:

> *In this case students are taken through a lot of activities, step-by-step. As they go through activities step-by-step the students finally understand concepts that are being taught.* (DD3)

Interviewees in this category could not differentiate actual science (scientific inquiry) from school science (science education) in which students imitate, practice, and learn the thinking processes and activities of actual scientists. The interviewees could not conceive that not everybody can do actual science. Many of them conceived scientific inquiry as involving students in "research" (Table 21). For example, a science teacher said:

> *My understanding of science inquiry-based activities is that students are made to make inquiries based on the lesson to be taught. That is, do their own "research", get deeper understanding of what they are about to be taught, and engage in activities that will enhance the teaching.* (ST9)

Research as used by interviewees in this category means students reading about already known information from books and the internet; and seeking information from friends, colleagues, parents, and resource persons to contribute to traditional science lessons in classrooms. One of the teachers who conceived research in this way said:

> *Supposing next week I will be teaching the topic "air", some students can go and ask other students at home. In these days of computers, other students can go to the internet and make their own "research". When the day for the lesson comes, the students will then bring out their ideas about the topic.* (ST13)

However, "research", as used by these interviewees, is completely different from research conducted by actual scientists. Actual scientists conduct research by identifying authentic problems and phenomena in the environment. They then formulate hypotheses; plan, design, and perform experiments; and collect and record data to test the hypotheses. Research conducted by actual scientists also involve examination and evaluation of the quality of data they collect; identification of inconsistencies in the data; creation of means to ensure reliability of the data; and explaining phenomena or solve problems based on the data they collect. The manner interviewees in this category used the term research is inaccurate. These factual inaccuracies expose the participants' uninformed conceptions of scientific inquiry.

Interviewees in this group also conceived scientific inquiry as elicitation of students' prior knowledge in order to deliver content to them during lessons (Table 21). For example, two science teachers said:

> *Scientific inquiry is inquiring and knowing from the students what they*

understand and what they know about the topic that we are going to talk about. (ST7)

I know scientific inquiry to be the imparting of knowledge to children. (ST6)

Some participants in the "Uninformed/Traditional" category attempted to describe the constructivist perspective of scientific inquiry by making vague references to "identification and solution of problems", and carrying out of "observation and experimentation" to understand phenomena in the environment (Table 21). For example, two teachers stated:

In science you make observations of phenomena and find solutions to problems. (ST11)

We are in the global village and this has to do with science. Therefore, everything deals with experimenting and activities in which one has to inquire before he comes to know. (ST1)

However, these interviewees could not give details about how scientists identify problems and solve them. They were also unable to give details about the processes involved in science experimentation.

"Partially informed" conceptions. About one-quarter 10(24.4%) of the interviewed teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education held partially informed conceptions of scientific inquiry (Table 23). They consist of 4 science teachers (ST10, ST16, ST17, ST18), 2 head teachers (HT1, HT3), 1 circuit supervisor (SC1), 2 science coordinators (SC2, SC3), and 1 deputy director (DD1). They

articulated conceptions of scientific inquiry that are partially consistent with the constructivist perspective. However, a few of them added some uninformed views to their partially informed conceptions. When asked to describe their conceptions of scientific inquiry they said it involves identification and solution of problems and research (Table 21). A deputy director and head teacher in this category said:

> *Inquiry by definition is to ask why and how of natural phenomena. It is through asking questions such as why and how that one can seek knowledge to the highest level, but not through speculation.* (DD1)

> *Science involves research and practical activities. In a nutshell, it is about everyday activities. So as things keep on changing there is the need for research.* (HT1).

These responses suggest that scientific inquiry involves deliberate and systematic research into problems and phenomena in the environment: which begins with asking questions and identifying problems. The responses further suggest that valid and reliable scientific knowledge is achieved only through research and not through speculation; and that scientific knowledge is tentative and subject to change based on new observations or data.

However, a few interviewees in the "Partially informed" category could not differentiate actual science (scientific inquiry) conducted by scientists from school science (science education) in which students practice and learn the thinking processes and activities of actual scientists. For example, one teacher said:

> *Inquiry-based method of teaching science means the teacher presents a*

topic to the students and then guides them by allowing the students to go and look for information to solve the given problem or question. (ST17)

Conceptions of inquiry teaching

Interview responses of teachers and educational administrators from the four districts and municipalities show that they held "Uninformed/Traditional" and "Partially informed" conceptions of inquiry teaching, with none of them holding fully informed conception of inquiry teaching.

"Uninformed/Traditional" conceptions. Over three-quarters 31(75.6%) of the interviewed teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education expressed traditional conceptions of science teaching, showing that they held uninformed conceptions of inquiry-based science teaching (Table 23). When asked to describe their conceptions of inquiry teaching, they said it involves practical hands-on activities in which teachers demonstrate phenomena for students to see and then allow students to have a feel of it (Table 21). This is exemplified by the statement of a circuit supervisor who said:

When teachers are teaching, they should teach science as practical not as theory. The teacher should carry out demonstrations for students to see and hear and allow them to practice it. (CS2)

They also conceived inquiry teaching as practical activities in which teachers gather required materials and try out activities to see if the desired results can be achieved. One of the deputy directors who held this conception said:

If the teacher is going to perform an experiment in a lesson, he needs *to perform the experiment at home to know if he can get the correct answer.* (DD3)

However, these practices are traditional teaching strategies conducted to verify science content already taught, but are not inquiry-based activities. In these activities teachers plan and design all the procedures involved without or with minimal students' involvement.

Many participants in the "Uninformed/Traditional" category conceived inquiry-based science teaching as involving lectures and delivery of content for students to receive (Table 21). For example, two head teachers stated:

The role the teacher should play is to get the necessary information and pass it on to the pupils. (HT6)

If the topic is related to the students' prior knowledge they give you answers that they know. However, for concepts that the students have not come across, you (the teacher) have to feed them (the students) with whatever you are trying to teach. (HT4)

When asked to describe their conceptions of the roles of teachers during inquiry teaching, interviewees in the "Uninformed/Traditional" group used several terms in their descriptions. They said that teachers involved in inquiry teaching guide, facilitate, monitor, supervise, moderate, lead, motivate, direct, and coach students (Table 21). A circuit supervisor and a science coordinator who held this view said:

During inquiry teaching the teacher serves as a guide, motivator, and a leader. (CS3)

The teacher is supposed to be a moderator. You moderate and direct students. (SC1)

While these terms represent proper roles of teachers in inquiry teaching, many interviewees in this group made vague references to these terms without giving details about how teachers assume such roles during lessons. Participants who tried to elaborate on these teacher roles end up describing traditional roles of giving instructions, rules and regulations, and safety procedures for students to follow (Table 21). For example, a head teacher and two science teachers said:

> *The role of the teacher is just to guide the children. The teacher gives students rules and regulations on what to do and what not to do.* (HT11)

> *By guidance I mean students should be given the instructions and steps necessary to perform experiments. Before they enter the lab or perform experiment anywhere the teacher should give them guidance.* (ST3)

> *Coaching involves set of rules or guidelines governing whatever the students are expected to do. Coaching involves giving students the rules and spreading out what they need to get in an orderly manner.* (ST4)

The manner interviewees in the "Uninformed/Traditional" group used terms such as coaching, guiding, facilitating, and directing is inaccurate. These factual inaccuracies revealed the participants' uninformed conceptions about inquiry teaching, and rather exposed their traditional views of science instruction. Inquiry-based teacher guidance includes employment of extensive questioning and scaffolding to help students arrive at answers and solutions by themselves.

"Partially informed" conceptions. About one-quarter 10(24.4%) of the interviewed teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education articulated conceptions of inquiry teaching that are partially consistent with the constructivist views (Table 23). When asked to describe their conceptions of inquiry teaching, they said that it involves real world authentic activities in which students are taken on field trips to experience real science and get first-hand information. This conception is illustrated by excerpts from a head teacher and a science coordinator who said:

> *The teaching should involve children in seeing real object and organisms; and allowing children to participate in practical activities.* (HT3)

> *When students go round in the environment, they get to know living things and non-living things. They get to know the habitat of some living things that make the living things adapt comfortably in the habitat. Students also get to know that some living things live in the forest, they can't live in the desert, and that when they live in the desert adverse things will happen to them.* (HT3)

> *Children learn by experience and by using all their senses. So if the lesson is activity-based, you allow the child to use all his senses in*

learning. By using inquiry approach the teacher allows the children's cognitive domain to be active and to find out things for themselves. (SC2)

These responses show the interviewees' appreciation of the need for teachers to actively engage students in science lessons. The interviewees appreciate the need for teachers to allow students to use all their senses to manipulate and interact with materials, make observations, and use their cognitive tools to construct science knowledge for themselves.

When asked to describe roles of teachers during inquiry-based science teaching, interviewees in the "Partially informed" category used terms similar to those used by participants in the "Uninformed/Traditional" group. They also said that teachers in inquiry teaching guide, facilitate, monitor, lead, supervise, motivate, direct, and coach students (Table 21). For example, a circuit supervisor and science coordinator in this group said:

The teacher facilitates, he gives students direction as to what they should do. He then allows the children to come out with their own solution. (CS1)

The teacher's role is only to monitor and facilitates but the actual work is supposed to be done by the learner. (SC2)

However, unlike interviewees in the "Uninformed/Traditional" group, interviewees in the "Partially informed" group articulated fairly accurate conceptions of how teachers assume these roles during inquiry teaching. They said that the role of teachers in inquiry teaching is to give students autonomy (Table 21) and freedom to engage in activities while he guides, facilitates, and coaches them. The teacher comes in or interferes in students' activities only when they are in difficulties or it is necessary to do so. For example, a deputy director and a circuit supervisor said:

> *Why I am saying the teacher becomes a facilitator is that, when the children are going wayward in the wrong direction then he gives them guidelines.* (DD1)

> *When students are finding the problem to be difficult then the teacher comes in and gives them direction as to what to do and where to go. Where they encounter difficulty they come back to the teacher, he adds one or two ideas, and gives them direction.* (CS1)

Interviewees in this group said also that teachers in inquiry teaching guide, facilitate, and motivate students to prevent them from becoming frustrated and abandoning investigations. This idea is illustrated by the statement of a science coordinator who said:

> *If students are allowed to do investigations on their own it gets to a point they may not know what to do and they become discouraged. This leads to students saying science is difficult. So teachers are to serve as guides to the students.* (SC3)

Although interviewees in the "Partially informed" group expressed fairly accurate conceptions of inquiry teaching, they did not fully articulate how teachers lead students through extensive questioning and scaffolding to plan and design investigations, collect and record data, examine and evaluate the quality of data, and interpret data to develop explanations for phenomena.

Again, two participants in this group articulated traditional conceptions of science teaching, suggesting that they hold conflicting conceptions of inquiry teaching. The two participants described guiding in inquiry teaching as giving students step-by-step procedures to follow. For example, a science teacher said:

> *For instance, if we are going to test for starch, you group the students and distribute the materials to them. Then you give them the first step "put the leaf in the water and boil it for a number of minutes". When they finish you give them the next step and continue until you finish. So I only give the order "do this, do that".* (ST18)

The practice whereby teachers give students step-by-step procedures to follow is not inquiry-based strategy.

Conceptions of Inquiry Learning

Interview responses of teachers and educational administrators from the four districts and municipalities show that they held "Uninformed/Traditional" and "Partially informed" conceptions of inquiry learning, with none of them holding fully informed conceptions of inquiry learning.

"Uninformed/Traditional conceptions". Over three-quarters 31(75.6%) of the interviewed teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education expressed traditional conceptions of science learning, showing that they held uninformed conceptions of inquiry-based science learning (Table 23). When asked to describe their conceptions of inquiry learning, most participants in this category said it involves child-centred and student-centred activities; with students having autonomy to actively get involved in lessons (Table 21). For

example, a circuit supervisor and a head teacher said:

> *The lesson must be child-centred. When the children are involved in the lesson, they will understand it better.* (CS2)

> *Whenever the teacher is teaching he has to involve the students in the lesson. It shouldn't be teacher-centred. It should be child-centred.* (HT7)

While student-centred, child-centred, students' autonomy, and students' involvement are proper terms associated with the constructivist view of learning, interviewees in the "Uninformed/Traditional" category used these terms in reference to traditional learning practices where students practice activities after teacher demonstrations, and where students interact with materials just to have a feel of them. This is illustrated by the statements of a circuit supervisor and science teacher who said:

> *The children should be involved in the lesson. The teacher should carry out demonstrations for the children to see and hear, and allow them to practice it.* (CS2)

> *If teachers perform experiments they have to allow the students to also practice. So students must also be given the chance to use the reagents and apparatus in order for them to know how the equipment and materials are used.* (ST8)

Interviewees in this category used these terms in reference also to traditional science learning environments where students follow instructions and procedures during hands-on activities to arrive at predetermined answers. For example, a head teacher and a science teacher said:

> *The students abide by rules and regulations, and limit themselves to examples given by the teacher in the conduct of their assignments and experiments. In this way the students may come out with desired results in the end.* (HT11)

> *The students follow rules given to them by the teacher. That is the main thing. If they go beyond that they will deviate from their aim.* (ST13)

The use of terms such as student-centred, child-centred, and student autonomy in reference to traditional learning environments and activities are factually inaccurate. These inaccurate references revealed that interviewees in this category held traditional conceptions of science learning and uninformed conceptions of inquiry-based learning. Again, many interviewees in this group said students in inquiry learning engage in "research" (Table 21). For example, a science teacher and head teacher said:

> *During inquiry-based science learning students should be involved in making "research" and activities in the class.* (ST9)

> *If the students are asked to do "research" it means they are to go and find out.* (HT12)

However, "research" as used by the interviewees mean students reading already known information from books and on the internet, and seeking information from their friends, colleagues, parents, and resource persons. A circuit supervisor and a science teacher who shared this sentiment said:

> *Apart from teachers teaching them, students have to inquire from other*

sources to build up their knowledge. (CS4)

First of all students have to read something about what they are going to do so that they will have fair idea about it. In this way, whatever the teacher will say will not be strange to them. They also have to read ahead of the teacher so that they can move along with the teacher. (ST12)

This "research" for information is done to equip students with the necessary information to answer questions during traditional science instruction, in which teachers elicit students' prior knowledge and link it to the next lecture. However, readings done by students in traditional learning are different from references done by students engaged in inquiry-based learning. In inquiry-based learning, students make references from books, internet, articles, magazines, and newspapers to check if explanations they have constructed from their investigations are consistent with existing body of scientific knowledge.

Some interviewees in the "Uninformed/Traditional" group attempted to describe the constructivist perspective of learning by saying students' roles in inquiry are to explore, identify and solve problems, present results and findings, and engage in critical thinking (Table 21). For instance, a circuit supervisor, two deputy directors, and a science teacher said:

During inquiry, the child would like to explore and know. The child becomes curious and would like to know what make things function. (CS3)

Children should be free to do whatever they are doing in the class. They should be free to interact with the materials that have been provided. It shouldn't be forced on them. (DD2)

Students shouldn't take their mind far from their environment. They should take it that everything that we are learning is really around us. (ST11)

Before the teacher tells students what to do, they should be thinking about is what likely to happen next. Students should be able to guess (hypothesize) the final outcome of their investigations or activities. (DD3)

The role of students is to think critically about questions the teacher has asked. (DD2)

However, the interviewees made vague references to these features of inquiry. They could not give details about how students engage in explorations, identification and solution of problems, presentation of result and findings, and critical thinking.

"Partially informed" conceptions. About one-quarter 10(24.4%) of the interviewed teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education articulated conceptions of inquiry learning that are partially consistent with the constructivist perspective (Table 23). When asked to describe their conceptions of inquiry learning, interviewees in this category said that it is a child-centred activity in which

students take active part in investigations and come out with answers to leading questions driving their investigations (Table 21). For example, a science coordinator and circuit supervisor said:

> *Everything concerning the lesson from the beginning to the end is supposed to be done by the learner.* (SC2)

> *The role the children play is to take active part in activities and come out with solution to the problem that have been given to them by the teacher or what they themselves set out to find.* (CS1)

Interviewees in the "Partially informed" group further said that students in inquiry learning engage in in-depth discussions to plan and design their own procedures for investigations and construct their own knowledge (Table 21). A head teacher who shared this view said:

> *As a teacher, after introducing the topic to the children, you give them the chance to bring out their views about how they can go about the activity. The children will bring out all their ideas. The students will even suggest how the activity should be designed and conducted.* (HT3)

The interviewees were of the view that students in inquiry learning ask a lot of scientifically-oriented questions, and collect and record data. For example, a deputy director and science coordinator said:

> *The students are to probe and do more questioning.* (DD1)

> *The students also need to do a lot of recording that will help them to gather their information as they move along, else they may forget the*

information or data, and the whole activity will be disorganized. (SC3)

Additionally, participants in the "Partially informed" category said that students in inquiry investigations "research" for information from books, internet, and other sources to help them answer leading questions or solve problems that drive the investigations:

> *When the teacher gives students the leading question, the children look for information from other sources. If the children want to "research" into books, the teacher tells them books that will be very helpful.* (DD1)
>
> *There is a question or a problem to be answered, the students' duty or role is to get information from a source, and answer the question based on the way they understand the situation.* (ST17)

The interviewees also said that students in inquiry learning work in groups, engage in discussions, share ideas, bring suggestions, and engage in useful criticisms to construct their own knowledge (Table 21). For example, a head teacher and science teacher said:

> *It involves children tying to inquire through discussions among themselves.* (HT1)
>
> *If students are in groups, all of them are to take part, share ideas, contribute, bring suggestions, and criticize their friends' ideas. Not criticisms per se but offer suggestions, weigh the suggestions or contributions of individual groups, and then come up with the best solution to a problem.* (ST17)

Again, interviewees in the "Partially informed" category said that science inquiry learning does not occur in classroom alone, but also in the field. Example of interviewees' quotes expressing this idea is:

> *Inquiry learning is not limited to only classroom work, but it can even take place outside the classroom. Wherever children find themselves they get the feeling that learning can take place there. So, scientific inquiry is not a straightforward thing that follows a certain procedure in the classroom.* (ST17)

However, two participants in this category articulated traditional conceptions of science learning in addition to the partially constructivist conceptions they articulated, suggesting that they hold conflicting conceptions of inquiry learning. The two participants said that students involved in inquiry learning practice activities demonstrated by teachers in order to arrive at the same answers:

> *... The children are allowed to practice it (activities) on their own, to try to get results that the teacher got when he did the demonstration lesson.* (SC2)

Learning that involves students in practising activities demonstrated by teachers is not inquiry-based.

Discussion

In summary, this study found that most of the interviewed science teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education from the four Ghanaian districts and municipalities held uninformed conceptions of scientific inquiry. This poses major challenges to inquiry-based science teaching in JHSs. This finding is partly consistent with some findings in industrialised and industrialising countries (Abell & Smith, 1994; Haefner & Zembal-Saul, 2004), but contradicts many others in the same countries (e.g., Abd-El-Khalick et al., 1998; Aguirre et al., 1990; Ireland et al., 2012; Park & Lee, 2009). Abell and Smith found that 19.3% of pre-service teachers they studied in USA conceived scientific inquiry from the perspective of teachers teaching and learners learning science. Similarly, Haefner and Zembal-Saul found that prior to an inquiry-based science methods course in USA, over half of the prospective teachers discussed science and doing science in the context of school or educational settings. In contrast, Abd-El-Khalick et al. (1998), Ireland et al. (2012), Park and Lee (2009), and Dudu (2014) found that most of the teachers they studied in USA, Australia, Korea, and South Africa respectively articulated adequate constructivist conceptions of the nature of science.

Again, this study found that most of the teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education held uninformed conceptions of inquiry teaching and learning in line with their uninformed conceptions of scientific inquiry. The participants rather held traditional conceptions of science teaching and learning. This finding is consistent with theoretical assumptions and empirical evidence that teachers' conceptions of scientific inquiry reflect in their conceptions of science teaching and learning (e.g., Abd-El-Khalick, et al., 1998; Aguirre et al., 1990; Crawford, 2007). This finding is similar to others in Africa (e.g., Ngman-Wara, 2015) and some findings in industrialised and industrialising countries (e.g., Aguirre et al., 1990; Haefner & Zembal-Saul, 2004), but contradicts many findings in the same countries (e.g., Crawford, 2000; Ireland et al., 2012). While majority of the science teachers Ngman-Wara studied in Kenya held weak knowledge of contextualised science instruction, Haefner and Zembal-Saul found that many of the prospective teachers they studied in USA initially conceived science teaching as dissemination of knowledge. Similarly, Aguirre et al. found that many of the teachers they studied in Canada conceived science learning as intake of knowledge. In contrast, Ireland et al. found that nearly all the teachers they studied in Australia conceived inquiry teaching as experience-centred, problem-centred, and question-centred activities. Likewise, the science teacher Crawford (2000) studied in USA held adequate conceptions of inquiry teaching and assumed multiple roles during inquiry lessons.

While empirical evidence show that inquiry-based science teaching is more effective than traditional instruction in promoting students' scientific literacy (e.g., Chang & Mao, 1999; Furtak et al., 2012), and while the current rationale for basic science education in Ghana requires teachers to engage all students in inquiry investigations (CRDD, 2007, 2012), the aforementioned findings suggest that most teachers in the four Ghanaian districts and municipalities cannot implement inquiry teaching in their lessons, since teachers do not teach what they do not know (Dudu, 2014; Lederman, 1992).

Again, while there is significant and growing population of pre-service and in-service teachers with adequate conceptions of scientific inquiry and inquiry teaching and learning in industrialised and industrialising countries (e.g., Abd-El-Khalick et al., 1998; Crawford, 2000; Ireland et al., 2012), this finding suggests that there is unavailability of teachers and educational administrators with informed conceptions of scientific inquiry and inquiry teaching and learning in the four Ghanaian districts and municipalities, as may be the case in other districts and municipalities. These findings have not been reported in the available literature searched, and are significant contributions to the science education literature.

Abell and Smith (1994) and Haefner and Zembal-Saul (2004) largely attributed the uninformed conceptions of scientific inquiry and inquiry teaching and learning held by pre-service teachers in their study to the fact that their studies were conducted in educational settings. However, semi-structured interviews with participants in this study show that most of the teachers and educational administrators formed and developed uninformed conceptions because they have never been exposed to and never experienced inquiry-based teaching and learning throughout their education as students. As a result, they do not have clear images of the processes of science, and activities and thinking processes that actual scientists employ to inquire into the natural world. Most of the Ghanaian teachers and educational administrators were taught science through traditional methods when they were students in elementary and secondary schools and in teacher training institutions. Therefore, they only have images of traditional science teaching methods. For example, a teacher said:

> *What my teachers were doing is what I am also doing now. In fact, I have not seen any change at all. It's like inheritance if I may put it that way.* (ST1)

The formation and development of uninformed conceptions of inquiry by the Ghanaian teachers and educational administrators is similar to those reported in other contexts (e.g., Abd-El-Khalick, 2012; Abelson, 1979; Crawford, 2000; Lederman, 1998; Pajares, 1992).

It is, however, noteworthy and encouraging that this study found a few teachers and educational administrators with conceptions of scientific inquiry and inquiry teaching and learning that are partially consistent with the constructivist views. These findings partly conform to those of Abd-El-Khalick et al. (1998) and Dudu (2014). The formation and development of partially accurate conceptions of inquiry by this group of teachers and administrators were not examined in this study. However, a deputy director of education in this group said he had his first degree education in United States of America. It is likely that he formed partially informed conceptions of the nature of science and inquiry teaching and learning in USA, where there is much awareness about the processes of science and contemporary strategies for teaching and learning science. Besides, the other interviewees in this category are professional teachers and educational administrators. It is likely that they formed partially informed conceptions of inquiry from science methods literature they have read and/or media they have watched (Pajares, 1992).

In most industrialised and industrialising countries, inquiry-based science methods courses and interventions are designed to engage pre-service and in-service teachers in experiences that explicitly change their conceptions and classroom practices from teacher-centred to student-centred approaches (e.g., Haefner & Zembal-Saul, 2004). However, more than three-quarters 34(82.9%) of the Ghanaian teachers and administrators interviewed in this study said that in-service trainings given to teachers are designed to treat challenging topics identified in the syllabus, but not to engage teachers in inquiry-based experiences. For example, a science coordinator said:

> *We identify areas or topics in the syllabus that teachers have difficulties teaching in class. We then mobilise the science teachers at one place and take them through resolving those difficulties.* (SC3)

The fact that most of the Ghanaian teachers and educational administrators have never experienced inquiry teaching and learning and are not provided with inquiry-based in-service training is worrisome. This is because they will continue to hold onto uninformed conceptions of scientific inquiry and traditional conceptions of science teaching and learning they have acquired.

