THE INFLUENCE OF THE INQUIRY INSTITUTE ON ELEMENTARY TEACHERS’ PERCEPTIONS OF INQUIRY LEARNING IN THE SCIENCE CLASSROOM

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Despite the positive outcomes for inquiry-based science education and recommendations from national and state standards, many teachers continue to rely upon more traditional methods of instruction. This causal-comparative study was designed to determine the effects of the Inquiry Institute, a professional development program that is intended to strengthen science teachers’ pedagogical knowledge and provide practice with inquiry methods based from a constructivist approach. This study will provide a understanding of a cause and effect relationship within three levels of the independent variable—length of participation in the Inquiry Institute (zero, three, or six days)—to determine whether or not the three groups differ on the dependent variables—beliefs, implementation, and barriers. Quantitative data were collected with the Science Inquiry Survey, a researcher-developed instrument designed to also ascertain qualitative information with the use of open-ended survey items. One-way ANOVAs were applied to the data to test for a significant difference in the means of the three groups. The findings of this study indicate that lengthier professional development in the Inquiry Institute holds the most benefits for the participants.
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CHAPTER 1
INTRODUCTION

During the 1940s, Bruner (2006) described the nation’s attitude surrounding education as though it were a second-class subject. He further explained education was not considered an important social issue. However, to improve social awareness, from 1920-1970, the attempt to integrate psychologists and social workers as specialists in the school system was part of a larger movement that was meant, “to establish, organize and reorganize school and school programs” (Doll, 1996, p.9). This movement was one of six during the period of 1860-1995 that served to effect curriculum change and improvement. Science in particular, became a controversial topic with its introduction as a discipline in schools in the middle of the eighteenth century. Topics of debate that are still occurring today included content, objectives, and teaching methods (Matthews, 1994). One teaching method, inquiry-based instruction, is the focus of this study, and I seek to better understand the use of this method in science classroom that has been a component of science reform efforts.

In order to situate the historical curriculum concerns and movements in education related to science and how social and cultural forces affected schools both directly and indirectly, careful examination of the political climate during the nineteenth century is essential (Doll, 1996). Just as World War II was ending, the United States and the Soviet Union, former wartime allies, were pitted against one another in a global contest for power (Foner, 2005). Known as the Cold War, these events lasted from the 1940’s to the early 1990’s. This ideological struggle produced a culture of competition for superiority. Coinciding with the end of World War II, Rudolph (2005) notes that “life-
adjustment” curriculum deeply rooted in progressive educational practices was predominant in American schools (p.17). Rudolph further explains this curriculum as a vocational model extended to general education and designed to meet the daily and social needs of all students, as opposed to an instruction to prepare students for college and work. Windschitl (2006) added, “academia and scientists charged that life adjustment focused on methods of instruction rather than content and promoted adjustment at the expense of learning” (p. 349). Two notable camps of science education reformers emerged by the early 1950s: those who wanted instruction based on students’ curiosity and life experiences and those who wanted a return to strong academic subject concentration (Rudolph, 2005).

A stronger call for reform came after the launch of the Russian satellite Sputnik in 1957 promoting educational concerns across both political and social arenas. Bruner (1996) described the government’s declaration as a “missile gap” that was ultimately translated into a “knowledge gap” issue. Regardless of wording, but without dispute, this “gap” propelled both science and mathematics to the forefront of the educational reform movement. In addition to improving scientific education, Sputnik symbolized the need for basic scientific research, in turn prompted sizeable increases in government spending with recipients such as the National Science Foundation (NSF). The impact of this Russian event also spurred new legislation that was quickly enacted to help our nation’s education system to compete. Mazuzan, NSF Historian, (1994) confirmed that “the National Aeronautics and Space Act (NASA), more than any other post-Sputnik law, had great impact on increasing federal funding of scientific research and development” (Mazuzan, 1994, p.13). In For Better or Worse: The Marriage of Science
and Government in the United States (2000), Mann describes how Congress,
responded with the National Defense Education Act (NDEA) of 1958. The act
emphasized science education and became a substantial part of the country's science
policy. Programs such as student loans, aid to elementary and secondary school
instruction in science, mathematics and foreign languages, and graduate student
fellowships were provided by the act. Underlying the curriculum reforms initiated by the
NDEA, was the learning theory of Bruner that stressed the structure of education, such
as the major concepts and methods of inquiry (Webb, Metha, & Jordan, 1996).

As meetings and conferences began to take place across the country, the NSF
put scientists in control of the curriculum reform leaving teachers and education faculty
in the background with little voice. This approach of "top-down" curriculum
development was meant to "teacher-proof" the curriculum (Matthews, 1994). The NSF
proclaimed that its curriculum projects were seeking "to respond to the concern, often
expressed by scientists and educators, over failure of instructional programs in primary
and secondary schools to arouse motivating interest in, and understanding of, the
scientific disciplines" (Crane, 1976, p.9). Perhaps questioning the achievement of its
goals, Matthews (1994) noted that "after twenty years of energetic involvement and $1.5
billion in financial support," the NSF withdrew their support for school curriculum (p. 18).
Many researchers began to question the effectiveness of the enormous federal support.
It was determined by several studies that these curricular reforms were only marginally
successful in achieving their goals and satisfying both society's and the government’s
hopes for education (Harms & Yager; 1981; Helgeson, Blosser, & Howe, 1977; Stake &
The early 1980s brought about another opportunity for science reform. Given its condemnation of public education, *A Nation at Risk* (1983), issued an imperative for education reform and encouraged individuals in business, education and government to closely reevaluate and change the teaching and learning processes in the United States. As a result of reform efforts since the 1940s, the educational system, particularly in the area of science education, has experienced multiple changes in the form of new curriculum, new programs, more financial support, stricter guidelines, innovative strategies, and creative methods touted necessary to improve student achievement (Moreno, 1999). Solid contributions to science reform in education emerged from two noteworthy publications, the *Benchmarks for Science Literacy* (AAAS, 1993) and the *National Science Standards* (NRC, 1996).

In order to help Americans become literate in science, math, and technology, the American Association for the Advancement of Science (AAAS) founded Project 2061. In the 1989 publication *Science for All Americans (SFAA)*, Project 2061 identified specific principles for effective teaching and learning, including the use of the scientific method of inquiry—a constructivist instructional model. In 1993, *Benchmarks for Science Literacy* (*Benchmarks*) was introduced as a companion report to the 1989 *SFAA* publication (AAAS, 1993). Both of these publications were intended as tools to guide science education reform.

More than a decade has passed since the National Research Council (NRC) and the National Academy of Sciences (NAS), funded by the National Science Foundation (NSF), published the landmark science education reform document *National Science Education Standards* (*Standards*). The *Standards* envisioned science teachers using
inquiry-based strategies to promote conceptual understanding through the use of critical and logical thinking and consideration of alternative explanations (National Research Council, [NRC], 1996). The intent of this constructivist-based science reform movement was to help students build a solid foundation of science literacy while engaging in authentic inquiry. This was developed as a comparison to research conducted by working scientists who are studying “the natural world and proposing explanations based on the evidence derived from their work” (National Research Council [NRC], 1999, p. 2).

In addition to the Benchmarks and Standards, the Texas Essential Knowledge and Skills (TEKS), a set of learning objectives developed as the state curriculum for Texas, supports the use of inquiry-based instruction in the state of Texas. Since 2004, the TEKS have provided a foundation for the state criterion-referenced test known as the Texas Assessment of Knowledge and Skills (TAKS) (Texas Education Agency, 1998). Science TEKS §112.2 requires K-12 students in Texas to develop skills necessary to follow a scientific process of inquiry (TEA, 1998). This method of inquiry, supported by these three documents, is a natural extension of constructivism—a conceptual framework based on observation and scientific study about how people learn. The theories of Dewey, Vygotsky, Piaget, and Bruner, which are discussed in chapter 2, lend support to constructivist learning theory which is the result of continual changes in our mental framework while we attempt to understand and create meaning out of our experiences (Osborne & Freyberg, 1985).
Conceptual Framework

My philosophical mind-set for this study is aligned with the Benchmarks, Standards, and the TEKS, but more importantly, firmly situated within the principles of constructivism. Understanding this learning theory, constructivism, is essential because it is the foundation to understanding inquiry-centered classrooms and the basis of this study. Constructivism, contrary to behaviorism, is based on a cognitive approach where learners are active participants who make meaning or construct knowledge by linking current and prior understanding (Llewellyn, 2002, p.30). Linking or assimilating new and prior knowledge is a critical assumption to this theory. The constructivist Ausubel (1978) wrote, “The most important single factor influencing learning is what the learner already knows” (p. iv). The views of other constructivist theorist are discussed in chapter 2.

Statement of the Problem

Our public school system is far from attaining the goal of inquiry-based instruction in science classrooms demanded by the TEKS (Crawford, 2007). Departing from the traditional learning environment is problematic due to existing curricular, developmental, and pedagogical realities (Waight & Abd-El-Khalick, 2007). Researchers have found that many teachers have a propensity to use the same pedagogic practices their own college professors used during their pre-service education (Akerson & Hanuscin, 2006; Cross, 1996; Felder, 1993; Gregg, 1994; Gregg, 2001). A majority of college education is delivered by lecture and dominated by teacher-centered instruction; this methodology can lead to disconnected facts and short-term memorization (Taylor,
Gilmer, & Tobin, 2002). Furthermore, Gregg (2001) found that teachers’ own concept of learning originates from their experiences as a student. Without inquiry-based professional development and support embedded within a constructivist perspective, many science teachers cover content and dispense facts without developing scientific skills and building science literacy, the goal of science reform (NRC, 1999). Supporting change, Coble and Koballa (1996) state:

A new conception of teaching is critical to realizing a new vision of science education. Consistent with the new vision, the teacher must assist students to construct new knowledge. The teacher can no longer be the giver of factual information; rather the teacher must be a facilitator and role model who gently guides students through the adventure of learning, encouraging them with questions, and feedback and sharing their curiosities and excitement. (p. 462)

Simply stated, the formation of a constructivist environment with the use of inquiry-based instruction can enable science education reform.

Despite the potential for positive outcomes through the use of inquiry-based science education, many teachers continue to rely upon traditional methods of instruction. Traditional methods include such activities as reading the textbook, answering questions at the end of the chapter, completing worksheets, watching videos, listening to lectures, and occasional observation of teacher demonstrations. As of 2001, about 80% of America’s K-8 school children experienced this traditional delivery of science instruction (Jorgenson & Vanosdall, 2002).

When viewed as a whole, the science education reform efforts since World War II cannot be considered effective (Moreno, 1999; Rutherford, 2005; Wheeler, 2008). Changing to inquiry-based science instruction has been an effort for some time; however, little research exists regarding the effectiveness of this methodology to support or deny its significant contribution to the reform efforts. To counter the minimal
data, Cohen and Hill (2000) and McNeil (2000) noted the need for research on professional development to effect teacher change impacting classroom instruction. In addition, Lee, Hart, Cuevas, and Enders (2004) argue that further research in instructional interventions promoting science inquiry is needed if we are to improve science achievement for all students. This study examined one such intervention, the Inquiry Institute professional development program, as an approach to inquiry-based science education reform.

Statement of Purpose

The purpose of this study is to determine the effects of the Inquiry Institute on Grades K-5 elementary science teachers by measuring their perceptions of inquiry learning in the classroom. This Institute is a professional development program that is intended to strengthen science teachers’ pedagogical knowledge and provide practice with inquiry methods based on a constructivist approach. The findings of this study provide a better understanding of the relationship between participation in this professional development and participants’ beliefs about inquiry, their behavior in the science classroom, and barriers effecting their implementation of inquiry methodology.

Participants were placed into one of the following groups depending on the length of inquiry-based professional development: Group 1 received zero days, Group 2 received three days, and Group 3 received six days of the Inquiry Institute professional development.
Hypotheses

The hypotheses tested in this study are the following:

**H_{o1}:** There is no statistically significant difference between mean scores on the belief subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, those who attended three days of the Inquiry Institute, and those who attended zero days of Inquiry Institute.

**H_{o2}:** There is no statistically significant difference between mean scores on the barriers subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, those who attended three days of the Inquiry Institute, and those who attended zero days of Inquiry Institute.

**H_{o3}:** There is no statistically significant difference between mean scores on the implementation subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, those who attended three days of the Inquiry Institute, and those who attended zero days of Inquiry Institute.

Research Questions

This study utilized the self-created Science Inquiry Survey (SIS), which is designed to gather data to answer the following research questions:

1. What is the effect of the Inquiry Institute on Grades K-5 science teachers' beliefs regarding inquiry-based instruction?

2. What is the effect of the Inquiry Institute on Grades K-5 science teachers' perceptions regarding the barriers to the implementation of inquiry-based instruction?

3. What is the effect of the Inquiry Institute on Grades K-5 science teachers' self-reported implementation of inquiry-based instruction?

Significance of the Study

The findings of this study add to the existing body of knowledge pertaining to the process of inquiry-based instruction and the influence of professional development in the use of this methodology. Huffman, Thomas, and Lawrenz (2003), confirmed that
research on the impact of professional development is limited. Determining the effects of professional development is even more critical for the growing number of science teachers obtaining emergency certification or teaching out of their field (National Commission on Teaching and America’s Future, 1996). Kennedy (1999) and Loucks-Horsley, Hewson, Love, and Stiles (1998) argued that a majority of elementary teachers are insufficiently prepared to effectively teach science using inquiry-based instruction. It is my desire to increase the knowledge base regarding inquiry-based instruction, ultimately leading to full engagement in reform-oriented instructional practices. If inquiry-oriented instruction is to be implemented consistently in elementary science classrooms, then the perceptions of the inquiry instruction among elementary science teachers who have received professional development in this area must be understood.

Definitions

The following terms are used in this study:

- **Benchmarks for Science Literacy (Benchmarks)** – This Project 2061 publication outlines standards of what “all students should know or be able to do in science, mathematics, and technology at the end of Grades 2, 5, 8 and 12” (AAAS, 1993, xi).

- **Constructivism** - The basic principle states all knowledge is actively constructed and not the result of passive reception (Noddings, 1995). Constructivists support the idea that people construct their own understanding and knowledge through experiencing things and reflecting on those experiences. Learning is the result of continual changes in our mental framework while we attempt to understand and create meaning out of our experiences (Osborne & Freyberg, 1985).
• **Discovery learning** – This is inquiry-based instruction that is considered a constructivist approach to education with a theoretical framework supported by Piaget and Bruner.

• **Hands-on learning** – An approach to learning in which students are provided the opportunity to explore investigation materials with their hands. Although it is considered more active than passive learning, “conducting hands-on activities does not guarantee inquiry” (NSES, 1996, p. 23).

• **Inquiry-based instruction** – Inquiry instruction is “teaching by which teachers and children study scientific phenomena with the approach and the spirit of the scientist” (Kuslan & Stone, 1968, p. 138). This means that students become cognizant of the difficulties, false starts, and process of formulating and testing ideas that scientists themselves encounter, which encourages “growth of the investigative and critical mind” (p. 5). This two-fold process requires learners to combine both scientific processes and scientific knowledge or content to develop critical thinking that leads to their understanding of science (NCR, 1996).

• **Inquiry Institute** – This is a professional development opportunity for science teachers to explore the theory and practice of inquiry-based teaching and learning. Divided into two separate sessions, the Inquiry Institute involves a series of investigations and activities designed to illuminate principles of inquiry-based instruction. Inquiry Institute I is a three-day workshop intended to provide the participants with the understanding of the fundamentals of inquiry. Inquiry Institute II is a three-day workshop that focuses on building the capacity within participants to design and facilitate inquiry in their own classroom. This professional development is based on
the underlying tenet that supports inquiry as a natural process; this process is built on
the belief that human beings are born as natural inquirers who are stimulated by some
experience, usually a hands-on activity (St. John, 2001a).

- **National Assessment of Educational Progress (NAEP)** – This is considered the
  Nation’s report card by Schrag (1997) because it periodically assesses what America’s
  students know and can do in mathematics, reading, science, writing, the arts, civics,
  economics, geography, and U.S. history. The science content portion, in which Grades
  4, 8, and 12 participate, utilizes three major types of assessment: performance or
  hands-on exercises, open-ended paper-and-pencil exercises, and multiple-choice items
  probing understanding of conceptual knowledge and reasoning skill (NAEP, 2000).

- **National Science Education Standards (Standards)** – These Standards present a
  set of guidelines describing what all students should know, understand, and be able to
  do at different grade levels. The criteria in the Standards support best practices
  designed to promote scientifically literate students, and more importantly, a society that
  is scientifically literate. They present a specific vision in which students are actively
  engaged in inquiry with the understanding that this can only be accomplished through
  systematic reform in education (NRC, 1996).

- **Professional development (PD)** – refers to organized adult learning that is
  designed for educators to acquire instructional and content knowledge with the goal of
  improving the education of students. Effective P.D. is essential in any science
  education reform.

- **Science literacy** – The understanding and habits of mind that enable people to
  make some sense of how the natural and designed worlds work. Scientifically literate
individuals will think critically and independently, including the consideration of alternative explanations of events, thus preparing them for the future (AAAS, Project 2061, 1990).

- Texas Essential Knowledge and Skills (TEKS) – Beginning September 1, 1998, the grade-level and content specific standards known as the TEKS, became the framework for Texas Assessment of Knowledge and Skills (TAKS) assessment objectives in Texas. A thorough understanding of the TEKS is essential for student success in the classroom, on state assessments, and as reflected in the state accountability system (TEA, 1998).

Limitations of the Study

One limitation of this study is the validity of the self-reported data. It is an expectation that responses from the participants reflected honest evaluations of their own beliefs and instructional behavior. However, in reality, participants’ responses may or may not depict the accurate account of their own classroom climate. Also, I was not be able to control responses to assure that specific numbers of teachers from each grade level participate in this study or that specific numbers of respondents are Inquiry Institute participants and non-participants.

Delimitations

The parameters for this study are confined to information gained from Grades K-5 science educators of a north Texas Independent school district. The sample includes participants and non-participants in the Inquiry Institute professional development.
Therefore, making a generalization for other grade level educators may not be possible due to secondary school culture and other environmental factors.

