ABSTRACT

The Impact of Science Teachers' Epistemological Beliefs on
Authentic Inquiry: A Multiple-Case Study

Dionne Bennett Jackson, Ed.D.

Committee Chairperson: Betty J. Conaway, Ph.D.

The purpose of this study was to examine how science teachers' epistemological beliefs impacted their use of authentic inquiry in science instruction. Participants in this multiple-case study included a total of four teachers who represented the middle, secondary and post-secondary levels. Based on the results of the pilot study conducted with a secondary science teacher, adjustments were made to the interview questions and observation protocol. Data collection for the study included semi-structured interviews, direct observations of instructional techniques, and the collection of artifacts. The cross case analysis revealed that the cases epistemological beliefs were mostly Transitional and the method of instruction used most was Discussion. Two of the cases exhibited consistent beliefs and instructional practices, whereas the other two exhibited beliefs beyond their instruction. The findings of this study support the literature on the influence of contextual factors and professional development on teacher beliefs and practice. The findings support and contradict literature relevant to the consistency of teacher beliefs with instruction. This study's findings revealed that the use of reform-based instruction,

or Authentic Inquiry, does not occur when science teachers do not have the beliefs and experiences necessary to implement this form of instruction.

The Impact of Science Teachers' Epistemological Beliefs
on Authentic Inquiry: A Multiple-Case Study

by

Dionne Bennett Jackson, B.A., M.S.E.

A Dissertation

Approved by the Department of Curriculum and Instruction

____
Larry J. Browning, Ed.D., Interim Chairperson

Submitted to the Graduate Faculty of
Baylor University in Partial Fulfillment of the
Requirements for the Degree
of
Doctor of Education

Approved by the Dissertation Committee

____
Betty J. Conaway, Ph.D., Chairperson

____
Elden R. Barrett, Ph.D.

____
Larry J. Browning, Ed.D.

____
Tony L. Talbert, Ed.D.

____
Kathy A. Whipple, Ph.D.

Accepted by the Graduate School
August 2010

____
J. Larry Lyon, Ph.D., Dean

Page bearing signatures is kept on file in the Graduate School.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

There are many people I must thank for their encouragement and support throughout this process. I would first like to thank Dr. Betty J. Conaway for all of the guidance and assistance she provided to me throughout my doctoral program. She not only served as my professor and Dissertation Chairperson, but also as my mentor. I truly appreciate you.

I also thank Dr. Tony L. Talbert for teaching me about case study research, and for all of the support and advice he gave to me regarding qualitative research. I am truly grateful.

Thanks to the professors who helped me on this journey. To Dr. Stephen D. Davis, thanks for raising my awareness of the need for students to question. To the members of my dissertation committee, Drs. Barrett, Browning, Conaway, Talbert and Whipple, thanks so much for taking the time to read my dissertation and provide me with quality feedback.

I must also thank this study's cases who were so willing to allow me into their classrooms and lives. I truly appreciate all that they did to make collecting my data such a wonderful experience.

Most of all, I thank my family and friends for their prayers and support throughout this process. I am so grateful to my church family, Toliver Chapel, for all that they did to make our family feel at home during our time in Waco; I am especially thankful to Tanya and Gail for their friendship. I thank my sister, Gillettie, my brother, Thomas, and my best friend, Kelandria, for praying for me and encouraging me throughout my time at Baylor. I thank my parents, Thomas and Christine, for their love and support throughout the years and for teaching me to dream big dreams. Thanks to my son Jamil for understanding when Mommy had to study and write, and to Chloe for coming just in time to encourage Mommy to complete her dissertation. I also thank my husband, Troy. Words cannot express how grateful I am to him for his love, support, and understanding throughout this process. I love you.

Finally, I thank God for blessing me with this opportunity. It is my hope that this study and my research in the future will be used to fulfill His purpose for my life.

CHAPTER ONE

Introduction

Several factors influence why teachers teach the way they do. Although content knowledge and context influence teachers' actions, their own unique belief systems also play an important role (Fang, 1996; Kagan, 1992; Nespor, 1987; Richardson, 1996). Over the past couple of decades, teachers' beliefs have been an important construct in educational research, and researchers continue to study them due to the vast number of educational issues they encompass.

Epistemological Beliefs and Science Instruction

Epistemological beliefs consist of a person's core beliefs about the nature of knowledge and how knowledge is acquired and peripheral beliefs about learning (Brownlee, Boulton-Lewis, & Purie, 2002; Hofer and Pintrich, 1997). These beliefs can be naïve, in which "truth is certain, absolute and able to be transferred by an authority" or more sophisticated, in which "truth is relative, changing, and actively constructed by the individual" (Brownlee, et al., p.1). Educational research on teacher beliefs suggests that epistemological beliefs influence reasoning, interpretation of knowledge, and monitoring of cognition (Brownlee, et al., 2002; Hofer & Pintrich, 1997; Pajares, 1992). This educational research provides several implications relevant to concerns in science education.

Recent concerns in science education include the lack of student engagement in argumentation and reasoning, in addition to the lack of student participation in investigations based on questions they generate (Chinn & Malhotra, 2002; Duschl, Shouse, & Schweingruber, 2008). All of these concerns address important elements of science instruction as set forth by the Association for the Advancement of Science (1993) text *Benchmarks for Science Literacy* and the National Research Council's (1996) *National Science Education Standards*. These instructional elements occur during inquiry instruction, the more authentic the inquiry, the more opportunities exist for these instructional elements to occur (Bonnstetter, 1998; Chinn & Malhotra, 2002; National Research Council, 1996).

There are many terms used to describe authentic inquiry. They include open or full inquiry (Martin-Hanson, 2002) and student directed inquiry (Bonnstetter, 1998). Essential features of authentic inquiry include student-generated questions (Barrow, 2006; Chinn & Malhotra, 2002) and student directed investigations (Bonnstetter, 1998). The effective use of the process of authentic inquiry provides an opportunity for teachers to assist students with understanding the development of knowledge and how this knowledge is based on the evidence they collect. Unfortunately, teachers often do not provide these opportunities.

There are several reasons why teachers do not engage students in inquiry instruction. For some teachers, it is what they perceive as the sheer difficulty of implementing inquiry lessons (Welch, Klopher, Aikenhead, & Robinson, 1981). For others, it is the lack of a clear understanding of what it means to use inquiry in the science classroom (Welch et al., 1981) or lack of understanding of the nature of science (NOS) (Gallagher, 1991).

School culture can also present factors that limit the implementation of inquiry instruction (Wallace & Kang, 2004). Additionally, a substantial body of evidence supports the idea that values and beliefs held by teachers strongly influence the decisions they make regarding classroom instruction (Cronin-Jones, 1991; Fang, 1996; Kagan, 1992; Tattoo, 1999; Wallace & Kang, 2004; Weiss, Pasley, Banilower, & Heck, 2003; Welch et al., 1981). More specifically, epistemological beliefs greatly influence how science teachers teach (Smith, 2005; Wallace & Kang, 2004).

Due to the influence epistemological beliefs have on how science teachers teach, it is important for them to value how learning occurs given the NOS and inquiry (Lederman, 2004). Instilling these values in science teachers would require a move from focusing on the "Hows" of science education to the "Whys" (Bybee, 1997). For this shift to occur, an understanding of these beliefs must occur on both preservice and inservice levels (Kagan, 1992; Tattoo, 1999). Therefore, there is a need for research that examines the relationship between science teachers' beliefs about knowledge and learning and how these beliefs impact their teaching practice (Hewson, Kerby, & Cook, 1995; Tsai, 2002).

The Problem

Based on a review of research, gaps exist worth examining regarding epistemological beliefs and authentic inquiry. Studies reviewed in science education regarding epistemological beliefs included studies that identified and analyzed science teachers' epistemological beliefs (Aguirre, Haggerty, & Linder, 1990; Boulton-Lewis et al., 2001; Tsai, 2002), investigations regarding the impact of epistemological beliefs on curriculum selection and implementation (Benson, 1989; Cronin-Jones, 1991), and studies that focused on the influence of beliefs about the NOS on teaching strategies

(Abd-El-Khalick, Bell, & Lederman, 1998; Bell, Lederman, & Abd-El-Khalick, 2000; Brickhouse, 1989; Gallagher, 1991; Lederman, 1999). All of these studies were focused on secondary teachers, whether preservice or inservice. Fang (1996) noted that few studies have examined teacher beliefs on the post-secondary level, and a review of the literature identified no studies that examined teacher beliefs, more specifically epistemological beliefs of teachers, on the middle, secondary and post-secondary levels.

Additionally, there is a need for studies that examine teachers' beliefs in specific components of subject areas rather than subject areas in general (Fang, 1996). Of the science education research reviewed regarding epistemological beliefs, specific components of the subject area that were investigated included the NOS (Abd-El-Khalick et al., 1998; Bell et al., 2000; Brickhouse, 1989; Gallagher, 1991; Lederman, 1999), discovery oriented curriculum (Cronin-Jones, 1991) and general science teaching strategies (Hashweh, 1996).

The Purpose

The purpose of this study was to gain a better understanding of how science teachers' epistemological beliefs influenced their instruction. This study examined the epistemological beliefs of four science teachers, at the middle, secondary and post-secondary levels, in Central Texas and how their beliefs about knowledge and learning impacted their science instruction. In particular the investigator wanted to know how their epistemological beliefs influenced opportunities for their students to experience authentic inquiry lessons. Thus the primary research question for this study was:

> How do the epistemological beliefs of science teachers impact their use of authentic inquiry in science instruction?

