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An Exploration of Elementary Teachers' Beliefs and Perceptions About Science Inquiry: A Mixed Methods Study

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ABSTRACT

In order for science-based inquiry instruction to happen on a large scale in elementary classrooms across the country, evidence must be provided that implementing this reform can be realistic and practical, despite the challenges and obstacles teachers may face. This study sought to examine elementary teachers' knowledge and understanding of, attitudes toward, and overall perceptions of inquiry-based science instruction, and how these beliefs influenced their inquiry practice in the classroom. It offered a description and analysis of the approaches elementary science teachers in Islamic schools reported using to promote inquiry within the context of their science classrooms, and addressed the challenges the participating teachers faced when implementing scientific inquiry strategies in their instruction.

The research followed a mixed method approach, best described as a sequential two-strand design (Teddlie & Tashakkori, 2006). Sequential mixed designs develop two methodological strands that occur chronologically, and in the case of this research, Quantitative→Qualitative. Findings from the study supported the notion that the school and/or classroom environment could be a contextual factor that influenced some teachers' classroom beliefs about the feasibility of implementing science inquiry. Moreover, although teacher beliefs are influential, they are malleable and adaptable and influenced primarily by their own personal direct experiences with inquiry instruction or lack of.

CHAPTER I

INTRODUCTION

Statement of the Problem

Human society has become increasingly complex, requiring thoughtful and deliberate integration of many disciplines, including science, in order to ensure a positive contribution. In 1962, Thomas Kuhn wrote *The Structure of Scientific Revolution*, introducing the concept of "paradigm shift" (p. 10), whereby he argued scientific advancement to be a "series of peaceful interludes punctuated by intellectually violent revolutions, and in those revolutions one conceptual world view is replaced by another" (p. 10). As it pertains to science classrooms, the revolution would deem necessary the changing of current teacher views about methods of teaching and learning science that would highlight the importance of making the student central to the implementation of science process skills. Although the acquisition of basic scientific facts and principles is necessary, it is insufficient for students to function successfully in our complex world today. Developing these attitudes and skills in all students requires long-term, comprehensive efforts by staff developers, teacher educators, and the teachers themselves, and as such, current reform documents by the American Association for the Advancement of Science (AAAS) and the National Research Council (NRC) promote science inquiry implementation in K-12 science classrooms (AAAS, 1993; NRC, 1996; NRC, 2011).

In the vision adopted by the National Science Education Standards (1996), inquiry is explained as a step beyond "science as a process," in which students learn skills, such as observation, inference, and experimentation. This vision required students to combine processes and scientific knowledge as they used scientific reasoning and critical thinking to develop their understanding of science. Inquiry is at the heart of the National Science Education Standards (NSES), enabling teachers to build on children's natural curiosity and human inquisitiveness, and is defined as “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). Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. Most recently, the Next Generation Science Standards (NGSS), as outlined by A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (NRC, 2011), place an unprecedented focus on the many practices involved in doing scientific and engineering work, including those central to science inquiry. By engaging students in practical versions of the actual cognitive, social, and material work that scientists do, the Framework provides specificity to the broader notion of scientific inquiry.

Those involved in developing national standards in the 1990’s were dedicated to including inquiry as both science content and knowledge to support students’ to think and learn science. Instead of only promoting "hands-on" or "laboratory based" teaching as the way to teach "science content and process," the writers of the NSES adopted inquiry as both a learning goal and as a teaching method, thereby enabling scientific inquiry to appear in several different places in the Standards including content and teaching across all grade levels (NCR, 2000). Engaging students in inquiry helps students develop an understanding of scientific concepts, an appreciation of knowing science, an understanding of the nature of science, and the becoming of independent inquirers about the natural world (NRC, 2000).

The basis for an inquiry approach in the science classroom stems from the way in which the brain learns. Inquiry consists of several interconnected processes that a person uses to answer a question (Cacciatore & Sevian, 2006). Inquiry therefore allows students to construct knowledge by exploring a new concept rather than being told exactly how to remember it. Cacciatore and Sevian (2006), Hofstein and Lunetta (2004), and Pea (2004) provide evidence that students have greater conceptual understanding of subject matter and improved scientific reasoning abilities in an inquiry based learning environment. Essentially, students retain more than a mere memorized list of facts and skills via inquiry based learning; they learn scientific reasoning skills that include problem solving and critical thinking skills and how to embed facts and skills in to a framework of understanding the discipline.

From the earliest grades, students in science classrooms are encouraged to engage in scientific inquiry and enhance their opportunities to develop the abilities of doing science, albeit within their developmental capabilities (NSES, 1996). This includes the ability to ask questions, plan and conduct investigations, use appropriate tools and techniques to gather data, think critically and logically about relationships between evidence and explanations, construct and analyze alternative explanations, and communicate scientific arguments. In this way, teachers may help their students understand science as a human endeavor acquire the scientific knowledge and critical thinking skills important in everyday life and, if their students so choose, in pursuing a scientific career. For these reasons, the National Science Teachers Association (NSTA) recommends that all teachers of science embrace the use of inquiry, and make it the centerpiece of the science classroom.

Despite these reform efforts to clarify what science teaching and learning should entail in order to achieve scientific literacy, researchers contend that most teachers are either not practicing reforms-based science instruction or reluctant to do so (Keys & Bryan, 2001; Lee, Hart, Cuevas, & Enders, 2004; Yoon, Joung, & Kim, 2012). A curriculum that emphasizes scientific inquiry cannot be enacted without a teacher who is prepared to facilitate these student opportunities. Davis, Petish, and Smithey (2006) conducted a review of literature exploring the challenges new science teachers faced and concluded that pre-service teachers, especially at the elementary level, seemed to lack adequate understandings of science content and science processes or thinking skills. Although several studies reviewed by Davis et al. explicitly characterized teachers as knowledgeable of specific inquiry practices, such as asking and answering scientific questions, collecting and analyzing data, making explanations based on evidence, and communicating and justifying findings, only a few teachers actually acquired these skills and demonstrated these high leverage practices of inquiry in their classrooms, indicating that these teachers' pedagogical content knowledge was inadequate in preparing them for teaching through science inquiry.

Shulman (1987) contended that pedagogical content knowledge (PCK) is what distinguishes the teacher from a mere content specialist, and he recognizes the PCK knowledge base to be scholarship in content area, materials and setting of educational process, research, and wisdom of practice or experience. A lack of preparation in terms of science subject matter knowledge and limited PCK specific to science, make implementing reform such as science-based inquiry instruction even more challenging (Shulman, 1987; Yager, 2005). Without the proper understanding of scientific inquiry and the demonstrating of specific pedagogical skills associated with its teaching, teachers are unlikely to be successful in promoting science inquiry learning in their classrooms.

Science teachers need to help students accept responsibility for their own learning and must "create a setting for student work that is flexible and supportive of science inquiry" (NRC, 1996, p. 43), but they tend to have concerns about classroom management, sometimes leading them to engage less in reform-oriented teaching practices, including science inquiry. Harris and Rooks (2010) claim that, in order for teachers to provide their students with rich opportunities to engage in science practice, they must change the way they approach managing their classrooms. Because of the complexities involved with this type of instruction, science inquiry puts a greater demand on students to take responsibility for their learning, which may require additional support from teachers (NSTA, 2004) in managing of instructional materials by adapting them to student needs as they deem appropriate (Crawford, 2007).

Other challenges are especially prominent for K-6 teachers. Multiple factors contribute to the problem for elementary science teachers including an emphasis on math and reading proficiency (Cronin-Jones, 1991; Fulp, 2002; Sunderman, Tracey, Kimg, & Orfield, 2004), lack of content knowledge and pedagogical content knowledge (Appleton, 2006; Lee et al., 2004; Shulman, 1987; Yoon et al., 2012), and lack of resources (Gillies & Nichols, 2015). Elementary teachers often state that there is not enough time to teach science, but this may in fact be a self-fulfilling prophecy influenced by their beliefs that they are not good at teaching science or do not feel as comfortable doing so, which results in more emphasis on other subjects (Cronin-Jones, 1991). Furthermore, elementary teachers are spread very thin in terms of staying current on professional development in the multiple content areas that they teach, and research has indicated that a lack of understanding of the inquiry process to be a contributing factor to teachers' lack of confidence in teaching inquiry science (Lee et al., 2004; Yoon et al,. 2012). As a result of these obstacles, they may need more support in their attempts at implementing reforms-based science teaching and changing beliefs and instructional practices.

Finally, a teacher's beliefs play a large role in determining their classroom practices. Beliefs, as defined by Pajares (1992), are existing presumptions or personal truths that everyone holds, and are characterized by making judgments and evaluations about phenomena, subject matter, and individuals. Furthermore, Pajares argued that these individual beliefs are sustained, even when they are contradicted by reason, evidence or experience. Kagan (1992) reviewed 27 empirical studies on the change of beliefs, behaviors or images of pre-service teachers and similarly, found that beliefs usually remain unchanged throughout teaching education programs and follow pre-service teachers into student teaching. She also found that many of these beliefs were based on pre-service teachers' own experiences in school. In addition, Keys and Bryan (2001) suggested that knowledge of teachers' beliefs is instrumental in understanding how inquiry is actually implemented in the classroom. Furthermore, Anderson (2015) concluded from a cross-site analysis of case studies that changes in classroom practice were dependent on changes in teachers' values and beliefs. Even if teachers' beliefs were consistent with the current reforms, Choi and Ramsey (2009) contended they still need to develop new teaching strategies and ways to assess their work, ultimately requiring them to unlearn previous approaches and acquiring a more complex set of practices. In light of these challenges, this study will be designed to investigate elementary teachers' implementation of science inquiry while seeking their insight as to concerns and barriers to teaching through inquiry, as well as what factors may encourage them to do so.

In order for researchers to come to grips with teachers' beliefs, they must first decide what they wish belief to mean, and how this meaning will distinguish personal beliefs from a personal knowledge construct. When examining the various knowledge constructs used in studies of teachers' beliefs, Pajares (1992) discovered a puzzling collection of terms including, "teachers' teaching criteria, principles of practice, personal construct/theories/epistemologies, beliefs, perspectives, teachers' conceptions, personal knowledge, practical knowledge-in addition to their own term, and personal practical knowledge" (p. 309). Regardless of which term was chosen, it was difficult to pinpoint where knowledge ended and belief began, and most of the constructs were simply different words meaning the same thing.

Teachers' attitudes about education-about schooling, teaching, learning, and students have generally been referred to as teachers' beliefs. When researchers speak of teachers' beliefs, however, they refer to teachers' educational beliefs which are specific to the educational process. But, even the construct of educational beliefs is in and of itself broad, vague, and encompassing, needing reduction and contextualization as well. For example, educational beliefs about a teacher's confidence in affecting students' performance are categorized as teacher efficacy, whereas the educational beliefs about the nature of knowledge are labeled as epistemological beliefs. Other educational belief substructures include those about causes of teachers' or students' performance, which are dubbed as attributions or motivation, about perceptions of self and feelings of self-worth and are called self-concept or self-esteem, and about the confidence to perform specific tasks, otherwise known as self-efficacy. There are also educational beliefs about specific subjects or within disciplines, such as a teacher's beliefs about reading instruction, or a science teacher's beliefs about inquiry (Pajares, 1992).

This study is grounded in theories about teacher beliefs and the constructs of science inquiry and teacher efficacy. Beliefs, as defined by Pajares (1992), are existing presumptions or personal truths that everyone holds, and are characterized by making judgments and evaluations about phenomena, subject matter, and individuals. Furthermore, Pajares argued that these individual beliefs are sustained, even when they are contradicted by reason, evidence or experience. He elaborated,

> Clusters of beliefs around a particular object or situation form attitudes that become action agendas. Beliefs within attitudes have connections to one another

> and to other beliefs in other attitudes, so that a teacher's attitude about a particular educational issue may include beliefs connected to attitudes about the nature of society, the community, race, and even family. These connections “create the values that guide one's life, develop and maintain other attitudes, interpret information, and determine behavior. (p. 319)

Interestingly, Lortie (1975) contended that the thousands of hours spent by teachers in the classroom as students to be fertile ground for the development of their educational beliefs, far outweighing the effects of their teacher education on belief development.

The study of beliefs is critical to education precisely because, as Kagan (1992) contended, "the more one reads studies of teacher belief, the more strongly one suspects that this piebald of personal knowledge lies at the very heart of teaching" (p. 85). The following is a summary of Pajares’ (1992) essential findings on teacher beliefs:

1. Beliefs are formed early and are persistent throughout adulthood, even if contradicted by reason, time, schooling, or experience.
2. Individuals gather their beliefs into belief systems to understand themselves and the world around them through cultural transmission.
3. Belief structures ultimately filter and/or reshape subsequent thinking, interpret new phenomena, and process information.
4. Belief substructures, such as educational beliefs, must be understood in terms of their connections not only to each other but also to other beliefs in the belief system.

5. Some beliefs are more disputable than others, and newly acquired beliefs are more variable.
6. Beliefs are instrumental in defining behavior and organizing knowledge and information.
7. Beliefs strongly influence perception, individual behaviors, and decisions regarding tasks.
8. Epistemological beliefs play a key role in knowledge interpretation and cognitive monitoring
9. Beliefs about teaching are well established by the time a student gets to college.

The aforementioned research leaves the science education community with many unanswered questions to making reforms-based science teaching a reality. Considering the sweep of changes and science reform efforts over the past twenty years, there is limited research into the impact of reforms such as NSES and NGSS on elementary science teaching and learning (Appleton, 2007). Moreover, elementary science teachers, face unique challenges in implementing these reforms in their classrooms. By acknowledging that educational change depends on what teachers do and think, it is therefore crucial that research is conducted at the individual classroom level to understand what is working in elementary science classrooms and how the experiences of these teachers have influenced their instruction and may influence others.

Purpose

The purpose of this study is to examine elementary teachers' knowledge and understanding of, attitudes toward, and overall perceptions of inquiry-based science instruction, and how these beliefs influence their inquiry practice in the classroom. In addition, it will offer a description of the types of methods teachers are using to promote inquiry within the context of their science classrooms and address the challenges teachers face when implementing scientific inquiry strategies in their instruction. Researchers have indicated that teachers' beliefs, attitudes, and practical knowledge are crucial factors in promoting a reform-based curriculum such as inquiry-based science instruction (Choi & Ramsey, 2009). In order to make science meaningful for all children, teachers must be capable of responding effectively to education reform, including incorporating of inquiry-based science lessons. This research will shed light on factors that promote or hinder the implementation of inquiry instruction in the Islamic schools' elementary classrooms. Furthermore, this study will enable participating science teachers to reflect on their instructional practice and assessment methods and make modifications for improved students' science achievement. In light of the benefits mentioned above, the following research questions are purposed:

1. How do elementary science teachers in Muslim private schools describe scientific inquiry, and how is it evidenced in their classroom practice?
2. What are the participant teachers' beliefs towards inquiry-based science instruction?

3. What personal and external factors have influenced these practices and beliefs?

Significance of the Study

In order for science-based inquiry instruction to happen on a large scale in elementary classrooms across the country, evidence must be provided that implementing this reform can be realistic and practical, despite the challenges and obstacles teachers may face. While improved student achievement is the ultimate goal, it is crucial to evaluate initially how elementary science teachers can better incorporate inquiry in their classroom practices. This includes identifying the tools and support that teachers may need to overcome the barriers that discourage science inquiry teaching practices.

Today's reform rhetoric has promoted the concept of inquiry as representing the essence of science education, while documents such as the National Science Education Standards (NSES) and Next Generation Science Standards (NGSS) are endorsing inquiry as being crucial to these reforms (Keys & Bryan, 2001). Because the efficacy of reform efforts rests largely on teachers' shoulders, their voices need to be included in the design and implementation of an inquiry-based curriculum, thereby transforming them into true reform-minded science teachers, who's thinking and instructional practices are shaped by the tenets of science reforms, such as inquiry. McGinnis, Parker, and Graeber (2004) reviewed a growing body of literature that examined the obstacles reform-minded science teachers confront as they attempt to employ their instructional practices in contexts that are often designed around more traditional approaches to science teaching. By listening to science teachers and inviting them to engage in inquiry in ways that match their own beliefs and teaching styles, multiple modes of inquiry teaching arise, thereby promoting meaningful learning in diverse classroom situations (Keys & Bryan, 2001).

Research on teacher thinking recognized teachers as active curriculum creators that make instructional decisions based on a complex system of beliefs and knowledge, which thereby influence (a) knowledge acquisition and interpretation, (b) defining and selecting the task at hand, (c) interpretation of course content, and (d) choice of assessment (Keys & Bryan, 2001). However, research has continuously shown that various curriculum reforms are ultimately molded and changed by teachers' beliefs and understandings of their respective contexts (Brickhouse & Bodner, 1992; Bryan, 1998; Cronin-Jones, 1991; Wallace & Wildy, 1995). Furthermore, Hashweh (1996) found that differences in epistemological beliefs influenced classroom teaching actions and concluded that teachers who were learning and knowledge empiricists seldom recognized students' prior knowledge, believed in reinforcement as a method of learning, and emphasized the scientific method both as a paradigm for scientists and for instruction. On the other hand, Hashweh established that when the teachers' epistemology was rooted in learning and knowledge constructivism, they actively sought out prior knowledge of their students and used a wider variety of teaching strategies to promote the construction of conceptual understandings. Thus, research indicates that teacher beliefs have an important role in both planning and implementing instruction.

The setting of this study, the private Islamic school, is one that has been rarely visited by education researchers, in that it is a relatively new addition to the collection of school systems in the United States. The Council of Islamic Schools of North America

(CISNA) claims membership of 50 Islamic schools, including Universal School, and other educational organizations nationwide, and provides services to the over 300 Islamic schools in North America. Among CISNA's most prominent programs is the annual ISNA Education Forum which was started and continues to be held in the Chicago area since December 1999. The Education Forum provides networking and professional development opportunities to over 500 Islamic school educators annually. There are currently 16 Islamic private schools in Illinois, serving over 3,500 students. The majority of the relatively few studies on Islamic school curricula are focused on student identity, rather than on teachers or the implementation of curricular reforms (Keyworth, 2011).

In conclusion, there is a large body of research indicating that teacher beliefs about science, student learning, and the role of the science teacher substantially affect planning, teaching, and assessment. But, if teachers are responsible for implementing and sustaining the vision of reform set forth by documents such as the NSES and NGSS, their voices must be heard in order to develop the knowledge needed to facilitate science inquiry within their respectively diverse settings. Apparently, more research is needed on the beliefs of elementary science teachers implementing inquiry-based instruction, as well as studies of reflection on beliefs and change in their teaching practices, especially within the Islamic school setting.

Theoretical Frameworks

Like all teachers, science teachers espouse beliefs about teaching and learning that ultimately impact their decisions and classroom practices (Bryan, 2012; Keys & Bryan 2001; Riggs & Enochs, 1990). For example, when a teacher's epistemological views consider science to be a body of knowledge, their teaching strategies tend to be more teacher-centered and transmission oriented, whereas those teachers who hold more constructivist views about science knowledge are more willing to use open-ended science inquiry practices with their students (Bryan, 2012; Woolfolk Hoy, Hoy, & Davis, 2009). Additionally, given that classroom behavior is the result of beliefs that have been altered by experience, changes in teachers' experiences may have the potential to change their beliefs (Pajares, 1992). According to Bandura (1997), beliefs are thought to be the best indicators of the decisions people make throughout their lives, and his work surrounding the concept of self-efficacy has been useful in examining the influence of personal beliefs on teaching. Bandura defined self-efficacy as "... beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3), and he believed self-efficacy to be the most powerful influence on teaching practices.

When attempting to understand and study the impact of self-efficacy on this connection, it is helpful to draw upon Bandura's work around the construct of self-efficacy, which is grounded in social learning theory and consists of two dimensions: personal self-efficacy and outcome expectancy (1977, 1986, 1994, 1997). Personal self-efficacy is defined as "a judgment of one's ability to organize and execute given types of performances" (Bandura, 1997, p. 21), whereas outcome expectancy relates to an individual's "...judgment of the likely consequences such performances will produce" (p. 21). Both of these dimensions are posited to influence behavior, enabling self-efficacy to be an ideal framework in determining and understanding the instructional decisions that teachers make.

Teacher efficacy beliefs have been found to be valid predictors of practicing and prospective elementary teachers' behaviors in regard to the teaching and learning of science (Bandura, 1986; Enochs & Riggs, 1990; Fulp, 2002). As explained by social learning theory (Bandura 1977), if teachers did not have successful experiences teaching or learning science using inquiry practices, it is unlikely that these teachers will continue to implement science as inquiry in their elementary science classrooms. Elementary teachers are expected to promote inquiry learning in their science classrooms, but they themselves must first have an informed understanding of teaching science as inquiry, as well as opportunities to experience success with inquiry teaching and learning (Smolleck & Yoder, 2006). Because most elementary teachers have minimal experiences with teaching science through inquiry, they doubt their abilities to implement this practice and consequently resort to more familiar and traditional methods of science teaching. As Bandura (1997) eloquently explains, “Unless people believe they can produce desired effects by their actions, they have little incentive to act” (p. 3).

The level of motivation an individual has for a given situation, their associated feelings toward the situation, and their subsequent behaviors are “based more on what they believe, rather than on what is objectively true” (Bandura, 1997, p. 2), and “unless people believe they can produce desired effects by their actions, they have little incentive to act” (p. 3). Bandura (1995) explained the differences of the effects of high and low personal self-efficacy on human behavior; “People with high assurance in their capabilities in given domains approach difficult tasks as challenges to be mastered rather than as threats to be avoided” (Bandura, 1994, p. 11). On the other hand, “People who have a low sense of efficacy in given domains shy away from difficult tasks, which they view as personal threats. They have low aspirations and weak commitment to the goals they choose to pursue" (p. 11). Bandura's self-efficacy theory supports previously discussed factors that contribute to the implementation of inquiry-based instruction in the science elementary classroom. Understanding the foundation of this framework will allow a better understanding as to how elementary teachers' beliefs and attitudes affect science inquiry implementation in their classrooms.

Sociocultural theory, originated in the socio-historical and cultural-historical work of Vygotsky and his Russian colleagues in the early twentieth century, and emphasized the relationships between people, contexts, actions, meanings, language, communities and culture. Within this framework, attention is given to how sociocultural influences construct and transform knowledge, rather than how knowledge is merely transmitted (Forman & McCormick, 1995; John-Steiner & Mahn, 1996). Thus, when adopting a sociocultural approach, one must examine the environment, context, relationships, and culture surrounding the teachers, in order to analyze the attitudes and beliefs and how they inform teachers' practices. Vygotsky's (1986) concept of internalization recognized that interactions take place between learning and development within socially and culturally shaped contexts. Moreover, Riggs and Enochs (1990) claimed that teacher efficacy beliefs appeared to be dependent upon the specific teaching situations, hence acknowledging the importance of grounding this type of study in a sociocultural framework. Because of its naturalistic, ethnographic, and interpretive nature, the sociocultural constructivist framework was among the four theoretical frameworks recommended by Keys and Bryan (2001) for conducting research on teacher beliefs, knowledge, and practice of inquiry.

Wertsch (1993) contended that, “in order to understand the individual, it is necessary to understand the social relations in which the individual exists” (pp. 25-26), and teachers are no exception. Elementary science teachers come into contact daily with teachers, administrators, professors, other students and people they had never met, all of whom, according to the sociocultural framework, communicated with them in some form and thus, contributed to their thinking about teaching science (Wertsch, 1993). Recognizing the context within which teaching and learning therefore occurs, this study will also draw upon Jones and Carter’s (2007) *Sociocultural Model of Embedded Belief Systems*, which describes belief systems as a simultaneous interaction of attitudes, knowledge and epistemologies within sociocultural contexts. Within this model, knowledge is defined as one’s socially constructed understandings of content, while attitudes represent the affective, emotional component, of one’s belief system. Epistemologies are comprised of one’s individually constructed views about science, teaching science and learning science.

Zapata (2013) argued that teachers must analyze their practice along with the corresponding sociocultural factors, because the sociocultural attitudes and beliefs they bring to the learning environment will directly impact their interactions with students. Unfortunately, the sociocultural framing of science teaching and learning is usually not taken into consideration by teachers in the science classroom in a way that allows them to adjust their teaching practices to incorporate strategies to address issues and bring them to the surface. Instead, teachers uphold and perpetuate their practices and teach how they were taught, rather than questioning their own attitude and beliefs behind their practices (Lortie, 1975; Zapata, 2013).