Assumptions

As a prior participant in the Inquiry Institute I in 2004, I assume that teachers who took part in the same professional development experience attempted to incorporate inquiry-based instructional practices into their own classrooms, in a similar manner as myself. While I was comfortable with the fundamentals of inquiry-based instruction, frustration soon followed my excitement, and I made the decision that I needed additional professional development in order to extend my capacity and practice in science inquiry. Two years later, another school district presented me with the opportunity to participate in Inquiry Institute I again followed by Inquiry Institute II. This professional development was conducted in the same manner using the same materials as the one I previously attended. Upon completion of the second professional development course, my understanding and comfort level increased dramatically, allowing me to extend my implementation of inquiry-based instruction in my classroom. Therefore, I assume that the more extensive the professional development, the stronger the implementation patterns for participants.

Summary

In this chapter, I discussed initiatives for science education reform that identify a constructivist model with inquiry-based instruction as a seminal component for success (AAAS, 1993; NRC, 1996; TEA, 1998). In essence, this type of reform is both
pedagogical and methodological in nature, requiring that teachers understand how children learn and also requiring them to possess the strategies to help students succeed. This dual responsibility places great importance on the classroom educator. Beck, Czerniak, and Lumpe (2000) aptly noted, “teachers are a critical component to reform” (p. 324). A constructivist inquiry-based model of professional development, designed to provide participants with both pedagogical and methodological instruction, could facilitate science education reform. This study investigated one such professional development, the Inquiry Institute, looking at the influence of this professional development on elementary teachers and their perceptions of inquiry learning in the science classroom. Additionally, barriers affecting implementation were also explored. Understanding both of these components, inquiry-based instruction and constraints impeding its use, is necessary to bring about greater implementation and contribute to stronger reform initiatives. Chapter 2 provides a discussion of inquiry-based instruction attributes and presents a review of the literature surrounding this topic.
CHAPTER 2
REVIEW OF LITERATURE

If a single word had to be chosen to describe the goals of science educators during the 30-year period that began in the late 1950s, it would have to be inquiry.

~DeBoer, 1991

Introduction

Agreeing on the purpose of education is a challenge for those inside the educational system, and even more daunting for those on the outside. There has never been a clear consensus on what our schools are really supposed to achieve (Postman & Weingartner 1973; Wood 1990). Lipman (1991) asserted that an educated person is one who can think for herself or himself, who is self-reflective and self-corrective, and who values the act of thinking critically. Schank (2004) concurred with Lipman’s basic tenets of education when he stated, “What we need to do is enable children to think for themselves. In an ever changing world, the winners will be those who can do more than recite what they were taught” (p. 37). In addition to producing successful students, this type of education is meant to produce successful citizens for the future.

Bruner (2006) affirmed that “the first objective of any act of learning…is that it should serve us in the future” (p. 40). In order for education to accomplish this significant task, allowing us to be self-reflective, critical thinkers, we need the ability “…to apply what we learn in different contexts, and recognize and extend that learning to completely new situations” (Haskell, 2001, p.3). There are, according to Bruner (2006), two ways our learning can be transferred to serve us in the future. The first is specific applicability of skills needed to complete tasks similar to those we originally
learned, often called specific transfer. Haskell (2001) referred to new situations that are closely similar but not identical as near transfer. An example of this type of skill-to-skill transfer would be applying the knowledge of riding a bike to driving a motorcycle, and later perhaps an automobile. Much of what is taught in schools today is geared toward this type of transfer. The second way in which previous learning is transferred is what Bruner referred to as non-specific transfer—the transfer of principles, attitudes, and ideas. In essence, it consists of using the understanding of general ideas to subsequent problem-solving in the future. Ideally, this type of transfer, Bruner (2006) believes, should be at the heart of the educational process—“the continual broadening and deepening of knowledge in terms of basic and general ideas” (p.40).

If the goal is simply to arm children with facts, then the current skill-based standards and assessments conceivably should help students to achieve that goal. There is no argument that reasonable testing, high standards, and skill acquisition are essential elements in the education establishment. However, these elements alone are not sufficient to completely educate children with the aforementioned purpose of education in mind, particularly in science. Kuslan and Stone (1968) held the perspective that science is built on facts; but they also understood that the goals for science instruction were “far nobler than mere recall of facts” (p. 2). As a commitment to renewing strong public schools, an education think tank, The Forum for Education and Democracy (FED) (2008), released a report noting:

In addition to the demand for higher levels of education, the kind of thinking and performance skills people need has changed radically. As all other achieving nations have recognized, schools must focus much more on the ability to find, analyze, and use information in new ways than to remember large numbers of discrete facts. (p.14)
This study is based on the understanding that inquiry-based instruction promotes critical and logical thinking while consideration of alternative explanations in science (NRC, 1996). In turn the problem-solving techniques promoted by inquiry would allow for the future transfer of knowledge, discussed by Bruner (2006). It is precisely this transfer of principles and attitudes/beliefs relating to the effects of the Inquiry Institute on science teachers that I seek to understand through this study.

Theoretical Framework

The Programme for International Student Assessment (PISA) calculated the United States’ international academic ranking in science in 2006 (Baldi, Jin, Skemer, Green, & Herget, 2006). Students from 30 countries participated in the PISA assessments that “evaluate[d] the ability to apply knowledge to new problems, not merely to recognize discrete facts. On tasks that require complex problem-solving, U.S. students [fell] furthest behind” (FED, 2008, p. 2). On a science literacy scale, the U.S. ranked 21st out of 30 countries. According to Baldi, Jin, Skemer, Green, and Herget (2006), students’ science achievement in the United States, relative to the participating countries has dropped dramatically, moving toward the lowest portion of the rankings.

According to national testing, the most recent science assessment results from the 2005 National Assessment of Educational Progress (NAEP), often referred to as the Nation’s Report Card, indicated that fourth-grade students are making small gains, but eighth-grade students in the United States were not learning any more than they were in 1996; more alarming is the decline in twelfth grade average scores, indicating that the longer students are in school, the poorer they perform on science assessments.
Furthermore, the percentage of students in Texas who performed at or above the NAEP Proficient level was only 25% in 2005, which was not significantly different from the 23% in 2000 (NAEP, 2008). Of the 44 states that participate in this student assessment, 25 scored higher than students in Texas, placing the state in the lower half of the scores. Simply stated, 57% of the participating states’ students scored higher than Texas students. These national and international rankings are indicators that science education reform in states such as Texas is needed to achieve science literacy enabling competition at a national level and, more importantly, at an international level.

The goal of science literacy for all is an important topic, not only in the education realm, but also in the business world, particularly in a global climate (NRC, 1996). Scientifically literate individuals are able to make some sense of how the natural and designed worlds work; they think critically and independently, including the consideration of alternative explanations of events, thus preparing them for the future (AAAS, 1989). Shamos (1995) provided the following realistic description:

We will never get the mass of our population to understand science in detail, but we may be able to instill some understanding of how the enterprise works and how scientists practice their discipline—enough, one hopes, to serve the societal purpose of scientific literacy. (p. 45)

Since the release of A Nation at Risk (1983), an imperative for education reform, many researchers and policy-makers have called for the reform of science teaching (Taylor, Gilmer, & Tobin, 2002). For the past twenty-five years, science education has experienced multiple changes such as new curriculum, different programs, stricter guidelines and assessments, new teaching strategies, and even financial support, all with the expectation of science education reform designed to increase student achievement. An important figure in this reform, Fensham (1992), remarked “the most
conspicuous psychological influence on curriculum thinking in science since the 1980s has been the constructivist view of learning” (p.801).

However, when making decisions on what and how to teach, many science educators have relied upon textbook-based methods with a “drill-and-kill” emphasis (Bellen, Bellen & Blank, 1992; Huber & Moore, 2001; Roth, Roffie, Lucas & Boutounne; 1997; Sanchez & Valcarecel, 1999). Furthermore, science taught in this manner is, to some degree, taught from a behavioral-philosophy standpoint. According to Matthews (1994), at a minimum, “the teacher’s own epistemology or conception of science, is conveyed to students and contributes to the image of science that they develop in class” (p. 83). From where do the teachers’ philosophical ideas emerge? These teachers, argues Llewellyn (2002), “are products of an educational system that is based on the work of early philosophers from hundreds of years ago” (p.39). In the 1600s, the British philosopher Locke theorized that children were born with a tabula rasa, or blank slate, waiting to be filled with information. By the 1900s, the behaviorists began to shape educational psychology, with the names of Watson, Thorndike, and Skinner becoming well recognized as leading the behavioral movement in the U.S. (Schunk, 2004). These behaviorists basically “considered learning to be a change in behavior” (Llewellyn, 2002, p.41), and they also believed “that a behavior could be learned as long as the task was practiced enough and the learning had positive consequences” (p.41). This theory supports a teacher-centered curriculum with the assumption that students will learn and understand the information presented by the teacher. Llewellyn also insists “much of our present educational system is predicated on early behavioral studies” (p.39). During the early part of the 20th century, there was a subtle shift from behaviorist theory to
cognitive psychology, illustrated by the works of such constructivists as Piaget, Bruner, Dewey, and Vygotsky, who will be discussed in the next section.

**Constructivism**

The body of literature that shaped this study is situated within the theoretical framework of constructivism, as “the principles of constructivism lay the foundation for understanding inquiry” (Llewellyn, 2002, p. 29). Constructivism is a conceptual framework based on observation and scientific study about how people learn. It has been described as a philosophy, an epistemology, a cognitive position, a theory, and a pedagogical orientation. For the purposes of this study, constructivism is viewed as an overarching epistemology that directly leads to inquiry practices in the classroom. Von Glasersfeld (1995) held that “constructivism does not claim to have made earth-shaking inventions in the area of education; it merely claims to provide a solid conceptual basis for some of the things that, until now, inspired teachers had to do without theoretical foundation” (p.2). No matter the description, one of the basic tenets of constructivism is that all knowledge is actively constructed and not the result of passive reception (Abruscato, 2004; Chaille & Britain, 1991; Noddings, 1995; Phillips, 1995; Taylor, Gilmer, & Tobin, 2002). Constructivists support the idea that people construct their own understanding and knowledge through experiencing things and reflecting on those experiences. Von Glasersfeld (1995) argued, “…from the constructivist perspective, learning is not a stimulus-response phenomenon. It requires self-regulation and the building of conceptual structures through reflection and abstraction” (p.14). Matthews (1994) summarized the constructive views of learning as:
Learning outcomes depend not only on the learning environment but also on the knowledge of the learner.
Learning involves the construction of meanings. Meanings constructed by students from what they see or hear may not be those intended.
Construction of a meaning is influenced to a large extent by our existing knowledge.
The construction of meaning is a continuous and active process.
Meanings, once constructed, are evaluated and can be accepted or rejected.
Learners have the final responsibility for their learning.
There are patterns in the types of meanings students construct due to shared experiences with the physical world through natural language. (p. 144)

The process of learning from one’s own experiences and questions is supported by Piaget’s theory. Piaget (1970) posited that “understanding and inventing” allow individuals to build structures by structuring reality around them (p. 27). Matthews (2002) provides an uncomplicated view of Piaget’s learning theory “as a process of personal, individual, intellectual construction arising from their activity” (p. 138). This type of exploratory experience assists children in the development of deeper conceptual understanding by incorporating their new understanding with more complex cognitive organization (Njoo & de Jong, 1993). Additionally, when children construct their own learning, they are acquiring an essential life skill.

Undoubtedly, Piaget offered the most systematic and detailed view of cognitive stages of development. Ornstein and Hunkins (1993) summarize Piaget’s stages as follows:

1. Sensorimotor (birth to age 2) – The child realizes that objects have permanence and there is a simple relationship between objects.
2. Preoperational (age 2 to 7) – The child understands that both objects and events have symbolic meaning. Through experiences, the child is able to learn concepts that are more complex.
3. Concrete operational (ages 7-11) – Problem-solving becomes possible as the child begins to organize and manipulate data.
4. Formal operations (ages 11 forward) – Characterization of this stage includes formal and abstract operations. Additionally, adolescents are able to analyze ideas and use logic to construct theories and conclusions. At this stage, there are few limitations on what can be learned.

Piaget’s ideas are dependent on the learner’s experiences with their environment. As a foundation of his theory, he used three basic cognitive processes—assimilation, accommodation, and equilibration. Assimilation and accommodation are processes that incorporate new experiences with old experiences and then organize and structure new ideas and thinking. Equilibration is the process of balancing the first two processes; knowledge from old experiences must fit together with what is yet to be learned from new experiences. The influence of Piaget’s cognitive theory is recognizable in Bruner’s ideas on how learning occurs (Ornstein & Hunkins, 1993).

For Bruner (2006), the cognitive act of learning consists of three processes similar to Piaget’s. Acquisition is the process of seizing new information; this corresponds to assimilation. Transformation is the capacity to translate or transfer knowledge to another form; this is related to accommodation. The last process is evaluation, which involves looking at the new information to see where and if it fits with the accretion of other knowledge; this is comparable to the process of equilibration. Bruner felt that “intellectual development of the child is not clockwork sequence” (p. 50); it is not the precise stages or the specific process that is important, but instead, “what is most important...is that the child be helped to pass progressively from concrete thinking to the utilization of a more conceptually adequate mode of thought” (p.49). Moving the learner along in this constructivist manner helps cultivate analytical thinking.

Bruner’s focus on the students as active problem-solvers eventually led him to the theoretical framework that embraced discovery learning. In his article, The Act of
Discovery (1961), Bruner argues for the use of learning by discovery that he defined as “obtaining knowledge for oneself by the use of one’s own mind” (p. 22). Bruner believes that allowing students to be their own discoverer provides powerful effects as the student puts things together for himself or herself. In essence, it gives the learner autonomy and self-propulsion to becoming a thinker long after formal education ends (Bruner, 1961; Chaille & Britian, 1991). Bruner hypothesizes that:

Only through the exercise of problem solving and effort of discovery that one learns the working heuristic of discovery, and the more one has practice, the more likely is one to generalize what one has learned into a style of problem solving or inquiry that serves for any kind of task one may encounter. (p. 64)

Adler (2000), agreeing with Bruner’s beliefs about discovery, suggested that all learning occurs either by discovery that is done independently or with the help of instruction. Furthermore, without discovery, the instruction makes an impression in the memory of the student, but without true understanding. Bruner goes further to say that discovery taught in the inquiry method builds intellectual potency for students by leading the learner to be a constructivist. Discovery and inquiry learning are both nestled in the much larger context of constructivism.

Bruner (1967) expanded this idea with the principle of sequencing. According to Bruner, effective instruction leads the student through content to increase the learner’s ability to understand, transform, and then transfer the knowledge. He went on to explain that sequencing progresses in three stages: enactive to iconic to symbolic. The enactive stage includes the manipulation of objects with a hands-on or concrete component. The iconic system involves the student using mental images that are sensory based. The last stage of sequencing is symbolic, which consists of reasoning and abstract thought. Although without the rigidity and time-sensitive feature, Bruner’s sequencing theory
theme holds similarities to that of Piaget’s.

Vygotsky has greatly influenced modern constructivist thinking through his emphasis on cognitive development (Schunk, 2004). He too believed that learners actively construct their knowledge (Bandura, 1986; Kuhn, 1979; Pass, 2004), but that such construction occurs in a social environment, because “human learning presupposes a specific nature and a process by which children grow into the intellectual life of those around them” (Vygotsky, 1978, p. 88). Affirming his constructivist view, he wrote, “We have seen that where the child’s egocentric speech is linked to his practical activity, where it is linked to his thinking, things really do operate on his mind and influence it” (Vygotsky, 1987, p.78-79). He was referring to “things” as the reality encountered in the learner’s environment.

Dewey also referenced the core tenets of constructivism in the form of inquiry in the early 1900’s. Dewey, arguably one of the most influential educational philosophers and theorists of the 20th century, believed that learning must involve personal meaning for the student (Llewellyn, 2002). He also thought that cognitive ability was utilized most effectively when the learner was confronted with a problem actively engaging the student in critical thinking. Dewey (1959) promoted child-centered learning based on authentic learning experiences that are connected to each other. The constructive concept in education was presented by Dewey (1910) as one of the first inquiry-based learning methods in the United States, and he advocated for scientific inquiry as the central focus of science education in schools. Dewey rejected the idea of schools focusing on repetitive, rote memorization of facts. Instead, he supported the use of instruction in which students engaged in real world, practical situations via experiences.
that are connected to each other (Dewey, 1959). The theories of these constructivists work in tandem with inquiry-based methods to help individuals think for themselves and thus support the purpose of education as described by Lipman (1991), Schank (2004), and Bruner (2006).

Inquiry

Undoubtedly, inquiry is a recognizable theme in science education today. “Few things in science education are as popular these days as inquiry” (Rudolph, 2005, p.803). Since this study is focused on inquiry-based teaching methods in the classroom, defining it is essential to understanding the process of this methodology. This is a difficult task, asserts Settlage (2003), because it is “one of the most confounding terms within science education” (p.34). The NRC (1996) 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. (p. 23)

Inquiry-based instruction can be more simply defined as “the creation of a classroom where students are engaged in (essentially) open-ended, student-centered, hands-on, engaging activities. This means that students must make at least some decisions about what they are doing and what their work means—thinking along the way” (Colburn, 2003, p. 231). This method also requires the use of critical and logical thinking and consideration of alternative explanations (NRC, 1996). Another definition of inquiry provided by Kuslan and Stone (1968) is “teaching by which teachers and children study scientific phenomena with the approach and the spirit of the scientist” (p. 138). This
means that students become cognizant of the difficulties, false starts, and process of formulating and testing ideas that scientists themselves encounter, which encourages “growth of the investigative and critical mind” (p. 5). The *National Science Education Standards* (1996) define full inquiry as a process in which students (a) pose a productive question, (b) design an investigation directed toward answering the question, (c) investigate to gather data, (d) interpret and document findings, and (e) present or publish their findings to an open forum (NRC, 1996, p. 214).

Inquiry learning is not a new concept in education. John Dewey (1910) introduced one of the first inquiry-based learning methods in the United States and advocated for scientific inquiry to become the central focus of science education in schools. While addressing the American Association for the Advancement of Science, Dewey (1910) argued that the emphasis in schools at that time was on accumulation of information instead of concentrating on science as a method of thinking and attitude or consciences of the mind. This type of inquiry instruction has slowly emerged in science education and has provided a model for appropriate science education. Within the past century, inquiry as a pedagogical model has only begun to play a role in science classrooms (DeBoer, 1991). By the 1960s, the rationale for inquiry-based instruction was experiencing resurgence.