The investigator addressed this overriding research question by exploring the following specific research questions:

- What are the epistemological beliefs and instructional practices of one post-secondary, two secondary, and one middle school science teachers in Central Texas?
- How are the epistemological beliefs of one post-secondary, two secondary, and one middle school science teachers in Central Texas consistent with their observed science teaching practices?
- How do the epistemological beliefs of one post-secondary, two secondary, and one middle school science teachers in Central Texas promote student generated questions, student designed and led investigations, and the presentation of evidence, or authentic inquiry?

Several researchers (Abd-El-Khalick et al., 1998; Bell et al., 2000; Brickhouse, 1989; Gallagher, 1991; Lederman, 1999) examined the NOS, also known as the epistemology of science and defined as the values and beliefs important for the development of scientific knowledge (Lederman, 1992). This investigator notes the importance of these beliefs for science teachers but also considers the epistemology of science as a content specific form of teachers' overarching epistemological beliefs. This investigator chose to examine epistemological beliefs for this study rather than the NOS because she sees science teaching as more than teaching content specific information and thus would like to understand more about how general epistemological beliefs influence science instruction, specifically opportunities for students to experience authentic inquiry lessons.

Therefore, due to the lack of research on general epistemological beliefs and science instruction, this investigator drew upon both research on general epistemological beliefs (Hashweh, 1996) and research on the epistemology of science (Abd-El-Khalick et al., 1998; Bell et al., 2000; Brickhouse, 1989; Gallagher, 1991; Lederman, 1999) to generate the study's proposition. The study's proposition was that teachers with epistemological beliefs reflective of reform-based instruction, or Authentic Inquiry, would also incorporate opportunities for Authentic Inquiry in their classes if they additionally had experiences that led to their understanding and/or value of this method of instruction. This investigator created this proposition in order to focus the study on the theoretical framework while also providing focus for data analysis (Yin, 2003).

Significance of the Study

This study was significant because by identifying a specific factor common among the cases that influenced their epistemological beliefs and positively impacted their use of authentic inquiry, further investigating this common thread could lead to improvements in preservice and inservice science teacher professional development. These improvements could lead to the development of teachers better prepared to implement more authentic forms of inquiry, thus addressing some of the recent concerns in science education as identified by Chinn and Malhotra (2002), Duschl et al. (2008), and Abd-El-Khalick et al. (2004).

Delimitations and Limitations

This investigator imposed restrictions or boundaries on the study. The first was the delimitation of the study to Central Texas. For the convenience of the investigator and her travel during the study, all participants were within a 30-mile radius from the investigator. Additionally, the participants were delimited to the middle, secondary and postsecondary levels due to the examination of authentic inquiry and the developmental appropriateness of this form of instruction.

A limitation of the study was time. This investigator was limited by time because she was required to investigate the participants in the study during the time frames established by the schools, so even if the generation of new themes continued, the length of time she could observe was limited to the amount of time the teachers had to teach the courses observed. Time was also a factor because the investigator taught on Friday, therefore preventing observations on this day of the week. Time was a greater factor during the spring semester observations due to practice tests for the state's accountability testing and inclement weather days.

Study Definitions

- Epistemological beliefs: Science teachers' core beliefs about the nature of knowledge and the nature of knowing and their peripheral beliefs about learning (Brownlee et al., 2002; Hofer and Pintrich, 1997).
- Authentic inquiry: Student directed explorations based on questions they personally generate (Bonnstetter, 1998).

Investigator's Work, Role, And Setting

This investigator was a full-time graduate student and instructor of record within the Department of Curriculum and Instruction at Baylor University in Waco, Texas. She had 14 years of experience in the field of education. During her first four years she served as a seventh grade science teacher in an urban, public school in the South in which during her last year and a half she also served as the Science Enrichment Coordinator for an after school program. She then was the Coordinator of Academic Support Services for seven years at a small, private liberal arts college in the South. In this role, she developed programs to promote academic success. Over the past three years, while as a full-time graduate student, she served as an instructor of record for teacher education courses at Baylor University.

Throughout her time as a student and teacher in K-12 and post secondary schools, this investigator dealt with issues related to questioning. Although these issues existed, she hoped to begin to generate solutions to them with her research. As the principal investigator, she conducted interviews, observed, collected artifacts, and analyzed the data collected. Using established interview and observations protocols and participant validations of codes, this investigator aimed to remove any biases generated by past experiences in order to conduct her study effectively.

Overview of Dissertation Chapters

Chapter Two presents a review of important research related to this study. The literature review examines three major areas of the research. It begins with a discussion of epistemological beliefs and then transitions to science instruction with an emphasis on inquiry. The chapter ends with a discussion of recent concerns in science education.

Chapter Three emphasizes the research design. It provides details regarding the questions of the study, the choice of multiple-case study design, the pilot study, data collection and data analysis.

Chapter Four presents the four cases of the study. The narrative descriptions and graphical displays of the cases are based on what was captured in the study relative to this study's questions. This chapter also includes the cross case analysis.

Chapter Five notes this investigator's interpretation of the findings and the transferability of what was discovered to science teacher education.

Summary

The instructional techniques that science teachers use in their classrooms have a direct influence on the quality of their students' educational experiences. Decisions made regarding instructional techniques are influenced by science teachers' epistemological beliefs. Through this research the investigator wanted to gain a better understanding of the epistemological beliefs of one postsecondary, two secondary, and one middle school science teachers in Central Texas and how these beliefs impacted their engagement of students in authentic inquiry.

CHAPTER TWO

Literature Review

Teacher Beliefs: The Why of Education

Through the years, educational researchers have used several terms and definitions in reference to beliefs. Reviews of educational research on beliefs noted such terms as attitudes, orientations, values, dispositions, personal theories, and perspectives (Hofer & Pintrich, 1997; Kagan, 1992; Pajares, 1992). These inconsistencies extend to the definition of beliefs (Kagan, 1992; Pajares, 1992). Kagan (1992) defined teacher beliefs as "pre- or inservice teachers' implicit assumptions about students, learning, classrooms, and the subject matter to be taught" (p. 65). Luft and Roehrig (2007) defined them as "propositions that individuals think are true" (p. 47). Richardson (1996) noted that in general, anthropologists, social psychologists and philosophers define beliefs as "psychologically held understandings, premises, or propositions about the world that are felt to be true" (p. 103). Due to the many ways in which beliefs are referred to in educational research, it is important to define the concept when used for research studies (Luft & Roehrig, 2007; Pajares, 1992).

Although the definition of teacher beliefs is not consistent, common to most research on beliefs are attempts to clarify the terms belief and knowledge (Nespor, 1987; Pajares, 1992; Smith & Siegel, 2004; Southerland, Sinatra, & Matthews, 2001). Smith and Siegel (2004) described beliefs and knowledge as separate but related constructs; although they are distinct, beliefs are necessary, but not sufficient, for knowledge. Beliefs are more subjective, whereas knowledge is more objective (Pajares, 1992; Smith & Sigel, 2004).

Nespor (1987) drew from Abelson's (1979) work to describe four structures she used to distinguish beliefs from knowledge. The four structures were:

1. Existential presumption, which are personal truths;
2. Alternativity, when what is considered as ideal differs greatly from the present situation;
3. Affective and evaluative loading, which include personal preferences based on feelings and subjective evaluations; and
4. Episodic structure, when the power and legitimacy of what an individual believes comes from certain episodes or events in their lives.

Nespor (1987) established these four structures based on her research with math teachers and her findings regarding the strong beliefs the teachers held regarding their students' characteristics and their vision of what good teaching really entailed. Although Nespor's work provided a conceptual framework for beliefs, this area of research is broad. Due to the wide span of beliefs in educational research, different types of beliefs are examined in research studies (Pajares, 1992). One such belief is epistemological beliefs.

Epistemological Beliefs

Epistemology originated as a philosophical principle (Hofer, 2002; Southerland, Sinatra, & Matthews, 2001). It became an area of research in psychology in the mid-1950s due to an increase of interest in epistemological development or beliefs (Hofer & Pintrich, 1997). Early studies regarding epistemological beliefs included Perry's (1970) foundational research beginning in the late 1950s of mostly male, undergraduate students at Harvard and their intellectual and ethical development, and Belenky, Clinchy, Goldberger, and Tarule's (1986) research on women's ways of knowing. Through the years, researchers continued to extend Perry's foundational research beyond Belenky et al.'s focus on women. These studies included using quantitative methods to determine the ways of knowing of both male and female college students (Baxter Magolda, 1992), the reflective thinking of high school students to middle aged adults (King & Kitchener, 1994), and research on undergraduates and how their epistemological beliefs affected comprehension (Schommer, 1990). These studies play an important role in educational research because they, along with additional studies, provide a framework for defining epistemological beliefs.

Defining epistemological beliefs. Like general teacher beliefs, researchers used several terms in reference to epistemological beliefs. A review of the literature on epistemological beliefs revealed terms such as epistemological perspectives (Belenky et al., 1986), ways of knowing (Baxter Magolda, 1992), epistemological theories (Hofer & Pintrich, 1997), and personal epistemology (Schommer-Aikins, 2002). Although various researchers used a variety of terms in reference to epistemological beliefs, certain common characteristics seem central.