CHAPTER II

REVIEW OF LITERATURE

Inquiry Instruction in US Science Education

The history of science education in the United States has evolved over time and numerous revisions have been produced. Current and past trends in science education are addressed showing the foundations and the implications for change, which are rooted in educational philosophies and thinking throughout the decades.

Most science educators before 1900 viewed science mainly as a collection of facts that students were to learn via direct instruction. A major criticism of this point of view came when John Dewey (1902), in an address to the American Association for the Advancement of Science, claimed that science teaching gave too much emphasis to the accumulation of information and not enough to science as a way of thinking and an attitude of mind. He realized that science was more than a body of knowledge to be learned and that there was a process or method to be learned as well. Dewey (1933) directly influenced science teaching today through his discovery learning, an approach which emphasized more scientific thinking and processes and less content. By using his Lab School to uphold his notion of “discovery learning” as a key technique for acquiring knowledge, Dewey paralleled the first wave of inquiry type reforms of the 1950’s and 60’s (DeBoer, 1991).This learning methodology was, in reality, one of the precursors to inquiry, and a major component in the development of modern scientific literacy

(DeBoer, 1991; Bybee, 1997; Rakow, 1986). The progressive ideas of Dewey also aligned theoretically with Benchmarks because they emphasized general education for all students using inquiry based techniques in order for students to become responsible citizens (Benchmarks for Science Literacy, AAAS, 1993).

By the 1950s and 1960s, the argument for inquiry as an approach to teaching science was becoming increasingly apparent in the classroom. The educator Joseph Schwab was an influential voice in establishing this view of science education. Schwab argued that science should be viewed as conceptual structures that were revised as the result of new evidence (NSES, 2000). By structuring lessons where students are "asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments" (NSES, 1996, p. 105), an effective inquiry learning environment that provides an engaging classroom setting can be established. In addition, inquiry-instructional models enable students to think critically and analytically by developing deep conceptual knowledge over surface, rote learning and facilitate scaffolding and differentiated instruction in the classroom (Marshall & Horton, 2011).

Since the launch of Sputnik, the federal government appropriated funding to upgrade the teaching of science which resulted in various new curricular approaches such as The 3 Stage Learning Model and BSCS, all of which Rakow (1986) contended to have a common thread of inquiry. The goals of these inquiry-based curricula included hands-on engagement of students in the process of science, allowing students to engage in the same thinking skills and protocols that “real” scientists perform. The NRC (1996) referred to process learning as students obtain skills in observing, inferring, experimenting, inquiring and ultimately, parallel the methods and thinking processes of today’s scientific practitioners (Bybee, 1997; NRC, 1996, 2000).

Relatively recent reform documents by the National Research Council have set clear goals for how to attain scientific literacy in this country. The National Science Education Standards (NRC, 1996) summarized the knowledge, skills, and experiences that students need in order to achieve this scientific literacy. The NSES outlined content standards for achieving scientific literacy in terms of the natural sciences, but also included standards for teaching, professional development, assessment, school science programs, and the educational system as a whole. The changes in Table 1 provide an overview of the shift in teaching and learning that the NSES promote.

Table 1

National Science Education Standards Changing Teaching Emphases

Less Emphasis On
Knowing scientific facts and information
Studying subject matter disciplines (physical, life, earth sciences) for own sake
Separating science knowledge and science process
Covering many science topics
Implementing inquiry as a set of processes
More Emphasis On
Understanding scientific concepts and developing abilities of inquiry
Learning subject matter disciplines within the context of inquiry, technology, personal and social perspectives, and history and nature of science
Integrating all aspects of science content
Studying a few fundamental science concepts
Implementing inquiry as instructional strategies, abilities, and ideas to be learned

Note. NRC, 1996, p. 113.

A classroom emphasizing solely lecture, text, and demonstration for the purpose of recalling factual scientific knowledge on tests needs to be an image of the past. Teachers practicing reforms-based instruction place less emphasis on these traditional approaches and greater emphasis on more constructive strategies that foster inquiry in student-centered ways. By assuming a more facilitative role, the teacher may include instruction that is based on flexible curricula, provide opportunities for students to construct understanding through active learning, and focus on student understanding of inquiry processes, in addition to increasing scientific knowledge. The actual engaging in inquiry in the classroom will allow students to truly learn science and follow in the footsteps of a true scientist.

Science Inquiry Defined

Scientific inquiry has been a continuing focus of science education for much of the past century. Various reform documents (e.g., Benchmarks for Science Literacy, AAAS, 1993; A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, National Research Council [NRC], 2011) highlight the importance of developing inquiry skills of students, while the National Science Education Standards (NRC, 2000) emphasize the fundamental understanding about specific characteristics of scientific inquiry. This distinction is a necessary one, given that often times a learner's knowledge about scientific inquiry is assumed, and students performing inquiry do not necessarily develop understandings about inquiry.

Scientific inquiry refers to the combination of general science process skills with traditional science content, creativity, and critical thinking to develop scientific knowledge (Lederman et al., 2014). NSES defines inquiry as a

> …multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Students will engage in selected aspects of inquiry as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete inquiries. (NRC, 1996, p. 23)

Moreover, the NSES have established inquiry as an essential component of these reforms in K-12 science classrooms, deeming necessary that students develop both "abilities necessary to do scientific inquiry" and "understandings of scientific inquiry" (NRC, 1996, p. 121). Bybee (1997) outlined student understanding of inquiry with an instructional model that aligns with the learning cycle and consists of five phases of engage, explore, explain, elaborate and evaluate, all beginning with the letter "e". Based on this 5E model, the National Research Council (2000) developed five essential features of classroom inquiry, clarifying what an inquiry-oriented classroom looks like in practice. These include learners (a) being engaged in scientifically oriented questions, (b) giving priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions, (c) formulating explanations from evidence to address scientifically oriented questions, (d) evaluating their explanations in light of alternative explanations, and (e) communicating and justifying their explanations (p. 29). Students should experience science in ways that help them overcome misconceptions, which requires more than the accumulation of disconnected scientific facts. Since the standards for teaching and learning science are built around inquiry, many researchers use the words inquiry and reforms-based teaching interchangeably. The National Science Education Standards (NRC, 2000) additionally emphasize knowing about inquiry and stress what students should be able to do as well as what they should know.

Schwab's (1962) resolve that students in science classrooms were engaged in inquiry-based practices continues to be a paramount goal for science educators and policy makers, as evidenced by recent US national curriculum standards documents, including the Next Generation Science Standards (NGSS; NRC, 2013) and the Framework for K-12 Science Education (NRC, 2012). Most recently, the Framework for K-12 Science Education (NRC, 2012) included inquiry under the umbrella term "scientific practices" and stated, "we use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice" (p. 30). The Framework contended that "[e]ngaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world" (NRC, 2012, p. 42). The Framework document, which outlines theory and research that buttresses the standards, includes scientific and engineering practices as one of its three key dimensions for science learning. Scientific practices include the skills, reasoning abilities, and content knowledge that are necessary for students to engage in investigations about the natural world. The new term, scientific practices, was chosen, in part, to help clarify what is meant by inquiry-based science.

Engaging students in inquiry promotes investigative skills and the ability to engage and assess information, as explained by Lord and Orkwiszewski (2006). When classroom inquiry is student-centered or completely driven by students, it is called an open inquiry, whereas when it is facilitated by the teacher, it is called a guided inquiry. In guided inquiry, the teacher selects the question and works collaboratively with the students in reaching a consensus on how to research the question, collect, analyze, interpret data and communicate results or findings. Although the students are not necessarily engaged in full inquiry when it is guided by the teacher, they are nonetheless involved in scientific processes that require active participation and critical thinking (NRC, 2000). Students engaged in open or guided inquiry benefit by using these skills in the context of well-structured, science-subject-matter knowledge and the ability to reason and apply scientific understanding to a variety of problems. Crawford (2000) made a number of assertions as to what it means to teach scientific inquiry in science classrooms which include (a) inquiry is situated in context, (b) teachers need to embrace inquiry as content and pedagogy, (c) collaboration between teacher and students enhances inquiry,

(d) teacher and student roles are complex and changing, and (e) greater levels of involvement are required by teachers than in traditional teaching.

While Crawford (2000) provided valuable insight into the characteristics of effective science teaching in the context of real classrooms, the question still remains as to whether they can translate effectively to an elementary science classroom. Lederman et al. (2014) contended that all students should develop an informed understanding of the following aspects of scientific inquiry in order to facilitate true understanding of inquiry: (1) scientific investigations all begin with a question and do not necessarily test a hypothesis; (2) there is no single set of steps followed in all investigations (i.e., there is no single scientific method); (3) inquiry procedures are guided by the question asked; (4) all scientists performing the same procedures may not get the same results; (5) inquiry procedures can influence results; (6) research conclusions must be consistent with the data collected; (7) scientific data are not the same as scientific evidence; and that (8) explanations are developed from a combination of collected data and what is already known.

Lakin and Wallace (2015) claimed that a better understanding of scientific inquiry can be achieved through the use and dissemination of the more recent term scientific practices, rather than inquiry. The construct of inquiry has been fraught by misunderstanding and miscommunication for some four decades. The use of scientific practices as defined in the NGSS presents a more crystallized vision of what one does while engaged in science, such as asking questions or analyzing data that may be more easily recognized in the classroom. There are many specific examples of scientific practices in the NGSS, making it possible to teachers to develop a tangible sense of these practices.

Benefits of Science Inquiry Instruction

Greater emphasis, in recent years, has been placed on having teachers teach science using an inquiry approach where students are actively involved in scientific investigations that provide them with opportunities to explore possible solutions, explain phenomena, elaborate on potential outcomes, and evaluate findings (Duschl, Schweingruber, & Shouse, 2007; Harris & Rooks, 2010). Research contends that students have greater conceptual understanding of subject matter and improved scientific reasoning abilities in an inquiry based learning environment by sparking students' interest in science, thereby encouraging enrollment in high school science classes (Osborne, 2003, 2006), fostering collaborative student talk and group discussion (Kuhn, 2010), and promoting reasoning and scientific understanding (Kuhn, 2010; Harris & Rooks, 2010). Additionally, inquiry learning helps students to understand how science is carried out in the real world, where answers to problems do not readily appear. Rather, they are solved through investigating phenomenon, examining data, sharing ideas with peers, and reflecting on past experiences and learning (Duschl et al., 2007). Ultimately, inquiry can be used to meet students' academic needs and can potentially help to bridge science achievement gaps that exist in the school system as proposed (NRC, 1996).

An inquiry environment is student centered where students ask questions and discover new concepts. Often this means a classroom or laboratory is more discussion or activity oriented rather than the lecture method (Hofstein & Lunetta, 2004). From the earliest grades, students in science classrooms are encouraged to engage in scientific inquiry and enhance their opportunities to develop the abilities of doing science, albeit within their developmental capabilities (NSES, 1996). In this way, teachers can help all their students understand science as a human endeavor, acquire the scientific knowledge and thinking skills important in everyday life and, if their students so choose, in pursuing a scientific career. Marshall and Horton (2011) found that as teachers increase the time devoted to exploration of concepts, an initial step of the inquiry-based approach, the cognitive level of their students increased. On the contrary, when teachers spent more time explaining concepts to students in comparison to guided exploration, the cognitive level of the students actually decreased. The use of the inquiry-oriented middle school science curriculum resulted in considerable student learning in Fogleman, McNeill, and Krajcik's (2011) study, and students who completed the activities themselves had greater student gains than students in classrooms where the teacher completed the activities as demonstrations. This suggests that having the students conduct the activities and investigations themselves is a key factor in determining the successful implementation of the inquiry-oriented curriculum.

The National Science Education Standards (1996) argues that ‘‘students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry” (p. 105), highlighting the importance of reasoning and critical thinking as instructional goals. Yager and Akcay (2010) demonstrate that in some instances, students score significantly higher with respect to concept mastery while studying science in an inquiry based, constructivist learning environment. Each of the 12 teacher participants involved in the study taught two sections of science, one section using an inquiry approach (365 students), and the other using traditional methods of science instruction (359 students). In a comparison of student pre- and post-tests, the researchers found that students' ability to apply what they learned was enhanced through inquiry based learning. In addition, they found that students approached inquiry opportunities more creatively, developed enhanced processing skills, and that both teacher and student attitudes were more positive when engaging in inquiry scientific inquiry.

A study conducted by Ornstein (2006) analyzing reports from classrooms across the country concluded that in order for students as a whole to become scientifically knowledgeable adults, they must initially have an affinity for science as a subject and understand the need for scientific literacy in everyday life. Furthermore, the most effective approach to expanding for sciences is through the appropriate implementation of the science inquiry method. As a result, making students memorize scientific facts is not only futile, but discourages them from both scientific literacy and appreciation. The Detroit Public School system implemented a new inquiry-based science curriculum for the middle school students and participated in a three-year study with nearly 8,000 children in order to test whether students could improve their achievement in the area of science. Despite the low SES setting and the at-risk characteristics cast among this population, students' performance improved as students were exposed to inquiry-based learning (Marx et al., 2004).

Challenges and Barriers in Implementing Science Inquiry

The 2012 National Survey of Science and Mathematics Education: Status of Elementary School Science Teaching found that only five percent of elementary science teachers have undergraduate degrees in science, engineering or science education with 40 percent of elementary teachers indicating that they had taken four or fewer semesters of science coursework, suggesting that they had not received an adequate background in science (Gillies & Nichols, 2015). Similarly, the 2000 National Survey of Science and Mathematics Education: Status of Middle School Science Teaching found that two thirds of middle school science teachers received their undergraduate degree in areas other than science or science education raising concerns about the lack of in depth content preparation for teaching any science. Not surprisingly, when elementary teachers were asked about their perceptions of their preparedness to teach science, only 39 percent felt very well prepared to teach science (Gillies & Nichols, 2015). While the National Science Teachers' Association (2002) supports the notion that inquiry science must be a basic in the daily curriculum of every elementary school student at every grade level, research indicates that a lack of understanding of the inquiry process is a contributing factor to teachers' lack of confidence in teaching inquiry science (Lee et al., 2004; Yoon et al,. 2012).

Pedagogical Content Knowledge and Science Inquiry

There is a need to understand the teacher's perspective towards scientific inquiry in the classroom. A curriculum such as scientific inquiry cannot be enacted without understanding the role of the teacher in doing so. According to the NSES (1996) inquiry standards, students at all grade levels and in every area of science should have the opportunity to use scientific inquiry and develop the ability to “ask questions, plan and conduct investigations, use appropriate tools and techniques to gather data, think critically and logically about relationships between evidence and explanations, construct and analyze alternative explanations, and communicate scientific arguments” (p. 105). Furthermore, the NGSS practices should not operate in isolation, and Bell, Bricker, Tzou, Lee, and Horne (2012) argue that part of giving students opportunities to participate in authentic scientific and engineering work is ensuring that they can experience firsthand the interrelatedness of these practices—as an unfolding and often overlapping sequence, or a cascade. Unfortunately, appreciating the significance of an instructional strategy does not always result in the ability or desire of the instructor to implement that concept in the classroom. As learning occurs within a situated context, so does teaching. Putnam and Borko (2000) write that cognition is situated in “particular physical and social contexts” and “distributed across the individual, other persons, and tools” (p. 4). Researchers often write the ideas for effective curricula such as inquiry. However, the researcher does not always teach in the classroom, and ultimately, the teacher is responsible for running the class, facilitating the lessons, and putting the science inquiry curriculum into practice. It is therefore imperative to ask teachers how they implement scientific inquiry, and of specific interest are the methods used and adaptations made by the instructors relevant to their classroom environments.

Although curriculum materials provide critical support for teachers implementing reforms in their classrooms, students’ experiences with reform-based materials depend on how teachers choose to use these resources. Therefore, a difference in student learning can result with varied teacher adaptations, experience using the materials, and efficacy (Fogleman et al., 2011). Ball and Cohen (1999) assert that curriculum materials are one element of an instructional context that the teacher must mediate while managing a learning environment. They argue that while curriculum materials represent a formal curriculum that expresses learning goals and activities sanctioned by school policies or textbooks, teachers use available materials to design the enacted curriculum that is experienced by students. Even when teachers uniformly adopt an inquiry-based curriculum, as in the case of the McNeill and Krajcik (2008) study, they varied in their use of the instructional practices during the introduction of scientific explanation, which thereby influenced their students' learning of the scientific concepts. A 38% variation in middle school science students' gain scores occurred between teachers in Fogleman et al.'s (2011) study, suggesting the role of the teacher in implementing the inquiry curriculum and the factors that influenced this difference to be incredibly important. The quality of the science inquiry curriculum is important, but the manner in which the curriculum is used by teachers in the science classroom seems to be even more crucial to student learning.

Davis et al. (2006) conducted a review of literature exploring the challenges new science teachers faced and concluded that pre-service teachers, especially those at the elementary level, seemed to lack adequate understandings of science content, knowledge of science processes or thinking skills. This discrepancy between elementary and secondary level science pre-service teachers may be explained by a lingering notion that elementary school children cannot function as experimentalists because they have not yet attained the Piagetian formal operational thought, thereby deeming the inquiry approach unnecessary for these grades. A close analysis of inquiry thinking indicates that elementary school children do manipulate variables and appreciate some kind of rational control over their experimentation (Metz, 1995). Davis et al. (2006) reviewed studies explicitly characterized science teachers in general as knowledgeable of specific inquiry practices, such as asking and answering scientific questions, collecting and analyzing data, making explanations based on evidence, and communicating and justifying findings. Unfortunately, only a few teachers actually acquired these skills and demonstrated these high leverage practices of inquiry in their classrooms, indicating that these teachers' pedagogical content knowledge was inadequate in preparing them for teaching through science inquiry. Shulman (1987) contended that this pedagogical content knowledge (PCK) is what distinguishes the teacher from a mere content specialist, and he recognizes the PCK knowledge base to be scholarship in content area, materials and setting of educational process, research, and wisdom of practice or experience. Without understanding scientific inquiry and demonstrating the specific pedagogical skills associated with its teaching, teachers, whether they are at the elementary or secondary level, will experience limited success in promoting science inquiry learning in their classrooms.

In a non-constructivist science classroom, students memorizing facts and reading a science textbook is what constituted science learning. Reading or being told science information is emphasized for students rather than exploring concepts and questions through critical thought, argument, and inquiry (Rakow, 1986). Contrary to the aforementioned traditional approach, constructivism emphasizes that what students already have in their minds matters significantly and that they are active constructors of new knowledge (NRC, 1996). The experiences that a child has prior to learning new ideas have a profound effect on their ability to accept new and/or different scientific explanations. As a result, learning in science is more about changing and refining prior understandings than it is about just giving students explanations as if none existed before. In order to teach in a manner that enables this process among students, the teacher's role must shift from transmitting knowledge to facilitating the students' construction of knowledge. This transition can prove to be quite difficulty for teachers, since this transition represents a significant shift in both beliefs and practices (Crawford, 2007).

Elementary Science Teachers' Struggles with Inquiry

The NSES (1996, 2000) acknowledged that the role of the teacher is a critical aspect of the reforms in science education and that their beliefs about science teaching and learning need to be examined in order for instructional change to occur. The low priority that science in general and inquiry specifically are currently receiving in elementary classes may be explained by the low self-efficacy beliefs of elementary science teachers (Fulp, 2002). In fact, a recent study that examined the status of elementary school science instruction indicated that the average time spent per day teaching science is 25 minutes as compared to 114 minutes per day for reading/language arts instruction. Furthermore, of this instructional time devoted to science, fewer than half (41%) of the classes indicate an emphasis on “science process/inquiry skills” (Fulp, 2002, p. 11).

Why are elementary teachers reluctant to teach science inquiry? Gillies and Nichols (2015) contended that teachers often grapple with students taking scientific discussions in different and extended directions as it challenged their science content knowledge. They also struggled with limited physical resources and time restrictions in scheduling science inquiry activities. These time restraints were further exacerbated by the "increasing alignment between instruction and state standards for curriculum content, focusing on tested content at the expense of other subject matter, ignoring, reducing, or deleting aspects of the curriculum that are not tested, targeting through instructional time and resource allocation” (Sunderman et al., 2004, p. 4), a feat attempted by schools attempting to make adequate yearly progress (AYP) under NCLB. As a result of the various difficulties teachers faced in time management, scheduling science inquiry may be a challenge in elementary science classrooms.

Science Inquiry and the Functional Classroom

Science teachers need to help students accept responsibility for their own learning and must “create a setting for student work that is flexible and supportive of science inquiry” (NRC, 1996, p. 43), but teachers tend to have concerns about student discipline and struggles with management, sometimes leading them to engage in less reform-oriented teaching practices including science inquiry. The role of classroom management in new science teachers’ learning environments indicate that concerns about management made teachers unlikely to engage in reform-oriented science teaching practices such as inquiry (Davis et al., 2006). Historically, the efficacy of school systems depended on their leadership within individualized classrooms, and their proficient maneuvering among the various conditions of teaching they encountered (Lortie, 1975). Effective teachers had the "responsibility to coordinate, stimulate, and shepherd the immature workers in [their] charge" (p. 155). Similar social patterns have permeated into our modern schools, and much of the same organizational structures are still evident. Teachers are still encouraged to close their doors and work independently, with few opportunities for collaboration and team teaching. Despite this lingering organizational perspective, Harris and Rooks (2010) claimed that, in order for teachers to provide their students with rich opportunities to engage in science practice, they must change the way they manage their classrooms. Furthermore, they provide a framework for educators to better understand the complexities of this type of instruction, and to improve classroom management. This type of instruction puts a greater demand on students to take responsibility for their learning, which may require additional support from teachers. NSTA (National Science Teachers Association) standards recommend that teachers "guide and facilitate learning using inquiry by selecting teaching strategies that nurture and assess student's developing understandings and abilities" (2004). Teachers must therefore find a balance between how much guidance and independence to give students. In addition, teachers must manage instructional materials by adapting them to student needs as they deem appropriate.

Another challenge for teachers implementing science inquiry practices in the classroom involves insuring that inquiry lessons are cohesive and sequenced to help students build understanding over time (Harris & Rooks, 2010). By providing a comfortable and respectful environment for students, teachers can help students feel as though they are part of a learning community and facilitate inquiry learning in the classroom. Part of this task involves learning to ask questions that foster student thinking by focusing on helping students monitor their own learning. Methods such as questioning techniques that teachers use to teach inquiry are closely related to national standards and literature. The NSTA recommends through its standards that teachers should help students learn "that science involves asking questions about the world and then developing scientific investigations to answer their questions" (2004). In their review, Keys and Bryan (2001) suggest that teachers' use of inquiry based instruction often comes out of student asking authentic questions in class, and the teacher provides students with the opportunity to explore those questions. However, this task becomes even more difficult when, on average, fewer than three hours per week is set aside for science teaching in the elementary classroom (NCES, 2007).

Cohesive inquiry units also require the use of authentic formative and summative assessments that teachers can improve on by nurturing a classroom culture of assessment that is informative rather than judgmental. In developing relevant criteria for assessment of scientific thinking, and including vital elements in planning lessons, teachers can effectively inform their science inquiry instruction through assessment (Peters, 2008). The inquiry assessment's main goal is actually determining the extent of student learning in order to inform future instruction, rather than placing judgment on the value of work, a difficult feat in the current atmosphere of standards-based education and assessment.

Informal inquiry assessments such as two-way journaling, peer-assessment, and self-assessment may help promote a positive and informative assessment culture in the classroom. In addition, ways of knowing in science, processes of science, and science content are necessary components of scientific inquiry, deeming it necessary to include these concepts as part of student assessment (Peters, 2008).