Schwab (1962) concurred with Dewey’s ideal that the emphasis in science education on accumulation of facts had less to do with science as a way of thinking. In order to shift the focus, Beerer and Bodzin (2004) suggest “teaching of science inquiry be a priority in science education, that teachers teach both to conduct investigations in inquiry and to view science itself as a process of inquiry” (pp. 3-4). This new focus
would serve as a tool to promote understanding of the very nature of science and the type of thinking associated with scientists.

Suchman (1962) worked to develop an inquiry professional development course with the use of discrepant events, problems, or challenges. His goal was to help students learn independently. He used the scientific method as a basis to help students understand how the scholarly inquiry process works. By analyzing physical scientists’ research, he conceptualized the elements of their process and created an “inquiry training” instructional model. Suchman believed that individuals are naturally curious when presented with a problem, they become cognizant of their thinking, knowledge is tentative, and cooperative learning is derived from inquiry-developed thinking. His model consisted of five phases: (a) presentation of problem/discrepant event, (b) data gathering, (c) experimentation, (d) explanation, and (e) analysis. To kindle students' interest and elevate motivation, educators have long used Suchman’s inquiry technique for science teaching and learning. The foundation of Suchman’s technique always begins with exploration.

The fundamental idea behind Suchman’s work and inquiry itself can be captured in the simple statement, “Explore first; explain later” (Bricker, 2005, p.16). Exploration and concrete activities should always come before the vocabulary, explanations, and literary extensions. Comstock (2005) also stressed the idea that students should experience the science, and then make connections to the experience to attach conceptual labels and support meaning. This idea emerges from the well-established experiential learning model of Kolb (1984). It begins with a concrete experience that is an activity with the learner’s personal involvement and is the source of learning;
therefore, it precedes all other activities. After the experience, and sometimes during, the student examines objects, ideas, or questions. Explaining is the next step in the model, allowing the student to draw logical conclusions. The Kolb learning cycle becomes complete when the student is able to apply the newly learned knowledge (Svinicki & Dixon, 1985). Another well-known model of learning that has been successful in teaching student science is the 5 E Instructional Model, or the 5Es. This model was developed by the Biological Sciences Curriculum Study curriculum team (2006) and encompasses the following phases or steps: engagement, exploration, explanation, elaboration, and evaluation. This learning model is a functional framework for selecting activities and lessons that fit into inquiry-based instruction.

An explanation and argument for the use of inquiry-based instruction, explains Hendrickson (2006), is the ability for educators to use this methodology to achieve the goal of teaching students to think deeply. It facilitates the critical thinking process by incorporating the natural inquisitiveness of children with the lessons to actively engage them in the learning process. Students gain knowledge by seeking answers to their own questions or those posed by the teacher. Their own “I wonders” often lead to further investigations in the classroom (Bricker, 2005). One organization that supports the power of natural curiosity is the Institute for Inquiry (IFI), which is discussed later.

**Academic Achievement**

The *National Science Education Standards* emphasize that learning science is an inquiry-based process; therefore, science instruction should include inquiry-based methods (NRC, 1996). Gross et al. (2005), presented a contrasting view in *The State of*
the State Science Standards published by the Thomas B. Fordham Institute, a conservative think tank in Washington, D.C. Reviewers from the Fordham Institute expressed opposition to the inquiry method and believed efforts to engage students in building their own understanding are without merit. These critics have asserted that inquiry-based learning as a constructivist method is not effective, yet research indicates the opposite. Not only do inquiry methods build the foundation for a constructivist, critical thinking education, these methods promote higher academic achievement (Treisman, 2006). According to Jorgenson and Vanosdall (2002), student achievement on science tests for students exposed to inquiry-based methods exceeded the scores of students who received traditional text-based instruction. Research from Stohr-Hunt (1996) reported similar findings that indicated, “the frequency of hands-on activities in the classroom was strongly related to science achievement” (p. 107). A caveat to be noted here is the difference in “hands-on” and “inquiry-based”. Although “hands-on” science may or may not include inquiry methods, the two teaching strategies are often referred to as if they have the same meaning or outcome. It is possible to use hands-on methods without inquiry, but it is not possible to use inquiry-based methods without some hands-on activity or investigation. Used in conjunction with each other, these two pedagogical approaches have the greatest value for achievement in the science classroom.

Klentschy, Garrison and Ameral (2001) present support for the use of inquiry as the result of a seminal four-year study of high-poverty, high-ethnically Hispanic, traditionally low-performing schools, which found that inquiry-based instruction contributed to increased scores in other subject areas. “In the Valle Imperial Project in
Science (VIPS), the key to effective science teaching was to enable students to develop ideas and personal meaning about the world around them that fit evidence they collected” (Klentschy, 2005b, p. 27). The evidence in the VIPS speaks for itself; the sixth graders who were engaged in inquiry science scored approximately 35% higher in math and 28% higher in reading, on average, than their classmates who had not been exposed to inquiry-based science instruction. On their writing proficiency exam, students in the control group, who had not received inquiry science instruction, scored an average of 23%, while those in the experimental group, who received the hands-on methods for the full four years of the program, scored an average of 89%. Not only did the science scores improve, but also math, reading, and writing scores increased dramatically for students who experienced inquiry-based instruction.

Researchers are also examining teaching methods in other countries. Research on the strategies of Japanese elementary teachers (Linn, Lewis, Tsuchida, & Songer, 2000) examined the Japanese instructional approaches to determine why, according to international norms, American students fall behind in science performance between the 4th and 8th grades. The researchers found that “by U.S. and world standards, the Japanese curriculum is very frugal” (p.34). Japanese children study fewer science topics and in much greater depth than American children. This is not to say that they spend more total time on science; instead, they spend more time on each individual topic of study. For example, Linn, Lewis, Tsuchida, & Songer (2000) found that the 5th grade unit on levers would take 12 class periods. In the U.S., levers would be studied for probably no more than one day, two at the most. Not only does the Japanese in-depth curriculum allow for profound understanding and personal connections for the
students, it also supports the opportunity for a coherent inquiry process guided by the teacher. Researchers observed students building on what they knew, designing new investigations to fill in the gaps, reconciling contradictory findings, and reflecting on their progress in every classroom. These identified activity structures were all built upon the framework of inquiry. Using the inquiry method allows for science to be covered at a much greater depth compared to using the traditional approach, such as “drill and kill” that is often superficial (Jorgenson & Vanosdall, 2002).

Lack of Inquiry Implementation

Despite the positive outcomes for inquiry-based science education and recommendations from national and state standards, many teachers continue to rely upon more traditional methods of instruction, such as reading the textbook, answering questions at the end of the chapter, completing worksheets, watching videos, and occasionally observing a teacher demonstration (Huber & Moore, 2001). As of 2001, about 80% of America’s K-8 school children experienced this type of science instruction (Jorgenson & Vanosdall, 2002). Secondary students in Texas, due to the amount of labs required (40% of instructional time) from the TEKS, tend to experience more hands-on instruction but not necessarily inquiry instruction. According to Winters (2006), teachers at the secondary level often have science backgrounds and enjoy the subject, while educators at the elementary school level often lack expertise in science, and they may have “never liked science in the first place” (p.26). Given the significant volume of evidence that shows inquiry-based methods are successful, why do teachers still rely heavily on the passive textbook-based method to teach sciences? In addition to a lack
of understanding of inquiry, several barriers contribute to the lack of full implementation of inquiry-based science, particularly at the elementary level.

**Barriers**

Inquiry implementation can be particularly daunting for novice and experienced teachers alike. In her book *Children's Inquiry* (1999), Lindfors provides an uncomplicated characterization of inquiry as “a language act in which one attempts to elicit another’s help beyond his or her own present understanding” (p. 49). Additionally, the author remarks that it demands a significant shift from current practices on behalf of both the teacher and learner.

Welch, Klopfer, Aikenhead and Robinson (1981) found that this type of instructional program requires considerable planning and implementation time, and it is difficult from a classroom management standpoint. Baker, Lang, and Lawson (2002) noted further barriers including students wasting time, lack of student motivation, and material management. Jackson and Boboc (2008) provide suggestions to help educators overcome the barrier of classroom time constraints—for both teacher and student.

Organization and structure are imperative constructs for dealing with issues of time and classroom management. For example, one suggestion is to set up plastic storage bins that contain “materials, lesson plans, and activity sheets” (Jackson & Boboc, 2008, p. 64). This would be time-consuming initially, but subsequently cut down on yearly planning and preparation time. Material management becomes less overwhelming with storage bins. Also, investigations prepared in this manner place
responsibility on the students to setup and clean up, again freeing the teacher’s time. Clearly posted expectations and written directions will assist students in wise use of their time. Jackson and Boboc (2008) also suggest adhering to firm time limits and utilizing a timer to keep students on task. Both of the last two suggestions would also help with classroom management. Student focus and motivation are addressed by using activities that “reflect the interests of the students [so] they are more likely to put forth the effort and find a solution” (Jackson & Boboc, 2008, p.66).

Another barrier is the lack of content and pedagogical knowledge among elementary teachers needed to transform existing or new material into inquiry lessons (Stamp & O’Brien, 2005; Taylor, Gilmer, & Tobin, 2002). As mentioned earlier, both novice and experienced elementary teachers tend to rely heavily on textbooks and worksheets as “survival tools” for planning science instruction (Huber & Moore, 2001). Additionally, the open-ended nature of inquiry and the classroom management challenges associated with hands-on activities can be overwhelming for many teachers. Although a large body of literature exists for extending traditional lessons to inquiry-based lessons, they are often highly topic specific (Huber & Moore, 2001). Teachers would need substantial time to research and revise the lessons before they would be applicable. Furthermore, if the teacher has not received adequate professional development on inquiry-based instruction, the task quickly becomes overwhelming.

In order to further promote inquiry-based instruction in the science classroom, we must understand the specific barriers that educators are encountering. This study seeks to identify those barriers and, ultimately offer suggestions for overcoming them.
The inquiry continuum moves from teacher-centered “cookbook” labs, or labs that follow a recipe, to a structured model and ultimately to full student-directed inquiry. In the article *An Inquiry Primer*, Colburn (2000) shares the basics of the inquiry continuum that starts from a structured inquiry process and moves to open inquiry. He defines each step as follows:

- **Structured inquiry**—The teacher provides students with a hands-on problem to investigate, as well as the procedure and materials, but does not inform them of expected outcomes.

- **Guided inquiry**—The teacher provides only the materials and problem to investigate. Students devise their own procedure to solve the problem.

- **Open inquiry**—This approach is similar to guided inquiry, with the addition that students also formulate their own problem to investigate (p. 42).

Table 1 provides a visual aid to show the continuum moving from a teacher-centered to a student-centered inquiry-based instruction.

**Table 1**

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Demo</th>
<th>Structured Inquiry</th>
<th>Guided Inquiry</th>
<th>Open Inquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Teacher</td>
<td>Teacher Teacher</td>
<td>Student</td>
<td></td>
</tr>
<tr>
<td>Procedure</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Student</td>
<td>Student</td>
</tr>
<tr>
<td>Results/Analysis</td>
<td>Teacher</td>
<td>Teacher</td>
<td>Student</td>
<td>Student</td>
</tr>
</tbody>
</table>

Adapted from *Inquire Within: Implementing Inquiry-Based Science Standards* by Llewellyn (2002)
Total immersion into the inquiry method can be considered a difficult and discouraging endeavor. Brinker (2005) proposed a strategy for overcoming some of these challenges connected with implementation. She suggests that teachers work up to inquiry slowly by starting with a very structured format, as seen at the left of the continuum chart. For example, start with a whole-class project including modeling and scaffolding for support. An intermediate step could involve creating one small-group inquiry project with a limited and manageable number of students. Eventually, a teacher can transition into more and more student-centered inquiry groups by asking different questions to different groups. Making these subtle shifts allows for a wide variety for teaching practices moving towards full, open inquiry.

*Inquiry Tools*

There are tools that can help teachers integrate the inquiry process into their lessons. Hendrickson (2006) advocates for a backwards approach to inquiry that should be accomplished through a “means-to-an-end” process. It is a process that is used to teach the science standards. Teachers must ask themselves critical corollary questions: What do I expect the students to learn? How will I know when they have learned it? How will I respond when they do not learn? These questions help the teacher focus on the process. For the inquiry-based method to be truly effective, it must also be standards-based. With the standards at the forefront of the lesson planning, outcome indicators force educators to think about the big picture (Martin-Kniep, 2005). Thus, all the activities, instructional methods, and assessments are aligned with the goals and standards. One caveat is that without careful and purposeful guidance, student-directed inquiry can migrate off-course and result in unmet learning objectives or unintentional
learning outcomes. This guidance may take the form of teacher monitoring for understanding through informal formative assessment. The teacher emphasizes particular skills and knowledge and revises lessons accordingly. For example, if while conducting an inquiry-based lesson with magnets, the students have not made the connection between magnets and steel, a debriefing or teacher-led discussion could facilitate the students’ understanding of this connection. In this facilitator role, the teacher has shaped the inquiry-based activities to meet the learning objectives without sacrificing the purpose of student-led investigations.

**Cooperative Learning**

Constructivism and critical thinking are two constructs that make inquiry effective; however, the effectiveness of using inquiry methods can also be linked to “one of the most popular instructional strategies in education—cooperative learning” (Marzano, Pickering, & Pollock, 2001, p. 84). A majority of inquiry lessons take place in pairs or small groups. Kraft (2002) has suggested that organizing students into cooperative learning groups has a powerful effect on learning as they work toward common goals, create partnerships, and learn shared leadership. In a meta-analysis of social interdependence and achievement, Johnson, Johnson, Holubec, and Roy (1984) concluded that cooperative learning experiences promoted higher student achievement, regardless of age or subject matter. Each student had different experience and knowledge about the topic and they used different tools to help them understand. These individual experiences, knowledge, and tools helped to shape their unique viewpoint on the matter. This viewpoint allowed not only the individual, but also the group, to
understand their world (Larwa, 2001). Children benefit both socially and independently in the cooperative groups as they construct their learning from teaching their peers, while in turn learning from their peers. This type of cooperative structure is an essential element in the success of inquiry-based instruction.

*Science Notebooks*

Another opportunity for science educators to promote constructivism through inquiry-based instruction is with the use of interactive science notebooks. These notebooks provide students with the opportunity to write, read, describe, and think about the science they are learning. Students are also able to model real scientists in the collection and interpretation of the data while using the inquiry method to understand the science they are studying. These interactive notebooks rely heavily on an input/output format. Finch (2003) suggests that the input consists of lecture and observation notes, and lab data; output is a personal, reflective activity that includes items such as Venn diagrams, pictures, drawings, word webs, concept maps, stories, cartoons, and jokes. This constructivist innovation enhances meta-cognition strategies while simultaneously promoting inquiry-based science instruction where students engage, focus, experiment and reflect on their personal learning experiences to make meaningful connections to the content of the science lesson (Campbell & Fulton, 2003; Chesbro, 2006; Klentschy, 2005b; Williams-Rossi, 2005; Young, 2003).

*Kit-based Programs*

Additional tools that promote learning science through inquiry-based instruction
are kit-based programs, particularly for educators with lack of content knowledge. Research by Fulp (2002) showed that “Grade K-5 self-contained classes spent an average of 25 minutes each day in science education compared to 114 minutes of reading/language arts, 53 minutes in mathematics and 23 minutes in social studies” (p.11). A more recent report noted that an average of only 16 minutes a day was spent on science in elementary classrooms (Winters, 2006). An even more alarming problem reported by Gess-Newsome (1999) is that 25% of all elementary teachers do not teach any science in their classroom. The authors also presented additional findings that those who do teach science, the total allocated time accounts for less than 2 hours each week (p. 1). The lack of time spent on science education is a result of two main factors. First, reading and math have received the greatest time allotment in both elementary and secondary education because these subjects were the first to be tested under NCLB. Second, many teachers are uncomfortable teaching science due to their lack of content knowledge (Abell & Roth, 1992). Kit-based science modules, such as Full Option Science Systems (FOSS), incorporate materials that will support teachers in both of these areas. FOSS is a hands-on inquiry-based module program that was researched and developed for Grades K-8 with support from the National Science Foundation. With professional development and support, teachers can use the math activities, extensions, science stories, and other reading material to enhance cross-curricular connections and develop necessary skills in all three subjects. Additionally, the FOSS guides and website provide content background for teachers.

Although FOSS is probably the most well known kit-based science program, other programs offer the same benefits. The Science and Technology Curriculum (STC)
developed by the National Science Resource Center (NSRC, 2006), consist of research-based modules for Grades K-6. These kits also contain inquiry-based science education materials. Scientists and experienced educators served as consultants to teacher-developers during the research, development, and trial teaching of the STC units. The STC was subjected to further field-testing before the final units were produced, and the final editions incorporate teacher and student feedback. Additionally, the kits received positive technical reviews by leading scientists and science educators (NSRC 2006). As a result these kits are widely used in elementary science classrooms, but generally without incorporation of the inquiry component.

Technology

The use of technology is another avenue for incorporating inquiry into the science classroom. The Web-based Inquiry Science Environment (WISE, 2005), supported by the National Science Foundation, is a free online science-learning environment for students in Grades 4-12. In WISE, students work on inquiry projects on topics such as genetically modified foods, earthquake prediction, and the deformed frog mystery. Students learn about and respond to contemporary scientific controversies through designing, debating, and critiquing solutions. A similar free, web-based project, Scientific Inquiry through Plants ($Sip^3$), connects students, educators, and scientists around the country to enhance the experience of scientific inquiry. A web browser is all students need to take notes, discuss theories, and organize their arguments for these online programs. These programs prompt students to think like scientists, keep research journals, design experiments, and collect data (Scientific, 2006).
The above-mentioned tools, however, are of little value if educators have not received appropriate professional development in the use of effective instructional teaching methods. Rowan, Correnti and Miller (2002) found that higher student achievement outcomes were seen in classrooms where educators used effective instructional strategies, such as inquiry methods. This study is designed to look at a professional development experience, the Inquiry Institute, which provides elementary school science teachers with content and pedagogy to assist them in implementing effective practice of inquiry-based instruction in their own classroom. In order to evaluate the Inquiry Institute, it is necessary to first understand the best practices behind professional development itself.