In response to the lack of coherency in the framework of epistemological beliefs in educational research, Hofer and Pintrich (1997) proposed a conceptual framework for epistemological beliefs. Based on their comparisons of foundational studies on epistemological beliefs, they proposed that the core of epistemological beliefs consisted of individuals' beliefs about the nature of knowledge and the nature of knowing. Brownlee, Boulton-Lewis, & Purie (2002) also noted these two components as core beliefs based on their review of research studies involving epistemological beliefs.

By definition, the nature of knowledge is how an individual defines knowledge (Hofer & Pintrich, 1997). Considering knowledge on a continuum, it begins with what is certain or right and wrong and develops to what is purely contextual. The nature of knowing involves the process an individual uses to know (Hofer & Pintrich, 1997). It "involves beliefs about the source of knowledge, ranging from a reliance on experts to provide knowledge to more self-constructed processes," in addition to the role evidence plays in the process of justifying that knowledge (Hofer & Pintrich, 1997, p. 117). Thus to know something is either the "acquisition of knowledge without any transformation… [or] an active personal construction of meaning and change" (Brownlee et al., 2002, p. 10).

Brownlee et al. (2002) and Hofer & Pintrich (1997) also noted that there are beliefs related to these core beliefs about the nature of knowledge and the nature of knowing. These beliefs include beliefs about teaching, intelligence and learning, or peripheral beliefs.

Although foundational research studies on epistemological beliefs revealed a common thread for core beliefs, there was less agreement among research studies regarding how peripheral beliefs of learning, instruction, and intelligence played a role in epistemological beliefs (Hofer & Pintrich, 1997). This is because how knowledge is acquired, or the nature of knowing, is closely related to beliefs about learning and teaching but these peripheral beliefs were not closely examined by all of the studies used for Hofer and Pintrich's review. Hofer and Pintrich (1997) noted that because of the "psychological reality of the network of individuals' beliefs, beliefs about learning, teaching, and knowledge are probably intertwined" (p. 116). Additionally, other researchers noted and accepted the close relationship that exists between the nature of knowing and learning (Brownlee, Boulton-Lewis, & Purdie, 2002; Luft & Roehrig, 2007; Schommer-Aikins, 2004).

This study's definition of epistemological beliefs is based on the consistencies that exist across foundational studies in psychology on epistemological beliefs as examined by Brownlee et al. (2002) and Hofer and Pintrich (1997). Thus science teachers' epistemological beliefs are defined as their core beliefs about the nature of knowledge and the nature of knowing and their peripheral beliefs about learning.

Research on Science Teachers' Epistemological Beliefs and Practice

Several research studies reported forms of beliefs of science teachers and how these beliefs impact their practice as teachers (Benson, 1989; Brickhouse, 1989; Cronin-Jones, 1991; Gallagher, 1991; Hashweh, 1996; Hewson & Hewson, 1987; Lederman, 1999). Pajares (1992) and Kagan (1992) noted that the impact of beliefs on instruction occurs as early as entry into teacher education programs. In the studies reviewed by Pajares and Kagan, general teacher beliefs played an important role in how preservice teachers acquired and interpreted knowledge. Like general teacher beliefs, epistemological beliefs also play an important role in education because these beliefs provide an idea of how teachers view students' understandings and how students obtain knowledge and in turn, these views held by teachers affect their methods of teaching (Brownlee et al., 2002).

Studies reviewed regarding epistemological beliefs included studies focused on categorizing these beliefs. For example, Tsai (2002) investigated 37 Taiwanese secondary science teachers in order to explore their beliefs about teaching, learning, the NOS and the relationships that existed among these beliefs. The interviews on these three sets of belief systems revealed three categories of beliefs: traditional, process, and constructivist. Of the three categories, Tsai found that close to 60% of the beliefs held by teachers in each category were traditional and 57% of the teachers held what the researcher called "nested epistemologies," defined as consistent belief systems in all three categories. The researcher noted that these nested epistemologies occurred more frequently among teachers with more years of teaching experience.

Boulton-Lewis, Smith, McCrindle, Burnett, and Campbell (2001) also examined secondary teachers' conceptualized epistemological beliefs by investigating their beliefs about teaching and learning. Although the 16 Australian participants in their study were from a range of secondary subjects, two of the 16 were science teachers. Of the 16 participants, 12 held consistent conceptions of teaching and student learning, including the two science teachers.

Like Tsai (2002) and Boulton-Lewis et al. (2001), Aguirre, Haggerty, and Linder (1990) explored categorizing conceptions of science, teaching, and learning but instead of working with inservice teachers, they used preservice teachers as their study participants. Using a questionnaire, this case study examined the responses of 74 secondary preservice science teachers. Aguirre, Haggerty, and Linder's analysis of the data revealed that 40% of the responses regarding conceptions of the NOS were naïve, in which science was considered "…a body of knowledge consisting of a collection of observations and explanations of how and why certain phenomena function in the universe" (p. 384). Approximately half of the responses indicated that the students believed that the teacher was the source of knowledge or served as a guide. Additionally, 42% of the responses indicated that learning involved the intake of knowledge. Overall, like the secondary teachers in Tsai's (2002) study, the majority of the responses of preservice teachers reflected naïve, also considered Traditional, views of science and science teaching and learning.

Other than the identification and analysis of the types of epistemological beliefs of science teachers, research studies also reported the impact of epistemological beliefs on curriculum selection and implementation. For example, Benson (1989) investigated the relationship between epistemology and curriculum. Benson found that the three Canadian 12^{th} grade biology teachers' justified their epistemological beliefs regarding curriculum based on their conceptions of knowledge and the discipline in addition to situational constraints. All three teachers' views of knowledge were reflected in how they interpreted the curriculum they taught. Additionally, the teachers noted situational constraints, such as governmental and institutional control, as justifications for how they implemented the curriculum. Benson noted that the case study, although not conclusive in any way, provided suggestions regarding the relationships that existed among these three teachers' epistemological beliefs, situational constraints, and how they interpreted the curriculum.

Also investigating issues related to curriculum, Cronin-Jones (1991) found that views of science as a body of factual knowledge to be learned were contradictory to the discovery oriented environmental science curricula used for the study. This case study involved observing two middle school science teachers as they implemented a 20 lesson, discovery based curriculum package. Through observations, Cronin-Jones discovered that the contradictions that existed between the teachers' views of science and the type of curriculum hindered the implementation of the curriculum using the discovery teaching method.

Prevalent in science education research are studies of the epistemology of science, or the NOS, and its impact on teaching strategies. The NOS involves the values and beliefs important for the development of scientific knowledge (Lederman, 1992). Important to the NOS are seven key factors regarding scientific knowledge as outlined by Bell, Lederman, and Abd-El-Khalick (2000) and Lederman (1999). These factors were:

- Tentative (subject to change)
- Empirically based (based on and/or derived from observations of the natural world)
- Subjective (theory laden)
- Partly the product of human inference, imagination and creativity (involves the invention of explanation)
- Socially and culturally embedded
- Developed by observations and inferences
- Developed by an understanding of the relationships between scientific theories and laws (p. 564 and p. 917 respectively)

Gallagher's (1991) research study was designed to address what teachers understood about the NOS and how this knowledge influenced their teaching. This ethnographic research study examined 27 secondary science teachers. Although most of the teachers held reform-based thoughts regarding their purpose for teaching science, the methods they used to teach science were more Traditional. Gallagher concluded that this discrepancy was due to the lack of teacher knowledge of the history and philosophy of science.

Like Gallagher (1991), Lederman (1999) also examined secondary teachers' views of the NOS and their relationship to classroom practice. In this multiple-case study of five high school biology teachers, Lederman found through interviews and questionnaires that all five held reform-based views of the NOS. Although they had these views, through observations, inspection of lesson plans, and interviews, the researcher found that only two of the five had instructional practices that reflected these beliefs; these two were the more experienced teachers. Like Gallagher's study, this study revealed that although teachers might hold reformed based beliefs regarding the NOS, their practice might not match these views. Lederman found that it was the teachers' instructional intentions that significantly affected their classroom practice.

Brickhouse (1989) also examined teachers' philosophies of science and how these philosophies influence instruction. She examined three secondary teachers' views of the NOS by interviewing them and correlated these views to their teaching through observation. She discovered that these three teachers' philosophies of science were consistent with the methods they used to teach their subject.

In addition to investigating inservice science teachers' views of the NOS, research also exists on preservice science teachers' views. Bell, Lederman and Abd-El-Khalick (2000) and Abd-El-Khalick, Bell, and Lederman (1998) were interested in preservice teachers' beliefs regarding the NOS and the factors that led to the translation of these beliefs into planning and instruction. Based on the outcomes of a questionnaire and interviews, they found that the participants possessed an understanding of several components of the NOS. In the earlier study, Abd-El-Khalick, Bell, and Lederman (1998) found that although the 14 participants claimed to have taught the NOS, their lesson plans and observations of lessons did not reveal that they had done so. On the other hand, the 11 preservice teachers in the latter study had lessons, lesson plans, and portfolios that confirmed nine of the 11, or 82%, addressed the NOS in their instruction. In summary, Bell, Lederman and Abd-El-Khalick (2000) noted the perceived benefits of effectively engaging preservice teachers in discussions and activities to help them develop their understanding of NOS content followed by developing their ability to teach the NOS.