Extent to which teachers' attitudes pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities

Determining extent to which teachers' attitudes pose challenges to inquiry-based science teaching in JHSs in the districts and municipalities involved examination of four components of the teachers' attitudes (perceived relevance, perceived interest, perceived difficulty, and perceived anxiety) to determine whether they are weak, moderate, or strong to facilitate or impede inquiry teaching. This involved calculation of average item means, average item standard deviations, frequencies, and percentages of items constituting the four components of attitudes: using quantitative data from the teachers' ratings of their attitudes toward inquiry teaching. Then, I triangulated the quantitative results with qualitative themes, patterns, and sample quotations from interview responses of a subsample of the teachers on the same issues.

Table 24 shows average item means and average item standard deviations of the JHS teachers' ratings of their attitudes toward inquiry-based science teaching.

Table 24: *Average item means and average item standard deviations of JHS teachers' ratings of their perceived interest, relevance, difficulty, and anxiety toward inquiry-based science teaching*

Component of attitude	No of items	Min	Max	Average Item mean	Average Item Standard deviation
Perceived interest	4	1	5	4.07	.73
Perceived relevance	5	1	5	3.90	.70
Perceived difficulty	4	1	5	2.08	.74
Perceived anxiety	6	1	5	3.54	.71
Attitudes toward science inquiry teaching	19	1	5	3.44	.42

Note: high mean is inquiry-based. low mean is traditional-oriented; N = 308

Source: Field data. Mohammed (2015)

In consistent with the operationalisation of Van Aalderen-Smeets and Walma Van der Molen (2015), average item means equalling 2 or less are associated with low attitudes, means between 2 and 4 are associated with moderate attitudes, and means equalling 4 or higher are associated with high attitudes.

Overall, the JHS teachers' ratings show that they held moderate attitudes toward inquiry-based science teaching (M = 3.44. SD = 0.42). While they highly perceived inquiry-based science teaching to be interesting (M = 4.07, SD = .73) and relevant (M = 3.90. SD = .70), they highly perceived it to be difficult (M = 2.08. SD = 0.74) and moderately perceived anxiety toward it (M = 3.54, SD = .71).

Most of the teachers agreed that it is interesting to implement inquiry-based science teaching in JHSs, saying it is exciting 272 (88.3%) and easy

192(62.3%) to allow JHS students to manipulate science equipment and materials, and is enjoyable 285(92.5%) to allow JHS students to work in groups (Table 25).

Table 25: *Frequencies and percentages of JHS teachers' ratings of their perceived interest, relevance, difficulty, and anxiety toward inquiry-based science teaching*

Item	Responses				
	SD n(%)	D n(%)	U n(%)	A n(%)	SA n(%)
Perceived interest					
Teaching science is exciting when JHS students manipulate equipment and materials.	0(0.0)	20(6.5)	16(5.2)	143(46.4)	129(41.9)
It is easy allowing JHS students to manipulate science equipment and materials	18(5.8)	58(18.8)	40(13.0)	98(31.8)	94(30.5)
It is enjoyable making JHS students work in groups.	0(0.0)	17(5.5)	6(1.9)	164(53.2)	121(39.3)
Perceived relevance					
Relevant to make JHS students work systematically like scientists.	0(0.0)	34(11.0)	22(7.1)	151(49.0)	101(32.8)
Relevant to make JHS students examine and evaluate quality of data.	0(0.0)	51(16.6)	14(4.5)	160(51.9)	83(26.9)
Appropriate to make JHS students examine and evaluate quality of data.	14(4.5)	46(14.9)	29(9.4)	162(52.9)	57(18.5)
Relevant to make JHS students plan, design, and perform experiments.	0(0.0)	51(16.6)	20(6.5)	117(38.0)	120(39.0)
Appropriate to make JHS students work systematically like scientists.	0(0.0)	40(13.0)	24(7.8)	162(52.6)	82(26.6)
Perceived anxiety					
It is uneasy to make JHS students interpret data to develop explanations for science phenomena.	53(17.2)	144(46.8)	38(12.3)	46(14.9)	27(8.8)

(Table 25, continued).

Item	Responses				
	SD n(%)	D n(%)	U n(%)	A n(%)	SA n(%)
It is nervous making JHS students argue and discuss scientific ideas among themselves.	77(25.0)	143(46.4)	31(10.1)	34(11.0)	23(7.5)
Teaching takes too much time when I make JHS students examine and evaluate data.	16 (5.2)	63(20.5)	18(5.8)	133(43.2)	78(25.3)
It is nervous allowing JHS students to formulate hypotheses for science phenomena.	53(17.2)	135(43.8)	58(18.8)	39(12.7)	23(7.5)
It is nervous making JHS students collect and record data.	95(30.8)	147(47.7)	23(7.5)	43(14.0)	0(0.0)
Perceived difficulty					
I feel at ease writing science concepts and principles on the board for students to copy.	16(5.2)	44(14.3)	24(7.8)	154(50.0)	70(22.7)
It is easy defining and stating science concepts for students.	0(0.0)	32(10.4)	15(4.9)	165(53.6)	96(31.2)
It is difficult writing science concepts and principles on the board for JHS students to copy.	96(31.2)	140(45.5)	16(5.2)	56(18.2)	0(0.0)
It is comfortable defining and stating science concepts and principles for JHS students.	0(0.0)	48(15.6)	10(3.2)	140(45.5)	110(35.7)

N = 308

SD = Strongly Disagree, D = Disagree, U = Uncertain, A = Agree, SA = Strongly Agree
Source: Field data, Mohammed (2015)

While quantitative results from the teachers' ratings show that they highly perceived inquiry-based science teaching to be interesting, interview responses from a subsample of them revealed remarkable insights into their high interest. Responses from the interviewees show that while many teachers expressed high interest based on partially informed conceptions of inquiry.

most of them expressed high interest based on traditional conceptions of science teaching. Therefore, the qualitative results show that the teachers' interest in inquiry teaching is not as high as the quantitative results appear to show. Interviewees who expressed high interest based on partially informed conceptions of inquiry teaching expressed willingness to allow JHS students to plan and perform their own science investigations. However, interviewees who expressed high interest based on traditional conceptions of science teaching expressed unwillingness to allow JHS students to plan and perform their own science investigations.

Teachers who expressed high interest based on partially informed conceptions of inquiry felt that inquiry teaching improves students' understanding and retention of science knowledge than students' reception of content delivered by instructors. For example, a teacher said:

> *If students perform activities themselves, they understand it more than the teacher doing it.* (ST1)

The teachers felt also that when students are engaged in inquiry activities they become familiar with and know the names and uses of science instruments. Example of teachers' quotes expressing this idea is:

> *The students will be able to tell the names of the instruments since they have performed the activities themselves. The students will be able to tell that this is a thermometer and this is a measuring cylinder.* (ST1)

Again, the teachers felt that inquiry teaching gives students real science experiences and first-hand knowledge. Another teacher said:

> *If students engage in inquiry activities, it helps them because they get first-hand information of whatever they are learning. Seeing and*

handling things they are learning stick in their heads more than the teacher telling them everything. (ST15)

Additionally, the teachers felt that when students are engaged in inquiry activities they can transfer the knowledge gained into their future classes:

Students at the junior high school level should be allowed to plan and perform their own experiments so that when they go to senior high schools they won't suffer. (ST8)

However, teachers who expressed high interest in inquiry teaching based on traditional conceptions of science teaching felt that it is inappropriate to engage JHS students in science investigations because the students have low abilities, lack motivation for science work, have no familiarity with the inquiry process, cannot read and understand English language, and that allowing JHS students to conduct investigations might lead to accidents. These teachers felt that they will only allow JHS students to perform investigations when all safety procedures and step-by-step guidelines have been spelt out. For example, three teachers said:

Before you plan and conduct your own experiment you need English language because everything is done in English. Reading and understanding is a major problem (for the students). So they cannot perform any experiment on their own unless the teacher is involved. (ST10)

I will not allow JHS students to plan and perform their own investigations because the children are at the basic level and they don't know much about science apparatus and materials. If you allow *them to perform investigations on their own they might add water into acid and there will be an explosion.* (ST3)

It will be very difficult for JHS students to perform their own science investigations. The teacher will have to lead them. Sometimes, I write notes on the board to guide JHS students in performing certain experiments. So it's not appropriate to allow JHS students to perform experiment on their own. (ST12)

Responses from the teachers' ratings show also that they highly perceived inquiry-based science teaching to be relevant (M = 3.90, SD = .70) and expressed the importance of engaging students in inquiry activities (Table 24). More than three-quarters of the teachers agreed that it is important to make JHS students plan, design, and perform their own science investigations 237(77.0%); examine and evaluate the quality of data 243(78.8%); and work systematically like actual scientists do 252(81.8%) (Table 25).

While quantitative results from the teachers' ratings show that they highly perceived inquiry teaching to be relevant, responses from interviews with a subsample of the teachers also show the same results. Most of the interviewees felt that allowing JHS students to carry out their own investigations will help the students to acquire inquiry skills. They explained further that when JHS students are exposed to inquiry learning they will develop skills of identifying and finding solutions to problems in their day-to-day real-life experiences. For example, a teacher said:

Inquiry teaching will inculcate the attitude of problem identification in JHS students. If the procedures of science become familiar to a *student, he can identify certain problems and start thinking about how to solve them.* (ST16)

The interviewees felt also that inquiry teaching will encourage JHS students to take active part in the teaching and learning process and use their own ideas to construct and acquire knowledge for themselves. A teacher stated:

The importance of students planning their own investigations is that they will acquire knowledge for themselves. (ST2)

Again, the teachers felt that when JHS students are engaged in inquiry activities they will develop deeper understanding of science concepts and principles through experiences of real-life science phenomena. Example of teachers' quotes expressing this idea is:

When children are allowed to perform or make their own inquiries they get deeper understanding than the teacher delivering lectures to them. This is because they have a feel of science phenomena, they experiment or manipulate it, and they know it's real. (ST9)

Additionally, the teachers felt that inquiry-based science teaching will improve JHS students' attitudes toward science and science learning. They explained further that when students in their formative years are engaged in frequent inquiry activities, they find it easy to learn science and their confidence grows. For example, a teacher said:

If you inculcate inquiry "spirit" into kids at tender age, learning science will be easy for them when they grow up with it (inquiry spirit). They will have better understanding of science concepts and that will help promote their interests in science and learning science. (ST14)

Again, the teachers felt that inquiry teaching will remove misconceptions and superstitious beliefs held by students. They explained further that, as students explore and get to know the existence of natural and artificial science phenomena they become convinced about the reality of these phenomena:

> *Conducting their own investigations may clear superstitious beliefs they have that outbreak of sicknesses and epidemics are from gods or ancestors. They will see that it is when our environment is dirty that sicknesses and epidemics break out.* (ST4)

Responses from the teachers' ratings show also that they highly perceived inquiry-based science teaching to be difficult (M = 2.08, SD = .74), but perceived traditional science instruction to be easy (Table 24). Most of them agreed that it is easy and comfortable to engage in traditional teaching practices such as defining and stating science concepts and principles 250(81.2%) and writing them on the blackboard 224(72.7%) for JHS students to copy. They disagreed that it is difficult 236(76.7%) to write science concepts and principles on the blackboard for JHS students to copy (Table 25).

While quantitative results from the teachers' ratings show that they highly perceived inquiry-based science teaching to be difficult, interview responses from a subsample of them show the same results. Most of the interviewed teachers felt that it is difficult to implement inquiry teaching in JHSs because science equipment and materials are not available in schools. They explained further that, even where science equipment and materials are available JHS students don't know how to use them. For example, a teacher said:

> *The difficulty in leaving students to do their own investigations is that they will not be able to interact with the materials very well. The*

students have never seen most of the science equipment before. (ST2)

Again, some teachers felt that it will be difficult to achieve the objectives of science lessons because of students' unfamiliarity with the inquiry process. Example of teachers' quotes expressing this idea is:

> *JHS students might not have full understanding of theory behind the experiments they are going to perform. The students might not also have mastery of procedures required for the experiments.* (ST7)

Additionally, the interviewees felt that most JHS students' inability to read and understand English language make it difficult to implement inquiry-based science teaching. They expressed further that unless the teacher is there to explain certain statements and words to JHS students it will be difficult for the students to engage in science inquiry. For example, a teacher stated:

> *The students' inability to read is also part of the difficulty. Even if the teacher gives them the method and procedure to follow, reading to know that this is pipette or burette is a problem. So leaving them to plan and do investigations on their own is very, very difficult.* (ST2)

The teachers felt also that it is difficult to implement inquiry teaching in JHSs because most students have low abilities to engage in inquiry, lack motivation for science work, and are anxious toward science. For example, a teacher stated:

> *It depends on the class of students that you are teaching. We have a class where performance of majority of the students is below average or just average. It is therefore difficult for the teacher to allow such children to perform their own experiments.* (ST3)

Responses from the teachers' ratings show further that they held moderate anxiety toward inquiry-based science teaching (M = 3.54, SD = .71) (Table 24). While many of them agreed that it is not nervous to allow JHS students to collect and record 242(78.5%) and interpret 197(64.0%) data to develop explanations for science phenomena, 73(23.7%) of them agreed that it is anxious to allow JHS students to interpret data to develop explanations for science phenomena. Additionally, while many teachers agreed that it is not nervous to allow JHS students to formulate hypotheses 188(61.0%) and discuss scientific ideas among themselves 220(71.4%), a considerable number of the teachers agreed that is anxious 62(20.2%) to allow JHS students to formulate hypotheses for science phenomena, while others were uncertain about allowing JHS students to formulate hypotheses for science phenomena 50(18.8%) (Table 25).

Discussion

To sum up, triangulation of quantitative results from the teachers' ratings and qualitative results from a subsample of them show that they held low attitudes toward inquiry-based science teaching. Specifically, this study found that while most teachers in the four Ghanaian districts and municipalities highly perceived inquiry teaching to be relevant, they highly perceived it to be difficult and moderately perceived anxiety toward it. Additionally, while many teachers perceived high interest in inquiry teaching based on partial conceptions of inquiry, many others perceived high interest in inquiry teaching based on traditional conceptions of teaching. Instead, most of the teachers highly perceived traditional science teaching to be easy, less anxious, and interesting. This poses major challenges to implementation of inquiry-based science teaching in JHSs in the Ghanaian districts and municipalities.

While inquiry-based science teaching is more effective in improving students' learning outcomes (e.g., Furtak et al., 2012), the aforementioned findings suggest that most JHS teachers in the Ghanaian districts and municipalities lack strong favourable attitudes to adopt and implement it in classrooms. Teachers with unfavourable attitudes toward inquiry teaching exhibit lower confidence in using it, and are more dependent on traditional, top-down instructional methods (Van Aalderen-Smeets & Walma van der Molen, 2013, 2015; Van Aalderen-Smeets et al., 2012). Therefore, the present findings suggest that most integrated science teachers in the districts and municipalities cannot teach in line with the rationale for basic science education in Ghana (CRDD, 2007, 2012). The teachers need to develop strong and robust positive attitudes toward inquiry-based science teaching before they can effectively plan and implement it in their classrooms.

The aforementioned findings are similar to some findings in industrialised and industrialising countries (Choi & Ramsey, 2009; Turkmen, 2013), but contradicts many others in the same countries (e.g., Korur et al., 2016; Van Aalderen-Smeets, & Walma van der Molen, 2013). Choi and Ramsey found that while most of the teachers they studied in USA perceived inquiry teaching to be important, the teachers felt reluctant and dreaded the implementation of inquiry teaching in their lessons. Similarly, while the teachers Turkmen studied in Turkey perceived themselves as facilitators who guide students to engage in processes of science, they also perceived themselves as transmitters of knowledge who deliver facts students should know. In contrast, Korur et al. (2016) found that many teachers they studied in

Turkey and Spain had little or no perceived anxiety, fear, or stress toward teaching science. Similarly, Van Aalderen-Smeets and Walma van der Molen (2013) found that most of the pre-service and in-service teachers they studied in Netherlands held low perceived anxiety and dependency on context factors but high perceived enjoyment of teaching science.

While studies show that there is significant and growing population of teachers with strong favourable attitudes toward inquiry-based science teaching in industrialised and industrialising countries (e.g.. Korur et al., 2016; Van Aalderen-Smeets & Walma van der Molen, 2013), this study suggests that there is unavailability of teachers in the Ghanaian JHSs with strong favourable attitudes toward inquiry-based science teaching.

As is the case with teachers in other contexts (e.g., Choi & Ramsey. 2009; Minger & Simpson, 2006; Özdemir & Güngör, 2017; Tenaw, 2014), most of the Ghanaian teachers in this study developed less positive attitudes toward inquiry-based science teaching because they lacked exposure and experiences with inquiry science when they were students in elementary and secondary schools and in their undergraduate programmes. As a result, the teachers have developed disinterest and anxiety toward inquiry-based science teaching, and perceive it to be difficult. The teachers rather felt interested and less anxious about traditional science teaching and perceived it to be easy because they are more familiar with content-based programmes from their youth. Therefore, the teachers are more likely to teach in the traditional manner they were taught themselves.

In most industrialised and industrialising countries, pre-service and in-service teachers are engaged in science methods courses and professional development interventions that are explicitly focused on changing and developing their attitudes toward inquiry-based science teaching (e.g., Choi & Ramsey, 2009; Grigg et al., 2013; Marx et al., 1994; Minger & Simpson, 2006; Toolin, 2004; Van Aalderen-Smeets & Van der Molen, 2015). However, the situation is different in the Ghanaian districts and municipalities, as may be the case in other districts and municipalities. Science teachers in the districts and municipalities are rarely given in-service trainings. Even the rare in-service trainings given to them are designed to treat some difficult topics identified in the syllabus, but not to engage them in attitude-focused inquiry-based experiences. For example, a deputy director of education said:

> *Currently, funding to the district education office from the government has ceased since 2012. Those who are supporting us now are DANIDA, USAID, and DFID. They come with their own terms such as using the money for school inspections. So, we advise the head teachers that if the capitation grant is released by chance, they should use part of it to organise school-based INSETs.* (DD1)

This except indicates clearly that explicit attitude-focused inquiry-based professional development for science teachers is not currently a priority in the Ghanaian districts and municipalities. This means, most of the JHS teachers will continue to harbour the negative attitudes toward inquiry-based science teaching that they have developed.

Extent to which teachers' beliefs pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities

Determining extent to which teachers' beliefs pose challenges to inquiry-based science teaching in JHSs in the districts and municipalities involved examination of four components of JHS teachers' beliefs ("how students learn science", "science lesson design and implementation" "characteristics of science teachers and the lesson environment", and "nature of science curriculum") to determine whether they are weak, moderate, or strong to facilitate or impede inquiry teaching. This involved calculation of average item means, average item standard deviations, frequencies, and percentages of items constituting the components of beliefs; using quantitative data from the teachers' ratings of their beliefs about inquiry-based science teaching. I then triangulated the quantitative results with qualitative themes and sample quotations from interview responses of a subsample of the teachers on the same issues.

Table 26 shows average item means and average item standard deviations of JHS teachers' ratings of their beliefs about inquiry-based science teaching.

Table 26: *Average item means and average item standard deviations of JHS teachers' ratings of their beliefs about inquiry-based science teaching*

Component of belief	No of items	Min	Max	Average item mean	Average item standard deviation
Nature of science curriculum	3	1	5	4.32	.59
Science lesson design and implementation	3	1	5	4.17	.61
How students learn science	3	1	5	4.10	.65
Characteristics of science teacher and the learning environment	5	1	5	1.20	.76
Beliefs about inquiry-based science teaching	14	1	5	3.27	.35

Note: high mean is inquiry-based, low mean is traditional-oriented; N = 308

Source: Field data, Mohammed (2015)

Overall, the teachers' ratings show that they held moderate beliefs about inquiry-based science teaching (M = 3.27, SD = .35). While they held strong inquiry-based beliefs about the "nature of science curriculum" (M = 4.32, SD = .59), "science lesson design and implementation" (M = 4.17, SD = .61), and "how students learn science" (M = 4.10, SD = .65), they held weak inquiry-based but strong traditional beliefs about "characteristics of science teachers and the lesson environment" (M = 1.20, SD = .76). Quantitative results from the teachers' ratings show that they held strong traditional beliefs about "characteristics of science teachers and the lesson environment" (Table 27). Most of them agreed that JHS students are more likely to understand science concepts 269(87.4%) if the teacher is really good at defining and explaining concepts 239(77.6%) and writing them on the board for students to copy 213(69.2%).

Table 27: *Frequencies and percentages of JHS teachers' ratings of their beliefs about inquiry-based science teaching*

Item	Responses				
	SD	D	U	A	SA
	n(%)	n(%)	n(%)	n(%)	n(%)
Beliefs about characteristics of science teachers and the lesson environment					
A good science teacher is really good at explaining and defining science concepts for JHS students.	0(0.0)	51(16.6)	18(5.8)	121(39.3)	118(38.3)
JHS students are more likely to understand a concept if the teacher defines and explains it clearly.	0(0.0)	31(10.1)	8(2.1)	117(38.0)	152(49.4)
Science curricula need to focus on defining and explaining science concepts that JHS students need to know.	0(0.0)	35(11.4)	11(3.6)	144(46.8)	118(38.3)
Beliefs about the nature of science curriculum					
Science teachers should write science concepts on the board for JHS students to copy. Science teachers should write science concepts on the board for JHS students to copy.	14 (4.5)	60(19.5)	21(6.8)	141(45.8)	72(23.4)

(Table 27,continued).

Item	Responses				
	SD n(%)	D n(%)	U n(%)	A n(%)	SA n(%)
Science curricula should encourage JHS students to learn to interpret data to develop explanations.	0(0.0)	13(4.2)	5(1.6)	184(59.7)	106(34.4)
JHS students need to be given opportunities to work in groups.	0(0.0)	8(2.6)	3(1.0)	152(49.4)	145(47.1)
Science curricula should help JHS students develop skills of collecting and recording data.	0(0.0)	13(4.2)	12(3.9)	153(49.7)	130(42.2)
Beliefs about science lesson design and implementation					
To prepare students for future classes, science curricula should encourage JHS students to challenge scientific ideas.	0(0.0)	19(6.2)	25(8.1)	156(50.6)	108(35.1)
During lessons, JHS students need to be given opportunities to challenge scientific ideas.	0(0.0)	13(4.2)	20(6.5)	177(57.5)	98(31.8)
Teachers should allow JHS students to reason and reach collective decisions together to help determine the focus and direction of science lessons.	0(0.0)	13(4.2)	13(4.2)	179(58.1)	103(33.4)
Beliefs about how students learn science					
Lessons should be designed to allow JHS students learn systematically instead of through lectures.	0(0.0)	14(4.5)	13(4.2)	143(46.4)	138(44.8)
JHS students learn science the most when they interpret data to develop explanations for science phenomena.	0(0.0)	20(6.5)	37(12.0)	186(60.4)	65(21.1)
Science teachers should act as resource persons to support JHS students examine and evaluate quality of data rather than explaining how things work.	0(0.0)	28(9.1)	21(6.8)	171(55.5)	88(28.6)

Source: Field data, Mohammed (2015) N = 308

While quantitative results from the teachers' ratings show that they held weak inquiry-based but strong traditional beliefs about "characteristics of science teachers and the learning environment", interview responses from a subsample of them provide in-depth understanding into their traditional beliefs. Most of the interviewees strongly believed that in order to deliver science content to students, they must create conducive and quiet classroom environments. For example, a teacher said:

> *Before the teacher teaches, the environment must be conducive. You can't go to classroom and teach while the children are making noise and talking. Before teaching students, you can take them through some poems, riddles, and jumping exercises so that their attention will be in the class.* (ST4)

The interviewees explained that in creating conducive learning environments they need to employ traditional strategies such as controlling students' behaviours, and managing large class sizes and seating arrangements. This also involves grouping students and telling them what they should do and what they should not do. Example of teachers' quotes expressing these ideas is:

> *In order to monitor students, first of all you have to tell them what they should do and what they should not do. Then you have to create sizeable groups that wouldn't be difficult to monitor. You have to make sure to elect a leader for each group. Then you can monitor them.* (ST7)

Additionally, the interviewees believed that they need to use demonstration lessons in order to control students' behaviours in classrooms. For example, a teacher stated:

> *A student can be called in front of the whole class to demonstrate an experiment for others to listen and have a look at it. In that case also the teacher is controlling the class in order for the students not to*

disturb or interrupt the lesson. (ST11)

Again, quantitative results from the teachers' ratings show that they held strong inquiry-based beliefs about the "nature of science curriculum". Most of them agreed that science curriculum should encourage JHS students to develop skills of collecting and recording data 283(91.9%); learn to interpret data to develop explanations for science phenomena 290(94.1%); and give students the opportunity to work in groups 297(96.5%) to construct their own knowledge during science lessons (Table 27).