Professional Development

Access to the right material and the best strategies are only part of the puzzle to implementing inquiry. The success of any science education reform is dependent on the effectiveness of teachers (Darling-Hammond & McLaughlin, 1995; Garet, Porter, Desimone, Birman, & Yoon, 2001). Increased learning for students and adults begins with improved teaching. Professional development is a key factor in helping teachers become more prepared to facilitate student learning (Birman, Desimone, Porter, & Garet, 2000). Since professional development is the key factor in improved teaching, there is a shift from a “one-size-fits-all” strategy that provides a broad spectrum of content and pedagogy to a targeted audience with a central purpose (Mundry, 2005).

This study is informed by the theoretical perspective that successful implementation of inquiry learning is heavily dependent on the development of a strong
plan for professional development. “There is a growing belief,” states Klentschy (2005b), “that professional development should be targeted and directly related to teacher practices” (p.1). He goes further to say, “most teachers learn to teach by growing up in a culture watching their own teachers teach, then adapting these methods for their own practice” (p.2). If science reform is dependent on classroom teachers, then the culture of teaching must change teaching to a knowledge-based practice. A model of professional development presented by Loucks-Horsley, Hewson, Love, and Stiles (1998) is directed at changing the culture of teaching based on five values of professional development:

1. Professional development experiences need to have students and their learning at their core.

2. Excellent science and mathematics teachers have a very special and unique kind of knowledge that needs to be developed through their professional learning experiences.

3. Principles that guide the reform of students learning should also guide professional learning for educators.

4. The content of professional learning must come form both inside and outside the learner, and from both research and practice.

5. Professional development must both align with and support system-based changes that promote student learning. (p. xxv-xxvi)

Using a model such as this to focus on “increasing pedagogical content knowledge and teaching skills” (Mundry, 2005, p.11) is one vehicle that will produce positive effects on the students (Kennedy, 1999; Weiss, Pasley, Smith, Banilower & Heck, 2003). This model also allows teachers to become more involved in their own learning, which supports a smoother implementation process (Fullan, 1995).

Guidelines from the National Staff Development Council (2001) suggest that
successful professional development should model best practices using the process of scientific inquiry. With this goal in mind, the facilitators of the Inquiry Institute model teaching behaviors they desire the educators to adopt (Harlen, 2007). This modeling is reflective of the critical components of high quality professional development identified by Supovitz and Turner (2000); high quality professional development must:

- Immerse participants in inquiry
- Be sustained and intensive
- Engage educators in concrete tasks based on their teaching experience
- Concentrate on subject matter and strengthen content skills
- Be based on a common set of professional standards
- Be connected to school change

Incorporating these guiding principles does not assure practice changes in the classroom. Research on the effectiveness of inquiry-based professional development has been less than ample, but various studies are related to the impact of professional development on teaching (Harlen, 2004).

Professional development, in which teachers experience inquiry, has been shown to improve teachers’ science content knowledge as well as their use of inquiry-based teaching techniques (Bazler, 1991; Caton, Brewer, & Brown, 2000; Luft, 2001). Supovitz and Turner (2000) collected data from numerous local systemic change initiative projects across the United States. The authors found that it was “only after approximately 80 hours of professional development that teachers reported using inquiry-based teaching practices significantly more frequently… than the average teacher” (p.973). Their findings supported “a strong and significant relationship between professional development and teachers’ practices” (p.975). However, the length of most professional development is too brief to be truly effective. Other factors also influenced
change. For example, educators at schools with low socioeconomic status used more traditional methods than educators at schools with more affluent students.

Basista, Tomlin, Pennington, and Pugh (2001) studied a math and science professional development for 33 teachers in Grades 2-9. This 64-hour program consisted of a summer institute and follow-up meetings. The focus was on both physics content and inquiry-based instruction throughout the professional development. The participants showed statistically significant content knowledge gains (61%); based on self-reports, 85% of the teachers also had statistically significant growth in the ability and confidence to implement inquiry-based instruction in their classrooms.

These examples of successful inquiry-based programs share similarities of high-quality professional development, including sustained and intensive programs that are focused on content and pedagogy; based on professional development standards; and connected to educators’ experiences in the classroom (Supovitz & Turner, 2000). These studies support the fact that inquiry-based professional development can assist educators in the implementation of this reform strategy.

Institute for Inquiry (IFI)

For more than 30 years, the IFI, located in the Exploratorium Museum of Science, an internationally known science museum in California, has educated teachers, administrators, and professional development leaders in the use of the inquiry-based instructional methods in both theory and practice through professional development services. St. John (2001b) provides the background of this professional development as the basis of the underlying tenet that supports inquiry as a natural
process; this process is built on the belief that human beings are born as natural inquirers who are stimulated by some experience, usually a hands-on activity. A main objective of the IFI is to empower local educational leaders via professional development and support and to address systemic science reform focused directly on inquiry. This is accomplished with local, systemic change projects where trained leaders can present professional development to large groups of teachers locally, who would then use inquiry-based instruction to promote high achievement for their science students (St. John, 2001b). In a report evaluating the impact of the IFI through local projects, St. John determined the IFI to be a successful program offering high-quality professional development designed to empower local elementary reform (St. John, 2001b).

The Fort Worth Science and History Museum houses one such local systemic change project—Texas Center for Inquiry. This professional development is designed for science education leaders and supervisors who then provided professional development to classroom teachers. A second project, designed for individual teachers, is the Inquiry Institute provided by a north Texas school district. This study examines participants and non-participants in the north Texas school district endeavor called the Inquiry Institute (Institute), which is designed to promote a systemic change in science education by providing inquiry-based professional development to any classroom teacher in Texas. The Institute is divided into two parts, Inquiry Institute I and Inquiry Institute II, and teachers may participate in one or both sessions. This professional development workshop has occurred annually in a north Texas independent school district since 1999, with facilitators trained by the IFI. Inquiry Institute I consists of a
three-day professional development experience targeted at understanding and processing the fundamentals of inquiry-based instruction. Inquiry Institute II, also lasting three days, is designed to build capacity within the educators to plan, conduct, and reflect on inquiry in their own classrooms. Following the inquiry process, participants are moved from exploring materials, making observations and raising questions to designing and carrying out their own investigations. For example, one activity has participants observe and explore ice balloons (balloons that were filled with various types of water and then frozen) for the purpose of generating investigable and non-investigable questions. The goal is to enable learners to differentiate between questions that can be investigated and those that cannot. Another investigation explores shadows and had participants select a question, form groups and carry on the full inquiry investigation. Finally, the learners share their findings with others and present future questions to be studied. The complete process allows participants in the Inquiry Institute to explore areas that are fundamental to developing inquiry experiences that include:

- An exploration of the approaches to hands-on science.
- A variety of activities that examine process skills that serve as building blocks for inquiry.
- An exploration of the nature of questions and questioning and how they support inquiry investigations.
- First-hand experience with inquiry and small group investigations exploring the relationship between process skills and conceptual understanding.
- Inquiry experiences that teachers can use to give students the opportunity for their self-directed investigations.

Professional development, such as the Inquiry Institute, that supports teachers’ implementation of inquiry-based education is crucial to achieving the goal of cultivating scientifically literate citizens who think for themselves, engage in self-reflection, and use
logical and critical thinking. However, little independent research exists regarding the effect of the Institute on teachers’ perceptions regarding inquiry learning in the elementary science classroom. Therefore, the purpose of this study is to determine the effects of the Inquiry Institute on Grades K-5 elementary science teachers by measuring their perceptions of inquiry learning in the classroom.

Conclusion

The literature review provided an overview of the development of current classroom practices and discussed how the constructivist philosophies of Piaget, Bruner, Dewey, and Vygotsky, along with our current national and international education rankings, support inquiry-based instruction. Inquiry-based learning was discussed at length, with research supporting the use of inquiry methodology. Additionally, issues of implementation were illuminated and suggestions to overcome these barriers were noted. This chapter concluded with research describing the role of effective professional development and presented research describing successful inquiry-based professional development. This literature review has provided a rationale for this study of the implementation patterns and barriers experienced by participants and non-participants of inquiry-based professional development. The current study seeks to determine the effects on the Inquiry Institute on Grades K-5 elementary science teachers. Chapter 3 addresses the research design, methods and instruments of the study.
CHAPTER 3

METHODOLOGY

Introduction

In this chapter, the purpose of the study and the research questions are reviewed. The research design, along with a description of the sample population and setting, and discussion of the data collection methods leads to a description of the methods for the analysis of data in chapter 4. The summary and conclusion of the research methodology closes this chapter.

Statement of Purpose

The intended purpose of this quantitative study was to determine the effects of the Inquiry Institute on Grades K-5 elementary science teachers through their perceptions of inquiry learning in the classroom. The ultimate goal of the study was to better understand the relationship between this professional development program and participants’ subsequent teaching behavior in the classroom. More specifically, this study sought to determine teachers’ perceptions regarding their beliefs and implementation of inquiry learning in their classrooms as a function of their participation in the Inquiry Institute. This study also investigated barriers influencing implementation of inquiry methodology in the participants’ science classrooms. For this study, data was gathered to answer the following research questions:

1. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding inquiry-based instruction?

2. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ perceptions regarding the barriers to the implementation of inquiry-based instruction?
3. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ self-reported implementation of inquiry-based instruction?

Population and Sample

This study was conducted in a K-12 public school district located in the Dallas-Fort Worth metropolitan area with a population of 61,695 per the 2000 U.S. Census Bureau data. This district, covering about 54 square miles, has 1,700 employees, with over 30% holding Master’s degrees, and serves approximately 14,000 students. Almost 26% of the students are minorities, 14% are economically disadvantaged, 7% are in special education, and 7% are in the bilingual/ESL program. The target population members from whom the participants were recruited are Grades K-5 educators at 11 elementary campuses in the district and all degreed college graduates who hold elementary teaching certificates. These teachers were selected because they fit within the purpose of this study; therefore they are a purposeful sample (Gall, Gall, & Borg, 2003). Though teachers in this purposeful sample must currently teach science, both teachers who have and have not participated in the Inquiry Institute professional development program were included for the purpose of comparison. Furthermore, this sample is appropriate for studying the problem presented in chapter 1, because the target population varied to the extent in which they participated in the Inquiry Institute, allowing for three independent levels of Inquiry Institute participation to be compared within the data analysis. The causal-comparative research design, discussed below, was chosen because the target population had already participated in the professional development that created the three existing groups and no random assignment to a group has occurred.
Research Design

This study was structured as causal-comparative which according to Gall, Gall, and Borg (2003) is used in the “study of cause-and-effect relationships” (p.295). This research design was chosen because the target population is currently divided into three groups. The authors go further to explain that the presumed cause is the independent variable and the presumed effect is the dependent variable (p. 295). In order to determine a cause and effect relationship in this study, I used the length of participation in the Inquiry Institute as the independent variable to determine whether the groups differ on three dependent variable constructs—perceived beliefs about inquiry, barriers to using inquiry, and implementation of inquiry. In addition to collecting quantitative data, the survey instrument, discussed in detail below, also collected qualitative data with two open-ended survey items and was mainly designed to ascertain descriptive information with regards to inquiry implementation barriers encountered by participants.

According to Rossi, Wright, and Anderson (1983) surveys are a widely accepted instrument for conducting and applying research and are extensively used in educational research. Survey design also provides quantitative data about the sample population, enabling researchers to generalize the findings (Creswell, 1994). Upon investigation, few instruments were available that document changes in teaching practice from professional development activities, such as the Inquiry Institute course examined in this study (Garrison, 2006).
Instrumentation: The Science Inquiry Survey

I created the survey used in this study, entitled the Science Inquiry Survey (SIS), using Likert-scale format. This format structure is commonly used in survey research (Gall, Gall, & Borg, 2003). Gay and Airasian (1992) describe this type of scale as an attitude scale, because it is designed to determine individual beliefs and perceptions about self, others, activities or situations where “each response is associated with a point value” (p.131). Jordan, Thomas, Weerdmeester, and McClelland (1996) noted that a useable Likert scale is an instrument with items where respondents indicate the degree to which they concur or disagree based on a 5- or 7-point scale. The SIS instrument contains 22 forced-choice items with a Likert scale on the following range of qualifiers: 1=almost never, 2=seldom, 3=sometimes, 4=often, and 5=almost always. The qualifiers were selected based on examples presented by Czaja and Blair (2005) and the Constructivist Learning Environment Survey Comparative Form designed and validated by Taylor, Fraiser and White (1994). The items were divided into 3 subscales, or elements of information being researched. The relationship of the survey items to their construct are presented in the subscales below:

1. SIS Items 1-7 were designed to determine the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding inquiry-based instruction. This will be referred to as the “inquiry beliefs subscale”. The following SIS example item is designed to elicit how strongly the participant believes in the value of inquiry methodology: Inquiry is the most effective method for me to teach science.

2. SIS Items 8-15 were designed to determine the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding the barriers to the implementation of inquiry-based instruction. This will be referred to as the “barriers subscale”. The following SIS example item is designed to elicit whether or not local administrative support is a factor in inquiry implementation: Campus administrators support the use of inquiry methods.
3. SIS Items 16-22 were designed to determine the effect of the Inquiry Institute on Grades K-5 science teachers' self-reported implementation of inquiry-based instruction. This will be referred to as the “implementation subscale”. The following SIS example item is designed to elicit implementation patterns: *I plan my science instruction based on the use of inquiry methods.*

The SIS also contains the two open-ended response items asking for any other barriers that the educator or student experiences during inquiry and allows for any additional comments the respondent desires to write.

SIS items were developed after careful review and consideration of literature, analysis of instruments utilized in previous studies, and discussion with educators and administrators in the field. Leary's (1995) guidelines for creating surveys were used in the development of the SIS. The 7 guidelines are:

1. Use precise terminology in phrasing the questions.
2. Write the questions as simply as possible, avoiding difficult words, unnecessary jargon, and cumbersome phrases.
3. Avoid making unwarranted assumptions about the respondents.
4. Conditional information should precede the key idea of the question.
5. Do not use double-barreled questions, which ask more than one question but only allows for one response.
6. Choose an appropriate response format.
7. Pretest the questionnaire. (p.81-82)

*Instrument Reliability and Validity*

When an instrument can produce consistent results, it is considered reliable, and the study could be replicated under similar circumstances (Gay & Airasian, 1992). The Statistical Package for the Social Sciences for Mac, Rel. 16.0 (SPSS) was used to calculate a Cronbach’s alpha internal coefficient among all 20 quantitative items to check for reliability. Validity is an indicator that the instrument measures what it was designed to measure (Rudestam & Newton, 2007). There are two validity types considered for this study: content and face (Litwin, 1995). Content validity measures the
correlation of each item to the intended construct. Face validity means that, on face value, it appears to relate to the construct. Suskie (1996) explained that reliability and validity are enhanced when the researcher has a population with diverse backgrounds and viewpoints review the instrument. The reviewers are confirming that the items are clearly interpreted in the intended way and that the meaning behind each item is clear to those knowledgeable about the subject (Suskie, 1996, p. 59).

**Instrument Pretest**

In consideration of these principles, I conducted a conventional pretest with a panel of twenty Grades K-5 experienced educators and six graduate students in education who responded to the SIS instrument to determine face validity and assess for any misinterpretations of the questions (McGinnis, Kramer, Shama, Graeber, Parker, & Watanabe, 2002). Following Presser and Blair’s (1994) suggested techniques, the pretest consisted of a small group completing the survey and then attending a debriefing session. This pretest method resulted in editorial changes only, leaving the structure and content unchanged. Content validity was confirmed with the use of a subject-matter expert panel. In comparison with other methods, using an expert panel to review the survey item-by-item is a very effective method for identifying any problems with content (Presser & Blair, 1994). The subject-matter expert panel used to determine content validity for the SIS, all of whom use inquiry-based instructional methods, consisted of (a) a school district science interventionist, (b) a professor of science methods teaching undergraduates who are majoring in education, and (c) a college level biology instructor. The panel reached a consensus that the SIS had content
validity. As a result of both the administered pretest and expert panel consensus, the SIS was the data collection instrument used for this study.

Data Collection Procedures

Criteria for the sample selection consisted of degreed individuals holding elementary teaching certificates and currently teaching science. The SIS instrument was emailed in spring 2008 to 257 teachers selected for the study. Consent to participate in this study was obtained by acceptance and completion of the survey instrument. Gall, Gall, and Borg (2003) suggested that it is desirable to follow up with non-respondents. Based on this suggestion, a reminder email was sent to each initial sample member one week following survey distribution in order to elicit more responses. A third and final email was sent to all non-respondents. Each email contained access to the SIS survey via a URL link. This link directed the participant to Survey Monkey, an online survey website. A web survey was chosen as a consideration of convenience for participants. Teachers simply clicked on “radio buttons” to respond to the Likert-scale items. The open-ended questions provided a space for the participants to type a response of a more elaborative nature. All items, except for the open-ended items, required a response before the participant could submit his or her survey to any avoid missing data for analysis purposes. All surveys were secure on the website and only accessible to me with a protected login and password.

Each email sent to individuals in the sample contained a URL with a customized ending in order to track respondents by participant ID. To assure that participants’ information was confidential and allowed for a certain degree of anonymity, a master
code sheet containing the participants’ ID associated with each participant was created and kept separately from responses. As individuals completed the survey, I checked off the individual’s name on the master code sheet. The master code sheet allowed me to track non-respondents and to enter each respondent into a raffle to qualify for one of two $25 gift cards and one $50 gift card to Barnes and Noble bookstore as an incentive for participating in the survey. Data collection was also conducted face-to-face with non-respondents in fall 2008 at two curriculum revision meetings conducted by the district prior to the beginning of the 2008-2009 school year to increase the overall response rate. A paper copy of the web version was administered and 29 more responses were collected. The data from the paper survey were then manually entered into the Survey Monkey database. Using more than one mode for data collection assisted in maximizing response rates (Groves, Fowler, Couper, Lepkowski, Singer, & Tourangeau, 2004). Using both methods of data collection produced an overall response rate of 38%.

Data Analysis Procedures

The nature of this study required data analysis that was both quantitative and qualitative. The discussion of the quantitative aspect will be followed by a descriptive analysis of the open-ended survey items. Through the use of statistical tests, this study was aimed at determining the effect between participation in the Inquiry Institute professional development and the perception of beliefs about inquiry, barriers to using inquiry, and implementation in the science classroom.