External Factors Influencing Science Inquiry

The ways in which future teachers learn science powerfully influence how they later teach it to their own students. Yager (2005), one of the original writers of the NSES, called for the reform of science teacher education in today's universities to meet the global challenges of the education system. For elementary teachers, the gap between their personal science learning experiences as students and the demands they face when they enter their own classrooms as teachers is often vast and difficult to bridge (NRC, 1996, 2000, 2012). Ford, Fifield, Madsen, and Qian (2013) argued that science teacher preparation programs, which focus on incorporating inquiry, are crucial in developing the teachers' knowledge of inquiry instruction (a dimension of PCK), increase personal science teaching efficacy, and inspire an appreciation of problem-based learning as a model of instruction appropriate for elementary teaching PCK. Whereas traditional introductory science courses relied on delivering overwhelming amounts of scarcely contextualized science content to students, the reform-based science education methods course the prospective teachers were exposed to focused on using students' inquiry learning and teaching experiences to stimulate critical reflection, thereby bridging the gap between the teacher's personal science learning experiences and their classroom practices (Ford et al., 2013).

Engaging K-12 students with authentic inquiry experiences that progressively approximate scientific practice has been a consistent and major theme in science education reforms for the past half century. Toward achieving this goal, Houseal, Abd-El-Khalick, and Destefano (2014) delineate a three-step process for effective implementation of these reforms. The first step is to promote science teachers' understandings of scientific content and inquiry by engaging them with experiences similar to what they are expected to practice in their own classrooms. Taking Science to School (NRC, 2007) called for engaging teachers with "ongoing opportunities to learn science. . . [that] should mirror the opportunities they will need to provide for their students" (p. 7). In addition, the Framework (NRC, 2012) emphasized the need for professional development for science teachers that prepared them to meet the challenges of the Next Generation Science Standards in terms of disciplinary core ideas, crosscutting concepts, and scientific practices. The second step Houseal et al. (2014) claimed necessary in successful reform implementation is supporting teachers as they transfer their newly acquired understandings and skills in order to transform their own instructional practices. The assumption that the combined impact of the first two steps will eventually transform students' experiences in science classrooms to include engagement with approximations of authentic inquiry or scientific practice is the third and arguably the most problematic step in reform (Houseal et al., 2014). Motivated by these same reform-based science methods, Loyola University Chicago's teacher preparation program, Teaching, Learning and Leading with Schools and Communities (TLLSC), is tactically designed to prepare elementary science teacher candidates by developing their deep understandings of science concepts and practices aligned with the Framework, developing skills in assessing their student progress, and making evidence-based decisions in the classroom (Smetana, Coleman, Ryan, & Tocci, 2013).

Changing in-service teachers' instructional practices is not an easy task to accomplish, and the NSES promote practices that mean dramatic changes for most teachers. Putting changes such as the enacting of inquiry science instruction into practice is demanding for teachers, and has its challenges, deeming professional development essential for teachers and a crucial aspect of successful implementation of this type of instructional reform (Yager & Akcay, 2010; Harris & Rooks, 2010). A study that tracked science teachers' use of inquiry found that although inquiry-oriented science teaching was a significant component of current reforms in science teaching, relatively little work had been done to determine what science inquiry teaching looks like, as defined by the NRC (2000) and others (Ruebush, Grossman, Miller, North, Schielack & Simanek, 2005). Although this study explicitly characterized teachers' knowledge of specific inquiry abilities, such as asking and answering scientific questions, making explanations based on evidence, and communicating and justifying findings, only a few teachers demonstrated these practices in the classroom. High leverage practices (HLPs) that constitute science inquiry teaching (Ball, Sleep, Boerst, & Bass, 2009) need to be outlined, modeled for, and practiced by the science teachers in order to facilitate effective implementation of this reform in their respective classrooms.

Tseng, Tuan, and Chin (2013) stated that more experienced teachers contended that their sustained science inquiry practices in their respective classrooms were due to their positive experiences in inquiry during their own professional development. They strongly advocated that training teachers to implement science in the classroom should include inquiry learning experiences in order to recognize how meaningful and powerful inquiry is for students in their understanding of science concepts. Similarly, the teachers in the Gillies and Nichols (2015) study enjoyed the first-hand experience during their professional development of the same inquiry practices they were to implement in their own classrooms, which may have contributed to their willingness both to implement the inquiry during the professional development, as well in the classroom.

Evidence indicates that teachers who had previously taught the inquiry-oriented curriculum had greater student gains, which should promote professional development to allow science teachers more opportunity to teach inquiry in order to maximize its effectiveness (Fogleman et al., 2011). Interestingly, students who completed investigations themselves had greater learning gains compared to students in classrooms who observed their teacher completing the investigations as demonstrations (Fogleman et al., 2011). Furthermore, teachers who had previously enacted the reform based curriculum had larger student test gains than teachers who were using the curriculum for the first time, demonstrating the necessity of time for increased teacher efficacy in using innovative science curricula (Fogleman et al., 2011). Therefore, in order to have successful student inquiry learning in science classrooms, teachers who are new to the ideas that define inquiry-based learning in science must be allowed to invest the time necessary to become comfortable with the essential concepts and pedagogical skills involved. These training efforts and supports should begin by establishing the foundations of science content knowledge about inquiry, and developing the pedagogical content knowledge (PCK) of the teachers thereafter (Shulman, 1987).

Research suggests the importance of having teachers, who are playing the role of students during professional development, actively engaging in inquiry investigations to develop understandings of inquiry pedagogy. Without genuinely understanding scientific inquiry and emulating the specific skills associated with it, teachers are unlikely to be successful in teaching science through inquiry. According to Akerson and Hanuscin (2007), providing participants with mentors and models for implementing inquiry is a necessary component to maintaining a successful professional development program. Participants and researchers in the study concurred that the best way to learn about teaching authentic inquiry was through immersion in an inquiry exercise, tool development, and the subsequent application of these tools to open-ended questions. Metacognitive activities were also suggested by Baker et al. (2009) to be emulated in professional development for inquiry-based teaching strategies, in that teachers engage in reflective writing in notebooks or use a self-check form that identifies depth of understanding. Additionally, they are shown how to provide academic feedback to students using rubrics and examples of poor and quality work. Teachers are thereafter encouraged to modify and use these techniques to develop their students' ability to engage in metacognition in their classrooms. Ruebush et al.'s (2005) professional development model incorporated inquiry based learning throughout the professional development with the use of group problem solving, interpreting complex data sets, thereby encouraging the participants to defend their scientific models and reexamine their findings in light of other's interpretation of data.

In advocating for the training and professional development of teachers in science inquiry instruction, one must keep sight of the bigger picture, the context of implementing standards-based reforms like inquiry instruction in schools. Spillane (2004) describes the customary design for standards-based reform within the school setting to include the core elements of "development of curricular frameworks, alignment of state policies, teacher professional development, and development of accountability mechanisms" (p. 10). He elaborates on how the national standards and the state of Michigan's science standards both "promoted a major transformation in the pedagogy of science education toward an approach that was grounded in students' prior knowledge of scientific ideas" (p. 28). With this ambitious framework set forth by the state came the difficult task of aligning state policies, which fell into the hands of state policymakers, and changes in existing classroom practices. These state policymakers did not have adequate resources to effectively implement the lofty and new standards, nor were they the only reforms on their respective agendas. In referring to the Michigan example, "three state coordinators could not single-handedly reform science and mathematics in Michigan, [and] even if they had an abundance of funds, they were unlikely to reach more than a small fraction of Michigan's teachers" (p. 32). In addition, the messages conveyed by school leaders are not always in line with the proposed curriculum reform, and this discrepancy may further influence how teachers implement the curriculum in their classrooms (Coburn & Russell, 2008). Therefore, in facing these challenges in aligning policies with reforms, school leaders and policy makers may indirectly stifle efforts to support professional development for the reform, which in this case would be science inquiry.

Coaching is rapidly becoming the go-to strategy to support implementation of curricular reform in school districts. Yet Coburn and Russell (2008) argue that the coaching role does not necessarily increase the teachers' access to expertise in implementing these new initiatives, and that professional development is equally important for coaches and teachers. It is important to foster greater expertise in coaches because when they tap into fruitful professional development experiences, they will then more effectively impact teachers who make everyday decisions about curriculum implementation in the classroom (Coburn & Russell, 2008). This sentiment is shared by Spillane (2004), who observed internal, subject matter specialists to be the most successful in taking the initiative in making sense of the district policies about science and mathematics education in the school setting. These internal experts were regarded as the “primary suppliers of instructional knowledge” (p. 60) and fostered dialogue about instruction and best practices among colleagues.

The final component of standards-based reform as defined by Spillane (2004) is the development of accountability policies at the school level. These policies in and of themselves do not construct knowledge for teachers and administrators and are often disconnected from reform implementation activities, thereby creating the arduous task of sense-making for the teachers (Louis, Febey, & Schroeder, 2005). As Spillane explains, "the district administrators want to do good, but they don't know what good is" (p. 74). In making sense of these reforms, concepts that were more familiar to policy makers such as problem solving, hands-on, and integration in where often supported and propagated, while less familiar concepts such as constructivist learning were skimmed over or even ignored. This sense-making resulted in only a scratching of the surface of the standards as opposed to the intended "reconceptualization of science content or scientific inquiry" (p. 83).

Bandura, Self-Efficacy, and Teachers

Bandura (1997) defined self-efficacy as, "[P]eople's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives" (p. 71). Although there are many influences on human behavior, Bandura identified self-efficacy as critically impacting both one's behaviors and practices, as well as the development of one's cognitive skills. A high self-efficacy promotes ambitious intrinsic goals and encourages analytical thinking, whereas low self-efficacy beliefs can lead to diminished quality of task performance. Bandura (1977) posited that an accurate prediction of human behavior can be determined from the knowledge of personal self-efficacy, "a judgment of one's ability to organize and execute given types of performances" (p. 21), and outcome expectancy, "a judgment of the likely consequence such performances will produce" (p. 21). Bandura (1997) explained how self-efficacy can "influence the courses of action people choose to pursue, how much effort they put forth in given endeavors, how long they will persevere in the face of obstacles and failures, their resilience to adversity" (p. 3), and he proposed four main factors that impact self-efficacy: mastery experience, vicarious experience, verbal persuasion, and emotional arousal (Bandura, 1982, 1986, 1993, 1997).

Mastery experience is the interpretation and evaluation the results of performing a task. Successful mastery experiences increases one's personal efficacy belief, while failures decrease it, especially if failures occur before the self-efficacy belief of a person is firmly developed. Establishing resilient self-efficacy beliefs requires experience in overcoming challenges through continuous effort, whereas easy success with quick results may be easily discouraged by failure (Bandura, 1994; Usher & Pajares, 2008). On the other hand, vicarious experiences influence self-efficacy beliefs by observing people who have undergone similar or possess the skills needed to perform similar tasks successfully. The impact of modeling is strong influence for vicarious experience, and the more that the models are similar to the observers, the better they predict successes and failures for the observers. Therefore, learning from a more capable model such as a master teacher can improve self-efficacy beliefs more effectively (Bandura, 1994; Usher & Pajares, 2008). Verbal and social persuasion may also affect one's self-efficacy beliefs. Interestingly, unauthentic positive verbal persuasion, such as unrealistic praise does more harm than good, and can subsequently lead to lowered self-efficacy beliefs (Bandura, 1994; Usher & Pajares, 2008). Moreover, one's mood also affects how people perceive and interpret their self-efficacy, in that increasing physical and emotional well-being and reducing negative emotional states may strengthen self-efficacy beliefs (Bandura, 1994, 1997; Usher & Pajares, 2008).

Many factors influence the way teachers weigh, interpret, and integrate information from these four sources in evaluating their own teaching capabilities. Bandura (1993) explains, “Teachers’ beliefs in their personal efficacy to motivate and promote learning affect the types of learning environments they create and the level of academic progress their students achieve” (p. 117). Teacher self-efficacy beliefs are one of the few teacher characteristics that consistently relates to teaching and learning and are usually separated into two categories: (1) personal beliefs about one’s ability to accomplish a task, or personal self-efficacy and (2) judgements about actual performance on a specific task, or outcome expectancies (Bandura 1997). A teacher’s outcome expectancy largely depends on his/her judgment of how well they will be able to perform specific tasks, within a given context (Bandura, 1997; Pajares, 1997; Woolfolk Hoy et al., 2009). Research has consistently concluded mastery experiences, the interpreted result of one’s task performance, to be the most powerful source of self-efficacy (Usher & Pajares, 2008; Zimmerman, 2000). Additionally, effective mentors may also promote a positive sense of efficacy by structuring situations for those being mentored that bring about success and self-improvement (Bandura, 1994; Usher & Pajares, 2008). The importance of such self-efficacy mentors is particularly important in the first years of teaching where can lead to support increased efficacy beliefs (Woolfolk Hoy, 2000).

Comparable to Bandura’s self-efficacy framework and its two subcategories is the theory of personal agency beliefs, which analyzes how people achieve goals (Ford, 1992). Capability beliefs, similar to Bandura’s (1997) personal self-efficacy, are beliefs about one’s ability or skill to meet a particular goal, whereas context beliefs are beliefs about responsiveness of the environment include the role of the entire context or sociocultural environment in achieving desired goals. In an educational setting, context beliefs would include the students, administrators, parents, other teachers, institutions, organizations, and the physical environment (Ford, 1992). Ford contended that the identification and development of these personal agency belief patterns to be crucial in motivating people into specific target behaviors and performing of tasks, thereby motivating or hindering people from achieving their goals. Interestingly, Ford argued that his context belief concept to be more incorporating of the total environment that Bandura’s construct of outcome expectancy, because it went beyond simply defining the connection between a person’s actions and the context’s response to the action. Bandura (1997) later broadened his view of outcome expectancy and delineated an additional type of efficacy called Collective School Efficacy (CSE). Factors influencing this collective school efficacy include administrative support, student and teacher characteristics, and parental involvement.

Bryan (2012) summarized over three decades of research about the nature of teacher beliefs and concluded that these beliefs are more influential on a teacher’s decisions in regards to practice than academic knowledge, some beliefs are more strongly held than others, and thereby more resistant to change, and that one’s various beliefs coexist with one another and are influenced by contextual factors. With that in mind, it is therefore understandable that teachers with high self-efficacy tend to be more organized and generally plan better than those without a strong sense of efficacy. They also tend to be more open to new ideas and innovations, more willing to experiment with new teaching methods, and are more likely to use beneficial but sometimes difficult-to-manage practices such as inquiry and small-group work in their classrooms. Furthermore, high self-efficacy teachers tend to exhibit greater enthusiasm and commitment to teaching (Tschannen-Moran & Hoy, 2007).

Teachers' Beliefs and Science Inquiry

Recommendations from science educators have currently placed learning through inquiry at the core of science instruction for more active engagement of learners in the processes of science (AAAS, 1993; Bodzin & Beerer, 2003; Bybee, 1997; NRC, 1996, 2000, 2007, 2012; Rakow, 1986; Schwab, 1962). But, despite calls for science instruction reform since the launching of Sputnik (Barrow, 2006; Kelly & Staver, 2004; Pine et al., 2006), most science teachers have maintained the traditional method of science instruction. In order to understand how reform-based teaching can be done by new teachers, there is a strong consensus among scholars that teachers' beliefs and self-efficacy about the nature of science are important in science education today (Bybee, 1997; Pajares, 1992).

Teachers are the most vital factor in determining whether, and to what extent, their classrooms will embrace reforms-based teaching and learning (Bybee, 1997; Yager, 2005). All science teachers have beliefs about the teaching practice, and these beliefs may be a significant factor in the implementation of science education reform efforts. Extensive literature on teacher beliefs assert that teacher actions are heavily guided by personally held systems of beliefs (Bybee, 1997; Pajares, 1992). Work by Pajares supports the idea that multiple beliefs around a particular situation form attitudes and that these attitudes translate into action items. Friedman and Kass (2002) elaborated on this notion and explain how a “[t]eacher’s perception of his or her ability to perform required professional tasks and to regulate relations involved in the process of teaching and educating students” (p. 684) contributes to classroom efficacy. Furthermore, Keys and Bryan (2001) argued that almost every aspect of science teaching is influenced by teachers' attitudes and beliefs, including how they acquire and interpret knowledge, select instructional tasks for students, interpret science content, and design assessments.

A foundational study on the relationship between teacher beliefs and their intentions to implement reform-based teaching strategies in the classroom was conducted by Haney, Czerniak and Lumpe (1996), who posited that the intention to implement reform would be a direct result of teachers’ salient beliefs and attitudes towards the reform strategy, perceived social norms in their school context, and perceived behavioral control. Their research results in fact indicated that, “teacher beliefs are significant contributors of behavioral intention” (p. 985), and that a teacher’s attitude towards reform was the greatest contributor to a teacher’s planned intentions, whereas perceived behavioral control contributed moderately and perceived social norms contributed very little to their intention to implement reform-based teaching strategies. Since attitudes towards reform were so important, Haney et al., thereby proposed that developing positive attitudes could be an anchor for achieving reform, and further suggested that feelings of self-efficacy or success with reform-based teaching experiences might foster positive attitudes about reform. This phenomenon is demonstrated in Marshall, Horton, Igo, and Switzer’s (2009) study of over a thousand teachers at the elementary and secondary levels, which found that teachers with higher self-efficacy were more likely to have their students engage in inquiry, a reform-based science teaching strategy.

Anderson (2015) supported the findings of other researchers concluding that beliefs about purposes of science education, the nature of science, and science teaching and learning strongly influenced teacher practice and knowledge. Beliefs about the purposes of science education were found to be a particularly strong influence on practice in the observed cases. However, beliefs about students and the teachers' aims for education generally, as well as teachers' notions concerning vertical science curriculum, were also crucially influential on the type of science learning opportunities that were promoted. Additionally, teachers' beliefs influenced the nature of both subject matter knowledge and pedagogical content knowledge for science developed by the teachers. This phenomenon is best explained by Woolfolk Hoy et al. (2009), "[T]eachers who lack confidence in their knowledge of science content and pedagogy tend to deemphasize or avoid science teaching or teach using transmissive as opposed to inquiry methods" (p. 632).

The nature of teacher beliefs that influence learning has also received attention from researchers, with the recognition that they powerfully influence classroom practice (Mansour 2009; Pajares 1992). The distinction between knowledge and beliefs is not always made clear in research or agreed upon by researchers. For that reason, many teacher knowledge frameworks for science, such as that developed by Abell (2007), include beliefs along with knowledge. Recently, a role for teacher beliefs has been suggested in the development of pedagogical content knowledge (PCK) (Friedrichsen, Van Driel, & Abell, 2011; Gess-Newsome 2013).

Beliefs come in many forms including perceptions, attitudes, values, implicit and explicit theories and stem from processes of enculturation and social construction and are therefore highly contextualized (Mansour, 2009, 2013; Pajares, 1992). Bryan (2012) distinguished between espoused beliefs, which are self-reported statements and claims about the nature of things, and beliefs inferred from practice as observed from teachers' actions. The research highlighted inconsistencies between espoused beliefs and observed practice, which may be explained by Mansour's (2009) research showing that influencing factors, such as assessment pressures, a teacher's confidence with particular content, or lack of equipment, moderate the outworking of teachers' educational beliefs in the classroom. Furthermore, Pajares (1992) offered another explanation to these inconsistencies, by examining both the connected nature of beliefs and their contextualization, because different connections and applied values come into play in different circumstances.

Little of the aforementioned research on teachers' beliefs discussed above focuses specifically on primary teachers. Shulman (1987) noted that, while reasonably confident, he was not sure that his emphasis on the centrality of content knowledge held true for elementary (primary) teachers. Much of the research on PCK refers to secondary science teachers and focuses on PCK for specific topics. Studies of teacher knowledge and beliefs in the primary sector are few. Appleton (2006) stated that primary teachers often view science as a complicated set of facts and definitions to be found in accurate sources such as books, views that impact on the nature of teaching and learning that occurs. Fitzgerald, Dawson, and Hackling (2013) found that beliefs and practice were very intertwined for the primary teachers they studied.

Although the research is limited, there appears to be a role for beliefs in the development of primary teachers' knowledge for science teaching. Views of science as difficult and in the realm of experts (Appleton, 2006) can affect teacher confidence or self-efficacy, if such knowledge is seen as too difficult to attain. Appleton highlighted the role of confidence in beginning to teach science and consequently in the development of PCK that comes through the teaching of science. Primary teachers who believed that they were able to and should develop the knowledge they needed to teach science, actively sought out the content knowledge they needed (Fitzgerald et al., 2013; Mansour, 2009), thus influencing the elementary science teachers' knowledge development.

Anderson (2015) pursued research to examine the nature and influence of knowledge and beliefs of elementary teachers from schools well regarded for their science programs during the implementation of a unit of work in science. The study focused on the influences on the nature and focus of learning opportunities provided for students during the science unit, and the influences on the nature and development of teacher knowledge for science teaching and learning, specifically, science PCK and subject matter knowledge. Anderson contended that while views on the importance of practical work for learning meant that opportunities to engage in such tasks were provided, the influence of teachers' beliefs about the goals of science education was significant in terms of the learning focus developed through these activities. As

Fitzgerald et al. (2013) found in their study of effective Australian primary science teachers, the science teaching practice of these well-regarded New Zealand primary science teachers was strongly intertwined with their beliefs, and their espoused beliefs were most often reflected in their practice.

Although beliefs about the aims of science education, beliefs about science itself, the teachers' general educational aims for their students, beliefs about student needs and interests, beliefs about vertical curriculum, and beliefs about students and how they learn in science were all found to be influential on science learning in the classroom, the teacher beliefs that Anderson (2015) found to most strongly impact the focus of science learning opportunities experienced by students were those concerning the purposes and goals of science education. The differing beliefs of each of the teachers in this respect resulted in a wide variety of aspects of science learning for their students. The findings of the Anderson study support Friedrichsen et al. (2011) proposition that teacher beliefs about the nature of science, the purposes of science education and the nature of science teaching and learning may be key belief clusters that lead to particular classroom practices.

Anderson (2015) therefore concluded that beliefs about the purposes for science learning were the strongest influence on classroom practice, while beliefs about students and how they learn had a less significant impact on the focus of science instruction. Additionally, teacher beliefs, in particular those about the goals and purposes of science teaching, were also found to be strong influences on the development of teacher knowledge for science, affecting development of both PCK and subject matter knowledge. These results may be explained by Gess-Newsome's (2013) consensus model of teacher professional knowledge for science, which contended that teacher beliefs filter and possibly limit the type of classroom practices enacted by the teacher, thereby limiting the teacher's professional knowledge for teaching that topic.

The strong influence, demonstrated in Anderson (2015), of teachers' beliefs on student opportunities for learning in science and on teacher knowledge development suggested that teacher beliefs should be a focus of initial teacher education and further professional development in science. Lumpe, Czerniak, Haney, and Beltyukova (2011) found that elementary teachers who participated in a long-term, intense science professional development program, with over 100 contact hours annually, displayed significant gains in their science teaching self-efficacy. These findings support those of other studies in contending that teacher beliefs about the purposes of science education as well as about science itself should be a key focus in professional development. It additionally proposes that encouraging primary teachers to consider the impacts of their more general educational aims for their students on their science programs as being useful.

Beliefs about science teaching and learning have a renowned impact on a teacher's classroom practices (Anderson, 2015; Fitzgerald et al., 2013; Crawford, 2000, 2007; Friedrichsen et al., 2011; Lotter, Harwood, & Bonner, 2007; Waters-Adams, 2006). Kagan (1992) reviewed 27 empirical studies on the change of beliefs, behaviors or images of pre-service teachers and found that beliefs usually remain unchanged throughout teaching education programs and follow pre-service teachers into student teaching. She also found that many of these beliefs were based on pre-service teachers' own experiences in school. In addition, Keys and Bryan (2001) suggest that knowledge of teachers' beliefs is instrumental in understanding how inquiry is actually implemented in the classroom. Furthermore, Shulman (1987) suggested "The teacher also communicates, whether consciously or not, ideas about the ways in which 'truth' is determined in a field and a set of attitudes and values that markedly influence student understanding" (p. 9). However, there is no magic formula for conducting science inquiries. There are many classroom activities that fall on various positions on the inquiry continuum, and teachers must be allowed to choose those activities that they feel will be most successful in their own classrooms based on their own comfort with the subject, their prior knowledge and perceptions of their students, and the level of cognitive development characterizing their individual students (Yager & Akcay, 2010).