Like Abd-El-Khalick, Bell, and Lederman‘s (1998) study, Mellado, Bermejo, Blanco, and Ruiz (2007) found that the preservice secondary biology teacher in their study held beliefs about the NOS in addition to teaching and learning science that differed from his practice; although he held beliefs that were more relativist and constructivist in nature, his classroom practice was more traditional.

As far as the general epistemological beliefs of science teachers and the impact of these beliefs on teaching, fewer research studies exist. Hashweh (1996) designed a quantitative study to examine how science teachers' constructivist and empiricist epistemological beliefs influenced their teaching. Using questionnaires, Hashweh determined and analyzed 35 Palestinian science teachers' epistemological beliefs as they related to the types and number of teaching strategies they used. When their teaching strategies were compared to their epistemological beliefs, Hashweh found support for the hypotheses that those with constructivist epistemological beliefs were more likely to detect the students' alternative conceptions, had a greater repertoire of teaching strategies that they used to promote conceptual change, and that they valued and used effective teaching strategies more often than empiricist teachers.

As evident from the research studies reviewed, epistemological beliefs play important roles in science education. Whether gaining a better idea of these beliefs through their categorization, investigating their influence on curriculum selection and implementation, or investigating the impact a specific subset of these beliefs have on science teaching, they are a construct of importance worth continued investigation because they offer an abundant amount of information regarding the practice of science teachers.

Recent History of Science Instruction: Moving from What to Why

Like other subject areas, there are many ways to teach science. From teacher focused forms of instruction, such as lecture, to more student focused forms, such as inquiry, the instructional methods of science are plenteous. Most science educators would agree that the type of instruction used depends on the desired outcome of the lesson. Through the years, desired student outcomes in science have changed thus requiring varied methods of instruction.

The What: Traditional Science Teaching

Prior to the 1950s, science teachers' primary role was to impart knowledge on to their students. "Traditionally, science teaching consisted of lecture, discussion, and recitation. Science teachers relied on a single textbook, introduced few, if any, laboratory experiences, and used only an occasional film" (Bybee, 1997, p. 11). This Traditional method of science teaching was a transfer of knowledge from the teacher to the students (Tsai, 2002).

This transfer of knowledge not only involved the transfer of concepts but skills. The inclusion of the skills of scientists in science curriculum began to play an even greater role due in part to the creation of the National Science Foundation in 1950 and the launching of Sputnik in 1957 (Bybee, 1997; Duschl, Shouse, & Schweingruber, 2007). Scientists became very involved with science education during this time (Schwab, 1962), and this involvement led to the development of science curriculum that not only covered important science concepts, but also included teaching students the skills of scientists. Science instruction became more investigative in nature and teachers often taught the processes of science in order to teach their students how to think like scientists (DeBoer, 1991; Duschl, Shouse, and Schweingruber, 2007). The focus of instruction was on the structure of the discipline of science and the processes of science. A key figure in the structure of the discipline reform movement was Jerome Bruner. He emphasized the need for students to learn subject matter the way that scientists did. This included the development of the conceptual knowledge of the principles of the field and the development of the methods and attitudes necessary to conduct scientific investigations (DeBoer, 1991). The educators of this period emphasized the content of the curriculum and ignored other facets of education including student focused approaches (Bybee, 1997).

The How: Functional Science Teaching

During the 1940s and 50s, there were also progressive educators who wanted to make science instruction more functional (Bybee, 1997). During the late 1940s, these progressive educators called into question the authoritative means of teaching science based on the structure of the discipline. To sum up their viewpoint, The National Society for the Study of Education (NSSE) (1947) in their 46th yearbook suggested there were certain types of objectives to meet in science teaching. These objectives were:

- Functional information, such as facts about the universe and living things
- Functional concepts, such as the earth is very old
- Functional understanding of principles, such as all living things reproduce
- Instrumental skills, such as the ability to make accurate measurements
- Problem solving skills, such as testing a hypothesis
- Attitudes, such as intellectual honesty

- Appreciating such things as the contributions of scientists
- Interest in science as a hobby or vocation (p. 28-29)

Overall, NSSE emphasized that science education needed to become more functional. Critical to making science education more functional was developing student understanding (NSSE, 1947). DeBoer (1991) noted in regards to the 46th yearbook of NSSE that "the emphasis was away from the mastery of structured subject matter and toward real-world applications. All of the objectives of science instruction…were to be taught so that they would *function* in the lives of students" (p. 139). Therefore, these educators did not advocate verification of scientific facts and principles. Instead, students were engaged in experimentation to provide evidence to answer real life problems.

DeBoer (1991) indicated that by the end of the 1960s there was a turn from the more intellectual form of the structure of the disciplines to a focus on science as it related to human life. During this time, science educators coined the term "scientific literacy" to describe the type of science education desired; science education relevant to students' lives and with a focus on socially important issues.

The Why: Inquiry Science Teaching

As noted, from the late 1940s to the late 1960s, science education experienced Traditional and functional forms of instruction. Beyond this period, many curriculum reform efforts occurred due to society's criticisms of public school education (Bybee, 1997; Trowbridge, Bybee, & Powell; 2004). The release of the National Commission on Excellence in Education's (1983) *A Nation at Risk* played a major role in initiating this criticism. The mediocrity that this report warned of sparked many additional reports and reform efforts that still influence science education today.

The goals of inquiry instruction. Today the Association for the Advancement of Science (AAAS) (1993) text *Benchmarks for Science Literacy* and the National Research Council's (NRC) (1996) *National Science Education Standards*, that both emphasize inquiry-based science instruction, greatly influence science instruction. Although emphasized today, inquiry as a method of science instruction has been a major goal of science educators for many years (Bonnstetter, 1998; DeBoer, 1991). During years past a lot of confusion surrounded what was meant by inquiry, whether it related to the NOS or whether it was considered as a method of teaching (DeBoer, 1991). This confusion could have arisen due to what Schwab (1960) indicated as a dual need of those times: a need for schools to produce more fluid inquirers for research and a need for a society capable of understanding what scientists do. Confusion regarding inquiry still exists because of the lack of agreement for the definition of inquiry (Barman, 2002; Barrow, 2006).

There are several definitions used for inquiry. Examples include "a set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena…" (NRC, 1996, p. 214). Abruscato (2004) emphasized that it is a "systematic method of exploring the unknown so that discoveries are made" (p. 46)**.** Llewellyn (2005) defined it as "the scientific process of active exploration by which we use crucial, logical, and creative thinking skills to raise and engage in questions of personal interest" (p. 24). These definitions highlight some of the key goals of inquiry.

Schwab (1962) indicated that inquiry instruction aims to encourage and guide students through the process of discovery. Thus, students are no longer passive and dependent, but active. Chiappetta and Adams (2004) emphasized that inquiry-based science instruction should promote:

- Understanding of fundamental facts, concepts, principles, laws, and theories;
- Development of skills that enhance the acquisition of knowledge and understanding of natural phenomena;
- Cultivation of the disposition to find answers to questions and to question the truthfulness of statements about the natural world;
- Formation of positive attitudes toward science; and
- Acquisition of understanding about the nature of science. (p. 47)

Barman (2002) added that an inquiry-based classroom should focus on accomplishing two major goals: students should develop a proficiency in using the investigative skills of science, and they should learn specific science concepts by actively engaging in lessons to answer questions they generated or posed to them. These goals and definitions highlight several key features of inquiry instruction.

Features of inquiry instruction. Children have natural curiosities about their world, and these curiosities are much like those of scientists (NSSE, 1947). When used as a method of teaching, inquiry allows students to pursue these natural curiosities. There are many who advocate the engagement of students in inquiry lessons (Bonnstetter, 1998; Chiappetta and Adams, 2004; Llewellyn, 2005) and note the benefits of such engagement (National Research Council, 1996; Trowbridge, Bybee, & Powell; 2004). In order to engage students in inquiry instruction, science teachers must keep its essential features in mind.

The NRC (2000) indicated that there are five essential features of inquiry at all grade levels. They are:

1. Learners are engaged by scientifically oriented questions.
2. Learners give priority to **evidence,** which allows them to develop and evaluate explanations that address scientifically oriented questions.

3. Learners formulate **explanations** from evidence to address scientifically oriented questions.
4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
5. Learners communicate and justify their proposed explanations. (p. 25)

The NRC noted that as a whole, these features introduce students to many important features of science while also helping them to deepen their understanding of the concepts and processes of science. In essence, students become active investigators (Llewellyn, 2005). As active investigators, they not only develop skills of inquiry, but more importantly, they develop an understanding of how knowledge comes to exist and the ability to justify this knowledge through their use of evidence (Etheredge & Rudnitsky, 2003).

In order to promote inquiry in the science classroom, the NRC (1996) stressed the changing emphases in science. They included less emphasis on activities that demonstrate and verify science content and more emphasis on activities that investigate and analyze science questions. There should be less emphasis on science as exploration and experiment and more emphasis on science as argument and explanation. Additionally, there should be less emphasis on getting an answer and more on using evidence and strategies to develop or revise explanations. These changing emphases are evident in models of inquiry instruction.