While quantitative results from the teachers' ratings show that they held strong inquiry-based beliefs about the "nature of science curriculum", interview responses from a subsample of them show that many of them held strong beliefs based on partially informed conceptions of inquiry, whereas others held strong beliefs based on traditional conceptions of science teaching. Therefore, the qualitative results show that the teachers' beliefs about "nature of science curriculum" were not as strong as the quantitative results appear to show. Interviewees who expressed strong beliefs based on partially informed conceptions of inquiry believed that science curricula should focus on meaningful learning, engagement of students in science investigations, and devoid of wide content coverage. The teachers explained that avoiding wide content coverage involve removing or merging some content in the science syllabi or curricula. For example, three teachers said:

It is too much for students to go through such (the JHS) a curriculum. The content of the (JHS) syllabus is too loaded. It makes science to become "chew and pour" (rote memorization) without understanding. There are some topics that should be taken away from the syllabus. It *is better for students to learn to understand the little content that is available.* (ST12)

Given the number of topics in the (JHS) syllabus, you have to put in much effort before you can finish all the topics without experiments. We usually take out some topics that are not very relevant and only focus on the relevant ones, so that we can have some time for science experiments. (ST7)

Certain topics are repeated in the syllabus. I don't see the need for that. I think there are so many topics that should come together. (ST18)

However, interviewees who expressed strong beliefs about the "nature of science curriculum" based on traditional conceptions of science teaching believed that science curricula should consist of separate practical and theory aspects; where certain periods are allocated for learning science theory (concepts and principles) and others are allocated for hands-on activities to verify the concepts learned. Examples of teachers' quotes expressing these ideas are:

Some aspects of science involve theory. I wish that 2 periods should be allocated for theory and 1 period for practical work. (ST17)

I have three periods in each class. I can sufficiently use two periods for practical and use one period for the content aspect of science. (ST16)

The curriculum should be prepared in a way that time allocated for experiments will be much longer and time allocated for theory will be normal. (ST6)

Quantitative results from the teachers' ratings show also that they held strong inquiry beliefs about "science lesson design and implementation". Most of them agreed that JHS students should be given opportunities to challenge scientific ideas through arguments, discussions, and presentations 275(89.3%); and allowed to reason to reach collective decisions in order to help determine the focus and direction of science lessons 282(91.5%) (Table 27).

While quantitative results from the teachers' ratings show that they held strong inquiry beliefs about "science lesson design and implementation", interview responses from a subsample of them indicate that many of them held strong beliefs based on partially informed conceptions of inquiry, whereas most of them held strong beliefs based on traditional conceptions of science teaching. Therefore, the qualitative results show that the teachers' beliefs about "science lesson design and implementation" were not as strong as the quantitative results appear to show. Interviewees who expressed strong beliefs based on traditional conceptions of science teaching believed that science lessons should consist of separate theory and practical aspects, where students are taught science concepts in one lesson and engaged in hands-on activities to learn observation and measurement skills in another lesson. For example, a teacher stated:

Most of the science periods on the timetable are double. So after going through the theoretical aspect with the students in one period, you then organise the children to go to the lab in the next period. (ST3).

Again, the interviewees believed that teachers should strictly monitor the behaviour and actions of JHS students during hands-on activities. They explained that teachers should monitor students' behaviours by giving students step-by-step procedures and safety precautions to follow. Examples of teachers' quotes expressing these ideas are:

> *After the theory lessons, children should go to the lab and perform experiments with strict monitoring from the teacher.* (ST3)

> *You (the teacher) should set up the equipment and direct pupils on how to perform the experiment. You should give them the steps involved in doing the experiment.* (ST15)

Additionally, the interviewees believed that science teachers should plan lessons ahead, gather all the chemicals and materials needed, and try out the experiments before going to classrooms. For instance, a teacher said:

> *If there are some chemicals involved, you don't wait till that day before you start preparing. You prepare ahead. The teacher can also perform the experiment ahead to find out if the materials are working.* (ST16)

Again, quantitative results from the teachers' ratings show that they held strong inquiry-based beliefs about "how students learn science". Most of them agreed that JHS students learn science the most 251(81.5%) when teachers act as resource persons 259(84.1%) and support students to examine and evaluate the quality of data rather than explaining how things work (Table 27). Most of the teachers agreed that science lessons should be designed to allow JHS students learn new concepts systematically like scientists do instead of through lectures, reading, and demonstrations 281(91.2%).

However, interview responses from a subsample of the teachers show that while many of them held strong beliefs about "how students learn science" based on partially informed conceptions of inquiry, many others held strong beliefs based on traditional conceptions of science teaching. Therefore, the qualitative results show that the teachers' beliefs about "how students learn science" were not as strong as the quantitative results seem to show. Interviewees who expressed strong beliefs based on partially informed conceptions of inquiry believed that JHS students should be given the necessary support and favourable conditions to engage in science learning. A teacher said:

> *It is very good that we allow students to perform their own science investigations and inquiries by providing them with all the necessary conditions and support they need.* (ST7)

Again, the teachers believed that when students are engaged in inquiry learning they appreciate the need to be responsible for their own learning and not to depend on their teachers. Another teacher said:

> *Seeing that it is not the teacher who is coming to do it for him, but he is going to do it, the student sits up and read more. Where he doesn't understand then he consults the teacher.* (ST6)

On the other hand, interviewees who held strong beliefs based on traditional conceptions of science teaching believed that allowing JHS students to perform hands-on activities will not produce the desired answers. Example of teachers' quotes expressing this idea is:

> *It won't be a good thing to allow JHS students to plan and perform*

their own investigations. Their level of education is inappropriate for that. If you allow them to do it ...they won't do it as you are expecting. So, they always have to do it with the guidance of the teacher. (ST12)

Discussion

In summary, triangulation of quantitative results from the teachers' ratings and qualitative results from a subsample of them show that the JHS teachers held weak beliefs about inquiry-based science teaching. Specifically, this study found that most teachers in the four Ghanaian districts and municipalities held weak inquiry-based beliefs about "characteristics of science teachers and the learning environment". Again, while many teachers held strong beliefs about the "nature of science curriculum", "science lesson design and implementation", and "how students learn science" based on partially informed conceptions of inquiry, most of them held strong beliefs based on traditional conceptions of science teaching. Therefore, this study found that most of the teachers held strong beliefs about traditional science teaching. This poses major challenges to implementation of inquiry-based science teaching in the Ghanaian JHSs. While studies show that inquiry-based science teaching is more effective than traditional instruction in promoting students' learning outcomes (e.g., Lati et al., 2012; Wolf & Fraser, 2008), these findings suggest that most JHS teachers in the four districts and municipalities lack strong favourable beliefs to adopt and implement inquiry teaching in schools.

This finding is partly consistent with some findings in industrialised and industrialising countries (e.g., Karaman & Karaman, 2013; Saad & Boujaoude, 2012; Crawford, 2007), but contradicts many others in the same countries (e.g., Sahin et al., 2010; Sampson & Benton, 2006). For example, Karaman and Karaman found that overall, the prospective teachers they studied in Turkey held moderate beliefs about inquiry-based science teaching. Specifically, Karaman and Karaman found that while the prospective teachers held weak inquiry-based beliefs about "how students learn science" and the "nature of science curriculum", they held moderate beliefs about "lesson design and implementation" and "characteristics of teachers and the learning environment". Similarly, the pre-service teachers Crawford studied in USA held varying beliefs about inquiry-based science teaching, ranging from uniformed through intermediate to informed, with others holding conflicting beliefs. In contrast, most of the teachers and scientists Pomeroy (1993) studied in USA held weak traditional but strong contemporary (inquiry) beliefs about science education. Sahin et al. (2010) also found that most of the teachers they studied in Turkey held strong and favourable inquiry-based beliefs about science teaching.

While studies show that there is significant and growing population of pre-service and in-service teachers with strong favourable beliefs about inquiry-based science teaching in industrialised and industrialising countries (e.g., USA, Turkey, Canada, Taiwan, Australia, and UK), the aforementioned findings suggest that there is unavailability of teachers in the Ghanaian JHSs with strong favourable beliefs about inquiry-based science teaching. Therefore, it is unlikely for most teachers in the selected districts and municipalities to teach in accordance with the rationale for basic science education in Ghana (CRDD, 2007, 2012).

This study found also that most of the JHS teachers held strong beliefs based on traditional conceptions of science teaching while others held strong beliefs based on partial conceptions of inquiry. This finding confirms the assertion that teachers can hold beliefs based on incorrect or incomplete knowledge (Pajares, 1992) without being aware of it (Mansour, 2009). Changes in teachers' beliefs begin only when the beliefs are challenged and the teachers become aware and dissatisfied with their existing beliefs (e.g. Mansour, 2009; Pajares, 1992). However, since the existing beliefs of teachers in this study have not been challenged, the teachers are unaware and not dissatisfied with their existing traditional beliefs about science teaching. Therefore, the teachers will continue to hold onto strong traditional beliefs and think that they are teaching science effectively.

Interviews with the teachers in this study revealed that the detailed and episodic memories of traditional learning experiences they have, coupled with their lack of exposure and experiences with inquiry-based science teaching and learning, combine and interact with other factors to form and develop their strong traditional but weak inquiry-based beliefs about science teaching (e.g., Choi & Ramsey, 2009; Mansour, 2009; Pajares, 1992; Saad & Boujaoude, 2012). These beliefs that have formed and developed over a long period are now stable and powerful, and may be difficult to change (e.g., Crawford, 2007; Pajares, 1992).

Again, interviews with teachers in this study indicate that the formation and development of their strong traditional beliefs about science teaching is partly due to Ghana's educational system, which requires them to implement the nationally-mandated curriculum, cover the prescribed curriculum content, and prepare students to pass external examinations

(BECE) with good grades. This formation and development of the Ghanaian teachers' beliefs about science teaching is consistent with researchers' assertion (e.g., Mansour, 2009) and similar to the formation and development of teachers' beliefs in other contexts (e.g., Saade & Boujaoude, 2012).

It is, however, noteworthy that while most teachers in this study held strong traditional beliefs on all the components investigated, many teachers held some inquiry-based beliefs on some components. Literature indicates that teachers' beliefs about science teaching can be formed and shaped outside the classroom, through reliable books and journals they read and multimedia they watch and listen (e.g., Mansour, 2009; Pajares, 1992). In this sense, it is possible that some teachers in this study formed and developed some inquiry-based beliefs from their experiences outside the classroom, including the books they read and multimedia they watched and listened.

Extent to which teachers' self-efficacy pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities

Determining extent to which teachers' self-efficacy pose challenges to inquiry-based science teaching in JHSs the districts and municipalities involved examination of two components of JHS teachers' self-efficacy (Personal Science Teaching Efficacy - PSTE and Science Teaching Outcome Expectancy - STOE) to determine whether they are weak, moderate, or strong to facilitate or impede inquiry teaching. This involved calculation of average item means, average item standard deviations, frequencies, and percentages of items constituting the components of self-efficacy; using quantitative data from the teachers' ratings of their self-efficacy toward inquiry teaching. I then triangulated the quantitative results with qualitative results from interview responses of a subsample of the teachers on the issues.

Table 28 shows average item means and average item standard deviations of the JHS teachers' ratings of their self-efficacy toward inquiry-based science teaching.

Table 28: *Average item means and average item standard deviations of JHS teachers' ratings of their self-efficacy toward inquiry-based science teaching*

Component of self-efficacy	No of items	Min	Max	Average item mean	Average item standard deviation
Science Teaching Outcome Expectancy (STOE)	4	1	5	2.79	.69
Personal Science Teaching Efficacy (PSTE)	6	1	5	3.89	.75
Self-efficacy toward inquiry teaching	10	1	5	3.23	.51

Source: Field data, Mohammed (2015) N = 308

Overall, the teachers' ratings show that they held moderate self-efficacy toward inquiry-based science teaching (M = 3.23, SD = .51). While they held moderate inquiry-based science teaching outcome expectancy (M = 2.79. SD = .69), they held strong inquiry-based personal science teaching efficacy (M = 3.89, SD = .75). Most of the teachers held weak inquiry-based but strong traditional science teaching outcome expectancy (Table 29).

Table 29: *Frequencies and percentages of JHS teachers' ratings of their self-efficacy toward inquiry-based science teaching*

Item	Responses				
	SD	D	U	A	SA
	n(%)	n(%)	n(%)	n(%)	n(%)
Personal Science Teaching Self-Efficacy (PSTE)					
I wonder if I have the necessary skills to teach science content embedded in processes of science.	81(26.3)	142(46.1)	47(15.3)	29(9.4)	9(2.9)
It is difficult to guide JHS students to evaluate and examine the quality of data.	85(27.6)	177(57.5)	22(7.1)	24(7.8)	0(0.0)
I don't know what to do to turn JHS on to do science like actual scientists.	65(21.1)	153(49.7)	43(14.0)	41(13.3)	6(1.9)
When a JHS student has difficulty in how to manipulate science equipment, I am usually at a loss as to how to help him do it better.	93(30.2)	148(48.1)	23(7.5)	44(14.3)	0(0.0)
Science Teaching Outcome Expectancy (STOE)					
Increased effort in writing science concepts on the board for students to copy is related to their performance.	21(6.8)	48(15.6)	70(22.7)	135(43.8)	34(11.0)
If parents comment that their child is showing more interest in science, it is probably due to the teacher telling students answers they are expected to learn.	23(7.5)	73(23.7)	85(27.6)	77(25.0)	50(16.2)
If parents comment that their child is showing more interest in science, it is probably due to the teacher telling students answers they are expected to learn.	23(7.5)	73(23.7)	85(27.6)	77(25.0)	50(16.2)

(Table 29,continued).

Item	SD n(%)	D n(%)	Responses U n(%)	A n(%)	SA n(%)
If JHS students are not performing well in collecting and recording science data, it is likely due to ineffective teaching of how to collect and record data.	34(11.0)	47(15.3)	103(33.4)	98(31.8)	26(8.4)
The teacher is responsible for achievements of JHS students in how to formulate hypothesis for science phenomena.	8(2.6)	55(17.9)	114(37.0)	102(33.1)	29(9.4)
If JHS students are not performing like actual scientists do, it is likely due to ineffective teaching of how scientists work.	34(11.0)	94(30.5)	83(26.9)	79(25.6)	18(5.8)
JHS students achievement in science is directly related their teacher's effectiveness in defining and explaining science concepts and principles.	0(0.0)	33(10.7)	34(11.0)	161(52.3)	80(26.0)

N = 308

SD = Strongly Disagree, D = Disagree, U = Uncertain, A = Agree, SA = Strongly Agree
Source: Field data, Mohammed (2015)

Most of the respondents agreed that students' achievements in science are directly related to traditional teaching strategies such as effectiveness of teachers in defining and explaining 241(78.3%), and writing 169(54.8%) science concepts on the board for students to copy. In contrast, more than half of the respondents disagreed or were uncertain that effective inquiry teaching can enable students to collect and record their own data 184(59.7%), formulate hypotheses for science phenomena 177(57.5%), and work like scientists do 211(68.4%).

While quantitative results from the teachers' ratings show that they held weak inquiry-based but strong traditional science teaching outcome expectancy, interview responses from a subsample of them also show the same results. The interviewees said that JHS students are more familiar with rote learning and so engaging them in inquiry teaching and learning will be unproductive. For example, a teacher said:

> *When JHS students are allowed to engage in inquiry, their performance will be abysmal. The students started rote learning from Kindergarten. So what they know is rote learning. This is what they will do throughout their education. Even when they advance to SHS and beyond the rote learning will continue.* (ST12)

Again, quantitative results from the teachers' ratings show that they held strong inquiry-based personal science teaching efficacy beliefs. Most of them agreed that they have the skills to teach content embedded in the processes of science 223(72.4%), and find it easy guiding JHS students to examine and evaluate the quality of scientific data 262(85.1%) (Table 29). Additionally, most of the teachers agreed that they know how to turn JHS students on to do science like actual scientists do 218(70.8%), and know how to help JHS students manipulate science equipment better when the students are in difficulty of handling science equipment 241(78.3%).

While quantitative results from the teachers' ratings show that they held strong inquiry-based personal science teaching efficacy beliefs, interview responses from a subsample of them show that many of the teachers held strong personal science teaching efficacy based on traditional conceptions of teaching, whereas others held strong personal science teaching efficacy based on partially informed conceptions of inquiry. Therefore, the qualitative results show that the teachers' personal science teaching efficacy beliefs were not as strong as the quantitative results appear to show.

Interviewees who articulated strong personal science teaching efficacy based on partially informed conceptions of inquiry believed that they can effectively teach science by eliciting students' prior knowledge to create interesting investigations, and make students formulate hypotheses for science phenomena. For example, a teacher said:

> *The lesson should be planned in a way that is very interesting. Based on what the students already know the teacher helps them to predict what they are going to get from their explorations.* (ST2)

The teachers believed also that they can effectively implement child-centred science lessons, and actively involve students in manipulating materials, as well as guide students to know the processes involved in arriving at solutions to problems. Examples of teachers' quotes expressing these ideas are:

> *The planning of science teaching should be focused on the children. Everything should be centred on them because ... they are the target of lesson.* (ST9)

> *When the teacher is performing experiment he should call students to come and manipulate some of the materials or engage in some activities, so that by the end of the lesson the student will know what should be done to get certain results.* (ST17)

Additionally, interviewees who held strong personal science teaching efficacy based on partially informed conceptions of inquiry believed that they can effectively teach science by creating friendly and interactive classrooms where the teacher is not hostile to students. In this way, the teacher makes science attractive and interesting to students. This is exemplified by the statement of a teacher who said:

The teacher instructing students shouldn't be hostile to them. Children like a subject depending on how the teacher interacts with them. The teacher should be friendly to students to make the subject attractive and interesting to the children. (ST13)

In contrast, interviewees who held strong personal science teaching efficacy based on traditional conceptions of science teaching believed that they can effectively teach science through traditional approaches such as teaching science content separately in one lesson, followed by hands-on activities in another lesson to verify the content already taught. For example, a teacher stated:

After going through the theoretical aspect with students then you organise the children to go to the lab for hands-on activities during the next period. (ST3)

Additionally, this group of interviewees believed that they can effectively teach science when it involves step-by-step procedures and safety precautions that students must follow to carry out hands-on activities:

You set up the equipment and direct the pupils on how to perform the experiment. You give them the steps involved in doing the experiment (ST15)

These interviewees believed also that they can effectively teach science when they try out experiments prior to the lessons to ensure that the equipment and materials are working properly. One of the teachers who shared this sentiment said:

The teacher can also perform the practical in advance to find out if the materials are workable indeed. (ST16)

Discussion

To sum up, triangulation of quantitative results from the teachers' ratings and qualitative results from a subsample of them show that JHS teachers in the four Ghanaian districts and municipalities held weak self-efficacy toward inquiry-based science teaching. Specifically, this study found that the Ghanaian JHS teachers held weak inquiry-based science teaching outcome expectancy (STOE) and personal science teaching efficacy (PSTE). Instead, they held strong self-efficacy toward traditional science teaching. This poses major challenges to implementation of inquiry-based science teaching in JHSs in the districts and municipalities. While empirical evidence show that inquiry-based science teaching is more effective than traditional instruction in improving students' learning outcomes (e.g., Furtak et al., 2012), this finding suggests that most of the Ghanaian JHS teachers lack strong favourable self-efficacy to adopt and implement inquiry-based teaching in schools.

This finding is similar to some findings in industrialised and industrialising countries (Azar, 2010; Aktas, Kurt, Aksu, & Ekici, 2013), but contradicts many others in the same countries (e.g., Gavora, 2011; Kahraman, Yilmaz, Bayrak, & Gunes, 2014; Kazempour, 2014a; Lardy & Mason, 2011; Sahin et al., 2010). The pre-service and in-service teachers Azar studied in Turkey held moderate self-efficacy toward science teaching. Similarly, Aktas et al. found that the in-service teachers they studied in Turkey held moderate self-efficacy toward the teaching of biology. In contrast, Sahin et al. found that the in-service teachers they studied in Turkey held favourable self-efficacy toward science teaching, with most of the teachers having confident in their knowledge of science content required to teach science effectively. Similarly. the in-service teachers Gavora studied in Slovakia held high self-efficacy toward inquiry-based science teaching.

While studies show that there is significant and increasing population of pre-service and in-service teachers with favourable self-efficacy toward inquiry-based science teaching in industrialised and industrialising countries. this study suggests that there is unavailability of teachers in the Ghanaian districts and municipalities with strong favourable self-efficacy toward inquiry-based science teaching. Since the presence of teachers with strong self-efficacy is critical for the success of science education reforms (Kazempour. 2014a). the present findings suggest that implementation of inquiry-based science teaching in JHSs in the districts and municipalities may not be as successful as emphasized in the rationale for basic science education in the Ghana (CRDD. 2007. 2012).

Again. since teachers with both high science teaching outcome expectancy and personal science teaching efficacy are required to implement inquiry-based science teaching in an assured manner (Riggs & Enochs, 1989. the low science teaching outcome expectancy and personal science teaching efficacy demonstrated by teachers in this study suggest that most of the Ghanaian teachers will abandon implementation of inquiry-based science teaching immediately they encounter difficulties.

Additionally. this study found that most of the JHS teachers held strong self-efficacy based on uninformed conceptions of inquiry and traditional conceptions of science teaching. These conceptions of science and science teaching are different from the constructivist philosophy of science and science education. This finding is similar to that of Lardy and Mason (2011) who found that many teachers in their study held strong self-efficacy based on beliefs about "hands-on" science that are different from the constructivist perspective. Since the teachers in this study held a sense of self-efficacy based on conceptions and beliefs about science teaching that is different from the constructivist views, their high efficacy beliefs cannot be translated into successful inquiry-based science teaching in classrooms. Again, since the teachers believe that they are teaching science effectively, they feel little need to critically examine and reform their teaching practices. This situation is disturbing because the teachers will continue to hold onto efficacy expectations that do not promote effective inquiry-based science teaching.

Researchers assert that the formation and development of teachers' self-efficacy toward science teaching occur through mastery experiences, vicarious experiences, verbal persuasion, and emotional arousal (Bandura, 1977, 1994; Brown et al., 2013; Kazempour, 2014a; Lardy & Mason, 2011; Otieno et al., 2016). Teachers who are exposed to and who experience inquiry-based mastery experiences, vicarious experiences, verbal persuasion, and emotional arousal form and develop strong self-efficacy toward inquiry-based science teaching. In contrast, teachers who are exposed to and who experience traditional mastery experiences, vicarious experiences, verbal persuasion, and emotional arousal form and develop strong self-efficacy toward traditional science teaching.

Interviews with the teachers in this study revealed that they never experienced and were never exposed to inquiry-based science teaching and learning when they were students in elementary and high schools, and in their pre-service and in-service teacher education programmes. Instead, science teaching and learning experiences the teachers had largely involved transmission, memorization, and recall of science facts and principles, with occasional laboratory experiments to verify content they had already learned. This is exemplified by the statements of two teachers who said:

> *At the time some of us were in the training college, science was only presented to us in the classroom. It was presented to us just like the way we are presenting it now.* (ST1)

> *In the teacher training college, they took us through topics and content we are going to teach in the basic schools. So we didn't experience many experiments there. There were certain activities that the teachers did not even bother to perform.* (ST17)

These excerpts indicate that the teachers were not given hands-on activities to perform, let alone be engaged in inquiry-based investigations. On rare occasions when they experienced hands-on activities, such activities were highly structured and followed step-by-step procedures. One of the teachers said:

> *For the activities, the teachers gave us the steps, the results we should get, and things like that. The teachers taught us step by step and we did it. All of us finished with a step before we moved to another one.* (ST15)

These excerpts indicate that the traditional mastery experiences, vicarious experiences, verbal persuasion, and emotional arousal the teachers had when they were students in elementary and secondary schools led to the formation and development of their self-efficacy toward traditional science teaching. The experiences the teachers had in elementary and secondary schools were reinforced by traditional teaching and learning experiences during their pre-service and in-service teacher education courses. This strengthened their traditional self-efficacy and prevented the formation and development of their self-efficacy toward inquiry-based science teaching.