A student's knowledge of science, technology, engineering, and mathematics (STEM) begins during their elementary years. Recognizing the association between teacher preparation to teach STEM and student achievement in science, Nadelson, Callahan, Pyke, Hay, Dance, and Pfiester (2013) created, implemented, and examined the impact of a professional development program to address elementary teacher confidence for, attitudes toward, knowledge of, and efficacy for teaching inquiry-based STEM. An essential component of the STEM curriculum is the providing of opportunities for students to engage in authentic inquiry applications, hence the yearlong professional development program with a three-day summer institute focused on increased inquiry-based STEM teaching strategies, in addition to the exposure to the work of engineers. The professional development continued through the school year with online education modules and extensive support. The participating schools were chosen based on interest from the school principal to involve the teachers in STEM-related professional development, but many teachers were surprisingly reluctant to commit even with the enticements of paid college credits and classroom instructional materials. Results of the second year correlation analysis indicated increased age to be significantly related to more positive attitudes toward engineering ($p < .05$). In addition, both Year 1 and Year 2 cohorts' comfort with teaching STEM content was found to be positively correlated with knowledge of STEM content ($p < .01$), with efficacy for teaching STEM ($p <.05$) and with confidence in teaching STEM ($p < .05$), albeit with varying strengths. Overall, the findings showed variations in years of experience and age contributed to different outcomes in attitudes toward engineering, but indicated overall that the three-day professional development institute had a significantly positive influence on the first- and second-year participants' efficacy for teaching, confidence in teaching, and knowledge of STEM content, and the impact was consistent between the two years. The significance of the findings suggest that teacher professional development in STEM should focus on enhancing content knowledge as a means of impacting factors that influence teacher practice. In addition, the participants' years of teaching experience was not associated with the knowledge and comfort with teaching STEM or a greater feeling of effectiveness for teaching STEM, thereby deeming professional development in STEM knowledge necessary throughout an elementary science teacher's career.

The Lee et al. (2004) study described teachers' initial beliefs and practices about inquiry-based science and examined the impact of a professional development intervention on those beliefs. The research involved all 53 third and fourth-grade teachers at six elementary schools in a large urban school teaching students with diverse languages and cultures. The researchers contended that elementary teachers, especially those with culturally and linguistically diverse students, required professional-development opportunities to make science accessible, relevant, and meaningful for their students. Teachers indicated that the PD impacted the way they structured the science lessons for students and led them to develop lessons involving more hands-on activities and classroom discussion to promote group work during inquiry activities. Moreover, teachers, especially those of ELL students, described greater knowledge of subject matter and claimed that both the students and they themselves had more positive views about science as a result of the PD. Findings showed statistically significant changes in teachers' responses on the questionnaire for both the importance they ascribed to and their perceived knowledge of teaching science inquiry. On the other hand, statistical analyses of classroom observation data revealed teachers' instructional practices to not change significantly with regard to any of the four constructs of science instruction. The implications of the discrepancy between teachers' perceptions of their improved science knowledge and practice and the lack of significant change in their actual instructional practices point to the need for further professional-development efforts designed to help teachers fully implement reform-oriented instructional practices.

Choi and Ramsey (2009) have indicated that teachers' beliefs, attitudes, and practical knowledge are crucial factors in promoting a reform-based curriculum such as inquiry-based science instruction. In order to make science meaningful for all children, teachers must be capable of responding effectively to education reform, including the incorporating of inquiry-based science lessons. The current reforms in science education thereby dictate changes in teacher preparation programs to ensure teachers are exposed to inquiry-based teaching approaches. The majority of the elementary school teachers in this study did not have any beliefs about inquiry-based science instruction before the course due to their lack of exposure to and experience with this type of pedagogy. After completing the course, all of the 14 teachers constructed or expanded their beliefs on inquiry instruction and realized that it involved student-centered, open-ended exploration, and a deeper understanding of concepts that ultimately led to meaningful learning of science. Furthermore, the participants responded they no longer felt uncomfortable with the inquiry approach, while most agreed they actually enjoyed the use of science equipment and planning inquiry-instruction. The findings indicated that the teachers' beliefs, attitudes, and practical knowledge about inquiry were clearly influenced by the course. The majority of the teachers developed positive beliefs and attitudes that promoted inquiry instruction, improved their knowledge and skills of conducting inquiry, and successfully practiced inquiry-instruction in their science teachings. This study posed two major implications for implementing inquiry-based science instruction in the classroom. Firstly, teachers in this study stated that they needed more exposure to learning inquiry-based science instruction. Secondly, beliefs and attitudes towards inquiry-based science instruction of participant teachers may affect the practice of inquiry in teaching science in their classroom.

In addition to recommendations for the effectiveness of professional development, Supovitz and Turner (2001) presented some valuable data about barriers to implementing reforms. Teachers with more positive attitudes about the reform efforts and those with greater content knowledge were the most significant variables resulting in greater reforms-based instructional practices and classroom cultures. While support from principals and availability of school resources was important, this factor did not have as substantial an influence on teachers' use of inquiry-based instructional practices. Moreover, Van Aalderen-Smeets and Walma van der Molen (2015) contended that improving attitudes is a first and essential step for teacher professional development in science education. This approach is in accordance with the increasing consensus that science should be taught as the process of acquiring scientific knowledge (inquiry based learning approach) and should stimulate an understanding about the nature of scientific inquiry, rather than teaching science as a body of knowledge.

Van Aalderen-Smeets and Walma van der Molen’s (2015) attitude-focused training course positively influenced teachers’ self-efficacy beliefs regarding science and science teaching, thereby leaving them feeling more capable to teach science and to deal with science in daily life. In addition, the teachers also enjoyed teaching science more, felt less anxious about science, regarded science as being relevant to society, and felt less dependent on contextual factors in order to be able to teach science. Furthermore, these improvements in their attitudes impacted their self-reported science teaching behavior in that they reported to conduct more science related activities in their classroom. The results of the aforementioned study indicated that an attitude-focused professional development had positive effects on primary teachers' professional and personal attitudes towards science, demonstrated by the significant impact on teacher participants' self-reported science teaching behavior and science related activities in daily life.

Islamic School Education

Culture, as defined by Geertz (1973), is "an ordered system of meaning and symbols, in terms of which social interaction takes place….Culture is the fabric of meaning in terms of which human beings interpret their experience and guide their actions" (pp. 144-145). Within a given culture, there are norms, expectations, and meaning systems that its members associate with, and the school culture and its teacher members are no exception. When discussing the cultural context of school, Saka, Southerland, Kittleson, and Hutner (2013) refer to "the systems of meaning in place in a school, such as norms, expectations, and ways of thinking and acting that characterize how people act and interact in this particular context" (p. 1223), and posited that examining the school's cultural context is crucial to understanding how it shapes a teacher's induction experience specifically, and ultimately a teacher's overall identity. Their research claimed the cultural context of the school in which a teacher begins his or her professional career heavily influences the extent to which the teacher enacts reform-based practices, thereby highlighting the significance of context in shaping and reshaping teachers' identities. With that in mind, one must consider how the cultural context of an Islamic school shapes the elementary science teacher's identity and classroom practice.

Wertch (1995) described the goal of sociocultural research as the understanding of "the relationship between human mental functioning, on the one hand, and cultural, historical, and institutional setting, on the other" (p. 56). In regards to the educational setting, schools were equipped with suitable cultural tools, which were mediated by teachers to allow students to facilitate actions and solve complex problems, thereby enabling them to make sense of the world (Vygotsky, 1978; Wertsch, 1993). These cultural tools came in the form of chalkboards, overhead projectors, textbooks, computers and digital projectors, in addition to less tangible tools such as language, symbols, belief value systems and specialized discourses and practices (Lemke, 2001). It is evident that one must consider the impact an educational setting's social, cultural, and historical contexts, in addition to its respective cultural tools, has on a teacher's practices.

An Islamic school, as defined by Sirin and Fine (2008), is a religious school where Islamic principles, morals, and values are infused throughout the curriculum, in addition to the academic courses required by the school's respective state. Additionally, Qur'an is taught through Arabic language classes, enabling Muslims to read their Qur'an in this language and understand the meanings of it in English. Islamic schools and other similar organizations emerged in response to the daily struggles that Muslims encounter daily while living within a society that follows a considerably different way of life, in addition to the challenges of the influence of contemporary global events on social interactions (Elbih, 2012). Similar to Catholic, Jewish, and other religious-based communities, Muslim parents have an increasing concern that their children will lose their religious identity and cultural norms in an environment where religion cannot be publicly practiced, namely in the public schools (Keyworth, 2011).

The flourishing of Islamic schools in the United States is a relatively recent phenomenon. The in-depth 1989 study of the Islamic Society of North America (ISNA) recorded a total of fifty Islamic schools in North America. According to more recent research conducted by Keyworth (2011) of the Islamic Schools League of America, there were between 235 and 250 verifiable full-time Islamic schools in the United States at that time, with approximately 35,000 students in attendance. ISNA currently estimates the number of Islamic schools in the United States at about 400 and rising, with the majority of these schools being elementary and middle schools. High schools are found mainly in large states with large Islamic populations, such as Colorado, Michigan, Virginia, and Illinois. The desire for religious education has required the establishment of more Islamic schools in the United States to serve the Muslim populations. The Islamic Society of North America (ISNA) stresses on this point as well by Zarzour (2003) who explained:

> Islamic schools in the United States are a true grassroots' effort. Local leaders of the Muslim community all over the country are responding to a growing need in the community for Islamic schools by establishing schools at a fast rate. Most Islamic schools start out as a labor of love by a few extremely dedicated people who, at any cost, would like to provide their children and Muslim children at large a safe and supportive environment so they can learn not only reading, math, and writing, but also to learn about their religion and culture. (p. 1)

Numerous researchers (Barnaby, 2009; Haddad, Smith, & Moore, 2006; Keyworth, 2011; Merry, 2005; Nimer, 2002; Sirin & Fine, 2008) argue for the importance of Islamic schools as a legitimate substitute for public schools, in light of the increased marginalization and religious discrimination experienced by many Muslim students post-9/11. They are regarded as safe spaces in which Muslims learn Islamic knowledge and while protected from the un-Islamic behaviors such as drugs, alcohol, and premarital sex. Additionally, Islamic schools are a welcoming environment for Muslim women to express their religiosity and wear their Islamic dress code without discrimination. Merry (2005) contends the primary motivations for those parents who opt for Islamic schools are for religious, academic, and cultural reasons, usually in this order of importance. Fueled by recent immigrants with a more conservative religious identity as well as converts, the demand for Islamic schools is inexorably on the rise, and waiting lists at many schools are long, particularly in the younger grades (Merry, 2005).

Interest in Islamic schools throughout the West has grown considerably in recent years, but paradoxically, only a relatively small fraction of Muslims enroll their children. Although preparedness to live in a society with very different values rests mainly on the shoulders of the parents, Muslim parents are often torn over whether or not to send their children to Islamic schools (Merry, 2005). There are several debates in the literature about Islamic schools; among those debates is whether Islamic schools segregate Muslim students, thereby encouraging religious intolerance and rejection of society’s democratic and pluralistic ideals (Elbih, 2012). Additionally, there are discussions of whether Islamic schools are capable of developing a strong Muslim identity skilled to tackle future challenges (Halstead, 2007). Furthermore, some Muslims believe public education offers the best chance for their children to succeed by allowing them to socialize with their future coworkers, neighbors, and fellow citizens (Nimer, 2002).

Muslims parents are aware that their children need more than Muslim religious education made up of Islamic teachings and religious readings. They want their children to be enrolled in different schools and to participate in community activities with other Muslims, because these are the communities they will end up living in. Many Islamic schools in the United States took this point into consideration and have included community service programs, and other extracurricular activities, in their schools. Supporting the views of Muslim parents' on the importance of their children interacting with their societies and keeping their Islamic identity at the same time, Nimer (2002) contends, "parents who send their children to Islamic schools seek to ensure that their children are not only aware of their Muslim identity, but are also able to compete for jobs and college seats after graduation" (p. 55).

Clauss, Shamshad, and Salvaterra (2013) discuss in depth the phases of identity development of Muslims in America, who are largely immigrants, in attempting to adapt to American culture. Several recurring themes emerged from their research including the preserving of an Islamic identity and the Arabic language within the American culture, character building and the immersion in Islamic practices, and, interestingly, dialogue with non-Muslims. Contrary to the belief of the American mainstream, when the participants of the study were asked about the challenges of transitioning to public schools, teachers, alumni, parents, and administrators felt very strongly about the need to be in dialogue with non-Muslims.

The American mainstream, especially since 9/11, has become increasingly concerned that Islamic schools might foster anti-Western attitudes, and are therefore incompatible in integrating Muslims fully into American political and social life (Barnaby, 2009). Islamic schools may create harmony in the society if they teach both Islamic education and liberal democratic values. However, failing to provide good education in both the Islamic and the liberal may fail to produce well-adjusted individuals. Elbih (2012) argued that Islamic schools could ultimately act as ambassadors, bridging the gap between Muslims and American society by teaching the students both an Islamic education and liberal democracy's values, thereby ensuring a quality education for Muslim children and therefore benefit the society by producing good citizenry.

A database review indicated that although numerous studies have been conducted in regards to the identity (Barnaby, 2009; Elbih 2012; Halstead, 2007; Sirin & Fine, 2008), parental choice (Badawi, 2005; Elkhaldy, 1996), and gender issues (Merry, 2005; Nimer, 2002; Istanbouli, 2000) in Islamic schools, relatively few research studies have been carried out in Islamic schools in regards to curriculum and instruction. As a novel phenomenon, Islamic schools throughout the country face many challenges including organization, finance, stability, and accreditation, and Nimer (2002) touched upon one aspect of this situation by affirming:

> Generally, Islamic education suffers in the absence of quality control on curriculum and the lack of teacher development programs and instruction methods. There are no regional or national board's to help in the development of standards of learning, codes of conduct, and testing policies as there are, for example, in the case of Catholic schools. (p. 62)

First and foremost, an Islamic school is an actual school with teachers, students, and administrators working together, albeit within a unique culture. The curricular challenges faced by Islamic schools need to be studied, in order to address these challenges. Elsegeiny (2005) studied the leadership style and tasks of principals in Islamic schools in the United States and suggested that the leadership characteristics of Muslim principals in Islamic schools were very similar to those of other U.S. principals. Al-Lawati and Hunsaker (2007) researched the challenges of differentiation for gifted students in Islamic school classrooms and found that teachers at Islamic schools appear to be limited in their choice of differentiation strategies. Selby (1994) studied the history curriculum within the Islamic school setting. This dearth of research and the increased challenges suggest the dire need for further curricular study of Islamic schools in the United States.

Conclusion

During the second half of the twentieth century, good science teaching and learning has come to be distinctly and increasingly associated with the term inquiry (Anderson, 2002). If we are to achieve the scientific literacy goals as specified in reform documents such as and the National Science Education Standards and the Next

Generation Science Standards, extensive professional development efforts relative to inquiry are crucial, in addition to the establishing of adequate support systems within the schools, to promote and encourage inquiry-based science instruction. Most science teachers have never directly experienced authentic scientific inquiry during their education in the sciences or within teacher education programs. Teachers need to be well versed in scientific inquiry as an instructional approach, a set of process skills, and a content area. Furthermore, teachers need to develop specific science inquiry pedagogical content knowledge (PCK) to implement science inquiry effectively in the classroom (Shulman, 1987). In doing so, teachers may need to adjust their attitudes and beliefs about the value of inquiry knowledge and as important, if not more so, as “traditional” subject matter. Having the knowledge and the ability to teach scientific inquiry is of little use if science teachers do not value the importance of these instructional outcomes. Given that inquiry-oriented instruction can fall along a continuum of more to less student-directed (NRC, 2000), Davis et al. (2006) suggest that new teachers engage in more guided inquiry instruction strategies that involve more teacher direction until they overcome some of the previously mentioned challenges. In addition, science teacher trainers should engage in reform-oriented practices as with their teacher trainees as inquiry learners if they are to learn more inquiry-oriented teaching practices, become more knowledgeable about the science content, and apply this knowledge in their classrooms (Davis et al., 2006; Fogleman, et al., 2011).

The complicated task of classroom teaching is ultimately one of transformation, the ability of a classroom teacher to manipulate the subject matter of an academic discipline into the subject matter of a school subject in a manner appropriate for teaching and learning in classrooms (Deng, 2007). The above mentioned studies reveal that not every challenge that a teacher faces in implementing science inquiry can be bettered by teacher education, induction programs, professional development, or other supports, and some issues need to be addressed at the institutional or policy level. Most importantly, school policy makers need to provide support to the teachers that correlate to the challenges faced in implementing the new standards (Spillane, 2004). The picture would not be complete if we did not recognize the continuous struggle of policy sense-making at the district, school, and classroom level. Although policy and classroom instruction are usually seen as detached from one another, recent attempts in truly understanding science inquiry reform offer some cause for optimism in its successful implementation (Spillane, 2004).

Moreover, research has clearly indicated the need for additional research on changing teachers' beliefs and practices to meet the vision of science education reforms. With such limited research published on reforms-based instruction in elementary science, investigations that provide additional, varied accounts of these practices are essential. These include studies that address how teachers at different stages of their careers, and those with varying levels of background knowledge and beliefs about science instruction are implementing reforms, experiencing professional development strategies, and handling barriers.

In examining the above issues, I intend to establish that some elementary teachers, although well-intentioned, often do not have the content and pedagogical expertise to satisfactorily implement the newly established standard-based science reforms, thereby requiring aggressive and detailed training programs for them. Spillane (2004) suggests that limited implementation of reforms are not accounted for by resistance from teachers and administrators, rather the limited resources to provide adequate teacher professional development and proper accountability mechanisms. In addition, the extent of teacher implementation of science inquiry instructional practices in the classroom also seems to depend on effective professional development strategies (Davis et al., 2008; Ruebush et al., 2005).

Framing this study is the understanding that sociocultural perspectives to teaching and learning are based on the concept that human activities take place in cultural contexts and are facilitated by language, symbol systems, and other cultural tools (Lemke, 2001). John-Steiner and Mahn (1996) stated, “a sociocultural approach emphasize[s] the interdependence of social and individual processes in the co-construction of knowledge” (p. 1). In the science classroom, social interaction and construction of knowledge are viewed from a sociocultural perspective as an interdependent phenomenon. As such, the science classroom that does not emphasize Vygotsky’s (1986) internalization will suppress the necessary practices for both teachers and students and become a classroom that would fail in promoting the type of paradigm shift (Kuhn, 1962; Zapata, 2013) necessary to fulfill the call of NSES and NGSS.

CHAPTER III

METHOD

Purpose

Since the publication of the NSES in 1996, with its emphasis on learner-centered, constructivist pedagogies, researchers have investigated how to best help teachers understand the reform goals and translate these into effective classroom practices. Despite these foundational reform efforts to clarify what science teaching and learning should entail, researchers asserted that most teachers, especially those that teach elementary science classes, are perpetuating traditional classroom activity structures that "convey either a passive and narrow view of science learning or an activity-oriented approach devoid of question-probing and only loosely related to conceptual learning goals" (NRC, 2007, p. 253) and are ill-prepared to implement reforms-based practices (Anderson, 2007; Keys & Bryan, 2001). In many cases, teachers lack a sophisticated understanding of what constitutes reforms-based science instruction or what authentic inquiry-based science instruction consists of (Gess-Newsome, 2013). This suggests that there is disconnect between the policies, research, and what is taking place in classrooms.

The purpose of this study is to examine elementary teachers' knowledge and understanding of, attitudes toward, and overall perceptions of inquiry-based science instruction, and how these beliefs may influence their inquiry practice in the classroom. Researchers have indicated that teachers' beliefs, attitudes, and practical knowledge are crucial factors in promoting a reform-based curriculum such as inquiry-based science instruction (Bybee, 1997; Choi & Ramsey, 2009; Pajares, 1992). In order to make science meaningful for all children, teachers must be capable of responding effectively to education reform, including the incorporating of inquiry-based science lessons. Although many have studied teachers' beliefs around inquiry-based science, this research sheds light on factors that promote or hinder the implementation of inquiry instruction in the private Islamic schools' elementary classrooms, a specific context that has not been well studied. In addition, this study enables participating science teachers to reflect on their instructional practice and assessment methods and conceivably make modifications for improved students' science achievement. Toward these ends, the following research questions were proposed:

1. How do elementary science teachers in Muslim private schools describe scientific inquiry, and how is it evidenced in their classroom practice?
2. What are the participant teachers' beliefs towards inquiry-based science instruction?
3. What personal and external factors have influenced these practices and beliefs?

Rationale and Purpose of Mixing Methods

Mixed-method designs are defined as those that include at least one quantitative method, designed to collect numbers, and one qualitative method, designed to collect words, where neither type of method is inherently linked to any particular inquiry paradigm (Greene, Caracelli, & Graham, 1989). A mixed-method approach to research is one that combines or associates both qualitative and quantitative methodologies, with an emphasis on diversity and pluralism throughout the research (Tashakkori & Teddlie, 2010). The researcher collects and analyzes data, integrates the findings, and draws inferences using both qualitative and quantitative approaches and methods in a single study or a program of inquiry. Since one data source may be insufficient to understand "social phenomena, which are inherently complex and contextual" (Greene, 2007, p. 14), a mixed methods study provides quantitative outcomes to establish credibility and qualitative data to offer a rich description of the developmental process. This method lends itself to a richer and deeper study compared with quantitative or qualitative study alone, and it seeks to elaborate, clarify, and explain research using different methods to measure different facets of the same complex phenomenon (Creswell & Clark, 2010).

According to Greene (2007), the purpose for mixing methods in social inquiry is "to develop a better understanding of the phenomena being studied" by generating deeper and more inclusive understandings of especially complex human phenomena, such as teaching science (p. 98). The complementarity purpose of mixed method design (Greene, et al., 1989; Green, 2007), where research seeks to elaborate, clarify, and explain by using different methods either within a single research paradigm or across different paradigms, seems to be the best fit purpose for this study. In a complementarity mixed-method study, qualitative and quantitative methods are used to measure overlapping but slightly different facets of a phenomenon, yielding an enriched, elaborated understanding of that phenomenon. The complementary purpose differs from the triangulation purpose in that the logic of convergence requires that the different methods assess the very same conceptual phenomenon. Although the complementarity purpose of this study led to triangulation or a convergence of data in the findings, an initiation purpose emerged from the divergence of some of the data generated as well, which thereby generated and provided new perspectives, insights, and understandings (Greene et. al., 1989).

The mixed methods approach is particularly relevant for the questions posed in this study. Pajares (1992) advocated for obtaining evidence of beliefs from a combination of belief statements, indications of intentionality, and observed behavior, actions and responses concerning the area of belief. He therefore suggested a combination of methodologies to be appropriate in the researching of teachers' beliefs, including open-ended interviews and responses to situations and dilemmas and observation of behavior, in order to make accurate inferences. In using a mixed methods design, I seek to analyze factors that influence teachers' perceptions and beliefs about science inquiry, and the nature and extent of implementation of science inquiry in their respective classrooms, a complex phenomenon in its own right.

An additional benefit of using the mixed method methodology for this study is in adopting this research design's pragmatic approach. Pragmatism places an emphasis on the practicality of the study and what works best to answer the research question (Greene, 2007). Johnson and Onwuegbuzie (2004) advocated for the pluralistic epistemological view of pragmatism, which recognizes multiple ways of knowing and appreciates observation, experience, and experimentation as all being useful ways to gain knowledge and understanding of particular and complex situations. Pragmatism views knowledge as being both constructed and based on the reality of the world we experience and live in, while recognizing the influence of the inner world of human experience in action.

A pragmatic, interpretivist paradigm evidently guided this research. The practicality in examining teachers' understandings, beliefs, and attitudes in using inquiry-based science instruction, may promote a higher quality science curriculum in elementary science classes and support improved teacher practice. Hence, by allowing for the use of different methods and the collection of a variety of evidence types, this paradigmatic stance may enable a more complete understanding of a complex situation (Morgan, 2007). From a more personal perspective, having both a post-positivist mental model which prospered in the field of science, along with the appreciation as a teacher practitioner of the benefits and necessity of a constructivist paradigm for social inquiry, enables me as a researcher to comfortably take a more middle-grounded, pragmatic approach towards research as well.