Types and methods of inquiry instruction. There are various forms of inquiry depending on the level of student input in the lesson. Bonnstetter (1998) encouraged educators to view inquiry as an evolutionary process, one that progresses from Traditional, hands-on experiences to the ultimate goal of inquiry, student research. Table 2.1 highlights how this evolutionary process moves from more teacher centered instructional experiences to student centered. Martin-Hanson (2002) also emphasized this evolutionary process in inquiry instruction from structured inquiry to ultimately open inquiry. She noted that structured inquiry is more of a "cookbook" version of inquiry, so one could argue that it is not a true form of inquiry, whereas open inquiry requires students to create their own questions that in turn guide their investigations.

Table 2.1

Inquiry as an Evolutionary Process from Bonnstetter (1998)

Phases	Traditional Hands-on	Structured	Guided	Student Directed	Student Research
Topic	Teacher	Teacher	Teacher	Teacher	Teacher/Student
Question	Teacher	Teacher	Teacher	Teacher/Student	Student
Materials	Teacher	Teacher	Teacher	Student	Student
Procedures/ Design	Teacher	Teacher	Teacher/Student	Student	Student
Results/ Analysis	Teacher	Teacher/Student	Student	Student	Student
Conclusions	Teacher	Student	Student	Student	Student

Other than types of inquiry, there are a variety of methods and models used for inquiry instruction. One such model is the 5E model. This model, as described by Bybee (1997) and Llewellyn (2005), includes the following five phases:

1. Engagement involves the teacher initiating the learning task;
2. Exploration provides students with experiences to identify and develop concepts, processes, and skills;

3. Explanation provides students with the opportunity to demonstrate what they learned;
4. Elaboration challenges and extends students' understandings and skills; and
5. Evaluation involves teachers bringing closure to the lesson and assessing students' understandings.

In addition to the 5E Model, other methods of instruction associated with inquiry include the 3E, 4E, and 7E models (Leonard and Penick, 2009), discovery learning, the problem solving method, and heuristic teaching (DeBoer, 1991). Essential to science teachers' use of these models of inquiry is an understanding and belief regarding Constructivism, the philosophy of learning that inquiry is based on that emphasizes that learners construct or make meaning of their world based on their existing knowledge (Bybee, 1997; Etheredge & Rudnitsky, 2003; Llewellyn, 2005).

As noted, inquiry instruction occurs in varied forms. The most student focused form is authentic inquiry.

Authentic inquiry. There are many terms used to describe authentic inquiry. These terms include open or full inquiry (Martin-Hanson, 2002) and student directed inquiry (Bonnstetter, 1998). Regardless of the term used, there are essential features of authentic inquiry.

Several authors have highlighted the key features of authentic inquiry lessons. Leonard and Penick (2009) noted the following essential features performed by students:

- Make initial observations;
- Pose (or respond to) researchable questions;
- Formulate predictions or cause-and-effect hypotheses to test these research questions;
- Plan procedures that identify relevant variables and produce data to test these research questions;

- Collect, organize, and display data;
- Analyze data and craft tentative inferences to evaluate predictions or hypotheses;
- Share ideas, results, and inferences with a group that provides feedback on potential validity and utility;
- Revise, if necessary, the evaluation of the data; and
- Reach a formal consensus on answers to the research questions. (p. 41)

Chinn and Malhotra (2002) also noted the importance of students generating their own questions to investigate. Barrow (2006) emphasized that this generation of a question is an important step because it gives students ownership over the inquiry. Bonnstetter (1998) also noted that during authentic inquiry experiences students determine the materials and procedures used to conduct the investigation in addition to analyzing their results and drawing and sharing conclusions about their experience. Although students perform the tasks of authentic inquiry, teachers also have a role in this form of instruction.

Leonard and Penick (2009) highlighted the following as the role of a teacher during authentic inquiry instruction:

- Create a safe, stimulating environment where students feel free to explore, question, digress, and communicate;
- Ask questions that require thinking and thoughtful responses or action on the part of students;
- Listen to what students say and respond in ways that encourage students to examine and investigate ideas, questions, and suppositions;
- Promote multiple and creative ideas for researchable questions as well as ways to conduct investigations; and
- Develop classroom characteristics that place value on student communication, diversity, individuality, and intellectual freedom. (p. 41)

As a whole, the components of authentic inquiry provide an opportunity for teachers to assist students with understanding the development of knowledge and how it is based on the evidence they collect.

Authentic inquiry is the form of inquiry suggested by the National Science Education Standards (Bonnstetter, 1998). In as early as 1960, Charles Schwab summed up the essence of what a move to inquiry in science education meant:

> The gross implication of this revisionary process for science education is frighteningly obvious. It means that the notion of coverage, of conveying the current knowledge of the field, which was once the essence of science teaching, is called into question. It means that *expertise*, authoritative possession of a body of knowledge about a subject matter, is no longer enough to qualify men as the best teachers of science. It means that the education of the science teacher must be something more than, perhaps something quite different from, the inculcation of conclusions and training in ways and means to pass them on. It means that time-hallowed instruments of instruction—the lecture which aims to be simple, clear, and unequivocal; the textbook which aims to eliminate doubt, uncertainty, and difficulty; the test which aims primarily to discover what the student knows and how he applies what he knows about a subject—these will be inadequate or even inappropriate for much science teaching. (Schwab, 1960, p.7)

The move to inquiry in science education has encountered some challenges.

Recent Concerns in Science Education: Understanding the Whys

Although many changes to improve science instruction occurred over the past 50 years, today there are still concerns regarding the instructional techniques used in science classes. Recent concerns in science education include the lack of student engagement in argumentation and reasoning, in addition to the lack of students participating in investigations based on questions they generate (Chinn & Malhotra, 2002; Duschl, Shouse, & Schweingruber, 2007). There are also concerns regarding students' understanding of inquiry and the NOS (Lederman, 2004). All of these concerns address important elements of science instruction as set forth by the Association for the Advancement of Science (1993) text *Benchmarks for Science Literacy* and the National Research Council's (1996) *National Science Education Standards*. Many of these instructional elements occur during inquiry instruction, the more authentic the inquiry instruction, the more opportunities exist for these elements to occur (Bonnstetter, 1998; Chinn & Malhotra, 2002; National Research Council, 1996). There are studies that reveal these concerns.

Weiss et al. (2003) found within nationally observed science lessons only 15% or less of the instructional time in K-12th grades was spent on content regarding inquiry as science. By the 9th-12th grades only 2% of the content focused on this. Additionally, only 18% of the lessons observed portrayed science and math as investigative in nature. Moreover, although the teachers observed had classrooms in which there was a relatively high level of respect for students' ideas, questions and contributions, they found as a whole the lessons presented did not encourage students to generate their own ideas and questions.

Other than science lessons, texts used in science classes do not promote authentic inquiry, an understanding of inquiry knowledge, or the NOS. Often textbooks do not allow students to generate their own research questions (Chinn & Malhotra, 2002) and include exercises that are very structured (Germann, Haskins, & Auls, 1996). Although texts often do not promote the use of inquiry in science teaching, there are other reasons why teachers do not engage their students in inquiry lessons.

Some teachers do not engage students in inquiry instruction because of what they perceive as the sheer difficulty of implementing inquiry lessons (Welch et al., 1981). For others, it is the lack of a clear understanding of what it means to use inquiry in the science classroom (Welch et al., 1981) or lack of understanding of the NOS (Gallagher, 1991). In addition, school culture can also present factors that limit the implementation of inquiry instruction (Wallace & Kang, 2004). A substantial body of evidence supports the idea that values and beliefs held by teachers strongly influence the decisions they make regarding classroom instruction (Cronin-Jones, 1991; Fang, 1996; Kagan, 1992; Tattoo, 1999; Wallace & Kang, 2004; Weiss et al., 2003; Welch et al., 1981). This evidence does not only exist for general teacher beliefs, but also epistemological beliefs (Hashweh, 1996; Lederman, 2004; Smith, 2005; Wallace & Kang, 2004).

Because epistemological beliefs can serve as a factor of influence on how science teachers teach, it is important for them to value how learning occurs through inquiry and the NOS (Lederman, 2004). "Having the knowledge and the ability to teach scientific inquiry and NOS is of little use if science teachers do not value the importance of these instructional outcomes" (Lederman, 2004, p. 404). Instilling these values in science teachers would require a move from focusing on the "Hows" of science education to the "Whys" (Bybee, 1997). In order for this shift to occur, an understanding of these beliefs must occur on both preservice and inservice levels (Kagan, 1992; Tattoo, 1999). Therefore, there is a need for research that examines the relationship between science teachers' beliefs about knowledge and learning and how these beliefs impact their teaching practice (Hewson, Kerby, & Cook, 1995; Tsai, 2002).

CHAPTER THREE

Research Design

Epistemological Beliefs: The Theoretical Framework

Epistemological beliefs are a subset of teacher beliefs that focus on knowledge and learning. Recent studies support that the epistemological beliefs held by teachers influence the decisions they make regarding classroom instruction (Hashweh, 1996; Lederman, 2004; Smith, 2005; Wallace & Kang, 2004). These studies provide several implications relevant to concerns in science education.

Many of the recent concerns in science education relate to the lack of more authentic forms of inquiry in science instruction. These concerns include the lack of student engagement in argumentation and reasoning, in addition to the lack of students participating in investigations based on questions they generate (Chinn & Malhotra, 2002; Duschl, Shouse, & Schweingruber, 2007). There are also concerns regarding students' understanding of inquiry and the nature of science (NOS) (Lederman, 2004). All of these concerns relate to important elements of reform-based, or inquiry, science instruction (Association for the Advancement of Science, 1993; National Research Council, 1996); the more authentic the inquiry instruction, the more opportunities for these elements to occur (Bonnstetter, 1998; Chinn & Malhotra, 2002; National Research Council, 1996).