There are three separate comparison groups in the population for this study. The first group consists of only non-participants in the Inquiry Institute—those with zero days
of Inquiry Institute professional development. The second group consists of teachers who have participated in Inquiry institute I only, consisting of three days of professional development. The third group includes the teachers who have participated in both Inquiry institute I and Inquiry Institute II, totaling six days of professional development. This study examined whether there is a difference among these three groups to determine if a relationship exists between length of teachers’ participation in the professional development and their perceptions of beliefs, barriers, and implementation of inquiry learning in the science classroom.

My null hypotheses predicted that there is no cause and effect relationship between the professional development activities and perceived beliefs, barriers or implementation of inquiry. These null hypotheses below were tested using the statistical measures that follow.

H₀₁: There is no statistically significant difference between the mean scores on the inquiry belief subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, those who attended three days of the Inquiry Institute, and those who attended zero days of Inquiry Institute.

H₀₂: There is no statistically significant difference between the mean scores on the barriers subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, those who attended three days of the Inquiry Institute, and those who attended zero days of Inquiry Institute.

H₀₃: There is no statistically significant difference between the mean scores on the implementation subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, those who attended three days of the Inquiry Institute, and those who attended zero days of Inquiry Institute.

**Confirmatory Factor Analysis**

The first statistical technique used was confirmatory factor analysis (CFA). This factor analysis assisted me in verifying the factor structure of observed variables in
relationship to their underlying latent constructs (Kim & Mueller, 1978). In simple terms, the CFA allowed me to validate the following three factors or constructs: SIS Items 1-7 inquire about the participants’ beliefs regarding inquiry; SIS Items 8-15 pertain to barriers encountered; and SIS Items 16-22 are indicators of implementation patterns. The CFA also supported the use of total scores or composite scores in addition to each subset (Kim & Mueller, 1978, p.2).

**Descriptive Statistics**

The SIS instrument’s 22 Likert-scale items were coded with the following range of qualifiers: 1=almost never, 2=seldom, 3=sometimes, 4=often, and 5=almost always. SPSS descriptive statistics allows for summarization of these quantitative data and explaining descriptive responses according to frequency distributions, group mean and standard deviation. Frequency tables and descriptive statistics results, with respect to each of the three research questions are displayed with percents for ease in interpretation.

**Analysis of Variance**

Gall, Gall, and Borg (2003) describe an analysis of variance (ANOVA) as a “procedure for determining whether the difference between the mean scores of two or more groups on one or more dependent variables is statistically significant” (p. 618). Huck (2004) added that a one-way ANOVA allows the researcher to utilize the data to make a single inferential statement regarding the means of the study’s population. For this study, it was determined that one-way ANOVAs were the appropriate method to
answer the question, “Are the means for the various populations equal to one another?” (p. 268). For the purpose of this study, I sought to determine if there existed statistically significant differences in the mean scores of the three groups in each of the constructs: inquiry beliefs, barriers and implementation. The criterion, or level of significance, for rejecting the null hypotheses in this study was based on the most frequently used alpha level of .05 in an attempt to avoid a Type I error—rejecting a true null hypothesis, or a Type II error—neglecting to reject a false null hypothesis (Hinkle, Weirsma, & Jurs, 2003). This means that the decision to reject each hypothesis may be incorrect only 5% of the time (p. 179). SPSS was used to calculate the ANOVA.

Summary

This chapter presented the research design as a quantitative study that is causal-comparative in nature, but also designed to obtain qualitative data through open-ended survey items. Participants recruited from a population of science teachers from eleven elementary school campuses in a North Texas school district completed the SIS to answer the following research questions:

1. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ inquiry beliefs regarding inquiry-based instruction?

2. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ perceptions regarding the barriers to the implementation of inquiry-based instruction?

3. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ self-reported implementation of inquiry-based instruction?

The methodology for data collection was described, and it was also explained that the data analysis would consist of quantitative techniques, using SPSS to calculate
confirmatory factor analysis and one-way ANOVAs. Chapter 4 presents the results of the data gathering and analysis.
CHAPTER 4
ANALYSIS OF DATA

Introduction

Science education reform efforts have strongly promoted the use of inquiry-based methods in the classroom (NRC, 2000). Changing teachers’ classroom behaviors, such as from traditional methods to inquiry-based science instruction is typically attempted with the support of professional development; however, little research exists to support or deny the significance or effectiveness of such professional development. Cohen and Hill (2000) and McNeil (2000) noted the need for more research on professional development in order to change teacher behavior and ultimately make an impact on classroom instruction. The Inquiry Institute is one example of professional development that is intended to strengthen science teachers’ pedagogical knowledge and provide practice with inquiry methods based on a constructivist approach. The findings of this study have provided a better understanding of the relationship between participation in this professional development and participants’ beliefs about inquiry, their behavior in the science classroom, and barriers affecting their implementation of inquiry methodology. Specifically, this study was structured as a causal-comparative analysis to determine the effects of the Inquiry Institute on Grades K-5 elementary science teachers through their perceptions of inquiry learning in the classroom.

The findings from this study are the results of data collection from a survey administered between spring and fall 2008. The bulk of responses from this survey supported quantitative data analysis techniques, with the last two survey items providing
qualitative data through open-ended responses. A total of 97 participants completed the Science Inquiry Survey (SIS). The participants varied in the extent to which they participated in the Inquiry Institute, allowing for three levels of Inquiry Institute participation to be compared within the data analysis. This length of participation in the Inquiry Institute was used as the independent variable to determine whether the three groups differ on three dependent variable constructs— (a) perceived beliefs about inquiry, (b) barriers to using inquiry, and (c) implementation of inquiry. Within each subset of items assessing the constructs, higher scores on the SIS indicate a stronger perceived belief in the use of inquiry-based methods, fewer perceived barriers to using inquiry methods, and a stronger perceived implementation pattern of inquiry.

Before analysis could be completed, it was necessary to organize and code the data that were collected. This was completed separately for both quantitative and qualitative data. First, quantitative data collected from the SIS were retrieved from Survey Monkey, compiled into a spreadsheet, and then imported into SPSS for statistical analysis. Next, the qualitative data were retrieved and compiled into a separate spreadsheet and coded based on open-ended response items in order to analyze the emerging themes. The following discussion begins with presentation of participant demographics followed by results of the reliability and internal validity testing. A discussion of the quantitative analysis of data is presented as it relates to the three research questions and their corresponding hypotheses.

1. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding inquiry-based instruction?

2. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ perceptions regarding the barriers to the implementation of inquiry-based instruction?
3. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ self-reported implementation of inquiry-based instruction?

Finally, this chapter closes with a discussion of the qualitative data analysis that represents participants’ perceptions of the Barriers construct as well as the data provided that support additional findings.

Participant Demographics

Based on the number of completed surveys, the participant demographics for this study consisted of 93 females and 4 males (n=97). This imbalance in gender representation is to be expected given the grade levels under investigation. Their teaching experience ranged from 1 to 32 years, with a mean of 15 years experience and median of 13 years experience. Teacher participants from all K-5 grades were represented with the specific grade level distribution provided in Figure 1. These demographics illustrate the teacher participants are representative of all K-5 grades. This type of evenly dispersed sample enabled me to generalize the findings across all six elementary grades, and this sample, “which is assumed to be representative of the population” (Hinkle, Wiersma, & Jurs, 2003, p.141), provided data for the findings and conclusions in this study. Therefore, making a generalization for other grade level educators, such as secondary teachers, should be viewed with caution and is not the intent of this study.
Reliability of the Instrumentation

Determination of internal consistency is often obtained by calculating a Cronbach’s coefficient alpha (Cronbach & Meehl, 1955), to provide information “based on the extent to which test-takers who answer a test item one way respond to other items the same way” (Gall, Gall, & Borg, 2003, p.622). A Cronbach’s alpha internal coefficient was calculated among the three sets of data from the SIS on the following three pre-determined latent constructs: SIS Items 1-7 asked about the participants’ beliefs regarding inquiry (inquiry beliefs subscale); SIS Items 8-15 pertained to barriers encountered while implementing inquiry-based instruction (barriers subscale); and SIS Items 16-22 were indicators of implementation patterns (implementation subscale). Typically an alpha of 0.7 or higher provides support for internal consistency (Morgan, Leech, Gloeckner, & Barrett, 2004). The first set of items, inquiry beliefs subscale, had...
a Cronbach’s alpha of 0.735 and the third set of items, implementation subscale, had a Cronbach’s alpha of 0.803, both of which indicate a high level of internal consistency.

The second subset of items, barriers subscale, had a Cronbach’s alpha of 0.348, which does not meet the requirements of measuring a single latent construct. McGinnis, Kramer, Shama, Graeber, Parker, and Watanabe (2002) encountered similar challenges in their own research with reliability analysis and ultimately removed items that reduced the variable’s outcome. In a similar manner, I completed a second analysis, deleting all items except 8, 11, and 13 from the subset, producing a Cronbach’s alpha of 0.60, which is considered acceptable for this type of instrument (McGinnis, Kramer, Shama, Graeber, Parker, & Watanabe, 2002). After revaluation of these items, it was determined that they were all representative of one group of institutional barriers that measured support at three different levels: (a) collegial, (b) campus administration, and (c) district administration. It was determined that the Cronbach’s alpha values were satisfactory for this construct because support was evaluated at the collegial and campus administration level spread over 11 campuses, which accounts for some lack of internal consistency. In order to preserve the applicable responses from Items 9, 10, 12, and 14, the data is presented wherever applicable through qualitative analysis at the end of this chapter.

Confirmatory Factor Analysis

Validating the factor structure of observed variables in relationship to their underlying latent constructs was completed using confirmatory factor analysis, CFA, (Kim & Mueller, 1978). In simple terms, the CFA allowed me to validate the pre-
determined constructs. Roberts (1999) encourages the use of this analysis because it makes the research more empirically based and meaningful, and it is commonly used when the researcher has “an understanding of the constructs that underlie the data” (p.3). Another researcher, Gorsuch (1983), notes that CFA “tests specific hypothesis regarding the nature of the factors,” (p. 129) and therefore assisted in establishing construct validity. A summary of the factor component matrix is presented in Table 2 indicating that the factor analysis identified three reliable constructs as dependent variables.

For this study variables were assigned to a specific construct, where the factor loadings were the highest. Items 1-7, designed to test the inquiry beliefs subscale load as one scale. The initial CFA revealed Items 8-15, designed to test the barriers subscale, loaded as two scales that produced three items with low-loading factors. A revised CFA showed Items 8, 9, and 10 loading as one scale, which is consistent with the Cronbach’s alpha discussed earlier in the chapter. The last construct, implementation subscale, revealed Items 16-22 produced factors loading as a single scale. CFA is a multivariate method that combines variables in order to create a synthetic variable. The three synthetic variables created are shown in Figure 2 illustrating that Items 1-7 (inquiry beliefs subscale) explained 39.03% of the total variance, Items 8, 11, and 13 (barriers subscale) explained 55.23% of the total variance, and the remaining items (implementation subscale) explained 47.04% of the total variance. As Zillmer and Vuz (1995) noted, “the higher the total variance accounted for, the better the factor model represents the data” (p. 283-284). These strong values indicate the presence of the three subscales noted.
The analysis of data from Grades K-5 science teachers was used for the purpose of answering the three research questions that frame this study. Additionally, the data analysis was used for the purpose of rejecting or failing to reject the three null hypotheses presented in chapter 1. Generally accepted statistical procedures and methods were employed to analyze the data collected. A discussion of the methods used for analysis follows each question and hypothesis.

Figure 2. Variance of each construct as revealed by CFA.
Table 2

**Factor Component Matrix**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Inquiry Beliefs</th>
<th>Barriers</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>0.616</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td>0.559</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td>0.673</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>0.724</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q5</td>
<td>0.615</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q6</td>
<td>0.622</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q7</td>
<td>0.544</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q8</td>
<td>0.791</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q11</td>
<td>0.775</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q13</td>
<td>0.677</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q16</td>
<td>0.714</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q17</td>
<td>0.426</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q18</td>
<td>0.630</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q19</td>
<td>0.741</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q20</td>
<td>0.802</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q21</td>
<td>0.821</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q22</td>
<td>0.581</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: CFA extracted via Principal Component Matrix*

**Analysis of Variance for the Inquiry Beliefs Subscale**

The first null hypothesis was directed at the first research question, “What is the effect of the Inquiry Institute on Grades K-5 science teachers’ inquiry beliefs regarding inquiry-based instruction?”

\[ H_{01} : \text{There is no statistically significant difference between the mean scores on the inquiry belief subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, those who attended three days of the Inquiry Institute, and with those who attended zero days of Inquiry Institute.} \]

The inferential method selected for data analysis was an Analysis of Variance (ANOVA) since it is commonly used to test equality of more than two population means (Sullivan,
A one-way ANOVA was used to analyze the differences between the mean scores of Group 1 with 32 science teachers who attended zero days of Inquiry Institute, Group 2 with 31 science teachers who attended three days of Inquiry Institute, and Group 3 with 34 science teachers who attended six days of Inquiry Institute ($n=97$). The length of participation in the Inquiry Institute is the independent variable to determine whether the three groups differ on three dependent variable constructs. For this ANOVA, Items 1-7 were considered both reliable and valid to test the inquiry belief construct. The means determined in this one-way ANOVA are listed below in Table 3, followed by the summary results in Table 4.

Table 3

*Descriptive Summary of Means for Beliefs Construct*

<table>
<thead>
<tr>
<th>Group</th>
<th>$N$</th>
<th>Mean</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34</td>
<td>29.79</td>
<td>3.45</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>28.77</td>
<td>3.16</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>31.68</td>
<td>2.40</td>
</tr>
<tr>
<td>Total</td>
<td>97</td>
<td>30.09</td>
<td>3.24</td>
</tr>
</tbody>
</table>

*Note:* Total possible high score for each group = 35.

The mean in Table 3 for Group 1 that participated in zero hours of the Inquiry Institute was 29.79 ($SD=3.45$). The mean for Group 2 that participated in three days of the Inquiry Institute was 28.77 ($SD=3.16$). The mean for those that participated in six days of the Inquiry Institute, Group 3, was 31.68 ($SD=2.40$). The one-way ANOVA results in Table 4 indicate that there was a statistically significant difference since the criterion, or level of significance, for rejecting the null hypotheses in this study was
based on the most frequently used alpha level of 0.05. A Tukey’s HSD post hoc test was performed to determine the nature of the relationship between the groups. This multiple comparison is presented in Table 5 with specificity as to where the statistically significant difference exists.

Table 4

*One-way ANOVA Summary for Beliefs Construct*

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>138.31</td>
<td>2</td>
<td>69.16</td>
<td>6.46</td>
<td>0.001</td>
</tr>
<tr>
<td>Within groups</td>
<td>871.85</td>
<td>94</td>
<td>9.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1010.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5

*Multiple Comparisons of Beliefs Construct*

<table>
<thead>
<tr>
<th>Group</th>
<th>Group</th>
<th>MD</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>1.02</td>
<td>0.372</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>1.89</td>
<td>0.035</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>2.91</td>
<td>0.001</td>
</tr>
</tbody>
</table>

The Tukey’s post-hoc test results in Table 5 indicate that there was no statistically significant difference between Group 1 and Group 2; however, there is a statistically significant difference of $p=0.035$ between Group 1 and Group 3. Group 2 and Group 3 also had a statistically significant difference of $p=0.001$. Additionally, if the
null hypothesis were true, the between-samples would be close in value to the within-samples (Sullivan, 2004). This is clearly not indicated in Table 4, which shows a difference of 732.69 between the two values. Therefore, the null hypothesis, H₀₁, was rejected.

Description of the meaningful significance of the statistical results is accomplished by reporting the effect size. In other words, the effect size indicates the “magnitude of a reported relationship” (Gay & Airasian, 2003). Furthermore, the fifth edition of the *Publication Manual of the American Psychological Association* emphasizes, “for the reader to fully understand the importance of your findings, it is almost always necessary to include some index of the effect size” (APA, 2003, p.25). Cohen (1988) proposed values of $r$ as small = 0.1, medium = 0.3, and large = 0.5. Effect size is a tool to help evaluate the degree of how far the sample deviates from what is expected, but judgment must still be made by the researcher as to its relevance in the context of the study (Roberts & Henson, 2003). In this study, the effect size of the Inquiry Institute on Grades K-5 science teachers’ inquiry beliefs regarding inquiry-based instruction indicated an effect size of $r = 0.37$. Applying the suggested benchmarks provided by Cohen (1988), the findings of this construct are at a moderate level.

The data analysis supports the conclusion that the completion of six days of Inquiry Institute professional development strengthens elementary science teacher’s perceived beliefs about inquiry. There is no statistical significance on perceived inquiry beliefs between participants completing zero days or three days of the professional development. However, it is evident in the analysis that participants in three days of the professional development had a statistical significance from those participating in six
days. It can be concluded that those participating in the full six days had the strongest relationship between their inquiry beliefs and their professional development, and therefore received the most benefit. Discussion regarding implications of these findings will follow in chapter 5.

Analysis of Variance for the Inquiry Barriers Subscale

The second null hypothesis is directly related to the second question, What is the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding the barriers to the implementation of inquiry-based instruction?

H₀₂: There is no statistically significant difference between the mean scores on the barrier subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, with those who attended three days of the Inquiry Institute, and with those who attended zero days of Inquiry Institute.

This study confirms, though CFA measures, a subscale with three items as related to the barrier construct. Research has confirmed that subscales of 2-4 items can be considered reliable (McGinnis, Kramer, Shama, Graeber, Parker, & Watanabe, 2002; Scotti, Driscoll, Harmon, Behson, & Scott, 2007). The means determined in a one-way ANOVA are listed below in Table 6, followed by the summary results in Table 7. However, as with any research analysis using CFA with such a limited number of items, this analysis should be viewed with caution. For this reason, the qualitative data analysis that follows this section was an essential element utilized to answer the research question regarding the Barrier construct.

Table 6
**Descriptive Summary of Means for Barriers Construct**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34</td>
<td>13.15</td>
<td>1.62</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>12.71</td>
<td>1.70</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>13.00</td>
<td>1.52</td>
</tr>
<tr>
<td>Total</td>
<td>97</td>
<td>12.96</td>
<td>1.61</td>
</tr>
</tbody>
</table>

*Note: Total possible high score for each group = 21.*

The mean in Table 6 for Group 1 that participated in zero days of the Inquiry Institute was 13.15 (SD=1.62). The mean for Group 2 that participated in three days of the Inquiry Institute was 12.71 (SD=1.70). The mean for the group that participated in six days of the Inquiry Institute, Group 3, was 13.00 (SD=1.52). The one-way ANOVA results in Table 7 indicate that there was no statistical significance with \( p=0.884 \).