Research Design/Approach

The study of this mixed method research is best described as a sequential two-strand design (Teddlie & Tashakkori, 2006). Sequential mixed designs develop two methodological strands that occur chronologically, and in the case of this research, QUAN→QUAL. The conclusions that are made on the basis of the results of the first strand thereby lead to the formulation of questions, data collection, and data analysis for the next strand. In other words, the second, qualitative strand of the study is conducted to provide further explanation and depth for findings from the first, quantitative strand. Sequential mixed designs, as is the design for this study, may be easier to conduct by a researcher working individually, like myself, then other mixed methods designs, in that it is feasible to keep the strands separate, thereby allowing the study to unfold at a slower pace and in a more predictable manner.

The final inferences and meta-inferences of this sequential study are based on the results of both strands of the research. Moreover, the sequential design for this research methodology would additionally fall under Greene's (2007) component design cluster, in that the qualitative and quantitative strands remain distinct aspects throughout the study and are implemented independently throughout data collection and analysis. Eventually, the results from both strands are synthesized and interpreted to make inferences and draw conclusions.

The component design of this study initially serves the triangulation purpose of mixed methods research and assesses the same relative phenomena with its different data collecting methods (Greene, 2007, p. 123). Although Greene recommended the strongest convergent study designs to be implemented concurrently so that the phenomena being studied do not change, the designated sequential strands of this study are executed close enough in time to allow for an authentic comparison of the results from each method and an analysis of the nature and degree of convergence, or possibly divergence of the results. Hence, the intended purpose of complementarity may also allow for triangulation when the results converge, initiation when the results diverge, and vice versa.

Context

The Council of Islamic Schools of North America (CISNA) claims membership of over 50 Islamic schools, and other educational organizations nationwide. It also provides services to the over 300 Islamic schools in North America including advocating for Islamic education, facilitating Islamic school accreditation, offering professional development, and fostering professional relationships among educational institutions and agencies. Among CISNA's most prominent programs is the annual Islamic Society of North America (ISNA) Education Forum, which began in December, 1999 and continues to be held in the Chicago area. The Education Forum provides networking and professional development opportunities to over 500 Islamic school educators annually (http://www.cisnaonline.info/). Additionally, CISNA runs an annual professional development conference specifically for Islamic schools in Illinois during the fall.

The Private School Review has documented 16 Islamic private elementary schools in the state of Illinois, serving 3,432 students from grades Pre-K through 12 (http://www.privateschoolreview.com/illinois/islamic-religious-affiliation/elementary). Furthermore, most of these Islamic Schools are current members of the Illinois Coalition of Nonpublic Schools (ICNS), which is the voice of the nonpublic school community and represents more than twenty different nonpublic school associations. On behalf of its member schools, ICNS advocates for funding for the Illinois Textbook Loan Program and the Parent Transportation Reimbursement Program, supports School Choice legislation, as well as consults with Illinois State Board of Education (ISBE) in maintaining a nonpublic school friendly as well as high quality Nonpublic School Recognition review process.

Accreditation and recognition in Islamic schools, as with other nonpublic schools, are both optional. If they choose to, nonpublic schools may gain accreditation through a nonpublic, state-approved accrediting agency, such as AdvanceEd, thereby qualifying as a state-recognized school. After one year of being a registered school, a nonpublic school may submit an application for recognition. Minimum requirements for the recognition of nonpublic schools cover the organization, administration, instructional programs, extra-classroom activities, pupil services, school facilities, school food services, and personnel.

Although the Illinois State Board of Education (ISBE) encourages all teachers at nonpublic schools to have at least a baccalaureate degree in the subject they are teaching, teacher certification is not required for teachers at recognized nonpublic schools. Furthermore, attendance at a nonpublic or parochial school satisfies the Illinois compulsory attendance statute if the curriculum of various academic branches is in the English language. Many Islamic schools, similar to other private schools, do choose to require teachers to hold a teaching certification as a condition of employment. Moreover, they comply with the recognized nonpublic schools requirement of providing instruction in English in language arts, mathematics, biological physical and social sciences, fine arts, and physical development and health education. Despite the general criteria established by ISBE to guide nonpublic schools' instructional and curricular decisions, Islamic schools have full control of how they choose to make these decisions, and the decision-making process may vary from school to school.

In order to compete with the curricular approaches used in their public school counterparts, educators in private Islamic schools may choose to adopt national and/or state standards such as Common Core and the Next Generation Science Standards (NGSS). The Illinois State Board of Education (ISBE) encourages recognized nonpublic schools to participate in local assessment testing. However, ISBE does not require it by law, and the schools do not have to share their test scores with ISBE. Despite it being optional, many Islamic schools, nonetheless, administer yearly standardized tests to their students. These assessments are sponsored by private companies, such as the IOWA Basic Skills Test, and allow the school to compare the performance of their students to the national average (http://www2.ed.gov/about/offices/list/oii/nonpublic/illinois.html).

Participants

According to the Private School Review, there are 16 Islamic private elementary schools in Illinois, serving 3,432 students in Pre-K through twelfth grades (http://www.privateschoolreview.com/illinois/islamic-religious-affiliation/elementary). Initially, principals from these respective schools were contacted by email and/or phone and introduced to the proposed study and survey, in an attempt to facilitate administration of the survey to the science teachers at their schools and attain a higher response rate. Elementary science teachers teaching first through fifth grades from these schools were then contacted via their respective schools' email directory, or other means of communication as suggested by the principal, and asked to participate in completing an online questionnaire about their teaching practices. In an attempt to increase minimal survey responses, science teachers from Islamic elementary schools in Illinois that did not participate in completing the survey initially were contacted via the CISNA Islamic schools' email directory as well. The questionnaire, described in detail below, was distributed via Survey Monkey, with a total of 12 responses received from the original 52 elementary teachers that were invited to participate, representing seven of the 16 Islamic schools contacted.

For the second, qualitative strand of the study, a purposive sampling strategy was used, based on participants' responses on the questionnaire, and their agreement thereafter to be a part of an interview protocol and self-reflection activity. A total of seven participants completed both the quantitative and qualitative strands of the research.

Data Collection

This explanatory, sequential mixed-methods study explored elementary teachers' understanding of, attitudes toward, and overall perceptions of inquiry-based science instruction. In the quantitative phase of the study, initial data from 12 participants were collected, in the form of Likert scale numerical values, whereas the qualitative phase that followed generated data from the interview responses of seven participants and further explained the quantitative findings. The preliminary quantitative strand of research relied on data generated from one specific instrument, the TSI questionnaire, which was administered online via Survey Monkey (see Appendix A). The subsequent qualitative data were collected from the participating teachers through structured face to face interviews (see Appendix B). Additionally, the participants ranked various statements from the ITB instrument as to how much they reflected inquiry-based instruction, and the data collected was both quantitative and qualitative in nature (see Appendix C). The data collection plan is summarized in the table below and described in the sections that follow.

Table 2

Data Collection

Research Question #1 Science inquiry description Evidenced in practice	Research Question #2 Beliefs towards inquiry	Research Question #3 Personal/external factors Influence on practice/beliefs
Teaching Science as Inquiry (TSI) Questionnaire Inquiry Teaching Belief (ITB) Activity	Teaching Science as Inquiry (TSI) Questionnaire Interview Protocol	Teaching Science as Inquiry (TSI) Questionnaire Interview Protocol Inquiry Teaching Belief (ITB) Activity

Teaching Science as Inquiry (TSI) Questionnaire

The three research questions were answered using quantitative data collected from a self-report, Likert scale instrument, the Teaching Science as Inquiry (TSI) questionnaire (Dira-Smolleck, 2004; Smolleck & Yoder, 2006), designed to assess the self-efficacy beliefs of elementary teachers with regard to the teaching of science as inquiry (see Appendix A). This subject-specific instrument was created based on contemporary ideas about inquiry, and was grounded in Bandura's theoretical framework, particularly the understanding of self-efficacy as being a context-specific construct (Smolleck & Yoder, 2006). For example, questions asked if participants felt they could determine the best manner through which children can engage in scientifically-oriented questions, if they required students to defend their newly acquired knowledge during large and/or small group discussions, if they allowed their students to select among a list of given questions while investigating scientific phenomena, and if they provided opportunities for their students to obtain evidence from observations and measurements.

Twelve teacher participants completed this survey online, but only the scores of the seven participants that completed the subsequent interview protocol were used to generate data for the initial quantitative strand of the study. Their scored items were categorized into personal efficacy and outcome expectancy groupings, as well as grouped along a teacher/student centered continuum. The participants' scores were then analyzed using descriptive statistics. Table 3 describes how the various TSI instrument items were clustered.

There is a need to move beyond the quantitative survey in order to develop a better understanding of the contexts and experiences that promote teachers' development of teaching efficacy (Blonder, Benny, & Jones, 2014; Tschannen-Moran & Hoy, 2007). The qualitative strand of research is described below.

Interviews

Smolleck and Yoder (2006) recommended the use of the TSI instrument in combination with other data collection techniques to more fully determine the self-efficacy beliefs of prospective teachers. Furthermore, Merriam (2009) contended interviewing to be the best data collecting method in allowing the researcher to investigate concepts that cannot directly be observed such as feelings, thoughts, and intentions. In order to address research questions two and three, seven total participants, selected from those who completed the TSI questionnaire, participated in this qualitative segment.

Table 3

Distribution of TSI Instrument Items (Smolleck, 2004)

5 Essentials of Inquiry	A Highly Student Centered	B Student Centered	C Teacher Centered	D Highly Teacher Centered
Learner engages in scientifically oriented questions	***4, 19***, 25	7, ***11***, 51	***37, 38***, 48, 66	***18, 21***, 27, 45, 46
Learner gives priority to evidence in responding to questions	***36, 57***, 58	***5,*** 13, ***17, 30***	8, ***44, 49***, 53	29, ***40***, 47, 52, ***54***
Learner formulates explanations from evidence	***2,10***, 34, 35, 39	20, ***26***, 28	***1, 31***, 55	***67,*** 69
Learner connects explanations to scientific knowledge	***3***, 15, 61, ***63***	***14, 22***, 24	***23***, 41, ***43***	N/A
Learner communicates and justifies explanations	6, ***12, 33***	9, ***16, 32***, 59, 64, ***65***	50, 60 , ***62***	***42***, 56, 68

Note. Bold and italic numbers - Personal Self-Efficacy: Total Items = 34; Regular type numbers - Outcome Expectancy: Total Items = 35.

In establishing the interview protocol, some of the questions were developed a priori and are included in Appendix B, while other questions emerged as a result of the participants' responses. The interview questions were grounded within Bandura's theoretical framework of belief and the Five Essential Features of Science Inquiry model, known as the 5Es of inquiry (NRC, 2000). Additionally, some of the interview questions were adopted from the Teacher Beliefs Interview (TBI) instrument (Luft & Roehrig, 2007), a semi-structured, interview protocol which provided access to the thinking of teachers, and allowed the participants to reveal the complexity of their belief system. While the TBI instrument statements were not about inquiry specifically, they did encompass broader ideas about science teaching. Some of the TBI questions were incorporated into the interview protocol and were then followed up with probing questions that related explicitly to inquiry-based practices, if participants had not mentioned it themselves during the interview.

The seven semi-structured interviews took place in person and face-to-face, and included open-ended questions (see Appendix B) aimed at revealing the participants' perceptions, attitudes, and beliefs towards inquiry-based science instruction, and current instructional practices and external influences on those practices. For example, questions asked participants to include a description of their best and worst science lesson, to describe circumstances surrounding student science success, to explain their most effective strategies of teaching science, to clarify the role of NGSS in their science instruction, to portray the influence of school guidance and professional development, and to elaborate on other factors that impacted their perceptions and implementation of inquiry instruction. The interview protocol concluded with participants discussing their ranking of the Inquiry Teaching Belief Instrument (ITB) activity items, described below.

Inquiry Teaching Belief Instrument

The Inquiry Teaching Belief (ITB) Instrument (Harwood, Hansen, & Lotter, 2006) is a self-reflection tool that provided information about teachers' notions of science inquiry. It also elicited their current beliefs about inquiry teaching in science classroom (see Appendix C). During an item-sorting activity, participants were asked to rank the listed activity statements, depending on how strongly they felt each activity demonstrated an inquiry-based science classroom practice. Interview participants were asked to complete this activity prior to the interview and then reference it during the interview, when they were asked to explain their rankings. Discussion of this activity during the interview yielded additional data about teachers' understandings of inquiry, their classroom practice, as relevant to the first and third research questions, and facilitated in the triangulation or the complementarity of the interview data within the qualitative strand. Having participants complete the exercise and then explain their thinking, provided an internal validity check.

Analytical Techniques

A sequential QUAN→QUAL mixed data analysis typology, as named by Teddlie and Tashakkori (2009), is the most appropriate analytical technique for methods that remain distinctly identifiable throughout the study and are combined at the level of interpretation and conclusion. This analysis typology best suits a study in which the strands occur in chronological order, and the analysis of the second strand depends on the initial strand. In addition to meta-inferences integrated from the results from each strand, the data analysis was also informed from both data sets at the stages of data transformation, comparison, and integration, thereby allowing for the recognition of emergent themes and new insights (Greene et al., 1989). That is, after separate analyses of the quantitative and qualitative data, findings from all data sources were merged using the concurrent triangulation strategy, and the two data sets were compared for similarities and differences (Creswell, 2009). Although the interview and ITB data were collected subsequently to the TSI survey data in this dissertation study, the short time frame between them allowed for the concurrent triangulation strategy to still be used effectively for data analysis.

Quantitative Analysis

The quantitative strand consisted of data generated from the TSI online survey instrument (see Appendix A). Due to the small number of participants, a statistical analysis of the data through SPSS was not possible. Rather, descriptive statistics were calculated and used to highlight sample characteristics of the data. The participants' overall mean scores for the TSI instrument were calculated for each of the teacher/student centered continuum groupings. In addition, the mean scores for the subcategories of personal efficacy and outcome expectancy questions (Bandura, 1977) were calculated for each participant. TSI questions were also categorized according to the Five Essential Features of Inquiry, or 5Es of Inquiry model (NRC, 2000), and means were calculated for each participant and for each of these categories. Table 3 in the data collection section above displays how the TSI survey items were categorized based on personal efficacy and outcome expectancy, teacher versus student centered instruction, and the Essential Features of Inquiry model (Smolleck, 2004).

Qualitative Strand

Qualitative analysis further explored the results yielded in the quantitative phase, and followed recommendations by Miles and Huberman (1984) for an iterative, cyclical process of data reduction, data organization and display, and conclusion drawing. Interviews were audio-taped and then transcribed, organized, read, and coded. Structural coding, as defined by Saldana (2009), is a coding process where the researcher "applies a content-based or conceptual phrase representing a topic of inquiry to a segment of data that relates to a specific research question used to frame the interview" (p. 66). It is a first cycle coding method advocated by Saldana to be applicable to virtually all qualitative studies, and to be especially useful for analyzing interview responses of multiple participants. It was the researcher's preferred initial coding technique, because the structural coding system both codes and categorizes the qualitative data, thereby simplifying further analysis. Furthermore, it allows for the developing of codes and the organizing of concepts to occur simultaneously, which is more time efficient.

The initial coding scheme was defined by the researcher and grounded in Bandura's efficacy framework (1977, 1986, 1994, 1997), Vygotsky's sociocultural model (Forman & McCormick, 1995; John-Steiner & Mahn, 1996; Jones & Carter, 2007; Vygotsky, 1986), and the Five Essentials of Inquiry model (NRC, 2000). These preliminary code concepts included personal self-efficacy and outcome expectancy descriptors, in addition to terms that highlighted the five essentials of inquiry put forth in the Inquiry and the National Science Education Standards publication (NRC, 2000). Initial, first level coding categories used were as follows: meaning of inquiry, attitudes toward inquiry, students' response, science goals/inquiry purpose, inquiry benefits, how to do inquiry, lessons and activities, influencing factors, and ITB responses. The number of initial coding categories was kept below ten, as per Merriam's (2009) suggestion (p. 187) in order to allow for adequate abstraction of the data.

First level codes and categories were applied to the data by highlighting excerpts from the transcripts the same color and placing the excerpts in designated Excel columns. Then, further codes and subcategories were developed and applied as necessary. These secondary codes were thereby organized and highlighted the same color as the corresponding first level codes. For example, within the initial, first level code of "influencing factors," several subsets of codes were derived. Categories such as PD, experience, time, student interest were developed as secondary codes, colored the same color blue as the initial code, and positioned in the same corresponding excel columns. An analytic journal in the form of an Excel spreadsheet was kept to record these emerging themes, as well as to track the tasks of data reduction, display, conclusion-drawing, and verification (Miles & Huberman, 1984).

Following methods of constant comparison (Lincoln & Guba, 1985; Miles & Huberman, 1984), analysis sought to identify emerging themes within the data, including similarities and differences between participants. For example, an emerging theme that developed from the influencing factors category was professional development (PD), an external factor that dominated the theme grouping. Finally, conclusions were drawn to answer the research questions. Verification occurred throughout the analysis as emerging themes and eventual conclusions were validated against contradicting data and triangulated with the quantitative data sources. The overall data analysis process was inductive and iterative (Saldana, 2009).

Researcher Role/Position

My emic perspective in working at one of Illinois's most established Islamic school as a high school department chairperson is advantageous in that I have an insider's view and understanding of the Islamic school culture. Moreover, there is the additional incentive to enable improvement of my school's science program directly and Islamic school science programs at large. This researcher role allows for the study to take on an action research flavor and encourage those teachers who participate to take ownership in improving their science instruction for the benefit of their students and the school as a whole, while also allowing me to cultivate my science inquiry professional development skills. On the other hand, being a science department chair for 8th-12th grade subjects, I only conducted research with kindergarten through 7th grade science teacher participants, in order to avoid any power conflicts that could arise.

Validity Concerns and Limitations

Developing warranted inferences based on the integration of both quantitative and qualitative data is a central issue in mixed methods research (Tashakkori & Teddlie, 2008). Onwuegbuzie and Johnson (2006) contended that all mixed research studies must confront the problems of representation, legitimation, and integration but acknowledged "discussions about validity issues that characterize these problems are still in relative infancy" (p, 54). Yet, they recommended that *legitimation* be used as the mixed methods research term for validity. They claimed that the use of this term would enable inference quality and its component elements of design quality and interpretive rigor to be the gold standard for judging integrative mixed methods studies. Greene (2007) agreed with the sentiment of establishing mixed methods inference quality standards and claimed that the criteria for justifying inference quality needed to be blended to honor both the validity criteria from quantitative research and the narrative authenticity criteria of qualitative inferences.

The nine legitimation categories proposed by Onwuegbuzie and Johnson (2006) provide a framework in judging the quality of inferences of mixed methods studies. This section focuses on those legitimations that might have been particularly problematic in this study. The next section describes how these concerns were mitigated.

Sample integration legitimation was initially a concern, because the participants involved in both the qualitative and quantitative strands of the research were not equal in number. The insider-outsider legitimation type recognizes the difficulty on the part of the researcher in balancing the emic and etic perspective while conducting the research. Other mixed methods validity concerns that needed to be considered in this study included paradigmatic legitimation, “the extent to which the researcher’s epistemological, ontological, axiological, methodological, and rhetorical beliefs that underlie the quantitative and qualitative approaches are successfully (a) combined or (b) blended into a usable package” (p. 57), and commensurability legitimation, “The extent to which the meta-inferences made reflect a mixed worldview based on the cognitive process of Gestalt switching and integration” (p. 57). In addition to the specific legitimation types mentioned above, practically all mixed methods studies have multiple validities legitimation issues, in that the respective quantitative and qualitative validities must be addressed prior to integration to enable the study to have high inference quality.

Strengths

Legitimation and validity concerns, as a whole or at an individual level, account for the majority of limitations facing this mixed methods research. Admittedly, addressing the overall inference quality of the study was an ongoing challenge, in addition to issues of time restraints, organization of data of multiple facets of the study, and the authentic integration of data at all levels. The researcher was cognizant of these limitations, especially weaknesses in participants' self-reporting, researcher biases, and transferability, allowing many, if not all of these challenges to be mitigated.

Triangulation refers to the designed use of multiple methods, with offsetting or counteracting biases, in investigations of the same phenomenon in order to strengthen the validity of inquiry results. The premise of triangulation as a design strategy is that all methods have inherent biases and limitations (Greene et al., 1989). Therefore, the use of only one method will yield biased and limited results, whereas using two or more methods will enhance the validity. With this mixed method study, triangulation converges qualitative data in conjunction with quantitative data to assess teacher beliefs and the influence they have on science inquiry instruction.

There has been no mention of using the TSI questionnaire with a small number of participants by the researchers, nor have they reported on the validity of their instrument in regards to small groups. To alleviate possible internal validity concerns in using this instrument, concurrent triangulation was incorporated throughout the study, allowing the comparing and contrasting of quantitative descriptive results with qualitative findings and the use of two different methods in an attempt to confirm, cross-validate, or corroborate findings within a single study (Creswell & Clark, 2010). Multiple method designs are advocated and used in various mixed method studies for the common proclaimed purpose of triangulation of complementary data, in an attempt to offset or counteract biases in investigations of the same phenomenon, thereby strengthening the validity of inquiry results (Greene et al., 1989). Additionally, the seven interview participants promoted investigator triangulation and provided the study with qualitative data validity (Merriam, 2009). Furthermore, the interview participants completed a quantitative self-reflection instrument (TSI), and a ranking activity (ITB), which were both triangulated with the data generated from the interview protocol.

The quantitative concept of external validity and the associated threats, do not apply to this small scale study because the purpose was not to generalize. Instead, the study aims for transferability and authenticity (Denzin & Lincoln, 2005). Moreover, the study overcame limitations in sample size with its strengths including the complementarity purpose of mixed methods (Greene, 2007), planned transparency (O'Cathain, 2010), optimized breadth and depth (O'Cathain, 2010), design suitability (Tashakkori & Teddlie, 2008), and the incorporation of triangulation strategies (Creswell & Plano, 2010). Sample integration legitimation was initially a concern, because the participants involved in both the qualitative and quantitative strands of the research were not equal in number. But upon data integration, only the TSI scores of participants that partook in the interview protocol were used.

The qualitative research strand of this study, similar to most qualitative studies, might have experienced validity issues of researcher and response biases during the face-to-face interviews. Although these validity concerns may have arisen because of the relationships between the participants and the researcher, the qualitative analysis integrated semi-structured interview responses with self-reflection ITB instrument responses. Integration of these two data points not only enriched the study findings, but also provided internal validity through triangulation and promotion of transferability.

The seven participating teachers in the study were elementary science teachers at two Islamic schools in the area, whereby several actually worked in the same school as the researcher and interviewer. Although my emic perspective as a researcher gave great insight as to the contextual effects on teachers' implementation of science inquiry, my dual role as researcher and science department chair in my Islamic school may have been a threat to the insider-outsider legitimation. A strategy used to counter this threat to validity was obtaining the peer review of an outsider, in this case the dissertation chair, to examine the interpretations being made.

Schwandt, Lincoln, and Guba (2007) discussed the effect of context on data interpretations, and claimed that the researcher was always situated relative to the social circumstances of beliefs and practices behind the data. They contended that successful defense of a researcher's interpretations must attain both trustworthiness and authenticity, while they recognized embedded political and moral implications. Reflexivity was therefore crucial to clarifying the researcher's thinking, values, purposes, and beliefs, and this was accomplished by keeping a research journal throughout the data collection and analysis process. Additionally, the researcher situated herself at the beginning of each interview and established her role as a learner with the participants while explaining purpose of the study. This was done with the intention of alleviating the participants concerns of being judged in order to reduce response bias.

The concerns of blending two different methodological and epistemological approaches of paradigmatic legitimation were adequately minimized by recognizing the strengths and weaknesses of both types of methods, quantitative and qualitative. Once the paradigmatic legitimation issues were resolved, the matters of the resulting amalgamation of quantitative and qualitative meta-inferences of commensurability legitimation were thereby diminished. Furthermore, going back and forth between the qualitative and quantitative data sources and seeing the study as a whole that is greater than the sum of the individual parts, allowed both the of these legitimations to be mitigated.