Research studies indicate several conditions likely not to promote these elements of reform-based science instruction relative to science teachers' epistemological beliefs. Science teachers who hold beliefs about the NOS as a factual body of knowledge to be learned are less likely to use reform-based instructional practices (Cronin-Jones, 1991). Also, science teachers can hold reformed based beliefs about the NOS but due to their lack of knowledge regarding the nature and philosophy of science (Gallagher, 1991) or their instructional intentions (Lederman, 1999), their instructional practices would not reflect these reformed based beliefs.

Because epistemological beliefs serve as a factor of influence on how science teachers teach, it is important for them to value how learning occurs given the NOS and inquiry (Hashweh, 1996; Lederman, 2004). For example, Bell et al. (2000) noted how development of preservice teachers' understanding of NOS content, followed by the development of their ability to teach the NOS, led the preservice teachers to include reform-based teaching techniques in their lessons. In order to continue to promote this shift from more Traditional to reform-based teaching, preservice and inservice science teachers must have opportunities to develop an understanding of their epistemological beliefs (Kagan, 1992; Tattoo, 1999).

The Problem

Based on the review of the research literature, there are several factors worth examining as they relate to epistemological beliefs and authentic inquiry. Studies reviewed in science education regarding epistemological beliefs included studies that identified and analyzed science teachers' epistemological beliefs (Aguierre et al., 1990; Boulton-Lewis et al., 2001; Tsai, 2002), investigations regarding the impact of epistemological beliefs on curriculum selection and implementation (Benson, 1989; Cronin-Jones, 1991), and studies that focused on the influence of beliefs about the NOS, or epistemology of science, on teaching strategies (Abd-El-Khalick et al., 1998; Bell et al., 2000; Brickhouse, 1989; Gallagher, 1991; Lederman, 1999). All of these studies were focused on secondary teachers, whether preservice or inservice. Fang (1996) noted that few studies have examined teacher beliefs on the post-secondary level, and a review of the literature identified no studies that examined teacher beliefs, more specifically epistemological beliefs of teachers, on the middle, secondary and post-secondary levels.

Additionally, there is a need for studies that examine teachers' beliefs in specific components of subject areas rather than subject areas in general (Fang, 1996). Of the science education research reviewed regarding epistemological beliefs, specific components of the subject area that were investigated included the epistemology of science (Abd-El-Khalick et al., 1998; Bell et al., 2000; Brickhouse, 1989; Gallagher, 1991; Lederman, 1999), discovery oriented curriculum (Cronin-Jones, 1991) and general science teaching strategies (Hashweh, 1996).

The study presented here explores these gaps in the literature. This investigator explored the epistemological beliefs of teachers on the middle, secondary and post-secondary levels. This investigator also studied a specific component of science instruction, authentic inquiry, not investigated in the research studies reviewed.

Chosen by Qualitative Design: Case Study Research

Why Qualitative Research

The investigator of this study did not choose to conduct a qualitative study; the study chose the investigator. As an educator, this investigator's questions in the field have often begun with "How" or "Why." As a student, this investigator rarely had questions along that same line, nor was she often provided with opportunities to develop the ability to question or explore in this manner. As this investigator began to read more literature throughout her doctoral program and interact with and observe both preservice and inservice teachers, she began to return to a question she often had as a public school teacher, "Why am I teaching the way I am?" She then began to wonder if teachers had time to even explore this question and if she could design a study that would allow them to address it.

In addition to wondering whether teachers had an opportunity to truly explore why they teach the way they do, this investigator also began to think about her lack of "How" and "Why" questioning experiences on the secondary and post-secondary levels. She immediately began to recall the numerous failed attempts at competing in science fairs and how frustrated she was as a student about not knowing how to develop researchable questions. To make matters worse, as a doctoral student, the investigator took a leadership in science education course led by a science professor for which she was the only person from the School of Education in the course. Little did she know that the focus of the course was creating meaningful science education experiences for students, which in essence centered on providing learning opportunities in the natural world and of all things, questioning! She couldn't believe it! Again she was presented with a situation that caused her to doubt her ability to develop and investigate meaningful questions in science.

This realization led the investigator to wonder why she had not developed this skill. As a public school student, she took many advanced placement science courses, and as an undergraduate she received a degree in Biology. She began to wonder if there was something more she should have done as a student to develop this skill. The investigator also wondered if she was not taught how to question and did not engage in lessons that allowed her to generate her own questions and investigations because her teachers and professors were not taught in that manner. As she continued questioning along this line, she realized that all of her questions began to focus on the "How" and "Why" of instructional strategies with no control over the instructional events, and she soon realized that the best manner for addressing these types of questions was through the use of qualitative design, particularly, case study design (Merriam, 1998; Yin, 2003).

Case Study Research: Its Purpose

Case study research, like other forms of qualitative research, is a form of interpretive research (Merriam, 1998; Stake, 1995). From this philosophical lens, case study research is considered inductive in nature because cases are studied to gain understanding of the meaning each case makes within its context.

Definitions of case study research vary. Some researchers view case study research as an object of study (Merriam, 1998; Stake, 1995) while others view it as a methodology (Creswell, 2007; Yin, 2003). Yin (2003) defined a case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 13). Creswell (2007) defined a case study as an exploration of a "bounded system" or a case (or multiple cases) over time through detailed, in-depth data collection involving multiple sources of information rich in context. Unlike their definitions, Merriam (1998) "concluded that the single most defining characteristic of case study research lies in delimiting the object of the study, the case…the case is a thing, a single entity, a unit around which there are boundaries" (p. 27). Like the variations in definitions, qualitative researchers also conceptualized case studies differently.

There are several types of case studies. Yin (2003) noted four designs as found in Figure 3.1. This two by two matrix highlights the number of cases, single or multiple, and the types of units of analysis, holistic (single) or embedded (multiple).

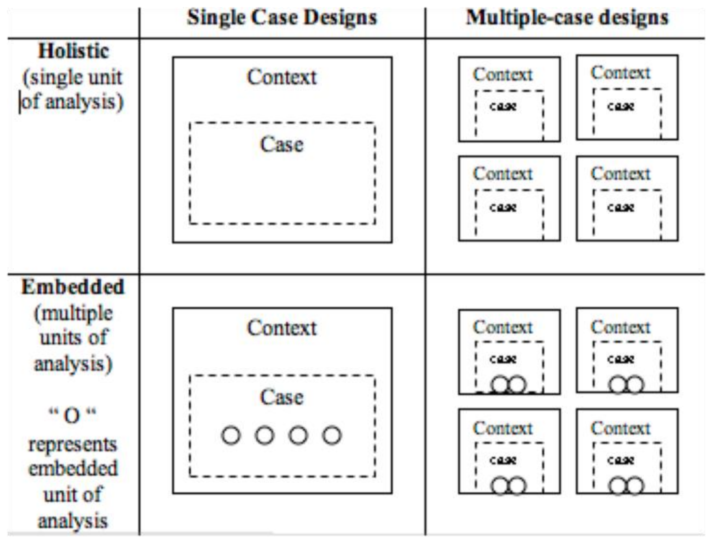

Figure 3.1. Yin's (2003) conceptualization of case study design. From Fletcher, S. S. (2006). *Exploring the Beliefs and Practices of Five Preservice Secondary Science Teachers from Recruitment through Induction in a University Preparation Program: A Longitudinal Study*. Ph.D. dissertation, p. 55.

Yin (2003) provided several rationales for single and multiple-case study research. Rationales for the use of single case study design included when cases represent an extreme case, when the case tests a well-formulated theory, to capture the conditions of something that is commonplace, to examine something previously inaccessible to investigation, or when there is a need to investigate something over a period of time. Rationales for the use of multiple-case studies included the use of two or more cases that literally replicate the outcomes of a theory, some prior knowledge of the outcomes in relation to the theory, and a focus on how and why the outcomes occurred with the hope for literal replications of these conditions from case to case.

In addition to rationales for single and multiple-case study design, Yin (2003) also differentiated between holistic and embedded case studies. Holistic and embedded were terms used by the author to refer to the number of units of analysis. In a holistic study, there is only one unit of analysis, the case itself, whereas in an embedded study there is at least one additional subunit within the unit of analysis or case. Yin (2003) noted that "holistic design is advantageous when no logical subunits can be indentified or when the relevant theory underlying the case study is itself holistic in nature" (p. 45). Otherwise, embedded design is necessary to effectively address subunits within the unit of analysis.

Unlike Yin's (2003) four types of case study designs, Stake's (1995) conceptualization of case study design involved two types of case studies, intrinsic and instrumental. He described intrinsic case studies as those studies designed to deeply understand a case. On the other hand, instrumental case studies were described as studies that provide details regarding a problem or issue of interest to an investigator.

Although the definitions and types of case study research vary, essential to this form of research are cases requiring the detailed collection of information with very little or no influence or control over the circumstances of the cases (Merriam, 1998; Yin, 2003). This is one of the reasons why case study research was significant for this study.