Research Question 4: To what extent do differences in attitudes, beliefs, and self-efficacy of teachers and teacher characteristics (i.e., school type, school location, gender, and academic qualification) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities?

Providing answers to this research question involved examination of differences in JHS teachers' attitudes, beliefs, and self-efficacy with regard to their gender (males versus females), school type (public versus private), school location (urban versus rural), and academic qualification (certificate versus graduate versus post graduate); and extent to which these differences impede or facilitate inquiry-based science teaching in JHSs in the four districts and municipalities. This involved conducting one-way Multivariate Analysis of Variance (MANOVAs) using gender, school type, school location, and academic qualification as independent variables, and components of attitudes, beliefs, and self-efficacy as dependent variables. I then triangulated quantitative results from the MANOVAs (derived from the teachers' ratings of their attitudes, beliefs, and self-efficacy) with qualitative results from interview responses (on the same issues) of a subsample of the teachers.

The MANOVA results show that there were no statistically significant gender differences in JHS teachers' attitudes [Wilks' Lambda = 0.995, F(4, 303) = 0.359, $p > .05$, $\eta^2 = 0.005$], beliefs [Wilks' Lambda = 0.974, F(4, 303) = 2.014, $p > .05$, $\eta^2 = 0.026$], and self-efficacy [Wilks' Lambda = 0.995, F(. 305) = 0.803, $p > 0.05$, $\eta^2 = 0.005$] toward inquiry-based science teaching. Again, there were no statistically significant differences in JHS teachers' attitudes toward inquiry-based science teaching with regard to their school location [Wilks' Lambda = 0.971, F(4, 303) = 2.245, $p > 0.05$, partial $\eta^2 = 0.029$] and academic qualification [Wilks' Lambda = 0.972, F(8, 604) = 1.081, $p > 0.05$, partial $\eta^2 = 0.014$]. Moreover, there was no statistically significant difference in JHS teachers' beliefs about inquiry-based science teaching with regard to their school location [Wilks' Lambda = 0.989, F(4, 303) = 0.834, $p > 0.05$, partial $\eta^2 = 0.011$]. Therefore, no further presentation of these non-statistically significant differences is made in this thesis report. Only statistically significant differences in teachers' attitudes, beliefs, and self-efficacy are fully presented in this thesis report.

Presentation of results and discussions of the statistically significant differences in teachers' attitudes, beliefs, and self-efficacy are organised in six separate sections. These are: Extent to which differences in attitudes of teachers and teacher school type (public and private) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities; extent to which differences in beliefs of teachers and teacher school type (public and private) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities; extent to which differences in beliefs of teachers and teacher academic qualification (certificate, graduate, and post graduate) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities; extent to which differences in self-efficacy of teachers and teacher school type (public and private) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities; extent to which differences in self-efficacy of teachers and teacher school location (urban and rural) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities; and extent to which differences in self-efficacy of teachers and teacher academic qualification (certificate, graduate, and post graduate) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities.

Extent to which differences in attitudes of teachers and teacher school type (public and private) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities

Providing answers to this section of the research question involved examination of differences in four components of public and private JHS teachers' attitudes (perceived relevance, perceived difficulty, perceived interest, perceived anxiety), to determine which group of teachers held weaker, more moderate, or stronger attitudes that present greater impediment or facilitation of inquiry teaching in JHSs in the districts and municipalities. This involved conducting one-way MANOVA with perceived relevance, perceived difficulty, perceived interest, and perceived anxiety as dependent variables and school type (public and private) as independent variable. The MANOVA shows that there was statistically significant difference between public and private JHS teachers when their "perceived relevance", "perceived interest", "perceived anxiety", and "perceived difficulty" were jointly considered at an alpha level of .05. Wilk's $\lambda = .966$, $F(4, 303) = 2.705$, $p < .05$, partial $\eta^2 = .034$. This shows that attitudes of JHS teachers toward inquiry teaching in the Ghanaian districts and municipalities differ according to their school type. This permitted the conduct of separate one-way ANOVAs to examine differences on each component of the teachers' attitudes.

Table 30 shows average item means, average item standard deviations, and differences between public and private JHS teachers (effect size and MANOVA results) for each component of attitude toward inquiry-based science teaching.

Table 30: *Average item means, average item standard deviations, and differences between public and private JHS teachers (effect size and MANOVA results) for each component of attitudes toward inquiry-based science teaching*

Component of attitude	Average item mean		Average item standard deviation		Difference	
	Public	Private	Public	Private	*F*	Effect size (η^2)
Perceived relevance	3.97	3.81	0.68	0.71	4.391**	0.014
Perceived anxiety	3.55	3.53	0.71	0.72	0.045	0.000
Perceived difficulty	2.15	1.99	0.78	0.69	3.392	0.011
Perceived interest	4.12	4.00	0.68	0.78	1.954	0.006

** $p < .05$, N = 176(Public teachers), N = 132(Private teachers)

Note: high mean is inquiry-based, low mean is traditional-oriented

Source: Field data, Mohammed (2015)

There was statistically significant difference between public and private JHS teachers' perceived relevance of inquiry-based science teaching $F(1, 306) = 4.391$, $p < .05$, partial $\eta^2 = .014$, with public school teachers (M = 3.97, SD = .68) holding higher perceived relevance of inquiry teaching than private school teachers (M = 3.81, SD = .71). However, there were no statistically significant differences between the public and private JHS teachers' perceived anxiety, $F(1, 306) = .045$, $p > .05$, partial $\eta^2 = .000$; perceived interest, $F(1, 306) = 1.954$, $p > .05$, partial $\eta^2 = .006$; and perceived difficult, $F(1, 306) = 3.392$, $p > .05$, partial $\eta^2 = .011$ toward inquiry-based science teaching.

Compared to private JHS teachers, public JHS teachers perceived higher relevance of engaging students in inquiry-based activities such as making JHS students plan, design, and perform science investigations; examine and evaluate the quality of scientific data; and working systematically like actual scientists do (Table 31).

Table 31: *Means and standard deviations of public and private JHS teachers' ratings of items on relevance of inquiry-based science teaching*

Item	Mean		Standard deviation	
	Public	Private	Public	Private
It is relevant to make JHS students work systematically like actual scientists	4.10	3.95	.82	1.03
It is relevant to make JHS students examine and evaluate quality of scientific data.	3.99	3.76	.94	1.03
It is appropriate to make JHS students examine and evaluate the quality of scientific data.	3.77	3.51	1.06	1.10
It is relevant to make JHS students plan, design, and perform their own science investigations.	4.07	3.89	1.01	1.11
It is appropriate to make JHS students work systematically like actual scientists.	3.93	3.93	.90	.97

N = 176(Public teachers), N = 132(Private teachers)

Note: high mean is inquiry-based, low mean is traditional-oriented

Source: Field data, Mohammed (2015)

While quantitative results from the teachers' ratings show that public JHS teachers held higher perceived relevance of inquiry-based science teaching than private JHS teachers, interview responses from a subsample of the teachers also show that more public JHS teachers perceived higher relevance of inquiry teaching than private JHS teachers. While five public school teachers felt that inquiry teaching will enable JHS students to acquire science process skills, only two private school teachers felt that inquiry teaching will enable JHS students to acquire science process skills. The teachers explained that students will acquire science process skills by becoming familiar with the names and uses of science instruments; asking scientifically oriented questions; developing creativity skills; and developing the attitude of identifying problems in their environment. For example, four public JHS teachers said:

> *It (inquiry) makes the child to become used to science instruments. Most students do not know the names of science instruments, but through science inquiry students get to know the names and uses of science instruments.* (ST1).

> *It (inquiry teaching) will enable the child who doesn't like asking questions to start asking questions.* (ST6)

> *Through inquiry students will be able to create something from their own ideas.* (ST14)

> *It (inquiry teaching) will inculcate an attitude of problem identification*

in the student. The student can sit back and identify what is wrong, and start thinking about how it can be solved. (ST16)

Again, while two public JHS teachers felt that inquiry teaching improves students' attitudes toward science, none of the private JHS teachers felt that inquiry teaching improves students' attitudes toward science. The teachers explained that inquiry teaching boosts students' morale, puts away the fear of science in students, make the learning of science easier for students, and promotes students' interests in science and science learning. Examples of public school teachers' quotes expressing these ideas are:

It (inquiry teaching) will help the students. It will enhance and boost their morale. It will also put away some fear of science from them. (ST6)

If you inculcate inquiry "spirit" into the kids at that tender age, when they grow up with it learning science will be easy for them. They will understand concepts in science and that will help promote their interests in science and learning science. (ST14)

Additionally, eight public JHS teachers compared to six private JHS teachers felt that inquiry-based science teaching improves students' understanding, retention, and application of science knowledge. The teachers explained that inquiry teaching encourage active students' involvement in their own learning, and enables students to acquire first-hand information that sticks in their minds better. The teachers explained further that the more students interact and manipulate materials the more their understanding of science concepts and ideas develop. For example, a teacher stated:

If the school has more instruments or science equipment that children can use to discover concepts we shall encourage them, because the more students interact with materials the more their understanding of science concepts and ideas develop. (ST17)

Discussion

To sum up, triangulation of quantitative results from the teachers' ratings and qualitative results from interview responses of a subsample of the teachers show that there was significant difference between public and private JHS teachers' attitudes toward inquiry-based science teaching in the Ghanaian districts and municipalities. Specifically, this study found that public JHS teachers held higher perceived relevance of inquiry-based science teaching than private JHS teachers. This shows that attitudes of public JHS teachers pose less challenges to inquiry-based science teaching in the four Ghanaian districts and municipalities than attitudes of private JHS teachers. Again, this finding shows that school type is a demographic characteristic that significantly influences the formation and development of teachers' attitudes toward inquiry-based science teaching in the Ghanaian districts and municipalities. This finding contradicts those in many countries outside Africa (Gheith & Al-Shawareb, 2016; Sonmez, 2007; Unal & Akman, 2013). The private preschool teachers Gheith and Al-Shawareb studied in Jordan held more positive attitudes toward inquiry-based science teaching than the public preschool teachers. Similarly, the private preschool teachers Sonmez studied in Turkey held more positive attitudes toward science teaching than the public preschool teachers; while Unal and Akman found no significant differences in attitudes between the public and private school teachers they studied in

Turkey.

Sonmez (2007) attributed differences in attitudes between the public and private school teachers in Turkey to the flexibility given to preschools in Turkey to implement the national curriculum, and the availability of more resources in private schools than in public schools. However, the situation within the Ghanaian context is different. Compared to public JHS teachers, the higher perceived dependency of Ghanaian private JHS teachers on external contextual factors strongly influenced the formation and development of their attitudes toward traditional science instruction (e.g., Van Aalderen-Smeets & Walma van der Molen, 2013, 2015; Van Aalderen-Smeets et al., 2012). Private JHSs in Ghana are highly examination-oriented, because their expansion and subsequent profitability depend on the extent to which their students pass external examinations (BECEs) with excellent grades. Therefore, science instruction in private JHSs in Ghana involve covering the nationally-mandated syllabus, providing extra classes for students, revising content already taught, solving past questions, teaching examination techniques, writing mock examinations, and other such activities. For example, a private JHS head teacher said:

> *These days we only want our pupils to perform at the BECE. So how to get students to perform is what teachers are doing.* (HT10)

As a result, most private JHS teachers in Ghana perceive excellent performance of their students in external examinations (BECEs) as ample proof of their effectiveness as science teachers. For example, a head teacher said:

> *The BECE results are excellent proof of how effective the science*

teachers are working here. We've been making the grades so the science teacher is doing very, very well. (HT9)

These traditional examination-oriented practices and perceptions have resulted in the development of strong and stable attitudes toward traditional science instruction among private JHS teachers than in public school teachers. This is worrisome, given that most students who are admitted into the best senior high schools and subsequently into tertiary institutions in Ghana are taught by private school teachers.

This finding adds to the literature that teachers' perceived dependence on external contextual factors strongly influence and is an indispensable component of their attitudes toward science inquiry teaching (e.g., Schwarz & Bohner, 2001; Van Aalderen-Smeets & Van der Molen, 2012, 2013, 2015).

Extent to which differences in beliefs of teachers and teacher school type (public and private) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities

Providing answers to this section of the research question involved examination of differences in four components of public and private JHS teachers' beliefs ("nature of science curriculum", "how students learn science", "science lesson design and implementation", and "characteristics of science teachers and the lesson environment"), to determine which group of teachers held weaker, more moderate, or stronger beliefs that present greater impediment or facilitation to inquiry teaching in JHSs in the districts and municipalities. This also involved conducting one-way MANOVA with the four components of beliefs as dependent variables and school type (public and private) as independent variable. The MANOVA results shows that there was statistically significant difference between public and private JHS teachers when the four components of beliefs were jointly considered at an alpha level of .05, Wilk's λ = .962, $F(4, 303) = 3.008$, $p < .05$, partial $\eta^2 = .038$. This indicates that JHS teachers' beliefs about inquiry-based science teaching differ according to their school type. This permitted the conduct of separate one-way ANOVAs to examine differences on each component of the teachers' beliefs, with each ANOVA being evaluated at a Bonferroni adjusted alpha level of .0125.

Table 32 shows average item means, average item standard deviations, and differences between public and private JHS teachers (effect size and MANOVA results) for each component of beliefs about inquiry-based science teaching.

Table 32: *Average item means, average item standard deviations, and differences between public and private JHS teachers (effect size and MANOVA results) for each component of beliefs about inquiry-based science teaching*

Component of belief	Average item mean		Average item standard deviation		Difference	
	Public	Private	Public	Private	*F*	Effect size (η^2)
Characteristics of science teachers and the learning environment	2.11	1.85	0.79	0.70	9.199*	0.029
Nature of science curriculum	4.31	4.33	.56	.63	0.124	0.000
Science lesson design and implementation	4.16	4.20	.58	.65	.321	0.001
How students learn science	4.14	4.05	.57	.75	1.545	0.005

*$p < .0125$, N = 176(Public teachers), N = 132(Private teachers)

Note: high mean is inquiry-based, low mean is traditional-oriented

Source: Field data, Mohammed (2015)

There was statistically significant difference between public and private JHS teachers' beliefs about "characteristics of science teachers and the learning environment" $F(1, 306) = 9.199$, $p < .0125$, partial $\eta^2 = .029$; with private school teachers (M = 1.85, SD = .70) holding weaker inquiry-based but stronger traditional beliefs than public school teachers (M = 2.11, SD = .79). However, there were no statistically significant differences between public and private JHS teachers' beliefs about the "nature of science curriculum", $F(1, 306) = .124$, $P > .05$, partial $\eta^2 = .000$; "science lesson design and implementation", $F(1, 306) = .321$, $p > .05$, partial $\eta^2 = .001$; and "how students learn science", $F(1, 306) = 1.545$, $p > .05$, partial $\eta^2 = .005$.

Table 33 shows means and standard deviations of public and private JHS teachers' ratings of items on beliefs about "characteristics of science teachers and the learning environment".

Table 33: *Means and standard deviations of public and private JHS teachers' ratings of items on beliefs about "characteristics of science teachers and the learning environment"*

Item	Mean		Standard deviation	
	Public	Private	Public	Private
A good science teacher is someone who is really good at defining and explaining science concepts and principles to JHS students.	2.16	1.80	1.11	.95
JHS students are more likely to understand a science concept if the teacher defines and explains it in a way that is clear and easier to understand.	1.88	1.54	.98	.81
The science curriculum should focus on defining and explaining science concepts and principles that JHS students need to know.	1.92	1.83	.91	.95
Science teachers should write science concepts and principles on the board for JHS students to copy.	2.47	2.21	1.22	1.09

N = 176(Public JHS teachers). N = 132(Private JHS teachers)
Note: High mean is inquiry-based, low mean is traditional-oriented
Source: Field data, Mohammed (2015)

Compared to public JHS teachers, private JHS teachers expressed stronger traditional beliefs that a good science teacher is someone who is really good at defining and clearly explaining concepts for students to understand; and writing the concepts on the board for students to copy. Private JHS teachers also expressed stronger traditional beliefs that science curricula should focus on defining and explaining concepts and principles students need to know (Table 33).

While quantitative results from the teachers' ratings show that private JHS teachers expressed weaker inquiry-based but stronger traditional beliefs about "characteristics of science teachers and the lesson environment" than public JHS teachers, interview responses of a subsample of the teachers also show that ten private JHS teachers compared to seven public JHS teachers expressed traditional beliefs in strategies for creating teacher-centred learning environments. The interviewees believed that teachers should control students' behaviours and deal with large class sizes by exercising strict supervision over students and making students comply with rules and regulations in classrooms and laboratories. For example, a private school teacher said:

> *There should be strict supervision. If you stand somewhere and don't put strict supervision over the children they will relax. Being children at the basic level ... you should always be on them.* (ST4)

Additionally, the private school teachers said that JHS students sit by their friends in classroom and chat while teaching is going on. Therefore, they believed that science instructors should change seating arrangements in classrooms in order to create conducive learning environments. For example, a private JHS teacher said:

> *Sometimes pupils sit by their friends in classroom and chat while teaching is going on. When you see pupils chatting whilst you are*

teaching, you separate them by changing their seating positions. (ST11)

Again, the private school teachers said that JHS students make references from their textbooks during teaching, which distract the students' attention from the content being delivered by instructors. Therefore, they believed that students should be prevented from making references from their textbooks in classrooms in order to create conducive learning environments. An example of teachers' quotes expressing this idea is:

> *At times pupils hide their textbooks under their desks during teaching in classroom. They then make references about whatever the teacher says from their textbooks. When that happens, children do not have full concentration on what the teacher is teaching. So when you (the teacher) go to class, you should tell pupils to close every book except their jotters or notebooks.* (ST11)

Discussion

In summary, triangulation of quantitative results from the teachers' ratings and qualitative results from interview responses of a subsample of the teachers show that there was significant difference between public and private JHS teachers' beliefs about inquiry-based science teaching in the Ghanaian districts and municipalities. Specifically, this study found that private JHS teachers held weaker inquiry-based but stronger traditional beliefs about "characteristics of science teachers and the learning environment" than public JHS teachers. This shows that private school teachers' beliefs pose major challenges to inquiry-based science teaching in JHSs in the four Ghanaian districts and municipalities than public school teachers' beliefs.

This finding contradicts that of Sahin et al. (2010) who found no significant difference in beliefs about inquiry-based science teaching held by public and private school teachers they studied in Turkey. However, the present finding is consistent with researchers' assertion that teachers' beliefs are situation specific and context dependent (e.g., Crawford, 2007; Mansour. 2009; Pajares, 1992).

Studies in many countries outside Africa (e.g., Germany, USA. Turkey, and UK) show that demographic characteristics such as gender (e.g., Decker & Rimm-Kaufman, 2008; Karaman & Karaman, 2013; Neuhaus & Vogt, 2012; Pomeroy, 1993), age (e.g., Decker & Rimm-Kaufman, 2008; Neuhaus & Vogt, 2012), teaching experience (e.g., Decker & Rimm-Kaufman, 2008; Forbes & Zint, 2011), ethnicity/race (e.g., Decker & Rimm-Kaufman, 2008), grade-level taught (Decker & Rimm-Kaufman, 2008), and number of coursework undertaken (e.g., Forbes & Zint, 2011) significantly influence the formation and development of teachers' beliefs about science inquiry teaching. However, studies available suggest that school type (public versus private) has no or little influence on the formation and development of teachers' beliefs about inquiry-based science teaching in many countries outside Africa. In contrast, the present finding shows that school type is a demographic characteristic that strongly influence the formation and development of teachers' beliefs about inquiry-based science teaching in the Ghanaian districts and municipalities, as may be the case in other Ghanaian and African districts.

Interviews with teachers in this study indicate that differences between the public and private school teachers' beliefs is due to heavy reliance of the Ghanaian private JHSs on traditional science instruction. This is reflected in efforts the private JHSs employ in covering syllabus; preparing students to pass external examinations with good grades; and the high expectations of parents, head teachers, and proprietors. These contextual elements have influenced the Ghanaian private JHS teachers to form and develop stronger traditional but weaker inquiry-based beliefs about science teaching than the public JHS teachers. These contextual elements are similar to those that influence the formation and development of teachers' beliefs in other contexts (e.g., Crawford, 2007; Mansour, 2009; Saad & Boujaoude, 2012).

The stronger traditional but weaker inquiry-based beliefs held by the Ghanaian private JHS teachers is worrisome, given that most students who are admitted into the best senior high schools and subsequently into tertiary institutions in Ghana are taught by private school teachers.

Extent to which differences in beliefs of teachers and teacher academic qualification (certificate, graduate, and post graduate) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities

Providing answers to this section of the research question involved examination of four components of certificate, graduate, and post graduate JHS teachers' beliefs about inquiry-based science teaching ("how students learn science", "nature of science curriculum", "science lesson design and implementation", and "characteristics of science teachers and the lesson environment"), to determine which group of teachers held weaker, more moderate, or stronger beliefs that pose greater impediment or facilitation of inquiry teaching in JHSs in the districts and municipalities. This also involved conducting one-way MANOVA with the four components of beliefs as dependent variables and academic qualification as independent variable. The MANOVA results show that there was statistically significant difference between certificate, graduate, and post graduate teachers when the four components of beliefs were jointly considered at an alpha level of .05, Wilk's λ = .938, $F(8, 604) = 2.470$, $p < .05$, partial $\eta^2 = .032$. This indicates that JHS teachers' beliefs about inquiry-based science teaching in the Ghanaian districts and municipalities differ according to their academic qualifications. This permitted the conduct of separate one-way ANOVAs to examine differences on each component of the teachers' beliefs, with each ANOVA being evaluated at a Bonferroni adjusted alpha level of .0125.

Table 34 shows average item means, average item standard deviations, and differences between certificate, graduate, and post graduate JHS teachers (effect size and MANOVA results) for each component of beliefs about inquiry-based science teaching. There were statistically significant differences between certificate, graduate, and post graduate JHS teachers' beliefs about "characteristics of science teachers and the learning environment" $F(2, 305) = 4.067$, $p < .05$, partial $\eta^2 = .026$, and "how students learn science" $F(2, 305) = 3.172$, $P < .05$, partial $\eta^2 = .020$. However, there were no statistically significant differences between certificate, graduate, and post graduate JHS teachers' beliefs about the "nature of science curriculum" $F(2, 305) = 1.498$, $p > .05$, partial $\eta^2 = .010$, and "science lesson design and implementation" $F(2, 305) = 2.121$, $p > .05$, partial $\eta^2 = .014$.

Table 34: *Average item means, average item standard deviations, and differences between certificate, graduate, and post graduate teachers (effect size and MANOVA results) for each component of beliefs about inquiry-based science teaching*

Component of belief	Average item mean			Average item standard deviation			Difference	
	Cert	Grad	Post G	Cert	Grad	Post G	*F*	Effect size (η^2)
Characteristics of science teachers and the learning environment	1.91	2.16	2.08	0.71	0.83	1.04	4.067**	0.026
Nature of science curriculum	4.30	4.33	4.89	0.60	0.58	0.19	1.498	0.010
Science lesson design and implementation	4.13	4.24	4.67	0.63	0.57	0.58	2.121	0.014
How students learn science	4.04	4.21	4.56	0.69	0.58	0.51	3.172**	0.020

*$p < .0125$, **$p < .05$, N = 200(Certificate teachers), N = 105(Graduate teachers), N = 3(Post graduate teachers); Cert = Certificate teachers, Grad = Graduate teachers, Post G = Post graduate teachers

Source: Field data, Mohammed (2015)

Post hoc analysis show that there was pair wise significant difference between certificate and graduate teachers' beliefs about "characteristics of science teachers and the learning environment"; with certificate teachers (M = 1.91, SD = .71) holding weaker inquiry-based but stronger traditional beliefs than graduate teachers (M = 2.16, SD = .83). However, there were no pair wise significant differences between graduate and post graduate, and certificate and post graduate teachers.