CHAPTER IV

RESULTS

Introduction

The purpose of this mixed methods study is to examine Islamic school elementary teachers' knowledge and understanding of, attitudes toward, and overall perceptions of inquiry-based science instruction, and how these beliefs influence their inquiry practice in the classroom. In addition, it offers a description of the types of methods teachers are using to promote inquiry within the context of their science classrooms and addresses the challenges teachers face when implementing scientific inquiry strategies in their instruction. This study contributes to the research on science education reform efforts by providing insight into the tools, beliefs, and experiences that elementary science teachers may employ to overcome many of the documented barriers of reforms based instruction. By understanding the impact of their backgrounds, beliefs, and professional development experiences on instructional practice, professional developers and teacher educators will be better equipped to help enable science teachers to reflect on their instructional practice and assessment methods and make modifications for improved students' science achievement. The research questions guiding this research included:

1. How do elementary science teachers in Muslim private schools describe scientific inquiry, and how is it evidenced in their classroom practice?

2. What are the participant teachers' beliefs towards inquiry-based science instruction?
3. What personal and external factors have influenced these practices and beliefs?

A critique of science education research, policy and curricula that promotes the use of science inquiry is that they have not provided "sufficient detail about how a teacher would actually implement [it] in an elementary or middle school classroom as a central aspect of science instruction" (Settlage & Southerland, 2012).

This chapter answers the aforementioned research questions and presents the findings and interpretations of the quantitative and qualitative data in the form of three narratives. The first story depicts the discrepancy between three participants' survey responses, which capture belief statements about science inquiry, and their interview responses that describe actual teaching behaviors and strategies for implementing science inquiry. A second narrative portrays three teacher participants reminiscing on their previous science inquiry-based teaching experiences, while the third chronicle illustrates the religious context of the Islamic private school setting and how it shapes an elementary science teacher's experience and decisions in the classroom. Triangulation of evidence from the various data sources is discussed to support each of the storylines.

Teacher Demographics

A total of seven elementary science teachers, teaching a variety of classes from kindergarten to fifth grades, partook in this study. All participants are female and currently teaching between 90-160 minutes a week of science in one of two private

Islamic schools in the suburbs of a large Midwest city. The following table summarizes their experience and background in science:

Table 4

Summary of Teachers' Experience and Background Information

Teacher	Years Teaching	Highest Degree Earned	Science Methods Courses taken	Additional Science PD attended	Additional Science Work Experience
Nada	6	B.A.	None	None	None
Kawthar	2	B.S. Biology	1	Pursuing Masters	1 yr lab prep assistant
Ayesha	15	B.A.	1	Pursuing Masters	None
Mona	8	M.A.	1-2	NGSS, STEMscopes UICExtensions	None
Raneem	8	B.A.	1	None	None
Hana	8	M.A.	2	None	None
Warda	5	M.A.	3	None	None

It is interesting to note that most elementary teachers did not take any science methods courses as part of their teaching certification, which they all attained, unless they were pursuing or had received a Master's degree in teaching.

Teaching Science as Inquiry (TSI) Instrument

The Teaching Science as Inquiry (TSI) instrument measures teachers' self-efficacy in regards to the teaching of science as inquiry, and can be used as a measurement tool to more completely understand the beliefs of prospective elementary science teachers (Smolleck, 2004). The TSI assesses elementary teachers' self-efficacy beliefs in regards to the teaching of science as inquiry through the two dimensions of self-efficacy: personal self-efficacy, "a judgment of one's ability to organize and execute given types of performances," (Bandura, 1977, p. 21) and outcome expectancy, "a judgment of the likely consequence such performances will produce" (p. 21). Table 4 below reports the average score for each participant on the TSI survey in terms of personal efficacy and outcome expectancy beliefs. Table 5 below reports the average score for each participant on the TSI survey in regards to teacher versus student centered beliefs.

Table 5

Teachers' Responses in Terms of Average Personal Efficacy and Outcome Expectancy

Name	Personal Efficacy	Outcome Expectancy
Nada	151/34 = 4.4412	134/34 = 3.9412
Kawthar	127/33 = 3.8485	122/34 = 3.5882
Ayesha	133/34 = 3.9118	130/34 = 3.8235
Mona	150/34 = 4.4118	129/34 = 3.7941
Raneem	158/34 = 4.6471	160/35 = 4.5714
Hana	128/34 = 3.7647	97/33 = 2.9394
Warda	138/34 = 4.0588	132/34 = 3.8824

Table 6

Teachers' Responses in Terms of Student/Teacher Centered Continuum

Teacher	Highly Student Centered A	Student Centered B	Teacher Centered C	Highly Teacher Centered D
Nada	78/18 = 4.33	79/19 = 4.16	67/17 = 3.94	61/14 = 4.36
Kawthar	66/18 = 3.67	68/19 = 3.58	66/17 = 3.88	55/14 = 3.92
Ayesha	68/18 = 3.78	72/19 = 3.79	68/17 = 4.00	54/14 = 3.86
Mona	64/17 = 3.76	67/19 = 3.53	63/17 = 3.71	60/15 = 4.00
Raneem	82/18 = 4.56	87/19 = 4.58	81/17 = 4.76	71/15 = 4.73
Hana	59/18 = 3.28	62/18 = 3.44	49/17 = 2.88	56/14 = 4.00
Warda	73/17 = 4.29	75/19 = 3.95	72/17 = 4.24	51/15 = 3.40

Note. The columns are arranged as a continuum, with column A responses the most student-centered and column D responses the most teacher-centered.

The average scores for each category in Tables 5 and 6 range from one, the lowest score, to a maximum score of five. The mean was calculated by totaling the Likert scale numbers for all the items on the TSI that were designated and answered for each category, then divided by the number of items that were answered by each participant from the specific grouping. The denominator represents the number of survey questions in the respective category, while the numerator is the total point value added for all corresponding survey responses in the category.

Inquiry Teaching Belief (ITB) Instrument

The Inquiry Teaching Belief (ITB) instrument seeks to provide information about how teachers' describe their notion of inquiry teaching and is designed to elicit the participants' current beliefs about inquiry teaching in a science classroom (Harwood et al., 2006). As a supplement to the semi-structured interview protocol, the ITB provides additional qualitative and quantitative information regarding teachers' beliefs inquiry teaching for this study. The TSI data and interview responses provide information that can be triangulated with the participants' ITB rankings and descriptions, thereby providing the opportunity to look for consistencies and inconsistencies across a range of beliefs. Participants were asked to rank a total of 18 statements from most to least inquiry-based, and given the option to have statements that were tied in ranking. Table 7 reports how participants ranked the items, each of which describes activities that are designated as "inquiry," "neutral," or "non-inquiry" by the instrument developers. The higher the ranking, the more inquiry-based the practice is, and the lower the ranking, the less inquiry-based the practice is considered to be by the participant.

Table 7

Summary of Teachers' Ranking of the Inquiry, Neutral, and Non Inquiry Items

ITB Items	Nada	Kawthar	Ayesha	Mona	Raneem	Hana	Warda
Students evaluating data	1	3	6	7	4	10	1
Students reflecting on their work	1	2	8	8	3	1	2
Students collaborating with one another	2	4	7	2	1	2	1
Students designing & implementing appropriate procedures	1	2	1	1	5	4	2
Students communicating their findings to the class	2	5	9	3	3	7	3
Students writing reports	6	6	12	-	11	15	4
Students using evidence to defend their conclusions	1	4	2	4	3	8	1
Students asking questions	1	1	3	5	2	3	1
Students formulating questions to investigate	1	2	4	6	2	5	1
Students researching what is known	2	3	5	9	4	9	4
Students engaging in activities with predetermined outcomes	2	2	10	11	4	6	3
Students receiving factual information from their teacher	2	3	11	13	5	17	3
Students listening to instructor lecture	3	5	14	14	6	18	3
Students reading assignments in textbooks	2	7	13	12	6	17	5
Students completing worksheets	5	6	16	15	7	14	5
Students working independently in class	2	6	15	16	7	13	4
Students taking paper-and-pencil tests	4	7	17	17	10	11	5
Students taking multiple choice tests	4	7	18	18	10	12	5

Note. Inquiry items are in bold, neutral items are in regular type, and non-inquiry items are in italic.

Opposite Sides of the Same Coin

As suggested by Pajares (1992), evidence of one's beliefs can be derived from one's belief statements in conjuncture with his or her observed behaviors, actions and responses concerning the area of belief. He therefore advocated using a combination of methodologies to study beliefs, including open-ended interviews, and survey responses, in order to make accurate inferences. Interestingly, when analyzing the data sources collected from Nada, Kawthar, and Ayesha, one finds a discrepancy between their survey responses, a measure of beliefs about science inquiry, and some of their interview responses, especially those describing actual teaching behaviors and strategies for implementing science inquiry.

Nada is a third grade teacher of six years at her current Islamic school, whose survey responses indicated that she associated science inquiry with activities including comparing, problem solving, and drawing conclusions. In her interviews, she reflected that her students love science inquiry because they are engaged and are able to experiment and discover things all on their own. She wants learning to be student-centered and expects students to be able to tell things in their own words and show their own data as evidence. Nada would love to see what her students can come up with before telling them what the outcome will be, and feels that inquiry could be a better way for students to show evidence of learning and problem solving skills than paper and pencil testing. She enjoys engaging her second grade students in tangible activities, such as making volcanoes, conducting demonstrations of bubbles and hot air balloons, and identifying different properties of rocks and minerals.

Although at first it may seem that she understood science content and process to be intertwined, in alignment with current science education research (NRC, 2012), as one probes deeper, it is evident from her interview responses that Nada is most focused on promoting science content knowledge separate from the skills used to develop that knowledge. This emphasis on content was demonstrated by her contention that the single barrier to implementing a science inquiry lesson in her third grade class is the students' limited background knowledge and research skills, which would lead them to not knowing what questions to ask or where to start in the inquiry process. She explained how she attempts to overcome this obstacle and facilitate the use of scientific inquiry in her classroom below:

> I start by asking a question to get them thinking about it. And I kind of like a KWL chart, I see what they already know, I bring it up. I give a very brief background about it and then I ask them what they already know about it. And we keep that on a chart as we go and then I have them come up with their questions, and in the end we discuss what we learned and how we can go beyond that.

Although Nada's KWL activity was an effective introductory activity that tapped into students' prior knowledge, her discussion of an ideal inquiry lesson ended at this point, with no further evidence of guiding students beyond the engage phase of the 5E model, where she discerned their prior knowledge (Eisenkraft, 2003). Her abridged version of the inquiry process supported findings by Appleton (2006), who stated that primary teachers often view science as a complicated set of facts and definitions to be found in accurate sources such as books, thereby impacting the nature of teaching and learning that occurs in the classroom. This narrow understanding of inquiry was further demonstrated by her understanding of the ITB items as all exhibiting features of inquiry and her difficulty in ranking any of the 18 learning activities a lower score. She explains:

> How could anybody think that some of these are 18s, because even like the ones that seem so general, like the teacher just reading it to them, or taking a paper and pencil test, because in the end, taking a paper and pencil test, multiple choice, they have to understand the content that they learn. So it's gonna require some inquiry. I don't know. Completing worksheets, it depends on the worksheets.

Here, Nada's response suggested that she sees any classroom activity that is associated with science content as being synonymous with scientific inquiry, without giving importance to any of the essential features of inquiry (NRC, 2000).

According to Bandura's social learning theory (1977), if elementary teachers are expected to encourage inquiry learning from their students, they themselves must first have a sophisticated understanding of teaching science as inquiry, as well as opportunities to experience success with inquiry teaching and learning. The problem, however, lies in the fact that if teachers have not had such prior experiences with inquiry teaching and learning, they often resort to traditional, didactic methods of teaching science (Smolleck, Zembal-Saul, & Yoder, 2006). Interestingly, Nada's average scores on the TSI for personal efficacy and outcome expectancy, 4.4412 and 3.9412 respectively, were relatively high and not reflective of her limited, simplistic understanding of science inquiry. These results are consistent with research that has reported that teachers who lack sophisticated understandings of inquiry strategies may overestimate and overrate their use of these strategies in the classroom, especially prior to a professional development intervention (Lakin & Wallace, 2015; Lee et al., 2004; Wheatley, 2000, 2002).

Smolleck et al. (2006) contended that the TSI should be used in combination with other data collection techniques to more fully determine the self-efficacy beliefs of elementary science teachers. The inclusion of interviews would allow for a more thorough analysis of the teachers' self-efficacy in regard to the teaching of science as inquiry, while helping the researcher find out if the teacher truly understood the meaning of the items on the survey. This holds true for this study, where the qualitative data provided a richer picture of participant understandings than the TSI scores alone did. We see this contradiction of TSI scores and other data sources again with the next two participants, Kawthar and Ayesha, but in the opposite direction.

As contrasting to Nada's example, Kawthar is a fairly novice teacher, who was just beginning her second year teaching third grade in an Islamic school. She holds a Bachelor's degree in Biology, and is currently pursuing a Master's in Teaching (MAT) degree. Additionally, she has experience as a lab prep assistant during her undergraduate studies. Her understanding of inquiry reflected her science background, in that she explained inquiry as "the many ways scientists and other professionals work to understand the world around us" including all the phenomena we encounter around us in our daily lives and around the world. She also described scientific inquiry as "a way for us to look into all of this to gain a better understanding through various means of study."

This understanding that emphasizes the many ways that scientists work, as opposed to the use of a single “Scientific Method,” is one that she attributed to her science methods class as part of her current MAT program.

In regard to how she applies science inquiry practices in her elementary classrooms, Kawthar felt it important to take her students away from memorizing textbook definitions and engaging them in higher level thinking skills, enabling them to retain more information, to ask more questions, and to apply information and personal experiences from outside of class. She noticed that her students tend to look forward to science class and learning new material, because they are enthusiastic to reach their own conclusions and to see science as part of their daily lives. By allowing students to use various resources around them, other than just the textbook to gain a clearer understanding of the natural world, Kawthar felt she showed them that there is an application to everything in science if they kept their eyes and minds open. She explained how she wants her students to appreciate that “science isn't something just reserved for scientists or ‘really smart people,’ but that they too are capable of seeing something, asking questions, and finding ways to reach some sort of explanation.”

In an ideal inquiry lesson, Kawthar explained her goals for her students to include following instructions, making observations, discussing results, and reaching conclusions, while completing various hands-on experiences to allow for a more concrete understanding of material. In her prized “making oobleck” activity, Kawthar’s students wrote down in their notebooks the observations they made about the properties of oobleck, after spending some time playing with it. She contended that she realizes the importance of giving them a visual and time to reach their conclusion, in this case the understanding that there are states of matter other than solid, liquid, and gas. This lesson plan, and most of Kawthar's learning about science inquiry, come from her MAT science methods class, and she explained that seeing her students engaged, focused, and benefitting academically has encouraged her to apply more of these types of activities in her elementary classroom. She uses a textbook as a reference for content and material, while concurrently referring to the standards to gage her instruction to the appropriate level to teach the students, and insistently includes an inquiry-based lab activity once a week. In light of evidence of Kawthar's in-depth appreciation of science inquiry, her weekly incorporation of inquiry practices within her classroom, and her appropriately ranked ITB statements of activities that represent high and low inquiry for various classroom activities, it was surprising to see her relatively low personal efficacy average of 3.8485 and outcome expectancy average of 3.5882 on the TSI.

Ayesha, a 15-year veteran elementary teacher, was also currently enrolled in a Master's program, and was also greatly impacted by her science methods course instructor. She recounted personally not liking school growing up because of the narrow perspectives about singular ways of knowing things that she felt were forced onto her, as well as her teachers' use of cookie cutter instructional methods. In her own classroom, she indicated she prefers more open-ended, inquiry-based approaches, as presented by the science methods course instructor in her Masters' program. As a student, vocabulary words meant nothing to her, and she didn't want to be told and lectured; she preferred to see things for herself as a student. She clarified, “There's different ways to approach things, and I think for education for a very long time, that, that traditional method, that one way of thinking, it's not effective, especially in today's world. It's just not." Ayesha felt that she benefitted immensely from this particular science methods course, where she was introduced to constructivist teaching practices like those that engage students in authentic science inquiry, and anticipated her students would greatly benefit from her participation in this course as well, in that they would make more and deeper connections to the science content, thereby strengthening their learning and improving their long-term retention of the information.

While teaching science to her first grade students, Ayesha explained that she wants them to love the science while seeing the practical and real life applications of the subject. That is, she wants them to appreciate how they can use the knowledge they gained, and how it can be transformative and even help them become better people. She felt that traditional learning approaches take away the challenge for her students, and they become disengaged. Her vision of science inquiry entailed posing a question, solving problems, making plans, talking, making mistakes, and learning as you go. From creating animal habitat dioramas to conducting magnets and electricity demonstrations, the students are "talking, they're communicating, they're asking questions, they're looking for answers," and she always gets excited when her students are excited. As she explained, "this is the kind of teacher I wanna be. I don't wanna be the kind of teacher where I just sit and I can't wait to go home." Furthermore, Ayesha encourages collaboration and sharing from her students, wherein the class "becomes a big family" and a "very conducive place to learn," thereby allowing her to no longer be "the teacher in the classroom," but instead "they (the students) are." She recalled how, as her first graders became more engaged and motivated, they began to actually want to come to school, find out about and learn different things on their own by taking out their science books and begin making connections, and eventually, "they don't need you at their side and realize that the teacher is not the only place I can find knowledge."

In addition to encouraging her students to be independent and life-long learners that see the practical application of science, Ayesha embraces inquiry as an instructional practice that allows students to design or build something that "could change the world". She recounted how, in one lesson, she shared with them the story of Steve Jobs and explained:

> That iPad you all love to play with, Allah put it in Steve Jobs' head, and he had to do a lot of questioning. He kept making mistakes. "He kept learning, and kept trying new things. And then, it popped, it happened, and he figured it out (iPad).

Ayesha then took the story and made a teachable moment out of it:

> Some things seemed like even though I'm gonna make mistakes, and I know because I'm not used to that type, I just am like, Okay, I know I'll learn. It's okay if I keep falling. I'll keep falling. I'll keep getting back up, but I know I'm gonna come out in the end better."

Although Ayesha's understandings of science inquiry teaching were rich and comprehensive, similar to Kawthar, her personal efficacy average on the TSI of 3.9118 did not reflect this thorough and thoughtful understanding. Throughout the interview, she contended the need to improve science instruction, on a personal and at the schoolwide level. She described her inquiry-based activities as being very basic and not inquiry-based to extent they should be, and explains her intimidation of science inquiry, “I'm nowhere where I need to be but I have a very basic understanding of it and I'm not very confident.” Although she likes taking the backseat and enjoys seeing her students make connections, Ayesha admitted that it was hard as a novice teacher to do, because she felt like she “had to say everything.” Additionally, she is continuously hesitant and unsure of her knowledge of science content, and is afraid that she may not explain concepts appropriately to her students, water down the information for them, or even give them information that is incorrect. She even invited a high school science teacher to class to conduct some demonstrations, and generally wished she had more support from science department in the form of profession development or seminars.

In addition to her insecurities in regards to science content knowledge, Ayesha admitted that insufficient time for teaching science in the day, inadequate teacher preparation, and the reliance on unit tests as opposed to informal assessments all impacted her self-confidence in teaching science and using inquiry teaching practices in her classroom. She confessed that the curricular focus is on language arts, thereby allowing little or no time to teach science as a separate subject. To compensate, she uses the language arts book as guide for science topics, develops the big ideas from them, then uses the designated science textbook as a reference, allowing her to complete the science curriculum. Moreover, Ayesha recognizes that often she is giving tests only for a grade, which she contended, “doesn’t benefit you or anyone else in the world,” but actually hinders their learning. She even considers them a waste of time, because the data collected is on their test-taking abilities and not necessarily on their science knowledge. Unfortunately, she feels obliged to give tests anyways, in order to avoid being marked down on her evaluation, “because if they come in and observe you and they see the kids out of their seat are talking, they’re gonna mark you down for it and on your evaluation. They will evaluate you in a certain way.”

The contradictory TSI scores for Kawthar and Ayesha, in comparison to their other data sources, may not be as surprising as they first appear, but for the opposite reason that was proposed for Nada. It has been shown that teachers with a stronger grasp of what inquiry-based teaching and learning entails may be more critical of themselves (Choi & Ramsey, 2009). Thus, when Kawthar and Ayesha had the opportunity to experience a science methods course that provided them an opportunity to experience the teaching of science as inquiry, they may have come to realize that the teaching of science as inquiry is much more complex and difficult than they had originally thought, hence the lower self-efficacy scores on the TSI. The opposite may also be true for Nada, where her scores on the TSI seemed to be inflated in relation to the interview responses, which explored her thoughts on inquiry more fully.

Wheatley (2002) suggested that teachers like Kawthar and Ayesha, who were critical of themselves and expressed some doubt in their self-efficacy and outcome expectancy, may be more motivated to learn and improve. Although teachers who experience uncertainties regarding their teaching efficacy may feel guilty and inadequate over this seeming ineffectiveness, these feelings may actually promote teacher learning and reflection. Wheatley believed that these “doubts are essential to widespread success of education reform, particularly for reforms that promote progressive meaning-centered education" (p. 5). This phenomenon may explain Kawthar's and Ayesha's discrepancies between their relatively low TSI efficacy scores and their in-depth understanding of science inquiry reforms, as evidenced by their interview responses and ITB rankings. Although Wheatley's assertions conflict with most of the previous research on teacher efficacy, it is important to carefully explore the meaning of these findings, as well as their relationship to education reform and more specifically, science inquiry.

Strolling Down Memory Lane

Pajares (1992) suggests that beliefs about teaching appear to develop from critical episodes and images held by teachers. The participant teachers introduced in this section, Mona, Raneem, and Hana, each recollected previous experiences of successful or unsuccessful science inquiry-based teaching, and continuously reminisced about them. Given that beliefs were found to influence the nature of both subject matter knowledge and pedagogical content knowledge developed by the teachers (Mansour, 2009), listening to their recollections added insight and understanding.

Mona, a new 5th grade teacher at her school, explained that she believes students engaged in scientific inquiry are able to find solutions and solve problems on their own, by designing an investigation for the problem, determining the needed materials, and conducting any necessary research. She compared solving problems through inquiry to a funnel that starts out very broad then narrows down to find a solution. Mona eloquently described her paradigm shift:

> I'm starting to change from teaching content to teaching them how to approach and solve problems, as opposed to just, 'Oh memorize these definitions' and things like that. Kind of finding out and solving problems, on their own. The talk is just worth more to me than the worksheet. And I think in their lives, that's a good skill to have.

The STEMscopes inquiry-based elementary science curriculum that Mona used in her previous school included many inquiry-based activities that posed questions, which required collaborative strategies to answer. In her former school setting, Mona was a 5th grade teacher who, as a teacher chosen to pilot the curriculum, completed two of the suggested inquiry investigations, incorporating the reading of related scientific topics in the 90-minute English/Language Arts (ELA) block period, and interpreting graphs in the 90-minute math block period. She admitted having to be “really crafty and think ahead and plan… but can't wait until the end when project is due then lot of problems,” in order to fully embrace the curriculum and integrate it within an English and Math centric schedule. An example of an inquiry-based problem Mona applied in her class last year was having her students choose an endangered species from the Illinois endangered species list, conduct research on its natural habitat and needs, determine what it is lacking currently, and finally develop a plan that would help remove it from the list. After receiving the guidelines, students needed to collaborate in choosing the endangered animal, and in determining each group member’s role in the research project and presentation. Mona truly appreciated the technology integration that curriculum encouraged, the honing of her students’ collaboration and presentation skills, the promoting of her students' self-reflection and peer-review abilities, and even more importantly, how the curriculum gave the students choices. She elaborated:

> Once you give them choices, the sky is the limit, right? Cause if I tell them, 'Here, this is all I want you to answer,' then that's all they're gonna do for me. But what if I told them, 'Okay, here's these three but I want more,' there's no top there, then there you go.

Mona recognized the challenges of finding and implementing an elementary science curriculum that is inquiry-based and aligns to the rigorous NGSS. She explained, "it's [NGSS] so different, to be honest when I first started it, I felt I needed that worksheet, pre-determined outcome labs in [the] book [was] better than nothing." Nevertheless, she found STEMscopes's structure and guidance helpful. Although her previous school piloted the "totally out of the box" STEMscopes curriculum for 5th grade for only one semester, she and her students loved the curriculum, which she remembered thinking:

> I'm not standing there lecturing, listing vocab words on board, not telling them what need to do or have to learn and tested on, they were using that vocabulary in their work and understanding because they knew how to use it and had examples solving problems in other parts of their lives, work with group and collaborate, have to learn how to share responsibilities state problem, have students come up with questions, devise a solution, present it.