Case Study Research: Its Significance for this Study

Case study design suited this investigator's study due to the nature of her research questions. Yin (2003) noted that there are some research questions that deal with operational links, meaning there is a need to investigate them over time rather than to only look at frequencies of occurrence. Important to this study was not only documenting the occurrences of inquiry instruction, but also if there was a progression or development of inquiry instruction over time or the aspects that affect instructional practice over time. Additionally, the investigator's questions were also explanatory in nature because she wanted to be able to explain how the epistemological beliefs of the teachers in her study impacted their use of authentic inquiry through the themes that were generated (Yin, 2003).

The investigator of this study was also examining a contemporary event, science teaching, in which the relevant behavior, epistemological beliefs, could not be manipulated (Yin, 2003). For this reason, case study research was necessary in order to explain the impact of this behavior on the event.

Other than the advantage of being able to examine variables that cannot be manipulated and having questions most suitable for the design, case study research provided more in-depth descriptions and analyses of the cases (Merriam, 1998, Yin, 2003). Through this research this investigator was able to receive extensive input from the teachers in the study regarding the questions of the study. These interviews, along with the observations, allowed for the collection of information that was more descriptive than if the investigator used other methods.

Overall, the specific aim for using case study methodology was to interpret the data in order to promote the transferability of what was discovered regarding the impact of epistemological beliefs of science teachers on the engagement of students in authentic inquiry. This was chosen as a goal of the study due to the lack of research on epistemological beliefs of science teachers at varying levels and the impact of these beliefs on inquiry instruction.

Creating Researchable Questions

The purpose of this study was to gain a better understanding of how science teachers' epistemological beliefs influenced their instruction. The epistemological beliefs of four science teachers, at the middle, secondary and post-secondary levels were researched. Specifically, how their beliefs about knowledge and learning impacted their science instruction. In particular, the investigator wanted to know how their epistemological beliefs influenced students experiencing authentic inquiry. Thus the primary research question for this study was:

> How do the epistemological beliefs of science teachers impact their use of authentic inquiry in science instruction?

The sub-questions were:

- Q.1.: What are the epistemological beliefs and instructional practices of one post-secondary, two secondary, and one middle school science teachers in Central Texas?
- Q.2.: How are the epistemological beliefs of one post-secondary, two secondary, and one middle school science teachers in Central Texas consistent with their observed science teaching practices?
- Q.3.: How do the epistemological beliefs of one post-secondary, two secondary, and one middle school science teachers in Central Texas promote student generated questions, student designed and led investigations, and the presentation of evidence, or authentic inquiry?

The study's proposition was that teachers with epistemological beliefs reflective of reformed based instruction, or Authentic Inquiry, would also incorporate opportunities for Authentic Inquiry in their classes if they additionally had experiences that led to their understanding and/or value of this method of instruction. This proposition was created in order to focus the study on the theoretical framework while also providing focus for data analysis (Yin, 2003).

The Pilot Study

This investigator conducted a pilot study that began March, 2009. The pilot study involved one case, a secondary biology teacher at a suburban high school in Central Texas. The purpose of the pilot study was to test and refine the study's methodology (Yin, 2003), specifically the interview questions and observation protocol.

The case, Elizabeth (pseudonym), was a second year teacher. She had a Bachelor of Science degree in Education with an emphasis in Secondary Life Science. The course observed was her third period, 9^{th} grade, Pre-AP Biology course.

The study began with Elizabeth's participation in two semi-structured interviews, the Science Education Experiences and Science Teaching Philosophy interviews conducted March, 2009. These interviews included questions derived from the semi-structured interview questions found in Smith (2005). This investigator transcribed and coded the interviews, and the codes were classified into categorical themes developed by Luft & Roehrig (2007). The themes were:

- Traditional: Focus on information, transmission, structure, or sources
- Instructive: Focus on providing experiences, teacher-focus, or teacher decision
- Transitional: Focus on teacher/student relationships, subjective decisions, or affective response

- Responsive: Focus on collaboration, feedback, or knowledge development
- Reform-based: Focus on mediating student knowledge or interactions (p. 54)

From these interviews, this investigator discovered that Elizabeth's science education experiences were mostly Traditional, although along with these methods she believed she also learned science best through Transitional methods, such as hands on experience related to her interests.

The Science Teaching Philosophy interview revealed that Elizabeth's primary reason for becoming a teacher was Traditional in nature; she had a desire to explain information to students. Her beliefs about how students learn science were Traditional (reading, prior knowledge, lecture) and Instructive (discussion, notes, labs). She emphasized during her interview that the greatest influence on her method of teaching was a summer teaching experience she had at Sea World. The experience added to her Traditional beliefs because it gave her confidence in knowing the content in addition to providing her with methods to structure and present information. When asked how her students influence the way she teaches science, her comments reflected Transitional beliefs, including consideration of her students' prior knowledge, interests, and how they learn.

Direct observations and the collection of artifacts began April, 2009. The Mathematics and Science Classroom Observation Profile System (M-SCOPS) (Stuessy, Parrot, & Foster, 2005; Stuessy, 2002) was used to document what was observed. This investigator observed Elizabeth's class six times for a total of 192 instructional minutes. By observing Elizabeth and coding her lesson documents, this investigator discovered that all of her lessons were teacher focused. Of the six lessons, the most student focused lesson was the squid dissection lesson taught in a Traditional Hands-on format. Most of the representations, items used to enhance the lessons, used during the lessons were provided by the teacher through her use of pictures, diagrams, and words on PowerPoint slides.

At the conclusion of observations and the collection of artifacts, Elizabeth participated in a semi-structured interview June, 2009 to clarify and confirm themes generated and to provide additional input related to the research questions. Once the pilot study was complete, this investigator adjusted the interview questions and the observation protocol. The Science Education Experiences Interview (SEEI) questions were revised in order to make them more open-ended and to reduce the number of questions asked (see Appendix D for updated questions). Additionally, the investigator decided to use the semi-structured interview questions from the Teacher Beliefs Interview (TBI) (Luft & Roehrig, 2007) to examine the teachers' epistemological beliefs (see Appendix D for these interview questions) instead of conducting the Science Teaching Philosophy interview.

This investigator also initially planned to use M-SCOPS (Stuessy et al., 2005; Stuessy, 2002) for observations. After conducting the pilot study, the investigator realized that M-SCOPS would limit what she hoped to document regarding the instructional practices of the cases. Therefore this investigator created and used a field note template to document descriptive and reflective notes for observations (see Appendix C for template).

Investigating Epistemological Beliefs and Authentic Inquiry: Structuring a Multiple-Case Study

Multiple-case study research involves the use of more than one case for an investigation (Merriam, 1998; Yin, 2003). For this study four cases were chosen in an effort to promote literal and theoretical replications within the study (Yin, 2003). Additionally, this methodology was most appropriate to investigate the research questions, provided an opportunity for a rich set of data for interpretation (Merriam, 1998), and provided the opportunity for more powerful analytic conclusions (Yin, 2003).

Investigator's Work, Role, and Setting

This investigator was a full-time graduate student and instructor of record within the Department of Curriculum and Instruction at Baylor University in Waco, Texas. She had 14 years of experience in the field of education. During her first four years she served as a seventh grade science teacher in an urban, public school in the South in which during her last year and a half she also served as the Science Enrichment Coordinator for an after school program. The next seven years she served as the Coordinator of Academic Support Services for a small, private liberal arts college. In this role, she developed programs to promote academic success. Over the past three years, while as a full-time graduate student, she served as an instructor of record for teacher education courses at Baylor University.

Throughout her time as a student and teacher in K-12 and post-secondary schools, the investigator dealt with issues related to questioning. Although these issues existed, she hoped to begin to generate solutions to them with her research. As the principal investigator, she conducted interviews, observed, collected artifacts, and analyzed the data collected. Through the investigator's use of established interview protocols and case verification of themes, she aimed to remove any biases generated by past experiences in order to conduct her study effectively.

Unit of Analysis

The unit of analysis of this study was each of the science teachers. This investigator chose this group of cases because she wanted to describe the epistemological beliefs of middle, secondary and post-secondary science teachers and how their epistemological beliefs impacted their use of authentic inquiry in science instruction. Following Yin's (2003) case study research design (see Figure 3.1), this study was a multiple-case (embedded) design. Figure 3.2 outlines this design. This model was used for the

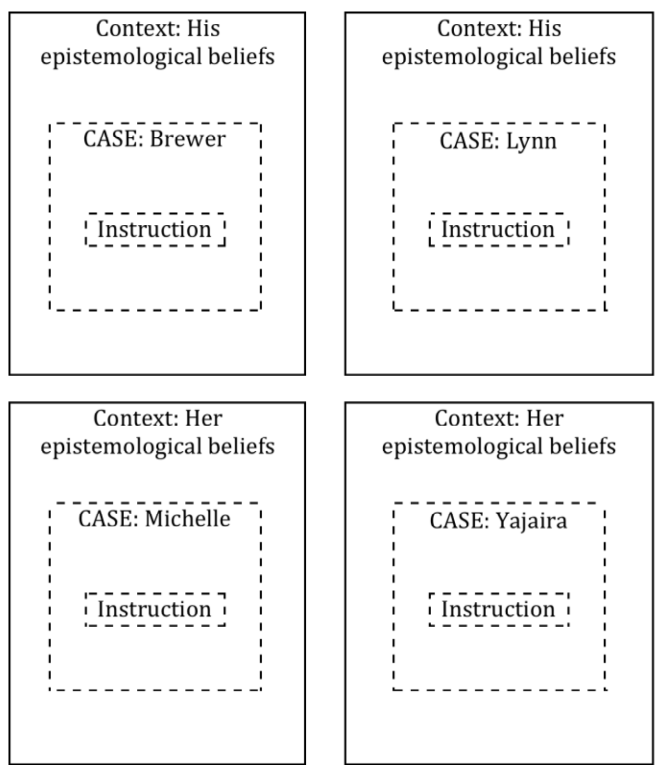

Figure 3.2. The case study design for this investigation.

following reasons. First, the cases, or science teachers, were studied in the context of their individual epistemological beliefs following replication logic. The particular form of replication logic applied was theoretical replication, in which contrasting results were predicted for predictable reasons (Yin, 2003). Secondly, the study was considered embedded because particular attention was given to a specific subunit of the units of analysis, their instructional practices.