Compared to graduate teachers, certificate teachers expressed stronger traditional beliefs that a good science teacher is someone who is really good at defining and clearly explaining concepts for students to understand, and writing the concepts on the board for students to copy. Certificate teachers also expressed stronger traditional beliefs that science curricula should focus on defining and explaining concepts and principles students need to know (Table 35).

Table 35: *Means and standard deviations of certificate, graduate, and post graduate JHS teachers' ratings of items on beliefs about "characteristics of science teachers and the learning environment"*

Item	Mean			Standard deviation		
	Cert	Grad	Post G	Cert	Grad	Post G
A good science teacher is someone who is really good at defining and explaining science concepts and principles to JHS students.	1.95	2.11	2.33	1.01	1.12	1.53
JHS students are more likely to understand a science concept if the teacher defines and explains it in a way that is clear and easier to understand.	1.64	1.91	1.67	.87	.99	1.16
The science curriculum should focus on defining and explaining science concepts and principles that JHS students need to know.	1.85	1.95	1.67	.89	1.01	.58
Science teachers should write science concepts and principles on the board for JHS students to copy.	2.19	2.68	2.67	1.10	1.24	1.16

N = 200(Certificate teachers), N = 105(Graduate teachers), N = 3(Post graduate teachers

Source: Field data, Mohammed (2015)

While quantitative results from the teachers' ratings show that certificate teachers expressed weaker inquiry-based but stronger traditional beliefs about "characteristics of science teachers and the learning environment" than graduate teachers, interview responses from a subsample of the teachers also show that more certificate teachers expressed traditional beliefs about science learning environment than graduate teachers. Compared to one graduate JHS teacher five certificate JHS teachers believed that science instructors should create conducive learning environments by controlling students' behaviour. The interviewees explained that controlling students' behaviour will make classrooms quiet and prepare students' mind to receive knowledge being transmitted by the teacher. For example, a private JHS teacher said:

> *The teacher must ensure that children's minds are on what they are going to learn. It is better for students to be attentive, quiet, looking on the board, and following the teacher.* (ST4)

Additionally, one graduate teacher as compared to four certificate teachers expressed traditional beliefs that creating learning environments for hands-on activities should involve putting students into sizeable groups or batches, depending on the class size and availability of science equipment and materials. Examples of teachers' quotes expressing these ideas are:

> *The classroom management depends on the teaching and learning materials that you (the teacher) are having.* (ST6)

> *If the number (of students) in the classroom is beyond your control you have to see to it that the students are divided into batches, so that if one group performs experiment in one day, then the next day it will be the turn of another group.* (ST8)

Again, the teachers expressed traditional beliefs that students should be made to interact with science materials in turn or by breaking hands-on activities into sections for different groups of students to perform. For example, a teacher stated:

> *The teacher should design lessons in such a way that one group of students will interact with materials at a time, and another group will also interact while other groups are observing. The teacher can also*

break the whole experiment into sections where one group of students will do one aspect and another group will also do another aspect. (ST17)

The interviewees believed that by putting students into groups and breaking up hands-on activities into sections or making students interact with materials in turn, every student can participate in the activity and students who are misbehaving can be identified and controlled. For example, two teachers said:

By the time the whole activity is completed every student in the class would have taken part in the process. (ST17)

When there are a few students in the classroom I can easily control them. If a student is misbehaving I can see him. (ST8)

As shown in Table 34 there was statistically significant difference between certificate, graduate, and post graduate JHS teachers' beliefs about "how students learn science" $F(2, 305) = 3.172$, $p < .05$, partial $\eta^2 = .020$. However, post hoc analysis showed that there were no significant pair wise differences between certificate and graduate, certificate and post graduate, and graduate and post graduate teachers.

Discussion

In summary, triangulation of quantitative results from the teachers' ratings and qualitative results from a subsample of the teachers show that there was significant difference between certificate and graduate JHS teachers' beliefs about inquiry-based science teaching in the four Ghanaian districts and municipalities. Specifically, this study found that certificate teachers in the Ghanaian districts and municipalities held weaker inquiry-based but stronger traditional beliefs about "characteristics of science teachers and the learning environment" than graduate teachers. This shows that certificate teachers' beliefs pose greater challenges to inquiry-based science teaching in JHSs in the four Ghanaian districts and municipalities than graduate teachers' beliefs. Again, this finding shows that academic qualification is a demographic characteristic that significantly influences the formation and development of teachers' beliefs about inquiry-based science teaching in the Ghanaian districts and municipalities. This finding is similar to that of Macugay and Bernardo (2013) who found that the number of science courses taken promoted strong development of a sample Philippine teachers' beliefs about student-centred teaching approaches. Similarly, Forbes and Zint (2011) found that the number of science methods courses taken by teachers in USA promoted positive development of the teachers' beliefs about inquiry-based science teaching. Again, Smith et al. (2007) found strong associations between inquiry-based classroom practices of teachers in USA and the majors (areas of specialisation) and degrees they earned in formal education.

Researchers assert that pre-service and in-service science education experiences of teachers (Mansour, 2009), the level of education of teachers (Decker & Rimm-Kaufman, 2008), the number of science courses taken by teachers, and teachers' background (major) in science (Macugay & Bernardo, 2013) influence the formation and development of their beliefs about science teaching. In this sense, the weaker inquiry-based but stronger traditional beliefs held by the Ghanaian certificate teachers can partly be attributed to the less number of science courses they have taken, and the low levels of their education. Apart from lacking adequate science content and pedagogical content knowledge, the reduced number of courses taken by the certificate teachers appeared to have limited specific knowledge anchors they need to employ in reflecting on their teaching practices (Macugay & Bernado, 2013).

Again, while most of the graduate teachers 64(61.0%) in this study had pre-service teacher preparation and undertaken many science and methods courses in their undergraduate programs, more than half of the certificate teachers 102(51.0%) were SSCE and WASSCE holders who have never taken any methods course at all. Due to their lack or limited exposure to teaching and learning theories taught in method courses, the certificate teachers lacked or have limited appreciation of students' involvement in science instruction. This has resulted in the certificate teachers' formation and development of weaker inquiry-based but stronger traditional beliefs about science teaching. This situation is disturbing, given that most science teachers in the Ghanaian JHSs are certificate holders, who may not be fully committed to implement inquiry teaching in accordance with the rationale for basic science education Ghana (CRDD, 2007, 2012).

Extent to which differences in self-efficacy of teachers and teacher school type (public and private) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities

Answering this section of the research question involved examination of two components of the public and private JHS teachers' self-efficacy (Personal Science Teaching Efficacy - PSTE and Science Teaching Outcome Expectancy - STOE), to determine which group of teachers held weaker, more moderate, or stronger self-efficacy that present greater impediment or facilitation of inquiry-based science teaching in JHSs in the districts and municipalities. This also involved conducting one-way MANOVA with PSTE and STOE as dependent variables and school type as independent variable. The MANOVA results show that there was statistically significant difference between the public and private JHS teachers when their PSTE and STOE were jointly considered at an alpha level of .05. Wilk's $\lambda = .941$, $F(2, 305) = 9.482$, $p < 0.05$, partial $\eta^2 = .059$. This shows that JHS teachers' self-efficacy toward inquiry-based science teaching in the Ghanaian districts and municipalities differ according to their school type. This permitted the conduct of separate one-way ANOVAs to examine differences on each component of self-efficacy, with each ANOVA being evaluated at a Bonferroni adjusted alpha level of .025.

Table 36 shows average item means, average item standard deviations, and differences between the public and private JHS teachers (effect size and MANOVA results) for each component of self-efficacy toward inquiry-based science teaching.

Table 36: *Average item means, average item standard deviations, and differences between public and private JHS teachers (effect size and MANOVA results) for each component of self-efficacy toward inquiry-based science teaching*

Component of self-efficacy	Average item mean		Average item standard deviation		Difference	
	Public	Private	Public	Private	F	Effect size (η^2)
Science Teaching Outcome Expectancy (STOE)	2.88	2.68	0.69	0.66	6.045*	0.019
Personal Science Teaching Efficacy (PSTE)	4.02	3.72	0.72	0.75	12.367*	0.039

* $p < .025$. N = 176(Public teachers), N = 132(Private teachers)

Note: high mean is inquiry-based, low mean is traditional-oriented

Source: Field data, Mohammed (2015)

There were statistically significant differences between public and private JHS teachers' STOE, $F(1, 306) = 6.045$, $p < .025$, partial $\eta^2 = .019$, and PSTE, $F(1, 306) = 12.367$, $p < .025$, partial $\eta^2 = .039$. Private JHS teachers (M = 2.68, SD =.66) expressed weaker inquiry-based but stronger traditional science teaching outcome expectancy than public JHS teachers (M = 2.88, SD = .69).

Compared to public JHS teachers, private JHS teachers expressed stronger traditional outcome expectations that improvement in students' interest and achievements in science are directly related to effectiveness of teachers in defining, explaining, and writing science concepts on the board, and telling answers students are expected to learn (Table 37).

Table 37: *Means and standard deviations of public and private JHS teachers' ratings of items constituting Science Teaching Outcome Expectancy (STOE)*

Item	Mean		Standard deviation	
	Public	Private	Public	Private
Increased effort in writing science concepts and principles on the board for JHS students is directly related to their academic performance.	2.79	2.42	1.14	.98
If parents comment that their child is showing interest in science at school, it is probably due to the teacher telling students answers they are expected to learn.	2.98	2.59	1.10	1.26
If students are not performing well in collecting and recording scientific data it is most likely due to ineffective teaching of how to collect and record data.	3.17	3.05	1.18	1.03
The teacher is responsible for the achievements of students in how they formulate hypotheses for science phenomena.	3.30	3.28	1.02	.87
If JHS students are not performing like actual scientists do, it is most likely due to ineffective teaching of how actual scientists work.	2.80	2.91	1.15	1.05
JHS students' achievements in science are directly related to their teacher's effectiveness in defining and explaining science concepts and principles.	2.23	1.85	.90	.83

N = 176(Public teachers), N = 132(Private teachers)
High mean = inquiry-based, low mean = traditional oriented.
Source: Field data, Mohammed (2015)

In contrast, public JHS teachers expressed more certainty in inquiry-based outcome expectations than private JHS teachers. Public JHS teachers expressed more certainty that students' inquiry skills will improve when the students are engaged in collection and recording of data, formulation of hypotheses for science phenomena, and working like actual scientists do.

As shown in Table 36, there was statistically significant difference between public and private JHS teachers' personal science teaching efficacy beliefs, with public JHS teachers (M = 4.02, SD = .72) expressing stronger inquiry-based PSTEs than private JHS teachers (M = 3.72, SD = .75). Compared to private JHS teachers, public JHS teachers expressed stronger personal efficacy that they can easily guide students to examine and evaluate the quality of scientific data, and help students in difficulty of manipulating science equipment to do it better (Table 38).

Table 38: *Means and standard deviations of public and private JHS teachers' ratings of items on Personal Science Teaching Efficacy (PSTE)*

Item	Mean		Standard deviation	
	Public	Private	Public	Private
I wonder if I have the necessary skills to teach content embedded in the processes of science.	3.97	3.65	1.00	1.01
I find it difficult guiding JHS students to examine and evaluate the quality of scientific data on their own.	4.15	3.91	.74	.88
I don't know what to do to turn JHS students on to do science like actual scientists do.	3.90	3.54	.94	1.04
When a JHS student has a difficulty in how to manipulate science equipment and materials, I am usually at a loss as to how to help him to it better.	4.05	3.80	.92	1.02

N = 176(Public school teachers), N = 132(Private school teachers)

Note: High mean is inquiry-based, low mean is traditional oriented

Source: Field data, Mohammed (2015)

Again, public JHS teachers expressed stronger efficacy that they can teach content embedded in the processes of science, and turn JHS students on to do science like actual scientists do.

While quantitative results from the teachers' ratings show that public JHS teachers expressed stronger personal efficacy beliefs than private JHS teachers, interview responses from a subsample of the teachers provide interesting insights into the differences. The responses show that most public and private school teachers held strong PSTEs based on traditional conceptions of science teaching, while others held strong personal science teaching efficacy based on partially informed conceptions of inquiry. Therefore, the qualitative results show that personal science teaching efficacy expressed by both public and private JHS teachers were not as strong as the quantitative results appear to show.

While more public JHS teachers expressed confidence in their abilities to implement inquiry teaching than private JHS teachers, more private JHS teachers expressed confidence in their abilities to implement traditional teaching than public JHS teachers. Two public school teachers as compared to five private teachers said they can effectively monitor JHS students to perform science experiments when they put the students into groups and give them rules and regulations to follow. For example, two private school teachers said:

> *I can effectively monitor JHS students to perform experiments. For monitoring, I will make sure that the students understand what they have to do and what they don't have to do. I will put the students into groups. Then I can monitor them.* (ST7)

> *You have to let the children be acquainted with the rules and*

regulations and precautions that they need to take at every experiment in the laboratory. (ST3)

Again, two private JHS teachers said that they can effectively teach science when it involves strict supervision of students' behaviours and activities while no public JHS teacher made such remarks. For example, two private teachers said:

There should be strict supervision. You have to ensure that children comply with the time to go to the lab for experiment. (ST3)

Let's say you have given an activity to students to do in school, you go round from group to group to check what they are doing. When necessary, you give them directions and move to the next group. (ST11)

Discussion

In summary, triangulation of quantitative results from the teachers' ratings and interview responses from a subsample of the teachers show that there were significant differences between public and private JHS teachers' self-efficacy toward inquiry-based science teaching in the four Ghanaian districts and municipalities. Specifically, this study found that private JHS teachers in the Ghanaian districts and municipalities held weaker inquiry-based but stronger traditional science teaching outcome expectancy (STOE) and personal science teaching efficacy (PSTE) beliefs than public JHS teachers. This indicates that private JHS teachers' self-efficacy pose greater challenges to inquiry-based science teaching in the Ghanaian districts and municipalities than public JHS teachers' self-efficacy. This finding shows that

JHS teachers' self-efficacy toward inquiry-based science teaching in the Ghanaian districts and municipalities differ according to their school type.

This finding contradicts others in industrialised and industrialising countries. For example, Lin and Chao (2015) found that private school teachers they studied in Taiwan held stronger self-efficacy toward teaching than the public school teachers. Similarly, Sahin et al. (2010) found that private school teachers they studied in Turkey held stronger self-efficacy toward inquiry-based science teaching than the public school teachers. However, the present finding is consistent with the assertion of researchers that formation and development and translation of teachers' self-efficacy into classroom practices depend on a number of contextual and demographic factors, including the school climate, and social and situational circumstances under which teaching occurs (e.g., Bandura, 1977; Bleicher, 2004; Lardy & Mason, 2011; Otieno et al., 2013; Page et al., 2014; Sahin et al., 2010; Tschannen-Moran, Hoy, & Hoy, 1998).

Lin and Chao (2015) attributed differences in self-efficacy between the private and public school teachers they studied in Taiwan to the fact that private school teachers in Taiwan engage in more community involvement, teacher-student interactions, and effective classroom management than public school teachers. Similarly, Sahin et al. (2010) attributed differences in self-efficacy between the private and public school teachers they studied in Turkey to the fact that private school teachers in Turkey have greater opportunities to work with inquiry-based instructional materials, equipment, and technology than public school teachers. However, differences in self-efficacy between the public and private JHS teachers in the Ghanaian districts and municipalities is largely due to differences in traditional science teaching and learning and assessment practices occurring in these schools. Private JHSs in the Ghanaian districts and municipalities, especially the urban private JHSs, are more examination-oriented. As a result, science instruction in the private JHSs involve coverage of syllabus content, provision of extra classes to students, revision of content already taught, solving past questions, teaching examination techniques, and writing mock examinations. Examples of teachers' and educational administrators' quotes expressing these ideas are:

> *Private schools want to produce results, so whatever they will do to produce results is what they do.* (SC1)

> *Private schools are concerned about the enrolment they get, and so they put in measures that will give them increased enrolment. The BECE (examination passes) is one of the measures they use to get more enrolment.* (ST7)

> *The head teacher wants me to bring out the best for my student in BECE results. He expects the students to come out with distinctions in integrated science when they go and sit for their final examinations. That is the main aim.* (ST13)

These contextual practices have enabled the private JHS teachers to form and develop weaker inquiry-based but stronger traditional self-efficacy toward science teaching than the public JHS teachers.

Extent to which differences in self-efficacy of teachers and teacher school location (urban and rural) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities

Providing answers to this section of the research question involved examination of two components of urban and rural JHS teachers' self-efficacy (personal science teaching efficacy – PSTE and science teaching outcome expectance – STOE), to determine which group of teachers held weaker, more moderate, or stronger self-efficacy that pose greater impediment or facilitation of inquiry-based science teaching in JHSs in the four districts and municipalities. This also involved conducting one-way MANOVA with the two components of self-efficacy as dependent variables and school location as independent variable. The MANOVA results show that there was statistically significant difference between urban and rural JHS teachers when their PSTE and STOE were jointly considered at an alpha level of .05, Wilk's λ = .975, $F(2, 305) = 3.942$, $p<.05$, partial $\eta^2 = .025$. This indicates that JHS teachers' self-efficacy toward inquiry-based science teaching in the Ghanaian districts and municipalities differ according to their school location. This permitted the conduct of separate one-way ANOVAs to examine differences on each component of self-efficacy, with each ANOVA being evaluated at a Bonferroni adjusted alpha level of .025.

Table 39 shows average item means, average item standard deviations, and differences between urban and rural JHS teachers (effect size and MANOVA results) for each component of self-efficacy toward inquiry-based science teaching.

Table 39: *Average item means, average item standard deviations, and differences between urban and rural JHS teachers (effect size and MANOVA results) for each component of self-efficacy toward inquiry-based science teaching*

Component of self-efficacy	Average item mean		Average item standard deviation		Difference	
	Public	Private	Public	Private	*F*	Effect size (η^2)
Personal Science Teaching Efficacy (PSTE)	4.00	3.80	.75	.74	5.197*	0.017
Science Teaching Outcome Expectancy (STOE)	2.86	2.73	.69	.68	2.580	0.008

*p < .025, N = 145(Rural JHS teachers). N = 163(Urban JHS teachers)

High mean is inquiry oriented. low mean is traditional oriented

Source: Field data. Mohammed (2015)

There was statistically significant difference between urban and rural JHS teachers' personal science teaching efficacy (PSTE) beliefs $F(1, 306) = 5.197$, $p < .025$. partial $\eta^2 = .017$. However, there was no statistically significant difference between urban and rural JHS teachers' science teaching outcome expectancy (STOE) beliefs $F(1. 306) = 2.580$, $p > .05$. partial $\eta^2 = .008$. Rural school teachers (M = 4.00. SD = 0.75) in the Ghanaian districts and municipalities expressed stronger personal science teaching efficacy beliefs than the urban school teachers (M = 3.80. SD = 0.74).

Compared to the urban JHS teachers, rural JHS teachers expressed stronger confidence in their abilities to guide students to examine and evaluate the quality of scientific data, and help students in difficulty of manipulating science equipment to do it better (Table 40). Again, compared to urban JHS teachers, rural JHS teachers expressed stronger confidence in their abilities to teach content embedded in the processes of science, and turn JHS students on to do science like actual scientists do.

Table 40: *Means and standard deviations of urban and rural JHS teachers' ratings of items on Personal Science Teaching Efficacy (PSTE) beliefs*

Item	Mean		Standard deviation	
	Rural	Urban	Rural	Urban
I wonder if I have the necessary skills to teach content embedded in the processes of science.	3.88	3.79	1.04	.99
I find it difficult explaining to JHS students how to examine and evaluate quality of scientific data on their own.	4.13	3.98	.74	.87
I don't know what to do to turn JHS students on to do science like actual scientists do.	3.87	3.64	1.00	.99
When a JHS student has difficulty in how to manipulate science equipment and material, I am usually at a loss as to how to help him do it better.	4.10	3.80	.93	.99

N = 145(Rural JHS teachers). N = 163(Urban JHS teachers)

Source: Field data. Mohammed (2015)

While quantitative results from the teachers' ratings show that rural JHS teachers expressed stronger inquiry-based personal science teaching efficacy than urban JHS teachers, interview responses from a subsample of the teachers show that most of the teachers expressed strong personal efficacy beliefs based on traditional conceptions of science teaching, whereas others expressed strong personal efficacy beliefs based on partially informed conceptions of inquiry. Therefore, the qualitative results show that personal science teaching efficacy beliefs held by both urban and rural JHS teachers were not as strong as the quantitative results appear to show.

While both groups expressed similar inquiry-based personal efficacy beliefs, more urban JHS teachers expressed traditional personal efficacy beliefs than rural JHS teachers. Compared to one rural JHS teacher, three urban JHS teachers said they can effectively teach science when they put students into groups and give them experimental procedures to follow. For example, an urban school teacher said:

> *Experiments will be effective when every student participates in it. If I have sizeable groups of students following step-by-step procedures to perform experiment, the first two steps will be performed by one person in the group, the second two steps by another person, and so on. At the end of the experiment every student will participate in it and I think it will be effective.* (ST6)

Discussion

To sum up, triangulation of quantitative results from the teachers' ratings and qualitative results from a subsample of the teachers show that there was significant difference between urban and rural JHS teachers' self-efficacy toward inquiry-based science teaching in the four Ghanaian districts and municipalities. Specifically, this study found that urban JHS teachers in the Ghanaian districts and municipalities held weaker inquiry-based but stronger traditional personal science teaching self-efficacy than the rural JHS teachers. This indicates that urban JHS teachers' self-efficacy pose greater challenges to inquiry-based science teaching in the Ghanaian districts and municipalities than rural JHS teachers' self-efficacy. This finding shows also that JHS teachers' self-efficacy toward inquiry-based science teaching in the Ghanaian districts and municipalities differ according to their school location.

This finding is consistent with that of Page et al. (2014), but contradicts that of Riggs and Enochs (1989). Studies in industrialised and industrialising countries show that demographic characteristics have significant influence on the formation and development and translation of teachers' self-efficacy into successful classroom practices (e.g., Aktas et al., 2013; Azar, 2010; Bleicher, 2004; Gavora, 2011; Jameson-Charles & Jaggernauth, 2015; Lin & Chao, 2014; Otieno et al., 2016; Page et al., 2014; Riggs & Enochs, 1989; Sahin et al., 2010; Wagler, 2011). However, studies available suggests that school location (rural versus urban) has limited influence on the formation and development of teachers' self-efficacy in industrialised and industrialising countries outside Africa. Only Page et al. (2014) found that school location in south-eastern USA has significant influence on elementary teachers' self-efficacy. In contrast, the present finding shows that school location (rural and urban) in the Ghanaian districts and municipalities is a demographic characteristic that significantly influences the formation and development of JHS teachers' self-efficacy toward science teaching. This is a significant contribution to the literature.

Literature shows that the ability of teachers to teach challenging and difficult students successfully generates positive self-efficacy in the teachers than teaching students without challenges (e.g., Bandura, 1977, 1994). In the present case, ability of the Ghanaian rural JHS teachers to teach science successfully to students who are not proficient in English might have generated slightly higher self-efficacy in the rural teachers than in the urban JHS teachers. For example, a rural JHS teacher said:

> *In such (rural) communities if the child is able to perform well then it's a "pat" on the back of the teacher.* (ST16)

This excerpt indicates that a teacher needs to have much confidence in his ability and exert much effort in order to improve science achievements of rural school students in the Ghanaian districts and municipalities.

Extent to which differences in self-efficacy of teachers and teacher academic qualification (certificate, graduate, and post graduate) pose challenges to inquiry-based science teaching in JHSs in four Ghanaian districts and municipalities

Answering this section of the research question involved examination of two components of certificate, graduate, and post graduate JHS teachers' self-efficacy (Personal Science Teaching Efficacy - PSTE and Science Teaching Outcome Expectancy - STOE), in order to determine which group of teachers held weaker, more moderate, or stronger self-efficacy that pose greater impediment or facilitation of inquiry-based science teaching in JHSs in the districts and municipalities. This also involved conducting one-way MANOVA with STOE and PSTE as dependent variables and academic qualification as independent variable. The MANOVA results show that there was statistically significant difference between certificate, graduate, and post graduate JHS teachers when their PSTE and STOE were jointly considered at an alpha level of .05, Wilk's λ = .942, F(4, 608) = 4.648, $p<.05$, partial η^2 = .030. This indicates that JHS teachers' self-efficacy toward inquiry-based science teaching in the Ghanaian districts and municipalities differ according to their academic qualification. This permitted the conduct of separate one-way ANOVAs to examine differences on each component of self-efficacy, with each ANOVA being evaluated at a Bonferroni adjusted alpha level of .025.