Despite her feelings of success with this curriculum, Mona's reality as a science teacher changed with her move to a new school and grade level. Whereas she had become accustomed to “just floating around classroom, listening on conversations, using informal assessments in addition to alternative assessments graded by rubrics, kind of check-in to see how far they are, are they behind, to keep them accountable for something,” she returned to feeling tied down by the textbook, being limited to traditional assessments and grading, and doing very few labs “that are not really inquiry because they have a predetermined outcome, and the students already know what's going to happen.” A reform-minded science teacher, like Mona whose thinking and instructional practices have been shaped by the STEMscopes PD she previously participated in, reported now experiencing difficulties, as she attempted to employ these instructional practices in her new school context, which she felt was characterized by more traditional approaches to science teaching (McGinnis et al., 2004). She explains, “That's why I feel like now, I'm reverting... I'm gonna cry.”

Moreover, Mona felt overwhelmed by the newness of her current situation. Although she confessed that there might be some inquiry-based prompts in her new textbook, she admitted that she was still becoming accustomed to the new grade level and science curriculum, so it had been difficult for her to try these out. She conceded that she “can't think ahead and be crafty in planning like last year.” Furthermore, she “wants to be on same page as other 4th grade teacher, and is already a week behind now.” Mona also worried that parents may not be open to her instructional style “moving away from traditional stuff and are more comfortable with worksheet and study guide.” Overall, she contended this year to be a “shaky one,” and reported she is focusing solely on familiarizing herself with the fifth grade curricula. However, she remained optimistic that she might get more confident to bring back inquiry-based activities to her science class later.

Mona's testimony about her experience with STEMscopes training and curriculum coincides with literature indicating that having a positive personal experience with science influences self-efficacy and outcome expectancy and teaching practice (Choi & Ramsey, 2009; Lee et al., 2004; Nadelson et al., 2013). This literature recommends that teachers have regular opportunities to provide a rich context of knowledge and experience on inquiry instruction. Moreover, in these studies, teachers described having greater knowledge of subject matter and claimed that both the students and they themselves had more positive views about science as a result of their pre-service training programs and professional development experiences. Similar to the elementary science teacher participants in the aforementioned studies, Mona felt better able and less anxious to engage in science-oriented activities, after taking part in a pilot science curriculum and receiving extensive PD, training, and support. Her relatively high personal efficacy average of 4.41 reflects her confidence with inquiry-based instruction as well.

Raneem, a first-year 5th grade teacher, had been teaching kindergarten at her current school for eight years. Her understanding of science inquiry entailed engaging in hands-on activities and in-depth discussion of science topics, conducting experiments, theorizing, and analyzing data. Although she acknowledged the importance of basic comprehension and the understanding of vocabulary, she appreciated the hands-on investigation and data analysis aspects of science teaching and learning. This view contrasted with her own studies as a high school student "back home" in the Middle East, where she recalled “just studying the material, going through theories by words and not seeing reactions…just book studies.” While studying in college in the US, Raneem explained that she began to recognize the benefit of learning science by personally interacting and experiencing the topic, dissecting specimens for biology, observing first-hand chemicals interacting, and overall, any science lesson that involved engaging activities and visuals.

As an elementary teacher, Raneem applies her awareness of the benefits of inquiry-based learning that she attained in her college years in creating interactive and meaningful science lessons. For example, she has found that students, even as early as Kindergarten, begin to actually use the science vocabulary to express themselves once the vocabulary take on meaning during investigations, “because they see it rolling…they see it sinking.” She reported that science inquiry activities make the vocabulary meaningful and the science valuable, thereby encouraging the students to be interested in and excited about science and appreciate how the concepts they are studying apply to their everyday lives. Admittedly, Raneem realized that if the science lesson is not interactive, her students are not as engaged, because they feel “it's boring and just work to do.” Her appreciation of the benefits of inquiry-based teaching strategies for her classroom are reflected in her high personal efficacy and outcome expectancy averages on the TSI of 4.65 and 4.57 respectively, the highest averages for each category among all participants of this study.

Although Raneem described a long list of inquiry-based science activities she conducted as a Kindergarten teacher including planting seeds to explore life cycles, sliding and throwing objects to explore forces, and floating and sinking objects to explore the concept of density, she admitted having a difficult time incorporating inquiry in her current 5th grade science class. The extent of what she described as inquiry instruction in this fifth grade class was limited to students sometimes presenting in groups, but lacked incorporation of the five essential features of science inquiry. While Raneem recognized the ideal inquiry lesson should involve some type of hands-on and interactive "pre-chapter activity…then doing an experiment or project, then teaching, at end reflect," she conceded having "no time to do the pre-chapter activity" and feeling rushed to complete the curriculum and meet the learning objectives, because the students "have to be tested". Moreover, as a new fifth grade teacher, Raneem described being more comfortable following what was agreed on by teachers that previously taught the grade level, even if it meant students learning about topics that she knew they had studied in third and fourth grades, and were bored with the topic. Additionally, she has noticed the curricular emphasis in the upper elementary grades is on basic comprehension and understanding of content, which is a stark comparison to the hands-on and interactive focus of the kindergarten curriculum, a teaching style she longed to return to.

Stressors in the daily life of a teacher may encourage them to revert to their old ways, as is the case with Hana, an eight-year veteran teacher of 4th grade, who confessed that when her classroom gets "too chaotic," she feels the need to "go back to normal way of teaching, the old-fashioned way." She felt inquiry-based science activities, at least in her classroom, are a hassle, and not always suitable for her students. Hana contended, "It depends on group if they can handle it, or if it takes too long to learn a procedure.

Certain students can't handle inquiry, because they can't keep their hands to themselves or need to take things from students." Moreover, other factors she felt contribute to her tendency to return to more traditional methods included the structure of her classroom, class size "because bigger the class, the harder it is," space availability, and inadequate amounts of materials. It is worth noting that Hana admittedly never had a science methods course, seminar, or workshop on science teaching, nor has she received any updates or PD through her school "on what's going on new in the curriculum or new teaching strategies." In addition, she scored the lowest personal efficacy and outcome efficacy averages of all participants that were surveyed, 3.76 and 2.94, respectively.

Religious about Teaching Inquiry

Inquiry-based learning experiences help students to understand how science is carried out in the real world, where answers to problems do not readily appear nor can they be found by quick reference to authority; rather, they are solved through conducting investigations, examining the available information, sharing ideas with peers, and reflecting on past experiences and learning (Duschl et al., 2007). Nonetheless, the school's cultural context heavily influences the extent to which a reform-based practice, such as inquiry, is enacted, and continuously shapes the teachers' identities (Saka et al., 2013). Thus, it is important to consider not only who the teacher is, but also how the cultural context in which a teacher participates shapes his or her identity and beliefs. In this section, the case of Warda demonstrates how examining the religious context of the Islamic private school setting is essential to understanding how the culture of the school shapes the teacher's experience and decisions in the classroom.

Warda's view of science inquiry as a Grade 1 teacher involved students looking at and observing the world around them, and conducting investigations to figure out answers to questions themselves. She explained classroom science inquiry entails students "going through a process and trying to put pieces together so they can really understand and see it, rather than someone lecturing and telling them." She felt this inquiry process consisted of observing, asking questions, finding answers, researching, evaluating, and analyzing, enabling students to understand the world around them. From Warda's perspective, an ideal inquiry activity does not necessarily start in the science class. Rather it may begin in a literacy class, where the teacher can introduce the topic through various texts, thereby allowing students' inquisitive nature to surface and facilitate their asking of questions. Subsequently, they battle to answer these questions by designing experiments and investigations. In addition, based on her success over the past four years as a middle school English teacher, Warda contended that giving students choices is essential to promoting inquiry in the classroom. She clarified:

> I had a lot of students in my reading class who were not readers. They hated reading. But the second I gave them choices, literally building our class together, they were very much so into it and the growth was substantial because of that. So I would hope that it would be the same thing in science.

Warda reported enjoying implementing various inquiry-based activities, one of which entails an in-depth, interdisciplinary moon investigation. In this unit, she models moon phases in her science classes by shining a flashlight on little balls that are half-dark and half-light. She also engages her students by having them observe the real moon throughout month, recording observations in their “little science journals.” Meanwhile, in her reading classes, she integrates various multicultural texts, each discussing the moon and its phases, “from a Native American’s perspective, from a scientist's perspective, and from a child’s perspective.” Even when running short on time, Warda manages to facilitate a student-centered classroom. For example, while she read the story *The River Ran Wild,* her students had questions about various events taking place, including why the river changed color. She then directed her students to research the topic online in order to answer their questions. Although time did not allow them to set up an actual scientific experiment, she still managed to conduct an inquiry-based learning activity, within her first grade reading curriculum. Warda’s student-centered approach promotes her teaching of science inquiry, and was most evident in her TSI survey responses, which indicated where her activities align along a teacher-centered vs. student-centered continuum. Her highest average of 4.29 out of 5.00 was for items in the farthest end of the student-centered continuum (see Table 3).

Born and raised in the US, Warda’s upbringing in the Muslim community has influenced her perception of science inquiry and has allowed her to recognize the important lessons that her students can derive from this instructional approach. As she discusses the significance of inquiry in the science versus faith debate, Warda contended:

> There are a lot of questions [students] could ask about the world around them. There is a process to things, and things don’t just magically appear. Especially with our Islamic school students because I have a lot of people that'll come and tell me, 'Allah made this happen.' But Allah makes it happen in a certain way, and

> our kids need to understand that. And a lot of Muslims seem to think that Muslims can't be scientists. Just so sad…It is sad, but I have seen that. To show them that even Allah has a process for things and you can figure out how Allah makes this happen…Memories. It's making me cringe…And even with me growing up, I see that a lot in my community.

Here, she described how she feels that the Muslim community has promoted the idea that Muslims can't be scientists because science and faith are in conflict with one another. Although she reported feeling that the Muslim community's hesitance to ask questions has improved, and "now that every generation is becoming more educated, we are starting to move away from that [mindset]," Warda senses that "it's still out there, and the culture is still being passed on down to us whether we realize it or not," thereby influencing how our curriculum is set up, in a way that "doesn't allow us to give kids that inspiration to pursue science." She also argued that because of "the culture we've raised them in," with an emphasis on following a provided plan to reach a known answer, some students do not appreciate inquiry-based activities, because they experience an "anxiety when they're out of the box and they're not doing exactly a worksheet, or a book, or this question." Ultimately, Warda attributed the students' struggle between wanting to have a scripted plan to follow to reach an answer, and being given an open-ended question with room to explore things in a number of different ways, to their religious cultural upbringing.

In addition to confronting the cultural baggage her students bring to school with them, Warda's inexperience teaching first grade necessitates more time to prepare, as she explained, “because I wasn’t as experienced with that subject, if I did do that experiment, I wasn’t sure how long it would take.” She reported feeling less confident in the new setting teaching a new grade level. Furthermore, in her previous school setting, the principal “gave teachers a lot of leeway…as long as we were staying within those standards.” Warda enjoyed this and felt it worked well for her and her students. She reflected:

> I didn't have a textbook. Well, I did, but then I said, ‘I don’t want to use my textbook,’ and I put it to the side and never looked at it. And I did my own thing according to the standards. So my heart was into it, my kids fed off of that, and I was able to tailor my lessons according to what my students wanted and what they needed.

Now, Warda described struggling with her new school setting, which relies heavily on the textbook for determining the curricular approach, and has just recently begun unpacking and aligning the curriculum with the new Next Generation Science Standards (NGSS). She described her experience:

> I think a part of the problem with my science class is also my own insecurities as an educator. I wanna make sure I'm doing the right thing. And according to what I've been taught, the book tells you what the right thing to do is… And I’ve told them this sort of a couple times, I look at my textbook and I’m like, ‘Can you just take this? Take it away…once you have that, it's too much of a crutch.

Warda described feeling stifled by the textbook and a curriculum that she believes is too prescriptive. Just as she described wanting to provide her students with opportunities to ask and answer more open-ended questions, she preferred a more individualized, open-ended curriculum. She elaborated:

> I think that was my struggle, and I think if I came in when you guys were doing standards already, I would have had an easier time with it. Like if I came in next year and you guys are already implementing the standards, it might be easier for me, because I was doing that before. I didn't have a textbook. Well, I did, but then I said, 'I don't want to use my textbook,' and I put it to the side and never looked at it. And I did my own thing according to the standards. So my heart was into it, my kids fed off of that, and I was able to tailor my lessons according to what my students wanted and what they needed… But I appreciate that that is the end goal. So it helps when I get frustrated and I'm trying to figure things out, it helps to know that there is a light at the end of the tunnel. We're just trying to get there.

Shulman (1987) has suggested, "The teacher also communicates, whether consciously or not, ideas about the ways in which 'truth' is determined in a field and a set of attitudes and values that markedly influence student understanding" (p. 9). Often times, Muslim parents place their children in the comprehensive religious environment of an Islamic school, do so because they are eager to shield their children from certain materialist and secular influences (Merry, 2005). Moreover, Pajares (1992) suggests that there is general agreement that beliefs eventuate from processes of enculturation and social construction and are highly contextualized (Mansour, 2009, 2013). Warda is striving to expose her students to a different perspective, because she recognizes the powerful forces of their parents' enculturation on her students' science epistemology. She reported feeling that her attempt to mediate them through the use of inquiry practices, is crucial to molding her students' understandings of the dogma of truth from a scientific perspective, which relies on empiricism and understands scientific knowledge to be tentative in nature (McComas, 2000).

CHAPTER V

DISCUSSION

Introduction

Over the past few decades, there have been serious concerns in the science education community and many unanswered questions as to how reforms-based science teaching can become a reality in elementary science classrooms. While the problem persists at all levels of K-12 science education, it is particularly critical for teachers at the elementary level, who face unique barriers to implementing science reforms (Davis et al., 2006; Gillies & Nichols, 2015). The focus on standardized testing has been particularly demanding on elementary science teachers, who are often overlooked, as resources and professional development are poured into tested subjects, such as literacy and math curricula instead (Sunderman et al., 2004). This research contributed to the existing literature reviewed and provided a glimpse into how practitioners are negotiating the challenges that reform efforts present, particularly within a specific population that has rarely been studied – elementary Muslim private school teachers. Since improved student achievement in science is the ultimate goal, it is crucial to understand how elementary science teachers understand inquiry, so that we can best help them to incorporate inquiry-based approaches in their classroom practices.

This study sought to examine elementary teachers' knowledge and understanding of, attitudes toward, and overall perceptions of inquiry-based science instruction, and how these beliefs influenced their inquiry practice in the classroom. It offered a description and analysis of the approaches elementary science teachers in Islamic schools reported using to promote inquiry within the context of their science classrooms, and addressed the challenges the participating teachers faced when implementing scientific inquiry strategies in their instruction. The following three research questions were examined, and findings corresponding to each of the questions will be discussed in the sections below:

1. How do elementary science teachers in Muslim private schools describe scientific inquiry, and how is it evidenced in their classroom practice?
2. What are the participant teachers' beliefs towards inquiry-based science instruction?
3. What personal and external factors have influenced these practices and beliefs?

Following the discussion of some of the key findings and situating them within the context of prior research, attention will be focused on the implications of the study's results on in-service elementary science teachers in Islamic schools. Finally, an examination of the study's limitations and suggestions for future practice and research will be shared.

Discussion of Findings

Research Question 1 Conclusions: Descriptions of Inquiry

The participant elementary science teachers in Muslim private schools varied in their depth of understanding and extent of practice of scientific inquiry, with multiple contextual factors contributing to a broad spectrum of findings. How well teachers were able to teach science-based inquiry depended first and foremost on their grasp of the meaning of inquiry and their familiarity with the NSES and more recently, the NGSS. As stated in the new Framework for K-12 Science Education, “science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge” (NRC, 2012, p. 26). It is well documented that “student learning of science depends on teachers having adequate knowledge of science” (NRC, 2007, p. 296) and how scientific knowledge is developed.

Several of the teachers participating in this study, particularly Nada and Hana, reflected Appleton’s (2006) conclusions that elementary teachers often view science as a complicated set of facts and definitions to be found in accurate sources such as books, views that impact on the nature of teaching and learning that occurs. This limited understanding of the inquiry process is a contributing factor to teachers’ lack of confidence in teaching inquiry science (Lee et al., 2004; Yoon et al. 2012), and was reflected in these participants’ responses accordingly. When teachers become more comfortable with both science content and the processes through which claims to scientific knowledge are generated and validated, they will be able to better incorporate the vision of the science education reforms of the Framework and NGSS in their classrooms (NRC, 1996, 2007, 2012).

Research Question 2 Conclusions: Beliefs Towards Inquiry-based Science Instruction

Research question two sought to characterize the teachers' beliefs and the extent to which their beliefs and practices align. This is significant, since the research clearly demonstrates that teachers' actions are heavily guided by deeply held belief systems (Bandura 1982, 1986, 1992, 1997; Pajares 1992). Therefore, an understanding of the beliefs of teachers who do and do not practice reforms based instruction is critical for future reform efforts.

Quantitative data was collected and analyzed from a self-report questionnaire, the Teaching Science as Inquiry (TSI) instrument (Dira-Smolleck, 2004; Smolleck & Yoder, 2006), to assess the self-efficacy beliefs of elementary teachers with regard to the teaching of science as inquiry (see Appendix A) . This survey instrument was created based on contemporary ideas about inquiry, as well as grounded in Bandura's theoretical framework, particularly the concept of self-efficacy being a context-specific construct (Smolleck &Yoder, 2006). However, Smolleck and Yoder recommended the use of the TSI instrument in combination with other data collection techniques, to more fully determine the self-efficacy beliefs of prospective teachers. Moreover, Tschannen-Moran and Hoy (2007) and Blonder et al. (2014) recommended the use of qualitative studies to fully appreciate the effect of vicarious experiences on teachers. In light of these recommendations, qualitative data was collected and analyzed from an interview protocol (see Appendix B), which included open-ended questions aimed at revealing the participants' perceptions, attitudes, and beliefs towards inquiry-based science instruction, and current instructional practices and external influences on those practices. Additionally, participants were asked during the interview to discuss the Inquiry Teaching Belief (ITB) Instrument activity items (Harwood et al., 2006), a self-reflection tool that provided information about how teachers describe their notions of inquiry, while eliciting their current beliefs about inquiry teaching in the science classroom (see Appendix C).

While results of this study demonstrated that teachers' beliefs, including their own self efficacy, influenced their instructional choices, the findings also revealed that beliefs are malleable and susceptible to change, for better, as in the case of Ayesha, Raneem and Mona. For example, Raneem’s transformational experience as a science student in college in the US and Mona’s participation as a teacher in an inquiry-based STEMscopes PD and curriculum positively influenced both of their beliefs about teaching science as inquiry.

Teachers’ previous experiences that influence inquiry instruction may not necessarily be positive. In a study by Nespor (1987) English teachers’ beliefs revealed that a teacher may model what was missing from his or her childhood experiences as a student. According to Nespor, teachers sought to overcome upsetting experiences they suffered in class as children, thus drawing inferences from their negative school experiences as students in becoming ideal teachers. Ayesha’s story is similar, in that her unenjoyable experiences in school of test taking, worksheets, and other traditional teaching strategies, are practices she purposefully avoids in her first grade classroom.

Another influencing factor was the presence or lack of science professional development. Nadelson et al. (2013), who recently reviewed the literature on teacher preparation for inquiry instruction contended that “Early and consistent exposure to inquiry may be fundamental for preparing future generations of teachers to teach using inquiry as well as future STEM professionals” (p. 159). Moreover, from their own research with teacher PD, they concluded that science PD should focus on enhancing content knowledge as a means of building teacher knowledge and comfort with teaching science. Similar to Nadelson et al.’s participants, the majority of elementary teachers’ in this study did not have prior experiences that exposed them to science inquiry. Hana and Nada, both veteran teachers who demonstrated little science inquiry implementation in their respective classrooms, admitted to not have participated in any science professional development during their careers. Their lack of understanding about inquiry instruction and the complexity of this approach, suggests that they would have benefited from more PD opportunities, such as Mona, Warda and Ayesha experienced.

Warda and Ayesha, who represented opposite ends of the spectrum in terms of experience with the first grade science content they were teaching, both recognized the importance of inquiry-based instruction and took the initiative to reach out to attend additional online science webinars and workshops, in addition to attending their MIT classes, and in the case of Warda, even consulting her sister, a middle school science teacher. Their shared belief of the importance of this reform-based instructional strategy and their acknowledgement that there was always more to learn about inquiry, motivated these participants to continuously enhance their content knowledge and pedagogical knowledge, regardless of how strong they already were.

In all, this study’s findings suggest that one factor influencing participating teachers’ beliefs and practices was their own personal direct experiences with inquiry instruction or lack of, confirming Lumpe et al. (2011) research that found teachers develop their beliefs about teaching from the years of experience spent in the classroom as both students and teachers. Understanding teachers’ beliefs as well as the various factors that led to the teacher participants’ current and changed beliefs contributes to an appreciation of teachers’ versatility, and informs efforts to move all elementary teachers in the direction of implementing science inquiry in the classrooms.

Research Question 3 Conclusions: External Factors

The third research question specifically addressed the external factors that have contributed significantly to the participants' instructional science inquiry practices. It particularly shed light on the political, cultural, and technical barriers to science instruction that they faced, in addition to emphasizing the impact of professional development on their instruction. The most significant barriers were found to be limited time and resources, the school’s testing preparation ethic, and teachers’ limited content knowledge. Each of the seven participants mentioned the barriers of lack of time available to discuss topics in depth, conduct investigations, and use alternative, informal assessments to demonstrate evidence of knowledge. Although determining the extent of student learning by two-way journaling, peer-assessment, and self-assessment may help promote a positive and informative assessment culture in the classroom, it is difficult to implement in the current, fast-paced atmosphere of standards-based education and assessment (Peters, 2008).

For this study, interviews showed that teachers felt that school environmental factors influenced their ability to enact structured inquiry. For example, Hana spoke often about how students were pulled off task and having difficulty “keeping their hands to themselves,” while Ayesha revealed that at times students were not highly motivated to do inquiry or not ready to take control of their own learning. A school and classroom environment that encourages student motivation and student taking control of their own learning of these are crucial to the 5 Essential Features of science inquiry and the establishment of student-centered teaching and learning.

This study’s findings add support to the argument that inquiry-based instruction cannot be sustained in school environments where elementary teachers believe that science should be placed on the backburner (Leonard, Barnes-Johnson, Dantley, & Kimber, 2011). Because science takes a backseat and is not really stressed at her school, Nada developed her own scope and sequence, picking and choosing the topics she enjoys or is more comfortable teaching, rather than what is supported by research or standards. Nada even conceded that science may not be a necessary subject for third grade:

> It’s just I feel like science is kind of…Third grade it’s not absolutely necessary, but I wish we had more time for it. And the time we…I wish we didn’t have to cover so many…Such wide variety of topics because it’s not enough time. That it’s just a few things where they could really get deep into it, where I could talk

> about the same thing for, let's say a month. Sometimes it just feels like it doesn't fit, and if we get to it, yay. If we don't, it's okay. You know what I mean?

Findings from these participants supported the notion that the school and/or classroom environment could be a contextual factor that influenced some teachers' classroom beliefs about the feasibility of implementing science inquiry.