**Table 7**

*One-way ANOVA Summary for Barriers Construct*

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>( F )</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>.455</td>
<td>2</td>
<td>0.227</td>
<td>0.124</td>
<td>0.884</td>
</tr>
<tr>
<td>Within groups</td>
<td>172.45</td>
<td>94</td>
<td>1.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>172.91</td>
<td>96</td>
<td>1.84</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The one-way ANOVA result indicates there was no statistically significant difference between any of the groups; therefore, I failed to reject the null for \( H_02 \). This statistical analysis does not provide sufficient evidence to support the claim that those teachers who participated in longer Inquiry Institute professional development perceived fewer barriers to inquiry implementation. As noted previously, data from this subset are
presented in the qualitative analysis section at the end of this chapter to glean a more complete representation of teachers’ perceptions about barriers.

**Analysis of Variance for the Inquiry Implementation Subscale**

The third null hypothesis is directly related to the last question, What is the effect of the Inquiry Institute on Grades K-5 science teachers’ self-reported implementation of inquiry-based instruction?

**H₀₃:** There is no statistically significant difference between the mean scores on the implementation subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute and, with those who attended three days of the Inquiry Institute, and with those who attended zero days of Inquiry Institute.

Consistent with the two previous research questions and hypotheses, the one-way ANOVA was used to analyze the differences between the mean scores of Group 1, Group 2, and Group 3. The mean scores for this construct are presented in Table 8 with a total possible high score for each group = 35.

**Table 8**

*Descriptive Summary of Means for Implementation Construct*

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34</td>
<td>27.62</td>
<td>3.98</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>26.90</td>
<td>3.39</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>30.09</td>
<td>3.16</td>
</tr>
<tr>
<td>Total</td>
<td>97</td>
<td>28.21</td>
<td>3.76</td>
</tr>
</tbody>
</table>

The mean shown in Table 8 for Group 1, who participated in zero days of the Inquiry Institute, was 27.62 (SD=3.98). The mean for Group 2, who participated in three
days of the Inquiry Institute, was 26.90 (SD=3.39). The mean for Group 3, who participated in six days of the Inquiry Institute, was 30.09 (SD=3.16). The one-way ANOVA results in Table 9 indicate that there was a statistically significant difference between the groups (p=0.001). A multiple comparison is presented in Table 10 with specificity as to where the statistically significant difference exists.

Table 9

One-way ANOVA Summary for Implementation Construct

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>178.42</td>
<td>2</td>
<td>89.21</td>
<td>7.122</td>
<td>0.001</td>
</tr>
<tr>
<td>Within groups</td>
<td>1177.46</td>
<td>94</td>
<td>12.53</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 10

Multiple Comparisons for Implementation Construct

<table>
<thead>
<tr>
<th>Group</th>
<th>Group</th>
<th>MD</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>0.714</td>
<td>0.696</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>-2.48</td>
<td>0.015</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>-3.19</td>
<td>0.002</td>
</tr>
</tbody>
</table>

As seen in Table 11, the Tukey’s post hoc test results indicate that there was no statistically significant difference between Group 1 and Group 2; however, consistent with the results from the one-way ANOVA applied to the Implementation construct, there was a statistically significant difference between Group 1 and Group 3 and also between Group 2 and Group 3. Therefore, the null hypothesis, H03, was rejected. These results are similar to those described for the inquiry beliefs construct. There was no difference found in the perceived implementation construct between those who participated in zero days and those who participated in three days of the professional
development. There is also evidence that participants in three days of the professional
development had a statistically significant difference from those participating in six days.
It can also be concluded that those participating in the full six days had the most
beneficial relationship between their perceived implementation and their professional
development. Again, because this noted statistical significance does not reveal the
strength of the relationship, it is important to discuss the relationship in terms of the
effect size. The effect size for this construct had a calculated $r = 0.36$. This effect size is
also at a moderate level using acceptable standards from Cohen (1988).

Qualitative Analysis

Two open-ended questions (a) Please list/explain any barriers or constraints that
you or your students experience while planning, preparing, or executing inquiry in your
science class; and (b) Please write any additional comments below that you wish to
share, yielded qualitative data that revealed four relevant and recurring patterns related
to the participants’ reported barriers that affect the implementation of inquiry-based
methods. This analysis began by transcribing the responses from the two questions
above onto a spreadsheet followed by a process of coding. The responses were
examined methodically searching for repeating words and phrases and any observable
patterns. When this process was finished, a color-code system was used to represent
each of the four barriers. For example, all responses referring to time were coded
yellow on the spreadsheet serving to expedite the analysis process through visual
recognition. Some degree of interpretation was involved when dealing with vague or
incomplete comments. These interpretations are considered valid because they were
supported by the data (Auerbach & Silverstein, 2003). This process was completed with the identification of the following barriers: (a) time, (b) materials/costs, (c) support, and (d) additional professional development needs. The relevant survey items that provided quantitative data about barriers are also included in this section.

Similar to research by Mansour (2007) the qualitative analysis indicated that these barriers could be classified as either external barriers or internal barriers. Mansour (2007) considered external barriers as those outside teacher control such as administrative directives, lack of time, lack of materials, etc. Those factors that are directly controlled by the teacher are internal barriers, such as teachers’ knowledge of content and methodology, professional abilities, beliefs regarding teaching, and so forth (p.486). All four barriers will be presented independently, categorized as either an external or internal barrier, to better inform the second research question, What is the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding the barriers to the implementation of inquiry-based instruction?

External Barriers

Time

This discussion begins with the idea of time because it emerged clearly as the most important barrier to the participants as supported by how frequently it was mentioned. As previous research asserts, there is no question that inquiry-based instruction requires considerable planning and implementation time (Baker, Lang, & Lawson, 2002; Jackson & Boboc, 2008; Welch, Klopfer, Aikenhead, & Robinson, 1981) and participant statements on the SIS support this assertion. Of the open-ended
responses received, a majority of respondents listed time as a barrier to planning, preparing, and executing inquiry in their classrooms. One participant noted that inquiry required “special planning and additional time to complete.” Another participant agreed that it was “time consuming,” but added, “[inquiry’s] payoff is big.” This idea was echoed by a participant who wrote, “[inquiry] maybe a little more time consuming, but it really pays off in the end.” These sentiments were also exemplified in the following participant response:

Planning takes extra time when lessons need to be shifted to inquiry-based. While I feel that inquiry is the best way to teach my kids and ensure that they have a deep understanding, the lack of adequate time tends to limit the effectiveness of the investigation.

Additionally, the analyses of Item 9—*Time constraints are a consideration when planning science instruction,* and Item 12—*Inquiry science investigations require extensive lab preparation time,* revealed that time was noted as *almost always* a significant concern to 75% of the participants. Interestingly, the comments regarding time were evenly distributed among the three groups of participants without regard to the length of participation in the Inquiry Institute professional development.

For many respondents, even though time was considered a significant concern, the outlay of time was perceived as worthwhile. The following quote suggests the respondent perceived time as an issue, but inquiry was worth the investment:

Inquiry is a great way to get the students active and learning the needed concepts. It may be a little more consuming, but it really pays off in the end. Students learn by being totally involved with what they are doing.

Similarly, this quote, "Time is always a constraint, but it is worth the end results" show that time management is an issue, but the outcome makes it a valuable endeavor. Another respondent remarked, "[Inquiry is] time consuming but brings about a big
reward." One other respondent perceived time as a barrier, but commented, "The kids gain so much and I really love to see them thinking and making connections." These data show that time is a perceived barrier to inquiry implementation, and some, realizing the benefits, still choose to incorporate this methodology. The element of time is an important issue and was discussed in the literature review, along with a few suggestions to overcome this barrier. The implications of time as a barrier to the successful implementation of inquiry-based science instruction will be presented in Institute 5.

**Concerns with Materials and Cost**

One complaint consistently heard in science classrooms is the amount of materials needed for hands-on instruction. Many of the open-ended responses suggested that participants considered materials/cost a major concern that impedes inquiry-based instruction. The responses regarding this barrier can be further subdivided into three groupings: (a) setup of materials, (b) purchasing materials, and (c) using materials. Several participants considered lab preparation to be a major concern, as noted by a participant’s explanation, “Setting up materials was the biggest barrier to using inquiry.” A second group of responses simply noted “materials and costs” as a constraint, while numerous responses suggested that “cost” or “money” were major concerns. Others explained that they “felt uncomfortable with the materials” or “uncomfortable using the materials.” Having the necessary materials does not assure that they are used. An example of this was noted by one participant who said, “Materials are available, but not enough information to use them.” It is noteworthy that this participant had not received any Inquiry Institute professional development. Also
worthy of mention is the finding that participants who received either three or six days of the professional development submitted the majority of responses regarding materials/cost. This suggests that professional development increases the use of inquiry by participants; and, in turn, the concerns surrounding material management for those participants became an issue. The participants in this study confirm that inquiry-based instruction requires more time and resources. The key to implementing inquiry is learning to manage both of these barriers.

**Support**

For the purpose of this study, the topic of support divided into three areas: teachers can obtain support from colleagues, support from campus administration, and support from central administration. Three items on the SIS, 8, 11, and 13 which were removed from quantitative data analysis, questioned participants about the level of support they received from each of these areas. Below are the three items relating to support:

- Item 8—“Campus administrators support the use of inquiry methods.”
- Item 11—“District administrators support the use of inquiry methods.”
- Item 13—“Coworkers support the use of inquiry methods.”

Participants had the following response choices: 1=almost never, 2=seldom, 3=sometimes, 4=often, and 5=almost always. Of the three areas where teachers responded that they received the most support, district administration was the strongest, with 94% participants selecting often or almost always as their choice. The open-ended items did not reveal any additional information about district administration, as it was not referenced by the respondents. The responses were also overwhelmingly positive with
regards to campus administrative support. One respondent commented that “inquiry is driven by the district administration,” demonstrating that this teaching method is heavily supported and strongly suggested for science teachers. According to these data, there is no lack of support from district or campus administration. One of the weakest areas of support for teachers, which is a definite area of concern, is discussed next.

Analysis of the data revealed the area where teachers are lacking in support is from their own colleagues at the campus level. Almost 50% of participants disclosed that they only sometimes or even seldom received the support from their coworkers. Some participants felt very strongly about collegial support as seen by this response, “Teachers need teacher support!” Another noted that “more teacher collaboration is needed” and found this a barrier to implementing inquiry methods, suggesting that support from the bottom up is the area of weakness.

Support from colleagues is particularly important to elementary teachers because of the close working relationships. Many teachers at this level plan together, particularly those teaching the same grade level subject. Although inquiry is a methodology, a considerable amount of thoughtful planning, as noted above, is required to accomplish objectives of the lessons. If team members are unwilling to support the use of inquiry-methods, it would certainly surface at the planning level. Planning and utilizing inquiry would be challenging for some teams that have different members planning different subjects. For example, if the teacher planning science does not have a constructivist foundation and utilize inquiry, lesson plans would not only lack inquiry, but also be structured in a sequence that might progress too quickly to adequately use inquiry-based methods. Additionally, if coworkers do not support inquiry, they are probably less
accommodating of schedule changes to allow for any extra time needed to complete some lessons. With the goal of science education reform through the use of inquiry-based instruction, the lack of collegial support cannot be overlooked.

Internal Barriers

Professional Development

As discussed in chapter 2, a majority of elementary teachers are insufficiently prepared to teach science effectively using inquiry-based instruction. Even though the Inquiry Institute is a professional development program that is intended to strengthen science teachers’ pedagogical knowledge and provide practice with inquiry methods based on a constructivist approach, the full program lasted only six days. Further research, also discussed in chapter 2, suggested that almost double the length of professional development is needed to alter teaching practices (Supovitz & Turner, 2000). Analysis of the quantitative data showed that over half of the respondents selected often or almost always to the item “Additional professional development would strengthen my use of inquiry methods”. Several respondents to the open-ended items also felt as if additional professional development would strengthen the use of their inquiry methods. Their comments suggested “additional training” or “direct modeling” would help them implement inquiry-based methodology.

Without specifically noting the lack of professional development as a barrier, some respondents provided comments that suggest more understanding and familiarity with inquiry was needed. For example, the quote, "Lack of labs for some concepts prevent preparing and executing inquiry," confirms that the participant did not fully
understand and absorb the Inquiry Institute’s objective of transforming current labs into inquiry labs. A portion of the professional development, called subtle shifts, was designed to enable teachers to use their own curriculum and begin to shift it slowly into inquiry lessons with the use of small, gradual changes. From the quote above, it is apparent the respondent is not comfortable or able to make subtle shifts with their own labs. This was also noticed with another respondent that wrote, “Adding inquiry is impossible because of curriculum requirements.” Three other respondents noted that “extensive curriculum,” “too much curriculum,” or “fitting it into the curriculum” was a perceived barrier to implementation. One respondent specifically stated that she “lacked the knowledge to change current curriculum into inquiry lesson.”

The respondents that perceived curriculum as a barrier had completed 0-3 days of inquiry. What they missed in the later three days of the Inquiry Institute had the potential to ease or remove this curriculum barrier— inquiry is not added to the curriculum; instead, it is a methodology used to teach the material. The data analysis illustrates the important role professional development plays in altering teacher classroom behavior. Furthermore, concurring with previous research, the length of professional development must be sufficient to provide both pedagogical knowledge and practice of the intervention. Teachers participating in Inquiry I (three days) only would receive less than half of the hours recommended by researchers. Recalling the research by Supovitz & Turner (2000), 80 hours was a minimum for instruction in inquiry-based methods. Suggestions for professional development, with regards to length, will be discussed in chapter 5.
Conclusion

Analysis of the quantitative data illustrated the claim that teachers who have participated in longer Inquiry Institute professional development have stronger perceived inquiry beliefs and implementation. This was supported by sufficient evidence from the one-way ANOVAs on both of these constructs showing a statistically significant difference between Group 1 (zero days participation) and Group 3 (six days participation) in favor of Group 3. There was additional statistically significant difference between Group 2 (three days participation) and Group 3 in favor of Group 3. These results suggest that lengthier professional development in the Inquiry Institute holds the most benefits for the participants. Although there was no statistically significant evidence with regards to the barriers, analysis on the qualitative data from the open-ended survey items did reveal four recurring barrier patterns including (a) time, (b) materials/cost, (c) support, and (d) additional professional development. Time, materials/cost, and support are considered external support because the teacher cannot control them. The last barrier, additional professional development, can be controlled to some extent and is considered an internal barrier (Mansour, 2007). All of the respondents acknowledged more than one of the barriers, with the majority noting at least three. With this increase in our knowledge base regarding barriers to inquiry-based instruction, we can begin to find solutions, ultimately leading to full engagement in inquiry-based, reform-oriented instructional practices.
CHAPTER 5
DISCUSSION AND IMPLICATIONS

Introduction

The rationale for this study was to understand elementary teachers’ perceptions of science education reforms focused on inquiry-based instruction from a constructivist perspective. At the center of science education reform is the goal of building science literacy, which is defined as:

The understanding and habits of mind that enable people to make some sense of how the natural and designed worlds work. Scientifically literate individuals will think critically and independently, including the consideration of alternative explanations of events, thus preparing them for the future. (AAAS, Project 2061, 1990)

With this goal in mind, I reviewed relevant literature and gained an understanding that inquiry-based instruction promotes critical thinking, logical thinking, and problem solving while supporting knowledge transfer to support learners in the future. Research also confirms that students who learn from inquiry-based instruction are more successful than students receiving traditional methods of instruction (Jorgenson & Vanosdall, 2002; Klentschy, Garrison & Ameral, 2001; Stohr-Hunt, 1996). Review of the literature, combined with my own experiences as an educator, led to the theoretical framework for this study, which is outlined next.

Theoretical Framework

Several substantial documents intended as tools to guide science education reform, including the Benchmarks for Science Literacy (AAAS, 1993), the National Science Education Standards (NRC, 1996), and the Texas state standards, the Texas...
Essential Knowledge and Skills (TEA, 1998), support the use of inquiry-based methods to teach science with a common goal to promote science literacy. Despite recommendations by these documents, our public school system is far from attaining the goal of inquiry-based instruction in science classrooms, which leads to science literacy and ultimately the purpose of education—critical thinking and problem-solving skills for future benefit.

Evidence of our lack of success in science education can be seen in the most current national and international testing results, which show that U.S. students rank poorly compared to students from other countries. What is needed for the success of science education reform, other than a clear, concise and agreed-upon goal, is a change in teachers’ own beliefs or epistemologies about education. Llewellyn (2002) wrote that teachers “are products of an educational system that is based on the work of early philosophers from hundreds of years ago” (p.39). Much of our present education system is predicated on these early behavioral theories.

During the early 20th century, a subtle movement began with the theory of cognitive psychology, illustrated by the works of Piaget (1970), Bruner (2006), Dewey (1910), and Vygotsky (1978), all of whom are considered constructivists. Constructivism is an overarching epistemology that lays the foundation for inquiry practices in the classroom, because it supports the idea that people construct their own knowledge through experiences first and then reflect upon those experiences. It was this shift that led to a natural progression into inquiry-based teaching methodology.

Inquiry-based instruction, according to Colburn (2003), occurs when “students are engaged in (essentially) open-ended, student-centered, hands-on, engaging
activities” (p.231) in a constructivist environment. Although this was not a new method of instruction, inquiry experienced a slow movement into mainstream science education over time. Inquiry as a pedagogical method has only recently begun to play a serious role in science education (DeBoer, 1991). This is perplexing due to the abundance of research discussed in chapter 2 that illustrates the success of students who learn with inquiry-based instruction (Jorgenson & Vanosdall, 2002; Kennedy, 1999; Klentschy, Garrison, & Ameral, 2001; Mundry, 2005; Stohr-Hunt, 1996; Treisman, 2006; Weiss, Pasley, Smith, Banilower, & Heck, 2003).