Table 41 shows average item means, average item standard deviations, and differences between certificate, graduate, and post graduate JHS teachers (effect size and MANOVA results) for each component of self-efficacy toward inquiry-based science teaching.

Table 41: *Average item means, average item standard deviations, and differences between certificate, graduate, and post graduate JHS teachers (effect size and MANOVA results) for each component of self-efficacy toward inquiry-based science teaching*

Component of self-efficacy	Average item mean			Average item standard deviation			Difference	
	Cert	Grad	Post G	Cert	Grad	Post G	*F*	Effect size (η^2)
Personal Science Teaching Efficacy (PSTE)	3.81	4.05	4.83	.74	.73	1.01	3.698**	0.024
Science Teaching Outcome Expectancy (STOE)	2.70	3.00	3.22	.65	.72	1.07	5.448*	0.034

*$p<.025$, **$p<.05$, N = 200(Certificate teachers), N = 105(Graduate teachers), N = 3(Post graduate teachers; Cert = Certificate teachers, Grad = Graduate teachers, Post G = Post graduate teachers

Source: Field data, Mohammed (2015)

There were statistically significant differences between certificate, graduate, and post graduate JHS teachers' personal science teaching efficacy (PSTE), $F(2, 305) = 3.698$, $p < .05$, partial $\eta^2 = .024$, and science teaching outcome expectancy (STOE) $F(2, 305) = 5.448$, $p < .025$, partial $\eta^2 = .034$. Post hoc analysis shows that there was pair wise statistically significant difference between certificate and graduate teachers' personal science teaching efficacy beliefs. However, there were no pair wise significant differences between certificate and post graduate, and graduate and post graduate teachers. Graduate JHS teachers in the Ghanaian districts and municipalities expressed stronger inquiry-based personal efficacy beliefs (M = 4.05, SD = .73) than certificate JHS teachers (M = 3.81, SD = .74).

Compared to certificate teachers, graduate teachers expressed stronger confidence in their abilities to guide students to examine and evaluate the quality of scientific data, and help students in difficulty of manipulating science equipment to do it better (Table 42).

Table 42: *Means and standard deviations of certificate and graduate JHS teachers' ratings of items on Personal Science Teaching Efficacy (PSTE) beliefs*

Item	Mean		Standard deviation	
	Cert	Grad	Cert	Grad
I wonder if I have the necessary skills to teach content embedded in the processes of science.	3.75	3.98	1.02	1.00
I find it difficult explaining to students how to examine and evaluate quality of scientific data on their own.	4.00	4.15	.83	.76
I don't know what to do to turn JHS students on to do science like actual scientists do.	3.64	3.96	1.00	.96
When a JHS student has a difficulty in how to manipulate science equipment and materials, I am usually at a loss as to how to help him do it better.	3.85	4.10	1.01	.88

N = 200(Certificate teachers), N = 105(Graduate teachers)

Source: Field data, Mohammed (2015)

Again, graduate JHS teachers expressed stronger confidence in their abilities to teach content embedded in the processes of science, and turn JHS students on to do science like actual scientists do.

While quantitative results from the teachers' ratings show that graduate JHS teachers expressed stronger inquiry-based personal science teaching efficacy than certificate JHS teachers, interview responses from a subsample of the teachers show that most graduate and certificate teachers expressed strong personal efficacy based on traditional conceptions of science teaching, whereas others expressed strong personal efficacy based on partially informed conceptions of inquiry. Therefore, the qualitative results show that personal science teaching efficacy held by both graduate and certificate teachers were not as strong as the quantitative results appear to show. The responses show that both graduate and certificate teachers expressed similar inquiry-based personal efficacy beliefs, while more certificate teachers expressed traditional personal efficacy beliefs than graduate teachers. While some certificate teachers said they can effectively implement inquiry-based science teaching by assigning different tasks to students during explorations:

> *By putting students into groups, you give them different tasks to explore. After that you use about 10 minutes for evaluation or anything that you think the students must know.* (ST15)

Some graduate teachers said they can effectively implement inquiry teaching by giving students autonomy to pursue their own investigations, and periodically ask the students to provide feedback about progress of their work.

> *I will implement inquiry teaching by asking students to report on the progress of their investigations regularly for me to know what they*

have done, what they have been able to discover, and at what stage they are. If it is a project for the whole class, I will give them timelines. I will not be too involving in the students' investigations, unless I see something going wrong that will lead to wrong conclusion. (ST18)

In contrast, seven graduate teachers as compared to fifteen certificate teachers expressed traditional personal efficacy beliefs, saying they cannot effectively monitor students engaged in hands-on activities when the class size is large and time allocated for the activities is insufficient. For example, a certificate teacher said:

I cannot monitor students effectively because the class size is large that it is difficult to move from one place to another. Additionally, time allocated for hands-on activities is insufficient. (ST16)

Again, the certificate teachers said that they can effectively teach science when they show and describe objects, organisms, events, and phenomena to students. Example of certificate teachers' quotes expressing this idea is:

If you are teaching about flowers in class, you (the teacher) go out and pluck a flower. You then take off parts of the flower one by one and describe them to students. (ST11)

Additionally, the certificate teachers said that they can effectively engage students in hands-on activities only when they ensure discipline and quietness in the classroom, and punish students when necessary. For example, a certificate teacher stated:

Sometimes the teacher needs not tolerate noise in the class. The teacher should ensure discipline in class all the time. Ensuring discipline in class involves proper use of punishment during science *activities.* (ST17)

Table 41 shows also that there was statistically significant difference between certificate, graduate, and post graduate teachers' science teaching outcome expectancy (STOE) beliefs. Post hoc analysis shows that there was pair wise significant difference between certificate and graduate teachers, with graduate JHS teachers (M = 3.00, SD = 0.72) holding more moderate outcome expectancy than certificate JHS teachers (M = 2.70, SD = 0.65). However, there were no pair wise significant differences between certificate and post graduate, and graduate and post graduate teachers.

Certificate JHS teachers expressed weaker inquiry-based but stronger traditional outcome expectancy beliefs than graduate JHS teachers (Table 43).

Table 43: *Means and standard deviations of certificate and graduate JHS teachers' ratings of items on Science Teaching Outcome Expectancy (STOE) beliefs*

Item	Mean		Standard deviation	
	Cert	Grad	Cert	Grad
Increased effort in writing science concepts and principles on the board for JHS students is directly related to their academic performance.	2.49	2.89	1.03	1.15
If parents comment that their child is showing more interest in science at school, it is probably due the teacher telling students answers they are expected to learn.	2.62	3.15	1.18	1.10
If JHS students are not performing well in collecting and recording scientific data, it is most likely due to ineffective teaching of how to collect and record data.	3.06	3.21	1.07	1.20
The teacher is responsible for the achievements of JHS students in how they formulate hypotheses for science phenomena.	3.25	3.37	.87	1.11
If JHS students are not performing like actual scientists do, it is most likely due to ineffective teaching of how scientists work.	2.97	3.00	1.21	1.73
JHS students' achievements in science are directly related to their teacher's effectiveness in defining and explaining science concepts and principles.	2.14	2.33	.78	1.53

N = 200(Certificate teachers), N = 105(Graduate teachers)
High mean is inquiry-based, low mean is traditional oriented
Source: Field data, Mohammed (2015)

Compared to graduate teachers, certificate teachers expressed stronger traditional outcome expectancy that improvement in students' achievements and interest in science is directly related to the effectiveness of teachers in defining, explaining, and writing science concepts on the board, and telling answers students are expected to learn (Table 43). In contrast, graduate teachers expressed more certainty in inquiry teaching outcomes that it can improve students' skills in data collection and recording, formulation of hypotheses for science phenomena, and working like actual scientists do.

Discussion

In summary, triangulation of quantitative results from the teachers' ratings and qualitative results from a subsample of the teachers show that there were significant differences between certificate and graduate teachers' self-efficacy toward inquiry-based science teaching in the four Ghanaian districts and municipalities. Specifically, this study found that certificate JHS teachers in the Ghanaian districts and municipalities held weaker inquiry-based but stronger traditional personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE) beliefs than graduate JHS teachers. This indicates that certificate JHS teachers' self-efficacy pose greater challenges to inquiry-based science teaching in the Ghanaian districts and municipalities than graduate JHS teachers' self-efficacy. This finding shows also that JHS teachers' self-efficacy toward inquiry-based science teaching in the Ghanaian districts and municipalities differ according to their academic qualification. This finding is not surprising, given that graduate teachers have taken more science content and pedagogical content courses than certificate teachers. This finding is similar to others in the science education literature (e.g., Bleicher, 2004; Lardy & Mason, 2011).

The number of science courses taken and the amount of content and pedagogical content knowledge possessed by the graduate teachers enhanced the formation and development of their self-efficacy toward inquiry-based science teaching (e.g., Bleicher, 2004; Lardy & Mason, 2011). Researchers assert that science content and pedagogical content knowledge are cognitive mastery experiences involving successes in understanding science concepts and teaching strategies. Ability of the graduate JHS teachers to understand science concepts and teaching strategies better, generated slightly higher self-efficacy in them than in the certificate JHS teachers.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The summary, conclusions, and recommendations of this study, as well as significant contributions to knowledge, and areas for further research are presented in this final chapter.

Summary

The purpose of this study was to investigate extent of implementation of inquiry-based science teaching and learning in JHSs in four Ghanaian districts and municipalities and some challenges confronting it. Specific challenges investigated are extent to which teachers' and educational administrators' conceptions of inquiry impede or facilitate inquiry-based science teaching; extent to which teachers' attitudes, beliefs, and self-efficacy impede or facilitate inquiry-based science teaching; and extent to which differences in attitudes, beliefs, and self-efficacy of teachers and teacher characteristics impede or facilitate inquiry-based science teaching.

This study employed the concurrent triangulation mixed methods design, involving the use of both quantitative and qualitative methods to collect quantitative and qualitative data. The quantitative methods are surveys and structured observations, and the qualitative method is multiple case studies. I addressed most of the research questions through triangulation of quantitative and qualitative data; while I addressed one research question using only qualitative data. Again, part of the qualitative data enabled me to gain insight and interpretation of the quantitative results and findings.

Samples for the quantitative surveys are 503 JHS2 students, 308 science teachers, and 31 observed integrated science lessons; while samples for the qualitative case studies are 12 head teachers, four circuit supervisors, three science coordinators, three deputy directors and a director of education, and a subsample of 18 teachers. The samples were from one urban municipality (Awutu-Senya East - Kasoa), two rural districts (Ajumako-Enyan-Essiam and Ekumfi), and one urban-rural municipality (Agona West) in the central region of Ghana. I used multistage sampling technique for selecting the participants.

Instruments for the data collection are two questionnaires (Appendices G and H), two structured observation schedules (Appendices I and J), and three semi-structured interview schedules (Appendices K, L, and M). I pilot tested the instruments and subjected them to rigorous validity, reliability, credibility, and dependability tests prior to the main data collection and analyses. The main data collection occurred in one phase but two parts. The first part involved administration of questionnaires to science teachers. The second part involved administration of questionnaires to students, lesson observations, and semi-structured interviews with head teachers, circuit supervisors, science coordinators, deputy directors and director of education, and a subsample of science teachers. The main data collection spanned from early September, 2014 to the end of February, 2015.

I used Statistical Package for Social Sciences (SPSS) (version 16) to analyse the quantitative data and Nvivo (version 8) to analyse the qualitative data. Statistical procedures used in the quantitative data analyses are Principal Component Analyses (PCA), Cronbach alpha, average item means, means, average item standard deviations, standard deviations, frequencies, percentages, One-way MANOVAs, and two-way MANOVA. The qualitative data analyses involved identification of emergent themes, patterns, categories, and sample quotations.

Summary of key findings

1. This study found that there was rare implementation of inquiry-based science teaching and learning in JHSs in the four Ghanaian districts and municipalities. Instead, there was frequent implementation of traditional science teaching. While there was considerable implementation of the social aspect of inquiry, important aspects of inquiry (procedural, epistemic, social, and conceptual) were rarely implemented in the JHSs.

2. This study found that there was implementation of inquiry-based Science, Technology, Mathematics, Innovation, and Education (STMIE) fairs in JHSs in the four Ghanaian districts and municipalities at times.

3. This study found that interaction of school location (urban and rural) and school type (public and private) significantly influenced the implementation of inquiry-based science teaching and learning in JHSs in the Ghanaian districts and municipalities.

4. This study found that while urban private JHSs in the Ghanaian districts and municipalities implemented inquiry-based social activities in half of the science lessons per term, rural private JHSs implemented inquiry-based social activities in a few science lessons per term. In contrast, while rural public JHSs implemented inquiry-based social activities in nearly half of the science lessons per term, urban public JHSs implemented inquiry-based social activities in a few science lessons per term.

5. This study found that while urban public JHSs in the Ghanaian districts and municipalities implemented inquiry-based conceptual activities in fewer

science lessons per term than rural public JHSs, both urban private and rural private JHSs implemented inquiry-based conceptual activities in a few science lessons per term.

6. This study found that while urban public JHSs in the Ghanaian districts and municipalities implemented inquiry-based procedural activities in fewer science lessons per term than urban private JHSs, both rural public and rural private JHSs implemented inquiry-based procedural activities in a few science lessons per term.

7. This study found that teachers and educational administrators in the Ghanaian districts and municipalities held conceptions of scientific inquiry which reflected in their conceptions of science teaching and learning.

8. This study found that most teachers, head teachers, circuit supervisors, science coordinators, deputy directors and director of education in the Ghanaian districts and municipalities held uninformed conceptions of scientific inquiry, and traditional conceptions of science teaching and learning; which pose major challenges to inquiry-based science teaching in JHSs.

9. This study found that a few teachers and educational administrators in the Ghanaian districts and municipalities held partially informed conceptions of scientific inquiry and inquiry teaching and learning, which pose considerable challenges to inquiry-based science teaching in JHSs.

10. This study found that most JHS teachers in the four Ghanaian districts and municipalities held low attitudes toward inquiry-based science teaching. Instead, they held high attitudes toward traditional science teaching, which pose major challenges to inquiry-based science teaching in JHSs.

11. This study found that while most teachers in the Ghanaian districts and

municipalities highly perceived inquiry-based science teaching to be relevant, they highly perceived it to be difficult and moderately perceived anxiety toward it. Additionally, while most of the teachers held high interest in inquiry teaching based on traditional conceptions of science teaching, many teachers held high interest in inquiry teaching based on partially informed conceptions of inquiry. Instead, most of the teachers perceived traditional science teaching to be easy, interesting, and less anxious.

12. This study found that most JHS teachers in the Ghanaian districts and municipalities held weak beliefs about inquiry-based science teaching. Instead, they held strong beliefs about traditional science teaching, which pose major challenges to inquiry-based science teaching in JHSs.

13. This study found that most JHS teachers in the Ghanaian districts and municipalities held weak inquiry-based but strong traditional beliefs about "characteristics of science teachers and the learning environment". Again, while most of the teachers held strong beliefs about the "nature of science curriculum", "how students learn science", and "science lesson design and implementation" based on traditional conceptions of science teaching, many teachers held strong beliefs based on partially informed conceptions of inquiry.

14. This study found that most JHS teachers in the Ghanaian districts and municipalities held weak self-efficacy toward inquiry-based science teaching. Instead, they held strong self-efficacy toward traditional science teaching, which pose major challenges to inquiry-based science teaching in JHSs.

15. This study found that most teachers in the four Ghanaian districts and municipalities held weak inquiry-based science teaching outcome expectancy

(STOE) beliefs. Additionally, while most of the JHS teachers held strong PSTEs based on traditional conceptions of inquiry teaching, many others held strong beliefs based on partially informed conceptions of inquiry teaching.

16. This study found that most JHS teachers and educational administrators in the Ghanaian districts and municipalities held uninformed conceptions, low attitudes, and weak beliefs and self-efficacy toward inquiry teaching because they have never been exposed to and never experienced inquiry-based science teaching and learning throughout their education and in-service trainings. Instead, the teachers and administrators were exposed to and had experiences with traditional science teaching experiences in their education and in-service trainings.

17. This study found significant differences in attitudes, beliefs, and self-efficacy between public and private JHS teachers in the Ghanaian districts and municipalities; with private JHS teachers holding lower attitudes and weaker beliefs and self-efficacy toward inquiry-based science teaching than public JHS teachers. This shows that private JHS teachers' attitudes, beliefs, and self-efficacy pose major challenges to inquiry-based science teaching than those of public JHS teachers.

18. This study found significant differences in beliefs and self-efficacy between certificate and graduate teachers in the four Ghanaian districts and municipalities; with certificate teachers holding weaker beliefs and self-efficacy toward inquiry-based science teaching than graduate teachers. This shows that certificate teachers' beliefs and self-efficacy pose major challenges to inquiry-based science teaching in JHSs than graduate teachers' beliefs and self-efficacy.

19. This study found significant difference in self-efficacy between urban and rural JHS teachers in the Ghanaian districts and municipalities; with urban JHS teachers holding weaker self-efficacy than rural JHS teachers. This shows that urban JHS teachers' self-efficacy pose major challenges to inquiry teaching than rural JHS teachers' self-efficacy.

20. This study found that the formation and development of lower attitudes and weaker beliefs and self-efficacy of private JHS teachers is mainly due to the predominance of traditional teaching and learning and assessment practices in private JHSs than public JHSs.

21. This study found that the formation and development of weaker beliefs and self-efficacy of certificate teachers is largely due to the fewer number of content courses and lack of methods courses taken by the certificate teachers.

22. This study found that the formation and development of slightly higher self-efficacy of rural JHS teachers is mainly due to their ability to teach science successfully to students who are not fluent in English language.

Other Findings of the Study

1. This study found that teachers' attitudes, beliefs, and self-efficacy toward inquiry-based science teaching are multidimensional.

2. This study found that teachers' perceived relevance, anxiety, difficulty, and interest explains a large part (52.07%) of their attitudes toward inquiry-based science inquiry teaching.

3. This study found that teachers' beliefs about the "nature of science curriculum", "science lesson design and implementation", "characteristics of science teachers and the learning environment", and "how students learn science" explains a large part (66.45%) of their beliefs about inquiry-based

science inquiry teaching.

4. This study found that a large part of teachers' self-efficacy toward science inquiry teaching (50.73%) can be explained in terms of their Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) beliefs.

5. This study found that there are many aspects (components) of inquiry teaching and learning, and that a large proportion of inquiry-based science teaching and learning (59.95%) occur in the form of procedural, epistemic, conceptual, social, and guidance activities.

6. This study found that nearly 90.0% of science teachers in JHSs in the four Ghanaian districts and municipalities were males, and more than half of them were certificate holders and novices with 1-5 years of teaching experiences. Additionally, more than half (51.89%) of the JHS students were females, and more than half of the students (59.84%) were in urban centres.

Implications of Research Findings for Educational Practice in Four Ghanaian Districts and Municipalities

Findings from this study have important implications for science teaching and learning and educational practice in the Ghanaian districts and municipalities:

First, for inquiry-based science teaching and learning in JHSs to be implemented in consistent with the constructivist views of science education, students must be engaged in important aspects of inquiry including procedural, epistemic, conceptual, social, and guidance activities. This means, teachers must coach and give JHS students autonomy to actively plan, design, and perform science investigations grounded in real-life contexts; collect, record, and examine the quality of their data; and interpret science phenomena based on data they have collected. Again, teachers must facilitate JHS students to formulate hypotheses for science phenomena and consider alternative explanations for phenomena; and engage in collaborative, discursive, and argumentative presentations with their mates and others, to construct acceptable scientific knowledge for themselves.

Second, for science teaching and learning to be meaningful for most rural and public JHS students, code-switching (mixing) of English and the students' local language in the context of real-life science investigations must be promoted in schools.

Third, for science teachers to effectively teach and for educational administrators to effectively supervise inquiry-based science teaching and learning in JHSs, they need to acquire complete and robust conceptions of scientific inquiry and inquiry teaching and learning in consistent with the constructivist philosophy of science education.

Fourth, for teachers to employ inquiry-based teaching strategies readily and effectively in their lessons, they need to cultivate strong favourable attitudes, beliefs, and self-efficacy toward this instructional approach.

Fifth, in organising in-service trainings to address teachers' attitudes, beliefs, and self-efficacy toward inquiry-based science teaching, specific needs of different groups of teachers (rural and urban; public and private; and certificate and graduate) must be considered.

Sixth, to assess implementation of inquiry-based science teaching and learning in JHSs, it is necessary to employ multiple methods (e.g., questionnaires, observations, interviews) and different types of data (quantitative and qualitative) to arrive at a more valid conclusion. Similarly, in assessing in-service and pre-service teachers' attitudes, beliefs, and self-efficacy toward inquiry-based teaching, it is necessary to employ multiple methods (e.g., questionnaires, observations, interviews) and different data (quantitative and qualitative) in order to gain insight, varied perspectives, and complexities of teachers' characteristics.

Conclusions

Based on results and findings from this study, I conclude that there was rare implementation of inquiry-based science teaching and learning in JHSs in the four Ghanaian districts and municipalities. While there was considerable implementation of social aspect of inquiry teaching and learning, important aspects of inquiry (procedural, epistemic, conceptual, and guidance) were rarely implemented. Instead, there was frequent implementation of traditional science teaching and learning in the JHSs.

Additionally, this study concludes that interaction of school location and school type has significant influence on implementation of inquiry-based science teaching and learning in JHSs in the Ghanaian districts and municipalities.

Again, this study concludes that uninformed and partially informed conceptions of inquiry held by teachers and educational administrators in the Ghanaian districts and municipalities pose major challenges to inquiry-based science teaching in JHSs.

Additionally, low attitudes and weak beliefs and self-efficacy held by teachers in the Ghanaian districts and municipalities pose major challenges to inquiry-based science teaching in JHSs.

Again, differences in attitudes, beliefs, and self-efficacy of teachers and teacher characteristics pose different challenges to inquiry-based science teaching in JHSs in the Ghanaian districts and municipalities.

Recommendations

Based on the findings and conclusions of this study it is recommended that:

1. The MoE and GES should to show more commitment and intensify their efforts to increase the implementation of inquiry-based science teaching and learning in JHSs in the Ghanaian districts and municipalities.

2. The MoE and GES should formulate policy and implement the code-switching (mixing) of English and students' local language as media of instruction for inquiry-based science teaching and learning in JHSs in the Ghanaian districts and municipalities, especially for rural and public JHSs.

3. The MoE, GES, and school authorities should form partnership with university researchers and educators with expertise in inquiry-based science teaching and learning to organise in-service trainings for teachers in JHSs in the Ghanaian districts and municipalities.

4. The MoE, GES, and school authorities should enter into partnership with institutions and organisations such as the museums board, department of parks and gardens, industries, forestry commission, and department of wildlife to enable students embark on field trips for inquiry-based science teaching and learning.

5. The MoE, GES, and international organisations (e.g., DFID, USAID, and DANIDA) should provide sufficient resources for organising regular in-service trainings that are specifically and explicitly designed to promote

conceptions, attitudes, beliefs, self-efficacy, and classroom practices of teachers in the Ghanaian districts and municipalities toward inquiry-based science teaching.

6. The MoE, GES, and school administrators should institute measures to monitor changes in conceptions, attitudes, beliefs, and self-efficacy of teachers in the Ghanaian districts and municipalities before and after engaging in inquiry-based in-service trainings.

7. The MoE, GES, school administrators, and international organisations should consider specific needs of different groups of teachers (rural and urban; public and private; certificate and graduate) in organisation of in-service trainings to address teachers' conceptions, attitudes, beliefs, and self-efficacy toward inquiry-based science teaching.

8. Teacher training institutions need to design authentic, inquiry-based methods courses that specifically and explicitly promote pre-service teachers' conceptions, attitudes, beliefs, self-efficacy, and classroom practices in alignment with the constructivist views of science and science education.