Muslim parents, similar to parents with children in other private religious schools, seek out Islamic schools "to keep their children 'uncorrupted' from the secular society" and may "feel that the only option available to them is an Islamic education" (Merry, 2005, p. 379). Some families, fearing their children's exposure to "potent influences of secularization" (p. 379), prefer they avoid integration into the liberal democratic society that surrounds them. This is especially true of Muslim parents who are recent immigrants. Although Muslim educators in Islamic schools have been tasked to critically examine existing curricula and make necessary revisions in order to reflect more traditional Islamic views in their classrooms, a mismatch sometimes occurs, in that teachers feel a disconnect between their ideas for a class environment and what the parents envision the classroom environment to be. Warda's conclusions corroborated Merry's findings, in that she felt the Muslim community has been wary of the idea of scientific inquiry because the nature of science as a way of knowing, a secular and liberal epistemology, would be in conflict with Islam. Similarly to Merry, Warda further acknowledged that the Muslim community's mindset to this regard has improved, because every generation after the first immigrant generation is becoming more educated. Overall, the cultural and religious context of the Islamic private school setting, which sometimes reflects the initial immigrant ethos, shapes the unique challenges facing students and teachers in Islamic schools. It is therefore essential to understand how this unique Islamic school culture shapes the elementary science teacher's experience and decisions in the classroom.

Implications

Beliefs and attitudes towards inquiry-based science instruction of participant teachers may affect the practice of inquiry in teaching science in their classroom (Choi & Ramsey, 2009). The current study's results give insight into how the teacher participants in this study think about inquiry-based science instruction and their practice within private Muslim elementary schools. This study contributes to the literature base by enabling readers to learn from these teachers' perspectives, including the factors that promoted or hindered inquiry-based instruction implementation in their classrooms. Based on the conclusions of this study, there are a number of implications for elementary science teachers, administrative personnel responsible for curriculum, and education professionals designing and delivering in-service professional development for elementary science teachers, that will be discussed below.

Some of the constraints that prevented teachers in this study from the implementation of inquiry-based instruction included lack of science content knowledge, process knowledge, time constraints, funding, and lack of support from administrators. Therefore, some teachers contended that if science should be tested at most grade levels like mathematics and English language arts, then administrators would be forced to promote the teaching and learning of science by allocating more funds, resources, and time. Furthermore, elevating the importance of science in schools would encourage administrators to promote science PD for their elementary teachers. Basically, the more supportive and accommodating schools are of science-based reforms, the more likely their elementary teachers would be willing to incorporate the science inquiry process in the classroom.

Teachers' beliefs about science teaching and learning as well as their sense of self-efficacy are impacted by a combination of personal and professional experiences. As such, it is difficult to pinpoint the exact combination of experiences that led to the strong beliefs of the current study's participants. However, the results of this study suggested that these beliefs did not develop from participants' undergraduate education programs, which raises the question of whether teacher preparation programs need to do more to prepare elementary teachers for teaching science. Further, even those in-service teachers in this study with years of experience felt they needed more exposure to learning inquiry-based science instruction, even years after they entered the classroom. By focusing formal professional development efforts on enhancing teachers' content and pedagogical knowledge, teachers are more likely to gain confidence in their abilities to teach elementary science (Choi & Ramsey, 2009). Initially, this effort would have to focus on increasing teachers' familiarity with what reforms-based practices look like. Once they understand the philosophy behind reforms-based instruction, they can begin to believe in it.

Since beliefs are malleable and susceptible to change, providing reflective activities to help teachers examine their beliefs and assumptions about science content may lead to them be more accepting of practical, concrete strategies for implementing science inquiry in the classrooms (Leonard et al., 2010). This study revealed that science inquiry exposure, in the form of PD or graduate education courses, enabled elementary teachers to have a higher confidence level for implementing inquiry. Ideally, participants also expressed the desire for professional development that provided opportunities to collaborate and implement new pedagogy concurrently while they were teaching. For example, Mona preferred to attend a workshop in person rather than being briefed by her co-teacher, and Ayesha suggested the high school science department conduct PD for the elementary science teachers. All seven participants acknowledged the benefit and identify the potential value of PD on improving their science teaching. Those teachers that experienced first-hand science inquiry teaching through PD or science methods courses, such as Ayesha and Mona, were more willing to transfer their knowledge of science inquiry to their students. Science inquiry implementation and teaching was not as daunting of a task as it was for other participants of this study (Harlow, 2007).

From the perspective of PD developers, the need to attend specifically to teachers' beliefs while conducting science professional development is a fundamental implication of the research. The apparent influence of elementary teachers' beliefs on knowledge and understanding of science inquiry in addition to their science classroom practices suggests that teacher beliefs should be a focus of science methods courses for teachers and further professional development in science. The findings support a wealth of literature (Anderson, 2015; Gess-Newsome, 2013; Lumpe et al., 2011; Van Aalderen-Smeets & Walma van der Molen, 2015) suggesting that teacher beliefs about the purposes of science education as well as about science itself should be a key focus in professional development.

Another component of a successful science inquiry PD would be one which modeled science inquiry for its participants, as was evident with Ayesha and Mona's experiences. Tseng et al. (2013) recounted that veteran science teacher participants in their study claimed that their persistence in implementing inquiry science in their classrooms was due to their positive experiences in implementing inquiry during their own learning and professional development. Teachers in Gillies and Nichols (2015) study also appreciated the first-hand experience of the same inquiry that they were to implement in their own classrooms, which may have contributed to their willingness both to implement the inquiry as well as to see the benefits inquiry brought to their students.

The results of Lakin and Wallaces's (2015) study indicate potential for teachers in achieving a better appreciation of and understanding of scientific inquiry through the use of the term scientific practices, rather than inquiry. The Framework for K-12 Science Education (NRC, 2011) includes inquiry under the umbrella term "scientific practices." and states, "we use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice" (p. 30). The construct of inquiry has been distressed by misunderstanding and miscommunication for over thirty years, but the use of scientific practices as defined in the NGSS present a more crystallized vision of what one does while engaged in science, such as asking questions or analyzing data that may be more easily recognized in the classroom. Furthermore, there are many specific examples of scientific practices in the NGSS, making it possible for teachers to develop a tangible sense of these practices. In contrast, the term inquiry has over the years referred not only to scientific practices, but also to entities such as understandings of the nature of science, a philosophy, an epistemology, a guiding principle of instructional design, a type of curriculum, and even a form of pedagogy (Settlage, 2013). Given the diverse range of inquiry understandings of the participants, it seems that a more unified concept of scientific practice, as deemed by the NGSS, would help promote better understanding of inquiry, deeming it crucial for curriculum personnel in schools to promote alignment of the elementary science curriculum to the NGSS.

Limitations

All educational research requires establishing equilibrium between what it takes to adequately accomplish research goals and the feasibility and practicality of doing work in schools. As a consequence, any investigation's results need to be carefully considered in light of its limitations. Methodological choices made for this study, although warranted based on the research questions and theoretical frameworks, may limit the interpretation of the results. Nonetheless, the findings and conclusions of the current study still support science education reform efforts and provide a platform for future research efforts.

The demographics of the study were restricted geographically to the Islamic Schools in the Chicagoland area, and fewer teachers were willing to participate in the study than was anticipated. Therefore, a limitation of this study is the small number of participants completing the ITB survey instrument, rendering the use of statistical analysis impossible. A larger sample size is prone to yielding statistically significant results, as opposed to small sample size used in this study, thereby allowing for more generalizability of the quantitative data (Patten, 2005).

Although self-reporting of participants is an efficient data collecting method for researchers, it is known to be problematic at times, and participants' responses may not always align with their actual practices (Supovitz & Turner, 2000). Another key issue faced with self-reporting is the possibility of response biases that stem from the participant's desire to impress others favorably; thereby leading participants to present impressions that are compatible with what they think will please the researcher (Podsakoff, McKenzie, Lee, & Podsakoff, 2003). In addition to the possibility of social desirability biases, the relatively weak understandings of science inquiry of some of the participants may have led to their over-reporting of their own use of inquiry. According to Lakin and Wallace (2015), a teacher who does not have a strong grasp of what constitutes inquiry, may not recognize it in practice or appreciate how it can be used effectively. Consequently, several researchers have concluded that participants partaking in self-reporting instrument surveys may overrate their own use of inquiry strategies (Lakin & Wallace, 2015; Lee et al., 2004). In order to compensate for the inadequacies of self-reporting, this study employed mixed methods.

Moreover, the absence of any observational data to assess how intention translated into practice was a significant limitation of the current study. Although ample survey evidence and interview responses was provided to both characterize teachers' beliefs and reveal the consistency of beliefs and practices, a future study should include observations of participant teachers using a reliable and valid inquiry observation protocol. Supplementary sources of data would increase triangulation with other findings and ensure better validity of the study as well.

Some of the participants of this study had unique interpretations of the addressed questions regarding how subjects interpret the activity items of the ITB instrument. Although most participants generally understood the ITB activity items as intended by Harwood and colleagues (2006), the authors alerted future researchers using their instrument to be mindful that subjects may still have unique interpretations of the listed activity items, and this variation in interpretation may threaten the reliability and validity of inferences concluded from the findings. However, by combining the quantitative ranking of the ITB activity items with the corresponding qualitative interview responses of the participants, this discrepancy can be compensated for. For example, in this study, Ayesha approached the ITB items from a student's perspective, while Raneem ranked the activity items by most enjoyable to her students. These alternative interpretations were only understood based on the qualitative data provided from the teachers' interviews responses.

As a primary instrument, the researcher's bias towards using inquiry in the classroom is a limitation. Due to the triangulation of the study, this bias should not present a significant problem with the results. Efforts to collect and analyze data in systematic ways and refraining from acting as a full participant helped reduce researcher bias. While these approaches certainly minimized the impact of the researcher's values, knowledge, and opinions on participants' instructional choices and beliefs, their impact cannot be mitigated completely and must be acknowledged. A personal interest in reforms-based instruction and a commitment to helping elementary science teachers was at the core of the current study and most likely apparent to study participants.

Recommendations for Practice and Future Research

Revisions in the research methodology could improve and expand the study. While the focus of this research was intentionally small, future large-scale studies could recruit participants from Islamic schools throughout the United States, rather than just the Chicagoland area. Furthermore, a longitudinal study of the participants that included classroom observations could provide new findings about the teachers' practices of science inquiry teaching and learning in the classroom. Funding would be needed to undertake a larger study of this scope.

Muslim private schools are a relatively new addition to the collection of school systems in the United States, but unfortunately, a school system that has been rarely visited by education researchers. Given that this novel and unique population is one that is neglected in the science education literature, this study serves as important foundational research for Islamic school educators, administrators, and curriculum specialists. By providing valuable information about science inquiry implementation in elementary classes in Islamic schools, findings of this study and future research will facilitate the development of standards of learning, aligned curricula, and other facets of the science educational program, alleviating challenges faced in the absence of quality curriculum control (Nimer, 2002).

It is evident from the results that a focus on developing and promoting self-efficacy beliefs about science teaching is vital, and this may be directly influenced by teachers' content and pedagogical knowledge. Changing in-service teachers' instructional beliefs and practices is difficult, and the NSES and NGSS promote practices that require dramatic changes for most teachers. Thus, to more fully understand and encourage the types of teacher efficacy that support teacher development and improved science inquiry instruction, new approaches to teacher efficacy research are needed. To discern how teacher efficacy, science content knowledge, and pedagogical content knowledge (PCK) may work together, teacher efficacy investigations should be conducted within the participants' cultural context of elementary science teaching and should include qualitative means of research.

It is apparent from this study's findings that the relationship between teacher's beliefs and the implementation of science inquiry in their respective classrooms is complex and multifaceted. Future studies may perhaps need to redefine what constitutes beliefs that actually impact teacher practice, perhaps using Hunter and Markman's (2016) operational definition of beliefs as "one of many types of mediating representations that is used in a cognitive process if and only if the belief is currently active" (p. 679). Unlike previous definitions of belief, this current definition is clearer about the relationship between beliefs, cognition, and practice. Furthermore, Hunter and Markman's operational definition of beliefs does not assume a direct relationship between beliefs and teacher practice; beliefs about inquiry-based science instruction are essential, but not the only factor contributing to if and how science inquiry teaching is practiced. As explained by Hunter and Markman (2016), "all beliefs do not influence action all of the time, and as a result, a science teacher can hold a belief without acting in ways that are congruent with such a belief" (p. 679).

As is evident from the current study, science professional development still has a ways to go before it reaches teachers' classrooms and influences practice as intended. A greater understanding of how professional developers and science supervisors can encourage the types of behaviors that positively impact teachers' self-efficacy and encourage them to engage in reform-based teaching, such as science inquiry, is still needed. Above all else, it is essential to recognize that classroom teachers are key to the implementation of science inquiry, because it is in their classrooms that this reform becomes a reality. Research that shares the success stories of teachers who are effectively teaching science inquiry and overcoming with a variety of obstacles, along with the stories of teachers who are struggling with science inquiry implementation, will provide valuable insight into what is possible and how it can be accomplished.

Summary

The NSES and more recently, the Framework for K-12 Science Teaching and the NGSS, advocate for science inquiry to be an essential practice in all K-12th grade science classrooms. It is the author's belief that students taught by the inquiry approach become more interested in science and develop their scientific literacy, thereby enabling them to compete scientifically with the top nations in today's more global society. Therefore, schools that adopt these standards and align their science curricula to them will prepare their students to conceptualize science more readily through their life experiences and enable them to think like scientists.

Although teacher beliefs are influential, they are malleable and adaptable. If elementary science teachers can practice more science inquiry techniques in various science PD opportunities, albeit with a focus on attitudes and beliefs, then perhaps their beliefs about the importance and usefulness of inquiry for their students would increase and translate into integration of this constructivist approach in the science classroom. Moreover, when elementary science teachers feel more confident about their abilities to implement science inquiry practices, their self-efficacy will increase, and they will be more willing to incorporate science inquiry into their classrooms. Hopefully, this dissertation research will be the catalyst for examining science inquiry in elementary Islamic school science classes with more scrutiny.

APPENDIX A

TSI SURVEY QUESTIONNAIRE

Teaching Science as Inquiry (TSI) Instrument—Inservice Version

Dira-Smolleck, L.A. (2004). The development and validation of an instrument to measure preservice teachers' self-efficacy in regards to the teaching of science as inquiry. Unpublished doctoral dissertation. The Pennsylvania State University.

Teaching Science as Inquiry (TSI-2) Instrument

ID Number: ____________________ **Circle One:** Male Female
Course Title: __________________ **Circle One:** K 1 2 3 4 5 6

Please indicate the degree to which you agree or disagree with each statement below by circling in the appropriate number as indicated below.

5 = Strongly Agree
4 = Agree
3 = Uncertain
2 = Disagree
1 = Strongly Disagree

When I teach science…

1. I am able to offer multiple suggestions for creating explanations from data. 5 4 3 2 1
2. I am able to provide students with the opportunity to construct alternative explanations for the same observations. 5 4 3 2 1
3. I am able to encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge. 5 4 3 2 1
4. I possess the ability to provide meaningful common experiences from which predictable scientific questions are posed by students. 5 4 3 2 1
5. I have the necessary skills to determine the best manner through which children can obtain scientific evidence. 5 4 3 2 1
6. I require students to defend their newly acquired knowledge during large and/or small group discussions. 5 4 3 2 1
7. My students select among a list of given questions while investigating scientific phenomena. 5 4 3 2 1

8. I provide opportunities through which children obtain evidence from observations and measurements. 5 4 3 2 1
9. I expect my students to make the results of their investigations public. 5 4 3 2 1

When I teach science…

10. I am able to provide opportunities for students to become the critical decision makers when evaluating the validity of scientific explanations. 5 4 3 2 1
11. I am able to guide students in asking scientific questions that are meaningful. 5 4 3 21
12. I am able to provide opportunities for my students to describe their investigations and findings to others using their evidence to justify explanations and how data was collected. 5 4 3 2 1
13. I create (plan) investigations through which students are expected to gather particular evidence. 5 4 3 2 1
14. I am able to negotiate with students possible connections between/among explanations. 5 4 3 2 1
15. I expect students to independently develop explanations using what they already know about scientifically accepted ideas. 5 4 3 2 1
16. I encompass the ability to encourage students to review and ask questions about the results of other students' work. 5 4 3 2 1
17. I am able to guide students toward appropriate investigations depending on the questions they are attempting to answer. 5 4 3 2 1
18. I am able to create the majority of the scientific questions needed for students to investigate. 5 4 3 2 1
19. I possess ability to allow students to devise their own problems to investigate. 54 3 21
20. My students make use of data in order to develop explanations as a result of teacher guidance. 5 4 3 2 1
21. I am able to play the primary role in guiding the identification of scientific questions. 5 4 3 2 1

When I teach science…

22. I am able to guide students toward scientifically accepted ideas upon which they can develop more meaningful understandings of science. 5 4 3 2 1
23. I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations. 5 4 3 2 1
24. I expect students to recognize the connections existing between proposed explanations and scientific knowledge. 5 4 3 2 1
25. I expect students to ask scientific questions. 5 4 3 2 1
26. I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence. 5 4 3 2 1
27. My students investigate questions I have developed. 5 4 3 2 1
28. My students create scientific explanations based on evidence, as a result of teacher assistance. 5 4 3 2 1

29. My students derive scientific evidence from instructional materials such as a textbook. 5 4 3 2 1
30. I am able to encourage students to gather the appropriate data necessary for answering their questions. 5 4 3 2 1
31. I am able to offer/model approaches for generating explanations from evidence.54321
32. I am able to coach students in the clear articulation of explanations. 5 4 3 2 1
33. Through the process of sharing explanations, I am able to provide students with the opportunity to critique explanations and investigation methods. 5 4 3 2 1

When I teach science…

34. I require students to create scientific claims based on observational evidence. 5 4 3 21
35. I expect my students to think about other reasonable explanations that can be derived from the evidence presented. 5 4 3 2 1
36. I am able to facilitate open-ended, long-term student investigations in an attempt to provide opportunities for students to gather evidence. 5 4 3 2 1
37. I am able to help students refine questions posed by the teacher or instructional materials, so they can experience both interesting and productive investigations. 5 4 3 2 1
38. I am able to provide demonstrations through which students can focus their queries into manageable questions for investigation. 5 4 3 2 1
39. I require students to develop explanations using evidence. 5 4 3 2 1
40. I am able to utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process. 5 4 3 2 1
41. My students refine their explanations using possible connections to scientific knowledge that have been provided. 5 4 3 2 1
42. I am able to model for my students prescribed steps or procedures for communicating scientific results to the class. 5 4 3 2 1
43. I am able to provide my students with possible connections to scientific knowledge through which they can relate their explanations. 5 4 3 2 1
44. I am able to provide my students with evidence to be analyzed. 5 4 3 2 1

When I teach science…

45. My students engage in questions I have provided them. 5 4 3 2 1
46. My students engage in questions that are provided by a variety of sources such as the textbook. 5 4 3 2 1
47. My students analyze data that has been supplied, while following teacher instruction 5 4 3 2 1
48. I expect my students to clarify the questions provided in an attempt to enhance science learning. 5 4 3 2 1
49. I am able to provide my students with data needed to support an investigation. 5 4 3 2 1
50. My students communicate and justify their explanations to the class using broad guidelines that have been provided. 5 4 3 2 1

51. My students choose the questions they would like to investigate from a list provided 5 4 3 2 1
52. My students analyze teacher provided data in a particular manner. 5 4 3 2 1
53. My students form their explanations using evidence that has been provided. 5 4 3 2 1
54. I am able to provide my students with all evidence required to form explanations through the use of lecture and textbook readings. 5 4 3 2 1
55. My students construct explanations from evidence using a framework I have provided. 5 4 3 2 1
56. I expect my students to follow predetermined procedures when justifying their explanations. 5 4 3 2 1
57. My students determine what evidence is most useful for answering their scientific question(s). 5 4 3 2 1

When I teach science…

58. My students design their own investigations and gather the evidence necessary to answer a particular question. 5 4 3 2 1
59. I expect my students to collaborate with me in an attempt to construct criteria for sharing and critiquing explanations. 5 4 3 2 1
60. My students share and critique explanations while utilizing broad guidelines that have been provided. 5 4 3 2 1
61. I expect students to use internet based resources or other materials to further develop their investigations. 5 4 3 2 1
62. I am able to model for my students the guidelines to be followed when sharing and critiquing explanations. 5 4 3 2 1
63. I am able to instruct students to independently evaluate the consistency between their own explanations and scientifically accepted ideas. 5 4 3 2 1
64. I expect my students to negotiate with me the criteria for sharing and critiquing explanations. 5 4 3 2 1
65. I am able to construct with students the guidelines for communicating results and explanations. 5 4 3 2 1
66. I expect my students to refine questions that have been provided. 5 4 3 2 1
67. I am able to provide my students with explanations. 5 4 3 2 1
68. I expect my students to justify explanations using given steps and procedures. 5 4 3 2 1
69. My students comprehend teacher presented explanations. 5 4 3 2 1

APPENDIX B

INTERVIEW PROTOCOL

Interview Protocol

Teacher Beliefs Interview Instrument (TBI) Questions (Luft & Roehrig, 2007):

1. How do you maximize student learning in your classroom? (learning)
2. How do you describe your role as a teacher? (knowledge)
3. How do you know when your students understand? (learning)
4. In the school setting, how do you decide what to teach and not to teach? (knowledge)
5. How do you decide when to move on to a new topic in your classroom? (knowledge)
6. How do your students learn science best? (learning)
7. How do you know when learning is occurring in your classroom? (learning)

Research Question 1: How do elementary science teachers in Muslim private schools describe scientific inquiry and how is it evidenced in their classroom practice?

What does scientific inquiry mean to you?
When did you first learn about scientific inquiry?
When you hear the term 'scientific inquiry' what comes to mind?

Research Question 2: What are the participant teachers' beliefs towards inquiry-based science instruction?

What are the goals for your students' learning of science?
When you hear the term 'scientific inquiry' what comes to mind?
What are some of the important lessons that children can learn through this type of learning?

Research Question 3: What personal and external factors have influenced these beliefs and practices?

What are some of your favorite science activities to do with your students?
How did you engage your students in scientific inquiry?
How did your students respond to this type of instruction?
What is your most memorable science lesson? What is your least memorable lesson?
The following questions relate to an exemplar inquiry lesson the interviewees will choose:

Describe an ideal inquiry lesson you have used in your classroom.
Can you talk about how you decided to structure your lesson this way?
What were your main goals for this lesson?
Did you feel those goals were realized? Why or why not?

Why did you select this particular lesson to share?

How are decisions about curriculum and instruction around science made in your school?

How do you plan your science instruction? Do you reference standards? Follow a textbook?

What types of materials do you use in your class for science instruction?

How does scientific inquiry fit within your curriculum?

What factors influence the use of inquiry in your classroom?

How are decisions about professional development for science made in your school?

Have you had any professional development regarding scientific inquiry?

APPENDIX C

ITB INSTRUMENT

Inquiry Teaching Belief (ITB) Instrument

Activity Items

Students evaluating data
Students reflecting on their work
Students collaborating with one another
Students designing and implementing appropriate procedures
Students communicating their findings to the class
Students writing reports
Students using evidence to defend their conclusions
Students asking questions
Students formulating questions to investigate
Students researching what is known
Students engaging in activities with predetermined outcomes
Students receiving factual information from their teacher
Students listening to instructor lecture
Students reading assignments in textbooks
Students completing worksheets
Students working independently in class
Students taking paper-and-pencil tests
Students taking multiple choice tests

Activity items from the most recent y-ITB version. Inquiry oriented activities are in bold, neutral activities are in regular type, and non-inquiry activities are in italic.

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VITA

Linda Mahairi Hamadeh is the daughter of Marwan and Hiba Mahairi. She was born in Chicago, Illinois on October 27, 1973. She currently resides in a suburb of Chicago with her husband and four children.

Linda Hamadeh attended public schools in various Chicago suburbs and graduated high school at the age of 16. She graduated from Northeastern Illinois University in 1997, summa cum laude, with a Bachelor of Science dual degree in Biology and Secondary Education, in addition to earning a Type 09 certification in 6-12 science with numerous endorsements. In 2004, Linda Hamadeh earned a Master of Arts degree in Education Supervision and Leadership, and qualified for a Type 75 School Administrative Certificate from St. Xavier University.

Linda Hamadeh has worked in the field of education for the past 25 years. While still in college, she began her career as an educator of students in weekend schools, tutoring students in the Arabic language and teaching religious studies. Linda Hamadeh has taught in numerous weekend schools, and is currently a principal of 12 years of the Mecca Center Sunday school, a weekend school in her area. She has taught high school science at Universal School for almost 20 years, has been the science department chair for almost 15 years, and is currently a curriculum coordinator at the private school.

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