Research has shown that about 80% of America’s K-8 school children experienced traditional methods of instruction, such as listening to lectures, reading the textbook and answering chapter questions, and completing worksheet assignments (Huber & Moore, 2001; Jorgenson & Vanosdall, 2002). Research has also shown that science often receives a smaller allotment of time than other subjects (Gess-Newsome, 1999). It was also noted that educators at the elementary level often lack expertise in science and may have “never liked science in the first place” (Winters, 2006, p.26). In addition to these obstacles, researchers have identified barriers for those teachers attempting to implement inquiry-based instruction, some of which, as discussed in the findings of this study, are the same barriers identified by participants of this study. Welch, Klopfer, Aikenhead and Robinson (1981) acknowledged that inquiry-based instructional barriers include considerable planning and implementation time, as well as difficulty with classroom management. Further barriers noted by Baker, Lang, and Lawson (2002) include students wasting time, lack of student motivation, and material management. Another barrier deals directly with professional development and is
discussed in detail below. There is a lack of content and pedagogical knowledge among elementary teachers needed to transform existing or new material into inquiry lessons (Stamp & O'Brien, 2005; Taylor, Gilmer, & Tobin, 2002).

The literature also provided some suggestions and tools to assist teachers using inquiry-based instruction in the science classroom. Jackson & Boboc (2008) suggested frontloading inquiry-based instruction by setting up storage bins complete with “materials, lesson plans, and activity sheets” (p.64). Similar to the subtle shift into inquiry-based instruction taught at the Inquiry Institute, Colburn (2000) presented a continuum structure of inquiry that moves from a teacher-centered structured inquiry environment to a full, open-inquiry environment designed to be student-centered.

By what means can teachers be influenced to use inquiry-based instruction? Literature suggests that professional development is viewed as the primary method with the greatest impact on altering teachers’ classroom behavior (Cohen & Hill, 2000; Garet, Porter, Desimone, Birman, & Yoon, 2001). It is through high-quality and effective professional development that teachers add important ideas, content, and methodology to their teaching. Research on the effect of professional development is plentiful; however, research on the effectiveness of inquiry-based professional development has been less than ample. Lee, Hart, Cuevas, and Enders (2004) argued that further research on instructional interventions promoting science inquiry is needed if we are to improve science achievement for all students. The sparse existing research on professional development, in which teachers experience inquiry, shows that professional development improves teachers’ science content knowledge as well as
their use of inquiry-based teaching techniques (Bazler, 1991; Caton, Brewer, & Brown, 2000; Luft, 2001).

Statement of Purpose

This study adds to the research on professional development for inquiry-based instruction in science. Specifically, the purpose was to determine the effects of the Inquiry Institute on Grades K-5 elementary science teachers by measuring their perceptions of inquiry learning in the classroom. This Institute is a professional development program that is intended to strengthen science teachers’ pedagogical knowledge and provide practice with inquiry methods based on a constructivist approach. The findings of this study provide a better understanding of the relationship between participation in this professional development and participants’ beliefs about inquiry, their behavior in the science classroom, and barriers affecting the implementation of inquiry methodology.

Review of Methodology

This study was structured as causal-comparative, which is used in the “study of cause-and-effect relationships” (Gall, Gall, & Borg, 2003, p.295). The authors further explained that the presumed cause is the independent variable and the presumed effect is the dependent variable (p. 295). The length of participation, divided into three groups—zero days, three days, or six days of participation in the Inquiry Institute—was the independent variable used to determine whether the three groups differed on three dependent variable constructs—perceived beliefs about inquiry, barriers to using
inquiry, and implementation of inquiry. In addition to collecting quantitative data, the survey instrument, discussed below, also collected qualitative data mainly designed to ascertain descriptive information with regards to inquiry implementation barriers encountered by participants.

The survey used in this study, entitled the Science Inquiry Survey (SIS), used a Likert-scale format and was designed to measure individual beliefs and perceptions about self, others, activities or situations where “each response is associated with a point value” (Gay & Airasian, 1992, p.131). The SIS instrument contains 22 forced-choice items with a Likert scale for the following range of qualifiers: 1=almost never, 2=seldom, 3=sometimes, 4=often, and 5=almost always. The qualifiers were selected based on examples presented by Czaja and Blair (2005) and the Constructivist Learning Environment Survey Comparative Form, designed and validated by Taylor, Fraser, and White (1994). The items were divided into three subscales, or elements of information for research. The relationships of the survey items to their construct are presented in the subscales below:

1. SIS Items 1-7 were designed to determine the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding inquiry-based instruction, referred to as the “inquiry beliefs subscale”. The following SIS example item is designed to elicit how strongly the participant believes in the value of inquiry methodology: Inquiry is the most effective method for me to teach science.

2. SIS Items 8-15 were designed to determine the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding the barriers to the implementation of inquiry-based instruction, referred to as the “barriers subscale”. The following SIS example item is designed to elicit whether or not local administrative support is a factor in inquiry implementation: Campus administrators support the use of inquiry methods.

3. SIS Items 16-22 were designed to determine the effect of the Inquiry Institute on Grades K-5 science teachers’ self-reported implementation of inquiry-based instruction, referred to as the “implementation subscale”. The following
The SIS example item is designed to elicit implementation patterns: *I plan my science instruction based on the use of inquiry methods.*

The SIS also contained two open-ended response items asking for any other barriers that the educator or student experiences during inquiry and allowed for any additional comments the respondent wished to provide. The SIS was reviewed for reliability using Statistical Package for the Social Sciences (SPSS) to calculate Cronbach’s alphas. It was also verified for both face and content validity. Face validity was confirmed by means of a pretest to assess any misinterpretations of the questions (McGinnis, Kramer, Shama, Graeber, Parker, & Watanabe, 2002), and content validity was confirmed with the use of a subject-matter expert panel, a very effective method for identifying any problems with content (Presser & Blair, 1994). The subject-matter expert panel used to determine content validity for the SIS, all of whom use inquiry-based instructional methods, consisted of (a) a school district science interventionist, (b) a professor of science methods teaching undergraduates who are majoring in education, and (c) a college-level biology instructor. The panel reached a consensus that the SIS had content validity. As a result of both the administered pretest and expert panel consensus, the SIS was the data-collection instrument used for this study.

The SIS instrument was emailed using Survey Monkey in the spring of 2008 to 257 degreed K-5 teachers holding elementary teaching certificates and currently teaching science. Two additional emails were sent to all non-respondents in order to elicit more data. Data collection was also conducted face-to-face with non-respondents at two curriculum-revision meetings conducted by the district prior to the beginning of the 2008-2009 school year to increase the overall response rate. A paper copy of the web version was administered in the face-to-face sessions. The data from the paper
A total of 97 responses were collected using both methods, which produced an overall response rate of 38%.

After reliability and a Confirmatory Factor Analysis were completed, quantitative analysis of data was completed with the use of one-way ANOVAs and was presented in chapter 4 as it relates to the three research questions:

1. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding inquiry-based instruction?
2. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ perceptions regarding the barriers to the implementation of inquiry-based instruction?
3. What is the effect of the Inquiry Institute on Grades K-5 science teachers’ self-reported implementation of inquiry-based instruction?

In addition, listed below are the null hypotheses that correlated to the research questions above and predicted that the data would show no cause and effect relationship between the professional development activities and perceived beliefs, barriers, or implementation of inquiry.

H₀1: There is no statistically significant difference between the mean scores on the inquiry belief subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, those who attended three days of the Inquiry Institute, and those who attended zero days of Inquiry Institute.

H₀2: There is no statistically significant difference between the mean scores on the barrier subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, those who attended three days of the Inquiry Institute, and those who attended zero days of Inquiry Institute.

H₀3: There is no statistically significant difference between the mean scores on the implementation subscale of the Science Inquiry Survey of respondents who attended six days of the Inquiry Institute, those who attended three days of the Inquiry Institute, and those who attended zero days of Inquiry Institute.
As discussed in chapter 4, statistical measures allowed for the rejection of both \( H_01 \) and \( H_03 \).

Discussion

This study provides empirical evidence that inquiry-based professional development can have a positive effect on elementary school science teachers’ beliefs about inquiry-based instruction and its implementation in the classroom. The findings presented in chapter 4 revealed that length of participation in the professional development was a crucial factor determining whether or not there was a significant change in teachers’ perceptions. The following section provides a discussion of the findings as they relate to each of the three research questions in order to situate this study within the broader literature on this topic.

*What is the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding inquiry-based instruction?*

The findings revealed a statistically significant difference between teachers who completed zero days and teachers who completed six days of the Inquiry Institute. Additionally, a statistically significant difference was evident between the group who completed three days and the group who completed six days of the Inquiry Institute. There was no statistically significant difference in beliefs about inquiry between those who completed zero days of the Inquiry Institute and those who completed three days. These findings suggest that the completion of the full six days of Inquiry Institute I and Inquiry Institute II proved to hold the best chances of positively affecting participants’ beliefs about inquiry-based instruction. For example, SIS Item 3 “My students gain more
control of their own learning with the use of inquiry,” was intended to explore teachers’ perceptions of the constructivist beliefs about inquiry. Data reflected that 18% of the teachers who attended zero days of the Institute indicated negative responses of *seldom*, while only 9% of the teachers who attended six days of the Institute selected the same negative responses. This reflects a 50% decrease in negative responses in perceived constructivist inquiry beliefs. These conclusions are contrary to the findings of Pajares (1992) who concluded that beliefs are difficult to change because they are a result of personal experiences. Evidently, the experiences that participants of this study had during the six days of the Institute were sufficient to alter their beliefs.

Why is changing teacher beliefs important? In a study designed to determine the impact of inquiry methods on pre-service teachers, Richardson (1996) concluded that “beliefs are thought to drive actions; however, experiences and reflection on action may lead to changes in and/or additions to beliefs” (p. 104). Both content and process pedagogy was consistently presented and infused throughout the Inquiry Institute; however, Inquiry Institute I consists of a three-day professional development experience targeted at understanding and processing the fundamentals of inquiry-based instruction. Inquiry II, also lasting three days, is designed to build capacity within the educators to plan, conduct, and reflect on inquiry in their own classrooms. The experiences and opportunity for reflection upon those experiences was concentrated in the later three days of the professional development. Participants were exposed to first-hand experiences with inquiry, while comparing it to more traditional methods. These experiences were then debriefed and followed by discussion and reflection. By engagement in these experiences, “teachers can understand the student’s perspective
of the lesson and the instructional process surrounding its implementation” (Luft, 2001, p. 520). This type of focus in the latter part of the Institute supports Richardson’s (1996) idea above and assists in answering the first research question—Grade K-5 science teachers’ beliefs regarding inquiry-based instruction were more likely to have a positive change if they participated for the full six days.

Another factor effecting participants’ beliefs in this study may have been the use of the articles and resources provided by the facilitators of the Inquiry Institute. Many of these resources were discussed in detail to elucidate the theory behind inquiry-based instruction and the benefits behind its use. Some of the resources provided also supported the positive outcomes of students who received inquiry-based instruction. Content was reinforced as facilitators modeled the research-based methods presented in the resources to make a direct link from theory to practice. All of these strategies were designed with the goal of increasing both pedagogical content knowledge and teaching skills with the underlying objective of changing teacher’s beliefs about using inquiry-based instruction with a constructivist approach. I felt it was important to investigate how this professional development affected teachers’ beliefs in light of the research that considers a change in belief as the most salient factor related to teacher practices (Garet, Porter, Desimone, Birman, & Yoon, 2001; Loucks-Horsley, Hewson, Love, & Stiles, 1998; McGinnis, Kramer, Shama, Graeber, Parker, & Watanabe, 2002; Ryder, Leach, & Driver, 1999). In seeking the answer to question one, “What is the effect of the Inquiry Institute on Grades K-5 science teachers’ beliefs regarding inquiry-based instruction?” this study has added the dimension of length of professional development participation and its importance on changing beliefs.
What is the effect of the Inquiry Institute on Grades K-5 science teachers’ perceptions regarding the barriers to the implementation of inquiry-based instruction?

As previously discussed, there was no statistically significant difference in teachers’ perception of barriers to inquiry between teachers who participated in zero days of the Inquiry Institute and teachers who completed three days. This suggests that specific identified barriers will continue to be concerns regardless of the length of time teachers participate in professional development. For example, the lack of time for learning, discussing and teaching inquiry will always be a barrier and materials will always be in high demand and short supply. With knowledge of identified barriers, it is possible to find solutions thorough professional learning communities (PLCs), which are discussed in the Implication section that follows.

Through qualitative analysis, I identified four major barriers to implementation of inquiry teaching methods through the use of qualitative and quantitative data analysis. These barriers were the lack of time, lack of appropriate materials and cost of materials, lack of support, and additional professional development needs. The barriers identified by this study are consistent with previous research that explored various barriers that may impede the use of inquiry-based instruction. These common barriers include: lack of time (Baker, Lang, & Lawson, 2002; Loughran, 1994), concerns with materials (Adams & Krockover 1997; Beck, Czerniak, & Lumpe, 2000; Brickhouse & Bodner, 1992), lack of administrative and collegial support (Brickhouse & Bodner, 1992; Emmer, Evertson, & Worsham, 2003; Loughran, 1994), and inadequate knowledge (Brickhouse, 1990; Crawford, 2000). Interestingly, this study did not find a sizeable change in the perception of the lack of time between groups of participants. For example, Item 9
“Time constraints are a consideration when planning science instruction” was considered *almost always* a barrier for 49% of teachers who attended zero days of the Institute and 40% of teachers who attend six days of the Institute indicated the same response. This confirms the idea suggested by Calfee, Miller, Norman, Wilson, and Trainin (2006) that the “emphasis is on instructional strategies that are efficient, not requiring additional enormous amounts of time to implement in the classroom” (p.81) are methods that teachers will continue to use because they are easier and have fewer constraints. Additionally, these “go-to” methods help maintain a comfort zone until teachers are provided strategies and supportive measures to alleviate these barriers to inquiry-based instruction.

The findings of this study also present material management as a concern in elementary science. One participant emphasized that “Dedicated funds [for science] continue to impede student opportunities”. This is similar to the research by Stamp and O’Brien (2005) who confirm materials as a barrier. The authors note that elementary schools typically have limited science equipment, limited materials such as consumables, and limited budgets to obtain needs supplies (p.70). Without the desire, determination, or ability to obtain materials for inquiry-based instruction, teachers will continue to maintain the use of less intrusive methodology comparable to the time management issue noted above.

The next barrier identified in this study is the lack of collegial support. Bybee (2004) found that novice teachers would have to defend their choice to incorporate inquiry-based instruction in their classroom if they did not have support from their colleagues. Even veteran teachers can find it a daunting task to promote the use of
inquiry, as illustrated by a respondent who stated “Motivating unsure colleagues is energy draining because they can't see past the “messy” lessons to get to the good stuff.” Collegial support is a vital component to cultivating a collaborative school environment. Research has shown that collaboration is a potentially powerful stimulus for personal reflection that leads to altering beliefs (Crawford, 2007). In survey research conducted regarding the influences on classroom teachers, Reeves (2009) noted that open-ended responses revealed that colleagues had a greater influence on teachers than other factors such as leadership or curriculum. Furthermore, the author noted that the most powerful factor was “direct modeling by colleagues” (p.85). Suggestions for overcoming this barrier are presented in the implications section.

The final barrier to the implementation of inquiry-based instruction identified in the study was the need for professional development. There is no question that professional development provides continuous learning that is at the center of promoting student success through education reform. Cohen and Hill (2001) found that teachers' ability to implement reform goals rests, in part, on effective professional development centered on the intended intervention. There are many variables influencing the actions of classroom teacher’s, but fundamentally the relationship between knowledge and practice is linear (Abd-El-Khalik & Lederman, 2000). It is obvious that the more effective the professional development, the stronger the linear relationship. Teachers themselves can recognize the need for additional professional development. In response to Item 10, “Additional professional development would strengthen my use of the inquiry method,” 38% of teachers agreed by responding with almost always. Several comments confirmed the need for additional knowledge in
specific areas with deficits. For example, one participant commented that “I need the knowledge to change current curriculum into the inquiry lesson,” while another noted that “direct modeling was needed.” Still others made general notes that more professional development was desired. This corroborates the ideal expressed by Lotter, Harwood, and Bonner (2006) that “teachers need time to practice, reflect on, and revise innovative techniques in a supportive, collaborative and real classroom environment” (p.186) in order to better understand their strengths and weakness. Suggestions for professional development will be discussed in the implication section.

What is the effect of the Inquiry Institute on Grades K-5 science teachers’ self-reported implementation of inquiry-based instruction?

The use of inquiry in the science classroom, as discussed above, is particularly linked to teachers’ beliefs. With this in mind, it is not surprising that the implementation data analysis provided similar results to that of the inquiry beliefs analysis. Participants who completed the full six days of the Inquiry Institute had the strongest likelihood of changing their beliefs about inquiry, and they reported increased implementation of inquiry practices. For example only 29% of teachers who attended zero days of the Institute selected *almost always* in response to Item 21, “My students ask questions, collect data, and analyze information with the use of inquiry methods.” Yet, 47% of teachers who completed six days of the Institute responded in the same manner, resulting in a 62% increase in the most positive response. That is not to say that those only completing three days of the Institute did not alter beliefs or practices; however, there was no statistically significant difference in implementation between participants completing zero days and those completing three days. The only mean differences
seen were between participants completing zero days and those completing six days, as well as mean differences between participants completing three days and those completing six days. Overall, these findings support the claim that participation in the Inquiry Institute had a positive effect on teachers’ beliefs and implementation of inquiry-based instruction. Participation in the Institute did not cause a change in the perceived barriers among any of the groups regardless of their length of professional development; however, length of participation is a critical factor of the effectiveness of the Institute as measured by implementation behaviors. These findings reinforce prior research that stresses length as a determining factor on implementation (Basista, Tomlin, Pennington, & Pugh, 2001; Supovitz & Turner, 2000). In a literature review of nine studies, Yoon, Duncan, Lee, Scarloss, and Shapley (2007) indicated that longer professional development was associated with higher student achievement. These researchers explained that 14 or fewer hours of professional development had no effect on student learning, whereas professional development lasting more than 14 hours had significant positive effects. Programs that lasted between 30-100 hours, spread out between 6-12 months, had the largest effects. Taken together, the prior research along with this study support the idea that the longer teachers’ participated in the professional development, the more often a change in beliefs and implementation were reported.