9. Teacher training institutions need to institute measures to monitor pre-service teachers' attitudes, beliefs, and self-efficacy before and after undertaken inquiry-based science methods courses.

Significant Contributions to Knowledge

This study makes a number of significant contributions to the science education literature:

First, it provides a conceptual framework/model that can be used to examine implementation of inquiry-based science teaching and learning in JHSs and challenges associated with it.

Second, while many industrialised and industrialising countries (e.g., USA, UK, Taiwan, Turkey, Australia, Canada, South Korea, and Malaysia) have made significant successes in implementation of inquiry-based science teaching and learning in their schools (e.g., Crawford, 2000; Jeanpierre, 2006; Oppong-Nuako et al., 2015), this study reveals that there has been no or little progress in implementation of inquiry-based science teaching and learning in JHSs in the Ghanaian districts and municipalities; contrary to the rationale for basic science education in Ghana (CRDD, 2007, 2012), and to persistent calls and efforts of the contemporary science education and research community (e.g. AAAS, 1990, 1993; Grigg et al., 2013; Krajcik et al., 1994; NRC, 1996, 2000, 2012). Although empirical evidence show that inquiry-based science teaching is more effective than traditional instruction in promoting students' achievements (e.g., Furtak et al., 2012), conceptual understandings (e.g., Anderson, 2002; Simsek & Kabapinar, 2010), critical and higher-order thinking skills (e.g., Gillies, 2008), attitudes toward science (e.g., Ackay & Yager, 2010), and scientific literary (e.g. Anderson, 2002), this study suggests that most JHSs in the Ghanaian districts and municipalities continue to implement traditional science instruction.

Third, while inquiry-based science teaching and learning is effective in promoting learning outcomes of diverse student groups (e.g., Cuevas et al., 2005) and the central strategy for science instruction in most industrialized and industrializing countries (e.g., NRC, 1996, 2000, 2012), this study adds to the literature that implementation of inquiry-based science teaching and learning in most JHSs in the Ghanaian districts and municipalities (as in most Ghanaian and African schools) will be problematic without code-switching (mixing) of English and the students' local languages. Conversely, while the poor English proficiency of most rural and public JHS students in the Ghanaian districts and municipalities have adversely affected their science achievements and advancement on the academic ladder, this study suggests that code-switching (combination) of English and the students' local language in the context of inquiry-based science teaching and learning can significantly improve their academic achievements, progress, and scientific literacy.

Fourth, while most industrialized and industrializing countries have significant and increasing population of teachers with adequate conceptions and strong favourable attitudes, beliefs, and self-efficacy to implement inquiry-based science teaching in schools, this study suggests that there is unavailability of teachers in the Ghanaian districts and municipalities with adequate conceptions and strong favourable attitudes, beliefs, and self-efficacy to adopt and implement inquiry-based science teaching in JHSs.

Fifth, while studies show that most industrialized and industrializing countries are reforming their pre-service and in-service teacher education courses to promote and change teachers' conceptions, attitudes, beliefs, and self-efficacy in alignment with the constructivist philosophy of science and science education (e.g., Haefner & Zembal-Saul, 2007; Kazempour, 2014a; Krajcik et al., 1994; Marx et al., 1994; Van Aalderen-Smeets & Walma van der Molen, 2015; Crawford, 2007), this study suggests that traditional pre-service and in-service science education courses and programmes persist in most Ghanaian institutions.

Sixth, while studies in industrialized and industrializing countries show that gender (e.g., Decker & Rimm-Kaufman, 2008; Karaman & Karaman, 2013; Neuhaus & Vogt, 2012; Pomeroy, 1993), age (e.g., Decker & Rimm-Kaufman, 2008; Neuhaus & Vogt, 2012), teaching experience (e.g., Decker & Rimm-Kaufman, 2008; Forbes & Zint, 2011), ethnicity/race (e.g., Decker & Rimm-Kaufman, 2008), grade-level taught (e.g., Decker & Rimm-Kaufman, 2008), and number of coursework undertaken (e.g., Forbes & Zint, 2011) are demographic characteristics that influence formation and development of teachers' beliefs about inquiry-based science teaching, this study adds to the literature that school type (public and private) is a demographic characteristic that influence formation and development of teachers' beliefs about inquiry-based science teaching in the Ghanaian districts and municipalities.

Seventh, while studies in many countries outside Africa show that private school teachers held more positive attitudes (e.g., Gheith & Al-Shawareb, 2016; Sonmez, 2007; Unal & Akman, 2013) and stronger self-efficacy (e.g., Lin & Chao, 2015; Sahin et al., 2010) toward inquiry-based science teaching than public school teachers, this study adds to the literature that private JHS teachers in the Ghanaian districts and municipalities held lower attitudes and weaker self-efficacy toward inquiry-based science teaching than public JHS teachers.

Suggestions for Further Research

Key issues identified during this study that need separate research to explore include:

1. The impact of inquiry-based science teaching on Ghanaian JHS students' content knowledge, process skills, and attitudes toward science.
2. The impact of inquiry-based science methods course on Ghanaian teachers' conceptions of scientific inquiry, inquiry teaching, and inquiry learning.

3. The effects of inquiry-based methods course on Ghanaian teachers' attitudes, beliefs, and self-efficacy toward science teaching.

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APPENDIX A

Introductory Letter from DSME, UCC

DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION

E-mail: dsme@ucc.edu.gh
dsme@gmail.com
UNIVERSITY, CAPE COAST
OFFICE 03321-34890

FACULTY OF EDUCATION
UNIVERSITY OF CAPE COAST
CAPE COAST, GHANA

Your Ref.: Our Ref.: DSME/P.3/ V.1/1 Date: 15th August, 2014

TO WHOM IT MAY CONCERN

RESEARCH VISIT

The bearer of this letter, Mr. Salifu Maigari Mohammed is a PhD (Science Education) student with registration number ED/SED/12/0001 at the Department of Science and Mathematics Education, University of Cape Coast.

He is undertaking a research project on the topic "An Investigation into use of Inquiry Based Activities in Teaching and Learning Integrated Science in Ghanaian Junior High Schools" as part of the requirements for the award of Doctorate Degree.

We would be grateful if your outfit could assist him with the information that he needs.

Thank you

for Prof. K. Mereku
SUPERVISOR

APPENDIX B

Letter for Approval and Consent Form (Directors)

15th August, 2014

Dear Director,

Subject: Seeking Approval for research in Junior High schools in the Municipality/District

I am Salifu Maigari Mohammed, from University of Cape Coast, Cape Coast. I am conducting a research on use of inquiry-based activities in teaching and learning integrated science in Ghanaian Junior High Schools (JHSs) as part of my study in Doctor of Philosophy in Science Education.

The rationale for the research is to explore avenues that can create opportunities for JHS students to learn integrated science. The resulting implications of the research will be to recommend measures to improve effectiveness of integrated science teaching and learning at the basic level.

Briefly, the data collection methods will include completion of questionnaires, interviews, observations and documentary reviews. The research will be conducted at a time that is considered convenient for you.

If you agree with me using your schools (i.e. teachers and students) in this research, please kindly fill in the consent form attached.

I await your response. If you require further information I can be contacted through Email *Salif.Maigari@yahoo.com* or cell phone numbers 0242984946 and 0202719745.

Thank you for your consideration.

Salifu Maigari Mohammed.

Participant's Consent Form

I______________________________, of___________________________ give consent for Salifu Maigari Mohammed, to carry out his research. I understand the research will involve completing questionnaires, interviews, observations and documentary reviews. I understand that all information including my name, names of schools in the directorate, and the name of the municipality, will be kept confidential. I understand that these activities will not disrupt our programme.

Signed: ______________________________

Date: ______________________________

APPENDIX C

Letter for Approval and Consent Form (Head Teachers)

15th August, 2014

Dear Head teacher,

Subject: **Seeking Approval for research in Junior High schools in the Municipality/District**

I am Salifu Maigari Mohammed, from University of Cape Coast, Cape Coast. I am conducting a research on use of inquiry-based activities in teaching and learning integrated science in Ghanaian Junior High Schools (JHSs) as part of my study in Doctor of Philosophy in Science Education.

The rationale for the research is to explore avenues that can create opportunities for JHS students to learn integrated science. The resulting implications of the research will be to recommend measures to improve effectiveness of integrated science teaching and learning at the basic level.

Briefly, the data collection methods will include completion of questionnaires, interviews, observations and documentary reviews. The research will be conducted at a time that is considered convenient for you.

If you agree on me using your school (i.e. teachers and students) in this research, please kindly fill in the consent form attached.

I await your response. If you require further information I can be contacted through Email ***Salif.Maigari@yahoo.com*** or cell phone numbers 0242984946 and 0202719745.

Thank you for your consideration.

Salifu Maigari Mohammed.

Participant's Consent Form

I______________________________, of__________________________ give consent for Salifu Maigari Mohammed, to carry out his research. I understand the research will involve completing questionnaires, interviews, observations and documentary reviews. I understand that all information including my name, the name of my school, and the name of the municipality/district, will be kept confidential. I understand that these activities will not disrupt our programme.

S/N	SCHOOL	NAME OF HEAD TEACHER	SIGNATURE	DATE
1.				
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APPENDIX D

Teachers' Interview Consent Form

Invitation to Participate & Study Description:

As an integrated science teacher in a Junior High School (JHS) in Ghana, you are invited to take part in this research. The purpose of this research is to investigate use of inquiry-based activities in teaching and learning integrated science in Ghanaian JHSs. This study will help find an alternative method of teaching integrated science in Ghanaian JHSs. You are asked to take part in an interview that will take about an hour to complete. The interview will be audio recorded so as to enable me transcribe it later.

Risks & Benefits:

This research and interview do not involve any known risks whatsoever. There are no "right" or "wrong" answers in this interview. I am only interested in your opinions, feelings, experiences and beliefs about use of inquiry-based activities in teaching and learning integrated science at the JHS level. The information you provide will help me to better understand how integrated science lessons are taught in JHSs. Results and findings of this research will be published in journals, presented at professional meetings and disseminated to other stakeholders in education with the view to improve teaching and learning of integrated science. Results and findings of this study will also be made available to interested participants. Respondents are welcomed to contact me for further information.

Confidentiality, Anonymity and Privacy:

The information you provide me will be kept strictly confidential. To protect your privacy, your responses to the interview questions will only beidentified with a code number and will be kept by me. All interview responses and research materials will be kept till the research is over; and will only be accessible to me and my supervisors. Your name or the name of your school will not be associated with the interview responses or research findings. Your identity will not be revealed in anyway.

Right to Refuse or Withdraw:

Your decision to take part in this interview and research is completely voluntary. You may choose not to answer any question posed to you. You are free to withdraw from the interview at any time. I, however, urge you to take part in this interview to make this research a success.

Right to Ask Questions:

You have the right to ask questions about this research and to have those questions answered by me before, during or after the research. If you have any other concerns about your rights as a respondent that have not been answered, you may contact me as follows: Tel: 0242984946 and 0202719745; email: Salif.Maigari@yahoo.com or Salifmaiga@live.com

Consent:

I have read the information above, and have received answers to any question I asked. I consent to take part in the research.

Signature:...Date:...

Name of Participant:...

APPENDIX E

Head Teachers' Interview Consent Form

Invitation to Participate & Study Description:

As a head teacher in a Junior High School (JHS) in Ghana, you are invited to take part in this research. The purpose of this research is to investigate use of inquiry-based activities in teaching and learning integrated science in Ghanaian JHSs. This study will help find an alternative method of teaching integrated science in Ghanaian JHSs. You are asked to take part in an interview that will take about 40 minutes to complete. The interview will be audio recorded so as to enable me transcribe it later.

Risks & Benefits:

This research and interview do not involve any known risks whatsoever. There are no "right" or "wrong" answers in this interview. I am only interested in your opinions, feelings, experiences and beliefs about use of inquiry-based activities in teaching and learning integrated science at the JHS level. The information you provide will help me better understand how integrated science lessons are taught in JHSs. Results and findings of this research will be published in journals, presented at professional meetings and disseminated to other stakeholders in education with the view to improve teaching and learning of integrated science. Results and findings of this study will also be made available to interested participants. Respondents are welcomed to contact me for further information.

Confidentiality, Anonymity and Privacy:

The information you provide me will be kept strictly confidential. To protect your privacy, your responses to the interview questions will only beidentified with a code number and will be kept by me. All interview responses and research materials will be kept till the research is over; and will only be accessible to me and my supervisors. Your name or the name of your school will not be associated with the interview responses or research findings. Your identity will not be revealed in anyway.

Right to Refuse or Withdraw:

Your decision to take part in this interview and research is completely voluntary. You may choose not to answer any question posed to you. You are free to withdraw from the interview at any time. I, however, urge you to take part in this interview to make this research a success.

Right to Ask Questions:

You have the right to ask questions about this research and to have those questions answered by me before, during or after the research. If you have any other concerns about your rights as a respondent that have not been answered, you may contact me as follows: Tel: 0242984946 and 0202719745; email: Salif.Maigari@yahoo.com or Salifmaiga@live.com

Consent:

I have read the information above, and have received answers to any question I asked. I consent to take part in the research.

Signature:.. Date:...

Name of Participant:..

APPENDIX F

Ghana Education Service (GES) Staff Interview Consent Form

Invitation to Participate & Study Description:

As a circuit supervisor/science coordinator/director in the Ghana Education Service (GES), you are invited to take part in this research. The purpose of this research is to investigate use of inquiry-based activities in teaching and learning integrated science in Ghanaian JHSs. This study will help find an alternative method of teaching integrated science in Ghanaian JHSs. You are asked to take part in an interview that will take about 40 minutes to complete. The interview will be audio recorded so as to enable me transcribe it later.

Risks & Benefits:

This research and interview do not involve any known risks whatsoever. There are no “right” or “wrong” answers in this interview. I am only interested in your opinions, feelings, experiences and beliefs about use of inquiry-based activities in teaching and learning integrated science at the JHS level. The information you provide will help me better understand how integrated science lessons are taught in JHSs. Results and findings of this research will be published in journals, presented at professional meetings and disseminated to other stakeholders in education with the view to improve teaching and learning of integrated science. Results and findings of this study will also be made available to interested participants. Respondents are welcomed to contact me for further information.

Confidentiality, Anonymity and Privacy:

The information you provide me will be kept strictly confidential. To protect your privacy, your responses to the interview questions will only be identified with a code number and will be kept by me. All interview responses and research materials will be kept till the research is over; and will only be accessible to me and my supervisors. Your name, the names of schools you supervise or the name of your educational directorate will not be associated with the interview responses or research findings. Your identity will not be revealed in anyway.

Right to Refuse or Withdraw:

Your decision to take part in this interview and research is completely voluntary. You may choose not to answer any question posed to you. You are free to withdraw from the interview at any time. I, however, urge you to take part in this interview to make this research a success.

Right to Ask Questions:

You have the right to ask questions about this research and to have those questions answered by me before, during or after the research. If you have any other concerns about your rights as a respondent that have not been answered, you may contact me as follows: Tel: 0242984946 and 0202719745; email: Salif.Maigari@yahoo.com or Salifmaiga@live.com

Consent:

I have read the information above, and have received answers to any question I asked. I consent to take part in the research.

Signature:..Date:..

Name of Participant:..

APPENDIX G

UNIVERSITY OF CAPE COAST

DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION

Teachers' Questionnaire

Dear Teacher,

This questionnaire contains statements about teachers' feelings, opinions, beliefs and experiences about inquiry-based activities in integrated science lessons at the Junior High School (JHS). There are **no "right"** or **"wrong"** responses. You are expected to rate your agreement or disagreement with each statement about your feelings, opinions, experiences and beliefs about inquiry-based activities in integrated science lessons at the junior high school. Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements. On each statement, rate on a scale 1 – 5 (i.e. from 'strongly disagree' to 'strongly agree') by circling '()' the appropriate number. Be sure to respond to all items. If you change your mind about your response to an item, just cross it out and circle another. This questionnaire is solely for academic research purposes; and your **anonymity**, **confidentiality** and **privacy** is guaranteed. Your name and the name of your school will be kept anonymous, confidential and private in this research. You are therefore encouraged to feel free and respond to the items in the questionnaire.

THANK YOU.

SECTION A: BACKGROUND INFORMATION

1. Age (in years): ....

2. Gender: Male[ ] Female[ ]

3. Qualification: SSSCE[ ] WASSCE[ ] CERT "A"[ ] DBE[ ] BA[ ] BSC[ ] BED[ ] MA[ ] MSC[ ] MED[ ] MPHIL[ ]

Any other (please specify): ....

4. Teaching experience (years): ....

5. Type of school: Public[ ] Private[ ]

6. School location (Town): ....

7. District: ....

On a scale of 1 – 5 (5 = Strongly Agree, 4 = Agree, 3 = Uncertain, 2 = Disagree, 1 = Strongly Disagree), how would you rate your feelings, opinions, experience sand beliefs about inquiry-based activities in integrated science lessons at the junior high school?

Statements	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Section B: Attitudes toward science inquiry teaching					
8. I feel uncomfortable making JHS students plan, design and perform their own experiments during science lessons.					
9. I find it difficult making JHS students plan, design and perform their own experiments during science lessons.					
10. I feel it is not appropriate to make JHS students plan, design and perform their own experiments during science lessons.					
11. I enjoy making JHS students plan, design and perform their own experiments during science lessons.					
12. I feel it is not relevant to make JHS students plan, design and perform their own experiments during science lessons.					
13. I feel nervous making JHS students collect and record their own data during science lessons.					
14. I find teaching integrated science boring when I make JHS students collect and record their own data during lessons.					

15. I find it easy allowing JHS students to handle and use science equipment and materials during lessons.					
16. I find teaching integrated science exciting when I make JHS students handle and use science equipment and materials.					
17. I feel comfortable making JHS students learn science concepts and principles with hands-on activities simultaneously.					
18. I find it difficult making JHS students learn science concepts and principles with hands-on activities simultaneously.					
19. I find it suitable making JHS students learn science concepts and principles with hands-on activities simultaneously.					
20. I feel it is important to make JHS students learn science concepts and principles with hands-on activities simultaneously					
21. I feel nervous allowing JHS students to make their own suppositions for scientific phenomena during lessons.					
22. I don't find it easy allowing JHS students to make their own suppositions for scientific phenomena during lessons.					
23. I feel it is not appropriate to allow JHS students to make their own suppositions for scientific phenomena during lessons.					
24. I don't think it is important to allow JHS students to make their own suppositions for scientific phenomena during lessons.					
25. I find it difficult making JHS students examine and evaluate quality of scientific data on their own during lessons.					
26. Teaching integrated science takes too much time when I make JHS students examine and evaluate quality of scientific data on their own during lessons.					
27. I find it appropriate making JHS students examine and evaluate quality of scientific data on their own during lessons.					
28. I feel it is relevant to make JHS students examine and evaluate quality of scientific data on their own during lessons.					
29. I feel uneasy making JHS students interpret data to develop their own explanations for scientific phenomena during lessons.					

30. I find it easy making JHS students interpret data to develop their own explanations for scientific phenomena during lessons.					
31. I don't find it proper making JHS students interpret data to develop their own explanations for scientific phenomena.					
32. I feel it is not important to make JHS students interpret data to develop their own explanations for scientific phenomena.					
33. I enjoy making JHS students work systematically like actual scientists do during lessons.					
34. I don't find it appropriate making JHS students work systematically like actual scientists do during lessons.					
35. I feel it is not relevant to make JHS students work systematically like actual scientists do during lessons.					
36. I find it hard making JHS students to reason and reach collective scientific decisions together during lessons.					
37. I feel nervous making JHS students argue, discuss and do presentations of scientific ideas among themselves during lessons.					
38. I feel uneasy allowing JHS students to work in groups.					
39. I enjoy making JHS students work in groups during lessons.					
40. I find it proper to make JHS students work in groups.					
41. I feel comfortable defining and stating science concepts, principles and theories for JHS students during lessons.					
42. I find it easy defining and stating science concepts, principles and theories for JHS students during lessons.					
43. I enjoy defining and stating science concepts, principles and theories for JHS students during lessons.					
44. I feel at ease writing science concepts, principles and theories on blackboard for JHS students to copy during lessons.					
45. I find it difficult writing science concepts, principles and theories on blackboard for JHS students to copy.					
46. I think it is suitable to write science concepts, principles and theories on blackboard for JHS students to copy during lessons.					

Section C: Beliefs about science inquiry teaching					
47. JHS students know very little about how to plan, design and perform their own science experiments before they learn it in school.					
48. During science lessons JHS students should plan, design and perform their own science experiments before the teacher discusses any concepts with them.					
49. The integrated science curriculum should help JHS students develop skills of collecting and recording their own scientific data necessary to do science.					
50. Students' suppositions for scientific phenomena should be included in lessons as a way to reinforce the science concepts JHS students have already learned in class.					
51. Science teachers should primarily act as resource persons; to support JHS students examine and evaluate quality of their own scientific data rather than explaining how things work.					
52. The integrated science curriculum should encourage JHS students to learn to interpret data to develop their own explanations for scientific phenomena.					
53. JHS students learn integrated science the most when they interpret data to develop their own explanations for scientific phenomena.					
54. Whenever JHS students interpret data to develop explanations for scientific phenomena during lessons, the teacher should give step-by-step instructions for them to follow in order to prevent confusion and make sure students get correct results.					
55. Lessons should be designed in a way that allows JHS students to learn new concepts systematically like actual scientists do instead of through a lecture, a reading or a demonstration.					
56. A good integrated science curriculum should focus on making JHS students work systematically like actual scientists do.					
57. During a lesson, JHS students need to be given opportunities to work in groups with their peers.					
58. JHS students have difficulty challenging scientific ideas in school because their beliefs about how the world works are often resistant to change.					

59. During a lesson, JHS students need to be given opportunities to challenge scientific ideas through arguments, discussions and presentations.					
60. In order to prepare JHS students for future classes, college or a career in science, the integrated science curriculum should encourage students to challenge scientific ideas through arguments, discussions and presentations.					
61. Teachers should allow JHS students to reason and reach collective scientific decisions together to help determine the focus and direction of integrated science lessons.					
62. The integrated science curriculum should focus on explaining and defining science concepts, principles and theories that JHS students need to know.					
63. A good integrated science teacher is someone who is really good at explaining and defining science concepts, principles and theories for JHS students.					
64. JHS students are more likely to understand a science concept if the teacher defines and explains it in a way that is clear and easier to understand.					
65. Science teachers should write science concepts, principles and theories on blackboard for JHS students to copy.					
Section D: Self-efficacy towards science inquiry teaching					
66. I am not very effective in monitoring JHS students to collect and record their own scientific data.					
67. If JHS students are not performing well in collecting and recording their own scientific data, it is most likely due to ineffective teaching of how to collect and record data.					
68. I find it difficult to facilitate JHS students to plan, design and perform their own science experiments.					
69. When a JHS student has difficulty in how to handle and use science equipment and materials, I am usually at a loss as to how to help him do it better.					
70. The teacher is generally responsible for the achievements of JHS students in how they make their own suppositions for scientific phenomena.					

71. I wonder if I have the necessary skills to teach integrated science concepts and principles with hands-on activities simultaneously.					
72. I find it difficult guiding JHS students to examine and evaluate quality of scientific data on their own.					
73. I don't know what to do to turn JHS students on to do science systematically like actual scientists do.					
74. If JHS students are not performing systematically like actual scientists do, it is most likely due to ineffective teaching of how actual scientists work.					
75. Increased effort in facilitating JHS students to make public their scientific ideas through arguments, modelling and presentations will produce little change in some students' achievements.					
76. JHS students' achievement in integrated science is directly related to their teacher's effectiveness in defining and explaining science concepts, principles and theories.					
77. If parents comment that their child is showing more interest in integrated science at school, it is probably due to the teacher telling students answers they are expected to learn.					
78. I am typically able to answer students' questions related to integrated science taught from textbooks.					
79. Increased effort in writing science concepts, principles and theories on blackboard for JHS students to copy is directly related to their academic performance.					

APPENDIX H

UNIVERSITY OF CAPE COAST

DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION

Students' Questionnaire

Dear Student,

This questionnaire contains statements about your experiences of inquiry-based activities in integrated science lessons at the Junior High School (JHS). There are no "right" or "wrong" responses. You are expected to show how often you are allowed to do certain activities during integrated science lessons in a term.

On each activity, rate on a scale 1 – 5 (i.e. from 'never' to 'all lessons'), by circling '()' the appropriate number. Be sure to respond to all items. If you change your mind about your response to an item, just cross it out and circle another. This questionnaire is solely for academic research purposes; and your **anonymity**, **confidentiality**, and **privacy** is guaranteed. Your name and the name of your school are anonymous, confidential and private. You are therefore encouraged to feel free and respond to the items in the questionnaire.

THANK YOU.

SECTION A: BACKGROUND INFORMATION

1. Age (in years) of student: ....

2. Sex of student: Male[ ] Female[ ]

3. Type of School: Public[ ] Private[ ]

4. School location (Town):...

5. District: ....

SECTION B: SCIENCE INQUIRY-BASED ACTIVITIES

On a scale of 1 – 5 (1 = Never, 2 = A few lessons, 3 = Half the lessons, 4 = Most lessons, 5= All lessons), rate how often you are allowed to do each of the following activities during integrated science lessons in a term. Circle '()'the appropriate number in each case.

Activities	Never	A few lessons	Half the lessons	Most lessons	All the lessons
A. Procedural Domain					
6. Plan and design your own experiments.					
7. Perform your own experiments.					
8. Ask scientifically oriented questions.					
9. Handle and use science equipment and materials.					
10. Collect and record your own measurements and observations (data).					
11. Draw your own diagrams, charts, graphs and tables.					
B. Conceptual Domain					
12. Use your own past experiences to give explanations for scientific phenomena.					
13. Give your own suppositions (hypothesize) for scientific phenomena.					

14. Create your own explanations for scientific phenomena.					
15. Check on your own whether explanations you give for scientific phenomena are correct.					
16. Learn science concepts (ideas) without performing experiments.					
17. Learn scientific ideas (concepts) at the same time that you are performing experiments.					
18. Check that your own recorded measurements and observations are correct.					
19. Use your own measurements and observations to give explanations for natural phenomena.					
20. Do science systematically in the same way as actual scientists do.					
21. Change your old understandings of scientific knowledge after making new measurements and observations.					
22. Give explanations for scientific phenomena without doing measurements and observations.					
23. Change your old understandings of scientific knowledge without making new measurements and observations.					
24. Examine and take a look at how you understand scientific knowledge by yourself.					
D. Social Domain					
25. Do discussions with your class mates.					
26. Reason and take collective scientific decisions with your class mates.					
27. Work in groups.					
28. Communicate and share scientific ideas and understandings with your class mates.					
29. Work and collaborate with your class mates to understand scientific knowledge and processes.					
30. Argue with your class mates, and make scientific speeches and models.					
31. Work individually.					

E. Guidance Domain					
32. Teacher defines and state scientific concepts, principles and theories for students.					
33. Teacher tells JHS students answers they are expected to learn.					
34. Teacher asks JHS students to answer questions from textbooks into their exercise books.					
35. Teacher leads JHS students in class discussions.					
36. Teacher helps JHS students to come out with their own definitions of scientific concepts.					
37. Teacher writes scientific concepts, principles and theories on the blackboard for JHS students to copy.					
38. Teacher does most of the talking.					
39. Teacher demonstrates hands-on scientific activities.					

APPENDIX I

LESSON OBSERVATION SCHEDULE - A

1. BACKGROUN INFORMATION:

Name of school.. School location (Town)...

No of students: (Boys .... Girls............... Total ....) Name of teacher...

Gender.. Years of teaching...

Qualification... Subject observed...

Topic observed... Class...

Name of observer.. Date of observation...

Start time.. End time...

Make a mark for each observation of the following activities at the specified time. Record six observations per six minutes interval.

ACTIVITIES	6	12	18	24	30	36	42	48	54	60	66	72
Procedural domain												
1. Students ask scientifically-oriented questions about objects, organisms, events and interactions in the natural environment.												
2. Students plan and design experiments on												

ACTIVITIES	6	12	18	24	30	36	42	48	54	60	66	72
their own.												
3. Students manipulate materials in hands-on activities.												
4. Students collect, represent and record data on their own.												
Epistemic domain												
5. Students make predictions, develop interpretations and draw conclusions for natural phenomena based on evidence (data).												
6. Students examine and evaluate the quality of data/evidence.												
7. Students generate and revise theories.												
8. Students change prior knowledge, concepts and predictions based on new evidence; and give new interpretations to old evidence.												

9. Students learn that their processes of scientific investigations are similar to the ways actual scientists work.												
Conceptual Domain												
10. Students draw on their prior knowledge to formulate hypotheses, make predictions and give explanations about natural phenomena.												
11. Students test their predictions and explanations against current scientific knowledge.												

12. Students recognise and analyze alternative explanations and predictions for natural phenomena.												
13. Students providing conceptually oriented feedback, and using critical and logical thinking in solving natural problems.		/				/					/	
14. Students developing understanding of scientific facts, principles, theories and laws.												

15. Content of science embedded in scientific processes.												
Social domain												
16. Students communicate to peers, teacher and make public their scientific ideas and understandings through argument, discussions, presentations and modeling.												
17. Students collaborate to construct scientific knowledge.												

18. Students work in groups, reason and reach collective scientific decisions together.												
19. Students examine and evaluate their developing understanding of science through shared meanings.												
Guidance Domain												
20. Teacher asks questions to elicit students' scientific ideas about objects, organisms, events and interactions in the natural environment.												

21. Teacher observes and listens to students' interactions; guides and facilitates students' learning.												
22. Teacher delivers content to students through lectures and discussions, tells students answers they are expected to learn, and students become passive recipients of scientific knowledge.												

23. Teacher writes scientific concepts, facts, principles and theories on the board for students.												
24. Teacher reads scientific texts to students from book.												
25. Teacher explains, defines and states scientific facts, principles, theories and laws to students.												
26. Teacher asks students to answer questions from textbook orally and in writing												

27. Teacher demonstrates scientific activities to students.												
28. Students answer questions posed by teacher.												

APPENDIX J

LESSON OBSERVATION SCHEDULE –B

1. BACKGROUN INFORMATION:

Name of school.. School location (Town)..............

No of students: (Boys .... Girls........Total ....) Name of teacher................

Gender...Years of teaching........................

Qualification..Subject observed.............................

Topic observed..Class..

Name of observer...................................... Date of observation.............

Start time...End time..

On a scale of 1 – 5 (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5= Very Often), rate how often each of the following activities is observed during an integrated science lesson. Circle '()'the appropriate number in each case.

Activities	Never	Rarely	Someti-mes	Often	Very Often
A. Procedural Domain					
1. Students ask scientifically oriented questions about objects, organisms, events and interactions in the natural environment.					
2. Students plan and design experiments on their own.					
3. Students manipulate materials in hands-on activities.					
4. Students collect, represent and record data on their own.					
B. Epistemic Domain					
5. Students make predictions, develop interpretations and draw conclusions for natural phenomena based on evidence (data).					
6. Students examine and evaluate the quality of data/evidence.					
7. Students generate and revise theories.					

8. Students change prior knowledge, concepts and predictions based on new evidence; and give new interpretations to old evidence.					
9. Students learn that their processes of scientific investigations are similar to the ways actual scientists work.					
C. Conceptual Domain					
10. Students draw on their prior knowledge to formulate hypotheses, make predictions and give explanations about natural phenomena.					
11. Students test their predictions and explanations against current scientific knowledge.					
12. Students recognise and analyze alternative explanations and predictions for natural phenomena.					
13. Students providing conceptually oriented feedback, and using critical and logical thinking in solving natural problems.					
14. Students developing understanding of scientific facts, principles, theories and laws.					
15. Content of science embedded in scientific processes.					
D. Social Domain					
16. Students communicate to peers, teacher and make public their scientific ideas and understandings through argument, discussions, presentations and modelling.					
17. Students collaborate to construct scientific knowledge.					
18. Students work in groups, reason and reach collective scientific decisions together.					
19. Students examine and evaluate their developing understanding of science through shared meanings.					
E. Guidance Domain					
20. Teacher asks questions to elicit students' scientific ideas about objects, organisms, events and interactions in the natural environment.					

21. Teacher observes and listens to students' interactions; guides and facilitates students' learning.					
22. Teacher delivers content to students through lectures and discussions, tells students answers they are expected to learn, and students become passive recipients of scientific knowledge.					
23. Teacher writes scientific concepts, facts, principles and theories on the board for students.					
24. Teacher reads scientific texts to students from book.					
25. Teacher explains, defines and states scientific facts, principles, theories and laws to students.					
26. Teacher asks students to answer questions from textbook orally and in writing					
27. Teacher demonstrates scientific activities to students.					
28. Students answer questions posed by teacher.					

APPENDIX K

UNIVERSITY OF CAPE COAST

DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION

Interview Schedule for Science Teachers

Name of interviewer: ....

Gender of interviewer: Male [ ] Female [ ] Date of interview: ....

Place of interview: ....Time of interview: ....

SECTION A: Background Information of Interviewee

1. Name of school: ....
2. Type of school: Public [ ] Private [ ]
3. Town: ....
4. District: ....
5. Gender of interviewee: Male [ ] Female [ ]
6. Age (in years) of Interviewee:...
7. Academic and Professional Qualifications of Interviewee:.............................
8. Teaching experience (in years) of interviewee:...

SECTION B

Q1. Teachers' knowledge, skills and use of science inquiry-based activities

Researchers say "scientific inquiry" improves students' academic performance.

9. What is your understanding of "scientific inquiry?"
10. What are the aspects of science inquiry?
11. What are the roles of teachers in science inquiry teaching?
12. What are the roles of students in science inquiry learning?

13. Currently, to what extent do you allow JHS students to plan and perform their own science experiments?

[*Probes/prompts: Is there anything you would like to add? Can you explain further? Do you have a different view? No idea at all? Can't you say anything at all? Can you add more?*]

Q2. Teachers' attitudes toward science inquiry-based teaching

14. Explain if you would like JHS students to be allowed to plan and perform their own science experiments?

15. How difficult is it for JHS students to plan and perform their own science experiments?

16. How important is it for JHS students to plan and perform their own science experiments?

17. How appropriate is it for you to allow JHS students to plan and perform their own science experiments?

[*Probes/prompts: can you explain further? Is there anything you would like to add? Do you have a different view about this?*]

Q3. Teachers' beliefs about science inquiry-based teaching

18. How should integrated science lessons be planned to allow JHS students perform their own science experiments?

19. How should teachers manage classrooms for JHS students to do their own science experiments?

[*Probes/prompts: Is there anything you would like to add? Can you explain further? Do you have a different view? No idea at all? Can't you say anything at all? Can you add more?*]

Q4. Teachers' self-efficacy beliefs in using science inquiry-based teaching

20. How effectively can you facilitate JHS students to plan and perform their own science experiments?

21. What is the impact of allowing JHS students to plan and perform their own experiments on their academic achievements?

[Probes/prompts: can you explain further? Is there anything you would like to add? Do you have a different opinion about this?]

Q5. Teachers' background, professional training and development about science inquiry-based teaching

22. Describe how you performed science experiments when you were in elementary school.

23. Describe how you performed science experiments when you were in secondary school, training college and university?

24. What in-service trainings does your head teacher organise for integrated science teachers in your JHS?

25. What are the roles of resource persons during in-service trainings for science teachers?

26. What are your (teachers') roles during in-service trainings for science teachers?

27. How does your head teacher fund in-service trainings for integrated science teachers?

28. Tell me if your head teacher has a separate budget/financing for in-service trainings of integrated science teachers.

29. How adequate are in-service trainings for integrated science teachers in your JHS?

30. What in-service trainings does the district education office organise for

integrated science teachers?

31. How adequate are in-service trainings organised by the district education office for integrated science teachers?

[*Probes/prompts: can you explain further? Is there anything you would like to add? Do you have a different opinion about this?*]

Q6. Availability of science equipment, materials, adequate time and class size for scientific inquiry

32. How adequate are science equipments and materials for teaching and learning in your JHS?

33. What science equipments and materials does your head teacher provide for teaching and learning integrated science?

34. What science equipments and materials does the district education office provide for teaching and learning in your JHS?

35. How adequate is the time allocated for teaching and learning integrated science in your JHS?

36. What are your observations of the JHS integrated science syllabus?

37. How does class size of your students affects planning and performing of science experiments?

[Probes/prompts: can you explain further? Is there anything you would like to add? Do you have a different opinion about this?]

Q7. Administrative support and teachers' collaboration for science inquiry-based teaching

38. What support does your head teacher gives you in order to allow JHS students to plan and perform their own science experiments?

39. What are your head teacher's expectations of you as a science teacher?

40. What support does the district education office gives you in order to allow students to plan and perform their own science experiments?

41. What are the expectations of the district education office from you as a science teacher?

42. What collaborations exist among teachers in your JHS to facilitate students to plan and perform their own science experiments?

42. How adequate are the collaborations with other teachers to facilitate students plan and perform their own science experiments?

[*Probes/prompts: can you explain further? Is there anything you would like to add? Do you have a different opinion about this?*]

Q8. Effects of BECE on use of inquiry-based teaching in JHSs

43. What preparations do you give JHS students toward writing BECE integrated science papers?

44. How does the BECE affect the kind of teaching and learning of integrated science in your JHS?

45. What are your opinions about the type of questions that are set for BECE integrated science papers?

[*Probes/prompts: can you explain further? Is there anything you would like to add? Do you have a different opinion about this?*]

APPENDIX L

UNIVERSITY OF CAPE COAST

DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION

Interview Schedule for Head Teachers

Name of interviewer: ....

Gender of interviewer: Male [ ] Female [ ] Date of interview: ....

Place of interview: ....Time of interview: ....

SECTION A: Background Information of Interviewee

1. Name of school: ....
2. Type of school: Public [ ] Private [ ]
3. Town: ....
4. District: ....
5. Gender of Interviewee: Male [ ] Female [ ]
6. Age (in years) of Interviewee:...
7. Academic and Professional Qualifications of Interviewee:.......................
8. Working experience (in years) of interviewee:...

SECTION B

Q1. Importance, knowledge and use of science inquiry-based activities

Researchers say "science inquiry-based activities" improve students' academic achievements.

9. What are your views about this?
10. What are the roles of teachers in science inquiry-based teaching?
11. What are the roles of students in science inquiry-based learning?
12. Currently, to what extent do science teachers in your JHS allow students to plan and perform their own science experiments?

13. What difficulties do science teachers in your JHS have in allowing students to plan and perform their own experiments?

[*Probes/prompts: Is there anything you would like to add? Can you explain further? Do you have a different view? No idea at all? Can't you say anything at all? Can you add more?*]

Q2. Availability and professional development of integrated science teachers

14. How adequate are integrated science teachers in your JHS?
15. How trained are integrated science teachers in your JHS?
16. What is your opinion about who qualifies to teach integrated science in JHS?
17. What in-service trainings do you organise for integrated science teachers in your JHS?
18. What are the roles of resource persons during in-service trainings of integrated science teachers?
19. What are the roles of integrated science teachers during in-service trainings?
20. How do you fund in-service trainings for integrated science teachers?
21. What determines the amount of capitation grant given to your JHS?
22. What difficulties do you encounter in organising in-service trainings for science teachers?
23. How adequate are in-service trainings for integrated science teachers in your JHS?
24. Tell me if you have separate budget for in-service trainings of integrated science teachers?

[*Probes/prompts: Is there anything you would like to add? Can you explain further? Do you have a different view? No idea at all? Can't you say anything at all? Can you add more?*]

Q3. Availability of science equipments, materials, and adequate time for scientific inquiry

25. How adequate are science equipments and materials for teaching and learning in your JHS?
26. What science equipments and materials do you provide integrated science teachers in your JHS for teaching and learning?
27. By what ways and means are JHSs equipped with science equipments and materials?
28. How difficult is it to equip your JHS with science equipments and materials for teaching and learning?
29. How adequate is the time allocated for teaching and learning integrated science in your JHS?
30. What are your observations of the JHS integrated science syllabus?

[*Probes/prompts: Is there anything you would like to add? Can you explain further? Do you have a different view? No idea at all? Can't you say anything at all? Can you add more?*]

Q4. Administrative support and teachers' collaboration in use of inquiry-based activities

31. What support do you give to integrated science teacher(s) in your JHS for him/them to allow students to plan and perform their own experiments?
32. What are your expectations of integrated science teacher(s) in your JHS?

33. How do you monitor performance of integrated science teachers in your JHS?

34. What support does the district education office gives integrated science teachers in your JHS?

35. What are the expectations of the education office from integrated science teachers in your JHS?

36. How does the district education office monitor performance of integrated science teachers in your JHS?

37. What collaborations exist among teachers in your JHS to facilitate students to plan and perform their own experiments?

38. How adequate are collaborations among teachers to facilitate students to perform their own science experiments?

[*Probes/prompts: Is there anything you would like to add? Can you explain further? Do you have a different view? No idea at all? Can't you say anything at all? Can you add more?*]

Q5. Effects of BECE and other assessments on use of inquiry-based activities in JHSs

39. What preparations do you give JHS students toward writing BECE integrated science papers?

40. What are your opinions about the type of questions that are set for BECE integrated science papers?

41. How does the BECE affect the kind of teaching and learning of integrated science in your JHS?

[*Probes/prompts: can you explain further? Is there anything you would like to add? Do you have a different opinion about this?*]

APPENDIX M

UNIVERSITY OF CAPE COAST

DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION

Interview Schedule for Directors, Science Coordinators, and Circuit Supervisors

Name of interviewer: ....

Gender of interviewer: Male[ ] Female[ ] Date of interview: ....

Place of interview: ....Time of interview: ....

SECTION A: Background Information of Interviewee

1. Name of directorate: ....

2. Type of location: Urban[ ] Rural[ ]

3. Town: ....

4. District: ....

5. Gender of Interviewee: Male [ ] Female [ ]

6. Academic and Professional Qualifications of Interviewee:.............................

7. Age (in years) of Interviewee:...

8. Working experience (in years) of Interviewee:......................................

SECTION B

Q1. Importance, knowledge and use of science inquiry-based activities

Researchers say "science inquiry-based activities" improve students' academic achievements.

9. What are your views about this?

10. What are the roles of teachers in science inquiry-based teaching?

11. What are the roles of students in science inquiry-based learning?

12. Currently, to what extent do integrated science teachers in JHSs allow students to plan and perform their own science experiments?

13. What difficulties do science teachers in JHSs have in allowing students to plan and perform their own experiments?

[*Probes/prompts: Is there anything you would like to add? Can you explain further? Do you have a different view? No idea at all? Can't you say anything at all? Can you add more?*]

Q2. Availability and professional development of integrated science teachers

14. How adequate are integrated science teachers in JHSs in your district/circuit?

15. How trained are integrated science teachers in JHSs in your district/circuit?

16. What is the position of GES about who qualifies to teach integrated science in JHS?

17. What in-service trainings do you organize for integrated science teachers in JHSs in your district/circuit?

18. What are the roles of resource persons during in-service trainings for integrated science teachers?

19. What are the roles of integrated science teachers during in-service trainings?

20. How different are in-service trainings for public and private schools integrated science teachers?

21. How do you fund in-service trainings for integrated science teachers?

22. Tell me if you have a separate budget/financing for in-service trainings of integrated science teachers?

23. What difficulties do you encounter in organising in-service trainings for science teachers?

[*Probes/prompts: Is there anything you would like to add? Can you explain further? Do you have a different view? No idea at all? Can't you say anything at all? Can you add more?*]

Q3. Availability of science equipments, materials, and adequate time for scientific inquiry

24. How adequate are science equipments and materials for teaching and learning in JHSs in your district/circuit?

25. What science equipments and materials do you provide JHSs for teaching and learning integrated science?

26. By what ways and means are JHSs equipped with science equipments and materials for teaching and learning?

27. How difficult is it to equip JHSs with science equipments and materials for teaching and learning?

28. What determines the amount of capitation grant given to a JHS?

29. How efficient is disbursement of capitation grants to JHSs?

30. How adequate is the time allocated for teaching and learning integrated science in JHSs?

31. What are your observations of the JHS integrated science syllabus?

[*Probes/prompts: Is there anything you would like to add? Can you explain further? Do you have a different view? No idea at all? Can't you say anything at all? Can you add more?*]

Q4. Administrative support and teachers' collaboration in use of inquiry-based activities

32. What support do you give integrated science teachers for them to allow JHS students to plan and perform their own science experiments?
33. How different is the support for public and private schools integrated science teachers?
34. What are your expectations of integrated science teachers in JHSs?
35. How different are your expectations of public and private schools integrated science teachers?
36. How do you monitor performance of integrated science teachers in JHSs?
37. How different is monitoring of performance of public and private schools integrated science teachers?
38. What collaborations exist among teachers in JHS to facilitate students to plan and perform their own science experiments?
39. How sufficient are these collaborations among teachers in JHSs?

[*Probes/prompts: Is there anything you would like to add? Can you explain further? Do you have a different view? No idea at all? Can't you say anything at all? Can you add more?*]

Q5. Effects of BECE and other assessments on use of inquiry-based activities in JHSs

40. What preparations do you give JHS students toward writing BECE integrated science papers?
41. What are your opinions about the type of questions that are set for BECE integrated science papers?
42. How does the BECE affect the kind of teaching and learning of integrated

science in JHSs?

[*Probes/prompts: can you explain further? Is there anything you would like to add? Do you have a different opinion about this?*]

APPENDIX N

Integrated Science Lessons Observed in JHS 2 Classrooms

Lesson	School	School Location	School Type	Topic of Lesson Observed	Period
1	A	Urban Centre	Public	Force and pressure	72 minutes
2	A	Urban Centre	Public	Levers and work	60 minutes
3	B	Urban Centre	Public	Human circulatory system	55 minutes
4	B	Urban Centre	Public	Human circulatory system	60 minutes
5	B	Urban Centre	Public	Human circulatory system	77 minutes
6	B	Urban Centre	Public	Human circulatory system	57 minutes
7	C	Urban Centre	Private	Soil and water conservation	21 minutes
8	C	Urban Centre	Private	Life cycle of mosquito	57 minutes
9	C	Urban Centre	Private	Life cycle of mosquito	70 minutes
10	C	Urban Centre	Private	Life cycle of mosquito	57 minutes
11	D	Rural Area	Private	Human reproductive system	72 minutes
12	E	Rural Area	Private	Reproduction and grow in humans	57 minutes
13	E	Rural Area	Private	Reproduction and growth in humans	42 minutes
14	F	Rural Area	Public	Light energy	58 minutes
15	G	Rural Area	Public	Male and female reproductive parts	61 minutes

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6	B	Urban Centre	Public	Human circulatory system	57 minutes
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8	C	Urban Centre	Private	Life cycle of mosquito	57 minutes
9	C	Urban Centre	Private	Life cycle of mosquito	70 minutes
10	C	Urban Centre	Private	Life cycle of mosquito	57 minutes
11	D	Rural Area	Private	Human reproductive system	72 minutes
12	E	Rural Area	Private	Reproduction and grow in humans	57 minutes
13	E	Rural Area	Private	Reproduction and growth in humans	42 minutes
14	F	Rural Area	Public	Light energy	58 minutes
15	G	Rural Area	Public	Male and female reproductive parts	61 minutes

Lesson	School	School Location	School Type	Topic of Lesson Observed	Period
16	G	Rural Area	Public	Reproduction in humans	46 minutes
17	H	Urban Centre	Private	Calculating the volume and density of a solid block	84 minutes
18	I	Urban Centre	Public	Electronic configuration	68 minutes
19	I	Urban Centre	Public	Formation of ions	57 minutes
20	J	Urban Centre	Public	Mixture	67 minutes
21	J	Urban Centre	Public	Uses of compound	53 minutes
22	K	Urban Centre	Public	Chemical compound	60 minutes
23	K	Urban Centre	Public	Chemical formula of binary compound	65 minutes
24	K	Urban Centre	Public	Naming and balancing compounds	69 minutes
25	L	Urban Centre	Private	Reproduction in humans	59 minutes
26	L	Urban Centre	Private	Teenage pregnancy	69 minutes
27	L	Urban Centre	Private	Reproduction in humans	51 minutes
28	M	Urban Centre	Private	Mixtures	60 minutes
29	M	Urban Centre	Private	Miscible and immiscible liquids	56 minutes
30	M	Urban Centre	Private	Class test	57 minutes
31	N	Urban Centre	Public	WATER	57 minutes

Source: Field data, Mohammed (2015)