Implications

This research has implications for several audiences. In the following section, I will discuss the implications of the findings of this study for elementary science teacher
Implications for Teacher Education Programs

In order to be effective, teachers must understand three distinct areas of inquiry: how science is done, how science is taught, and how science is learned (Anderson, 2002). This means that teachers using inquiry must have a solid background from their own science education, including content and process. As discussed in chapter 2, this type of background would be the exception and not the rule in today’s teacher preparation programs, especially for elementary educators. Many elementary teachers appear unsure or even uncomfortable teaching science due to a lack of knowledge about science content and a limited exposure to inquiry-based instruction. Also discussed earlier was the research concluding that many teachers have a tendency to use the same pedagogic practices their own college professors used during their pre-service education (Akerson & Hanuscin, 2006; Cross, 1996; Felder, 1993; Gregg, 1994; Gregg, 2001). In other words, teachers’ own education background influences the implementation of inquiry lessons in their classrooms. Knowing this means that changing science practices in classrooms means changing the way we are teaching pre-service education.

Breaking the perpetual cycle of teaching in the same manner taught in undergraduate classes is the very foundation of changing science education in elementary classrooms. The National Science Education Standards (NRC, 1996) recommend that university science classrooms, similar to K-12, promote inquiry-based
instruction. If science education reform is to happen, change must begin in pre-service education and allow for a full cycle of K-16 implementation. Undergraduate education for teachers must undergo a change from the lecture-style instruction most commonly experienced to the use of inquiry-based instruction. In a longitudinal study of the school/student/university triad and the impact on pre-service teachers, Brouwer and Korthagen (2005) concluded that education preparation programs that combine theoretical study with the opportunity for practical exercise and experiences could impact teacher behavior once they are in the classroom. One suggestion to accomplish this would be to deviate from a typical science methods course taught solely by education professors. In place of these courses could be the creation of university collaborations between the science departments and colleges of education to provide science courses that are integrated and inquiry based. A team-teaching arrangement including science and education professors could provide a balance between content and pedagogy.

It is important that the tenets of effective inquiry from a constructivist perspective be introduced, incorporated, and consistently practiced in the undergraduate science education classrooms where students would obtain their own scientific content with authentic research experiences through both guided and open inquiry processes. This is not to say that all undergraduate science courses should exclusively utilize inquiry instruction, because science content contains common facts and some skills that are best learned from direct instruction (Schroeder, Scott, Tolson, Huang, & Lee, 2007). However, effective instruction in any classroom is not achieved by using one methodology. Instead, effective instructors teach from a constructivist epistemology
that supports inquiry-based instruction in a student-centered classroom. This is precisely the type of instruction needed, not only in pre-service education classes but also in other undergraduate content classes outside of education, in order to affect the beliefs, content, and pedagogic practices of future teachers.

The results of this study suggest that six days of professional development from the Inquiry Institute could make a positive effect in educators’ beliefs and implementation regarding inquiry-based instruction. A first step to introducing the methodology into current teacher preparation programs might be accomplished with the assistance of inquiry-based instruction facilitators, such as those from the Inquiry Institute. These facilitators could serve as guest presenters over six visits within a semester modeling the inquiry-based instruction process and creating inquiry experiences for the students in full capsulation of content specific to the intended lesson. These facilitators would also have the potential to model the methodology for the instructor and ultimately encourage its use. Thus, whole courses need not be revised to incorporate some of the experiences that can lead to change in teachers’ perceptions of inquiry instruction. Given that science reform is dependent on classroom teachers, we cannot continue to educate them in the same manner and expect them to behave differently once they are in their own classrooms. One significant change should occur in the instructional practices in post-secondary science courses for pre-service teachers—lecture should be limited with a focus on teaching content through inquiry-based instruction. The suggestions for pre-service education should continue once the teachers are in the classroom through professional development.
Implications for Professional Development

The findings of this study extend beyond professional development designed only for science and suggest a few ways to improve all professional development. The first suggestion concerns how facilitators provide professional development. Teachers who experience professional development through inquiry have been shown to gain science content knowledge as well as to increase their use of inquiry-based teaching techniques (Bazler, 1991; Caton, Brewer, & Brown, 2000; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Luft, 2001; Westerlund & Stephenson, 2002). This study also noted that participation in six days of the Inquiry Institute has a positive effect on implementation. This supports the idea that professional development is effective when facilitated with constructivist, inquiry-based methods because active learning brings about greater change in behavior than passive learning (Bruner, 2006; Piaget, 1970). Therefore, facilitators of all professional development must recognize that “experts” dispensing knowledge to educators are not an effective platform to bring about change in the classroom. Changing teacher behavior means not only their pre-service education but also changing the way professional development is organized and presented, because beliefs in practice are also shaped by the particular school context (Hoyles, 1992). Consequently, if there is lack of support for inquiry at the campus level, professional development becomes even more essential. Effective professional development should model constructivist, inquiry practices as opposed to transmittal methods. This includes collaboration, “…conversations with peers about the beliefs and assumptions that guide their instruction, and reflective practices such as journal keeping” (Sparks & Hirsh, 1997, p.11).
Another suggestion supported by literature (Gess-Newsome, 2001; Guskey, 2000; Luft, 2001) and the findings of this study are the two critical elements of professional development—longevity and sustainability. An extensive review of literature by Adey (2004) recommended that the length of professional development consist of at least 30 hours over two years to have a minimum impact on classroom instruction. Some researchers, such as Supovitz and Turner (2000), have suggested that approximately 80 hours of professional development is needed to change teachers’ behavior in the classroom. These authors collected data from numerous local, systemic, change-initiative projects across the United States, similar in nature to the Inquiry Institute. Based on prior research, my own findings, and the assumption from chapter 1 that, the more extensive the professional development, the stronger the implementation patterns for participants occur, the findings of the study suggest that a one-shot, four to eight hours of professional development has little impact on teacher behavior. Furthermore, participants in three days did not reveal a statistically significant difference from those whose did not participate at all.

As mentioned several times in this study, the classroom teacher is the crucial component to incorporating a strategy, concept or any other new idea into a school for educational change. Fullan (1989) described how educational change occurs where the teacher becomes the learner. As educators know, students rarely learn a concept that is quickly presented once and then provided with limited practice time. The same holds true for teachers as learners, because some of the same best practices that provide for student success will also work with adult learners. Teachers need professional
development that provided adequate time for content and pedagogical development (40 hours at a minimum), practice, and sustained support in the classroom.

The length of the professional development needs to be increased not only in hours, but also in duration. Support is needed long after the initial phase of professional development has ended. A suggestion for sustained support involves the development of professional learning communities (PLCs) within the schools. Support from PLCs is manifested as educators interact with their colleagues, sharing their profession and wisdom, learning from one another, and collaborating on issues of concern (Hall & Hord, 2006). According to Hord (1997), the foundation of PLCs is supported by the following five dimensions:

1. Shared values and vision: The staff’s unswerving commitment to students’ learning, which is referenced for the staff’s work.

2. Collective learning and application: The application of the learning to solutions that address students’ needs.

3. Supportive and shared leadership: Jointly held power and authority that involve the staff in decision making.

4. Supportive conditions: Physical and human capacities that promote collaborative organizational arrangements and relationships.

5. Shared personal practice: Feedback and assistance from peers that support individual and community improvement. (p. 26)

Monthly PLCs meetings, with the assistance of a professional development facilitator, could include: instruction modeling, discussion of curriculum concerns, and collaboration with colleagues.

In Implementing Change: Patterns, Principles, and Potholes, Hall and Hord (2006) reported that when teachers work in collaborative PLCs, outcomes were
significant and change happens more quickly than in traditional schools. These PLCs would serve a dual purpose: on-going professional development and increased collegial support, which was found lacking by participants in this study. Members of these PLCs could also participate in classroom observations of experienced educators who effectively use inquiry-based methods. These models, within the real classroom, could allow observers to later incorporate witnessed strategies into their own instruction.

A challenge many PLCs face is finding the suitable meeting times that allow for the most productivity. Smith, Wilson, and Corbett (2009) emphasized that “extended blocks of time during the school day are the most productive structure for [professional] learning communities worthy of the name” (p. 23). In the article *How Nations Invest in Teachers Learn*, presented in *Educational Leadership*, Wei, Andree, and Darling-Hammond (2009) found that high-achieving nations often use this model of built-in professional learning that provides allocation of time during the teachers’ workday. For example, “more than 85% of schools in Belgium, Denmark, Finland, Hungary, Ireland, Norway, Sweden, and Switzerland provide time for professional development in their teachers’ workday” (Wei, Andree, & Darling-Hammond, 2009, p. 29). The U.S. is lagging behind these progressive and successful job-embedded professional development models. Until we adopt some of the policies and procedures of these high-achieving nations, making professional development a high priority, and investing time and resources in improved learning for teachers and greater student achievement is not probable.

In consideration of the increasing demands on educators’ time, an alternative to meeting face-to-face could be addressed by incorporating the use of technology to
further extend the professional development opportunities throughout the year. The use
of video and digital-media files in the form of podcasting is currently common for
communication and training in many content areas (Cebeci & Tekdal, 2006; Hsu, 2007).
Podcasting’s popularity is derived from the fact that we find ourselves in a digital era
and as a society, we are overcommitted and short on free time. The advantage of
listening to and/or viewing podcasts is the ability to download and then use them at a
convenient time. This medium would not appeal to all educators but is just one more
way to extend the professional development for those interested.

Implications for Inquiry Institute

Personal experience as a participant in two separate Inquiry Institutes has given
me insight into the theory, procedures, and content of this professional development
experience. It follows the sound standards from the National Staff Development Council
and includes most of the ideas and suggestions from numerous researchers on
effective professional development as presented in chapter 2 (Bazler, 1991; Darling-
Hammond & McLaughlin, 1995; Fullen, 1995; Garet, Porter, Desimone, Birman, &
Yoon, 2001; Harlen, 2007; Klentschy, 2005b; Loucks-Horsley, Hewson, Love, & Stiles,
1998; Luft, 2001). The main goal behind this professional development is to address
systemic science education reform directly focused on inquiry-based instruction.
Although hundreds of educators have participated in this type of professional
development at various locations, evidence of this reform has not materialized. Neither
state, national, nor international assessment results provided evidence of more
scientifically literate students, which is the aim of science education reform. Likewise,
professional experience allowing for personal observations of educators confirms little
evidence of extensive use of inquiry-based instruction in the school district under investigation. Again, since the success of any education reform is dependent on the effectiveness of the classroom teacher (Darling-Hammond & McLaughlin, 1995), it is imperative to increase the depth of our research to allow us to find solutions to the chasm between strong, research-based professional development, such as the Inquiry Institute, and a change in teachers’ classroom behavior. The following suggestions are presented to increase the impact of the Inquiry Institute.

It is my belief that those currently teaching science would benefit from participating in an inquiry-based professional development, such as the Inquiry Institute. Ultimately this experience would have a positive effect on educators’ beliefs and implementation of inquiry-based instruction, with one stipulation—extending the length of the professional development. It should be noted that a review of literature suggests a minimum of 30 hours is needed to alter beliefs and classroom behavior to a minimal extent (Adey, 2004). This study found that minimum length of participation was even longer—between 36-40 hours. Although the current length of the Inquiry Institute, six days or approximately 40 hours, did positively effect participants’ beliefs and implementation of inquiry, personal participation in twice that number of hours increased my own understanding and comfort level dramatically, which enabled me to extend my implementation of inquiry-based instruction in my classroom. In addition, the earlier example of an increase in positive responses from participants in the full six days, suggests that there could be an even larger increase with the participation in additional days. An effective use of these days would most likely be distributed throughout the school year.
The barriers discussed in chapter 4, “lack of support”, “the need for direct modeling”, and “more professional development” indicates that sustained professional development throughout the school year, as opposed to a summer learning institute, would enable teachers to overcome barriers that prevent the implementation of inquiry. At the very least, the professional development should be extended to include three more days of instruction throughout the school year. Ideally, this extension of duration would connect the professional development directly to “teachers' real classroom context” (Supovitz & Turner, 2000, p. 964), with topics such as overcoming barriers and incorporating inquiry-based instruction with current curriculum.

**Implications for Science Education Policy and Practice**

Given the restraints and obligations of the federal No Child Left Behind Act of 2001 (NCLB, 2001), the liberty of pursuing science education reform is difficult. There is no argument that NLBC’s goal to eliminate achievement gaps is admirable, but the mechanism for accomplishing this needs a major overhaul. The high-stakes current mandates and regulations from NCLB affect all levels of education, from the state departments to local districts and all the way to the classroom (Sunderman, Kim, & Orfield, 2005). It is perhaps at the classroom level where constraints and directives have the most direct effect on the education of students. The standardized test-based accountability system has placed stress on teachers to make certain the students pass the state designated assessment. Many campus administrators demand the use of methodology they themselves perceive to promote academic achievement. Concentrating an entire year on professional development with inquiry, to enhance
pedagogical content knowledge, teach skills, and increasing teacher efficacy in just science alone is probably a very startling idea to administrators. After all, this would be for just one content area out of several that are tested by the state assessments. Lack of performance on these assessments has its consequences for schools. For example, schools could lose federal support in the form of Title I funding, causing hardship for many. Another penalty might include restructuring, a sanction in which the state can take control of the school (Sunderman, Kim, & Orfield, 2005). Most administrators are effective at communicating what is important on the campus. Expectations are high for all teachers, but these same high expectations must be held for students. Passing a minimal proficiency assessment can roughly be classified as a high expectation. This current high-stakes testing leads to mediocrity at best. A dichotomy is apparent between these assessments and the goal of education discussed in chapter 2, to develop self-reflecting, critical thinkers who are problem-solvers for students (Bruner, 2006).

This educational goal calls for high expectations of students who would learn to apply the knowledge they construct to other situations—ultimately—their education would serve them in the future. This is precisely the objective layout in Creating a New Vision for Public Education in Texas written by a group of Texas school superintendents whose desire it is to transform public schools in Texas (Texas Association of School Administrators, 2008). These authors declare, “Learning should be specified to the profound level, that is, students are able to apply their learning to new situations, to synthesize, solve problems, create knowledge, and cultivate and utilize the full range of their capabilities” (p.16). Research has shown that inquiry-based instruction supports the goals above while increasing academic achievement beyond science content
In addition to this shared vision, the school community must have common values and goals that, according Huffman and Hipp (2003), have “four critical attributes: (a) espoused values and norms, (b) focus on students, (c) high expectations; and (d) shared vision guides teaching and learning” (p. 9). With this foundation in place, a shared vision and common goals, administrators would be more likely to sustain continual and extended inquiry-based professional development and support the use of inquiry. Ideally, this would be followed with implementation of campus policy requiring all teachers not only to participate in inquiry-based instruction professional development but also to incorporate the methodology into their instruction. Drawing on the “less is more” axiom would apply, meaning that by limiting the focus for the campus and concentrating on a specific goal, the benefits could be maximized. All too often schools are spread thin trying to implement too many initiatives. DuFour (2002) described much of the leadership focus like this:

Many school leaders seem to embrace virtually every innovation available to educators.... They lose sight of the fact that it is the quality of a change initiative rather than the number of initiatives a staff is pursuing that is likely to bring about meaningful change. Meaningful, substantive changes in schools occur through focused, concentrated efforts. (p. 60-61)

Recommendations for Further Research

The findings of this study are encouraging for those who promote inquiry-based instruction in elementary science classrooms, but further research is warranted. Both
qualitative and quantitative research methodology could provide additional guidance to interested entities. There remain lingering research questions related to this study that could inform professional development providers, pre-service and other post-secondary educators, and elementary science teachers.

The first question, “What are the effects of participation in more than six days of Inquiry Institute?” provides opportunity for research if the Inquiry Institute was lengthened as suggested. This change could then lead to a follow-up study comparing participants with longer participation to those who participated in this current study. The purpose of this research would be to determine if the increase in professional development duration leads to differences in mean scores between these two groups.

Another question that has surfaced is “What are the effects of implementing inquiry-based instruction with pre-service teachers?” Clearly, what is still lacking in the literature is the connection between pre-service teachers and their subsequent classroom behavior. Earlier discussion regarding the implications for teacher education programs suggests the need for further research to fill the void. The research on inquiry-based instruction has mainly been conducted in an elementary or secondary school setting or in the area of professional development. Based on the suggestion of incorporating inquiry practices in both content and education classes for pre-service teachers, further research could examine the process and impact of such an intervention. Of interest would be the effects of inquiry-based methods on pre-service teacher performance during their own education, to better understand what forms of teacher education experiences lead to improved perceptions and practices of inquiry among pre-service elementary science teachers.
The final question, “What methodology do novice teachers employ in their first three years in the classroom?” presents the opportunity for a longitudinal study following beginner teachers in their classrooms. Additionally, the type of support and professional development experiences could also be researched.

Summary of the Dissertation

Despite the potential for positive outcomes through the use of inquiry-based science education, our public school system is far from attaining the goal of inquiry-based instruction in science classrooms demanded by the TEKS §112.2, the Benchmarks for Science Literacy, and the National Science Standards. This causal-comparative study was designed to determine the effects of the Inquiry Institute, a professional development program that is intended to strengthen science teachers’ pedagogical knowledge and provide practice with inquiry methods based on a constructivist approach. This study provided a better understanding of a cause and effect relationship within three levels of the independent variable—length of participation in the Inquiry Institute (zero, three, or six days)—to determine whether or not the three groups differ on the dependent variables—beliefs, barriers, and implementation. Quantitative data were collected with the Science Inquiry Survey (SIS), an instrument designed to also ascertain qualitative information with the use of open-ended survey items. One-way ANOVAs were applied to the data to test for a significant difference in the means of the three groups. The findings indicate that teachers who participated in longer Inquiry Institute professional development have stronger perceived inquiry beliefs and implementation. This was supported by sufficient evidence from the data analysis.
on both of these constructs showing a statistically significant difference between Group 1 (zero days participation) and Group 3 (six days participation) in favor of Group 3. There was additional statistically significant difference between Group 2 (three days participation) and Group 3 in favor of Group 3. Analysis of the quantitative data did not reveal statistically significant evidence with regards to the barriers, however, analysis on the qualitative data from the open-ended survey items revealed that time, materials/costs, support, and additional professional development were recognized by teachers as barriers to the implementation process. Understanding inquiry-based instruction and constraints impeding its use is necessary to bring about greater implementation and contribute to stronger science education reform initiatives.
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