Participants

Purposeful sampling was used to select the participants for this study; specifically criterion based sampling (Creswell, 2007; Merriam, 1998). The first criterion involved the selection of teachers that demonstrated in some way the active engagement of their students in science lessons. This was an important quality of those selected for the study because this investigator hoped to observe teachers who engaged students in much more than Traditional, direct instruction. Administrators and the participants' colleagues assisted this investigator with selecting participants using this criterion. Secondly, teachers within the study had to teach at either the middle, secondary or post-secondary levels. This was a criterion due to the abilities necessary for authentic inquiry that are often developed within these three age groups of students.

This investigator initially gained access to each middle and secondary teacher through their building principal or science specialist and the post secondary teacher based on previous contacts. She spoke with the potential cases about the nature of her research and the time required for the investigation. Of the seven teachers contacted, all but one agreed to participate. The one who declined to participate did so because she was changing teaching assignments the next year.

Once the teachers agreed to participate in the study, this investigator followed up with the principals of the middle and secondary teachers to receive their official approval to conduct her research in their schools. After this approval was granted, the potential participants reviewed and signed the informed consent form (see Appendix E) in addition to completing a brief questionnaire regarding their demographics that appeared on the back of the informed consent form (see Appendix E). Table 3.1 provides a brief overview of the four participants chosen from the potential pool of six teachers. Two of the initial six participants did not participate in the full study because one switched subjects from science to Spanish and the other was used as a pilot for the study.

Table 3.1

Participant Demographics

Teacher (Pseudonym)	Gender/ Race	Academic Degree	Current Position	Current Teaching Demographics
Brewer	Male/ Caucasian	B.S. Secondary Education	Middle School Science Teacher	Urban Public School
Lynn	Male/ Caucasian	Ph.D. Biology	Biology Professor	Private University
Michelle	Female/ Caucasian	M.A. Biology	High School Biology Teacher	Rural Public School
Yajaira	Female/ Hispanic	M.S. Medical Technology	High School Biology Teacher	Urban Public School

Timeline

Data collection occurred over the period of one year, from the end of the 2008-09 school year throughout the 2009-10 school year. Table 3.2 provides an overview of the data collection timeline.

Table 3.2

Data Collection Timeline

Participant (Pseudonym)	SEEI and TBI	Observation and Artifacts	Post Interview
Brewer	05/2009	12/2009-02/2010	03/2010
Lynn	05/2009	10/2009-12/2009	02/2010
Michelle	05/2009	10/2009-12/2009	02/2010
Yajaira	05/2009	12/2009-03/2010	03/2010

Sources of Data

Several forms of data collection occurred in order to examine the impact of science teachers' epistemological beliefs on their use of authentic inquiry. Table 3.3 outlines the questions of the study and the methods used to address each question. The methods used and the rationales for their use are described below.

Science education experiences and teacher beliefs interviews. Prior to the semester that observations occurred, participants engaged in a semi-structured interview to provide necessary information regarding their science education experiences and epistemological beliefs. The Science Education Experiences Interview (SEEI) was a semi-structured interview based on questions derived from Smith (2005). The information collected during this portion of the interview process focused on the participants' science experiences as a student and teacher. See Appendix D for the interview questions.

Table 3.3

Correlation of Data Collection to Research Questions

Primary Research Question: How do the epistemological beliefs of science teachers impact their use of authentic inquiry in science instruction?

Data Collection	Questions		
	Q.1.	Q.2.	Q.3.
Science Education Experiences Interview			X
Teacher Beliefs Interview	X	X	X
Observation	X	X	X
Artifacts	X		X
Post Interview	X	X	X

To determine the epistemological beliefs of science teachers, the investigator used the Teacher Beliefs Interview (TBI) developed by Luft and Roehrig (2007). This semi-structured interview protocol was used in order to provide more structure to obtaining information regarding the teachers' epistemological beliefs due to the difficulties that exist with conceptualizing and identifying beliefs (Kagan, 1992; Pajares, 1992; Richardson, 1996). The investigator contacted Dr. Luft May, 2009 by electronic mail for permission to use these questions, and permission was granted (see Appendix E for e-mail message). The interview consisted of seven questions. These questions were developed by Luft and Roehrig after field tests with preservice and inservice teachers. See the list of questions in Appendix D.

The SEEI occurred during the same session as the TBI (Luft and Roehrig, 2007) but prior to posing the TBI questions. The interviews occurred May, 2009. The average interview time was 45 minutes. This investigator conducted and digitally recorded each interview using a voice recorder. She also wrote field notes during the interview to document responses of the cases and thoughts of the investigator as the interview proceeded. Interviews occurred in various locations. Yajaira, Michelle, and Brewer's interviews were conducted in their classrooms. Lynn's interview occurred in his office. This investigator began each interview by stating the purpose and structure of the interview. The investigator then read the questions in sequential order and provided the cases with the time they needed to completely respond to the questions. When necessary, follow up questions were asked to clarify comments made or to provide additional details regarding the cases' experiences and beliefs. Upon the completion of each interview, teachers were asked to share any additional thoughts they had. Once they shared these thoughts they were thanked for their participation and reminded that they would be contacted during the fall semester to begin the observation phase of the study.

Observation. This investigator began observations October, 2009. The purpose of the observations was to document, using field notes and a digital voice recorder, the instructional techniques of the teachers. Fall observations began with two of the cases (See Table 3.2 for data collection timeline). Each case's selected class was observed once each week for a minimum of 400 minutes or approximately eight class sessions. If no new themes were generated at that point, observations ended. If the generation of new themes continued, observations continued until no new themes occurred.

The observation protocol was as follows. This investigator contacted each participant by e-mail at least a week prior to the beginning of observations in order to confirm their continued participation in the study and their current teaching assignment. Once confirmations were received, she met with the cases to discuss the protocol for observations, address any questions they had, and to let them know which week to anticipate the first observation. The protocol for observations consisted of this investigator arriving for the designated class period, greeting the case and taking her place in the area of the classroom designated for observations. When the case began to interact with students, this investigator turned on the digital voice recorder and left it on until the end of the observation period, which was usually when all students in the class left the room. The investigator used her field note form (see Appendix C) to document observations and reflections during the class session. If there were questions regarding the observation, they were addressed either at the end of the observation period or by an e-mail exchange with the teacher. As the field note forms were completed, they were organized by date and placed in the cases' file folders. See Appendix C for a detailed description of the observation protocol. During observations, this investigator also collected artifacts related to the day's lesson.

Artifacts. Instructional documents were collected from each case (Creswell, 2007). The documents included lesson plans, lesson handouts, and examples of student work. The purpose for collecting these documents was to review them and correlate them with the instructional techniques used by the teachers. Most often, this investigator collected and labeled these artifacts with the cases' pseudonyms, the date, and a letter code as the artifacts were used during the class period. In class sessions when this investigator could not collect these artifacts as the lesson progressed, she collected and labeled them at the end of the class session or at a later date. Once collected and labeled, all artifacts were placed in the cases' file folders with the lessons for which they were used.

Post interview. After observing the teachers for at least 400 minutes or eight class sessions, this investigator conducted semi-structured interviews of the teachers in order to clarify and confirm themes and categories and to provide additional input related to the research questions (Creswell, 2007). General concluding questions were asked of all cases, in addition to questions specifically addressing data collected from their initial interview and from the observations (see Appendix D for Post Interview questions) and were recorded using a digital voice recorder and field notes. When necessary, follow up questions were asked to clarify comments made. Upon the completion of each interview, cases were thanked for their participation in the study.

Triangulation of Data

As outlined in Table 3.3, the sources of data for this study directly addressed the three research questions. By conducting the SEEI, this investigator discovered more regarding the participants' experiences in science education as a student and teacher. The themes generated provided additional information to address question three and this study's proposition. The TBI (Luft & Roehrig, 2007) and observations provided necessary information regarding the epistemological beliefs and instructional practices of this study's participants, thus providing themes used to address all three research questions and the study's proposition. The coding of artifacts provided further details regarding the instructional practices of the study participants, thus addressing question one. Lastly, the Post Interview allowed the study participants to confirm the themes generated for epistemological beliefs and instructional practices in addition to providing an opportunity for them to share their final thoughts regarding how their epistemological beliefs impacted their use of authentic inquiry. Therefore this data source addressed all three research questions and this study's proposition. The themes generated by the data sources used for each question were used to triangulate the data (Yin, 2003).

Data Analysis

Data collection and analysis occurred simultaneously (Merriam, 1998). The process used for data analysis was Framework Analysis (Ritchie and Spencer, 1994; Ritchie, Spencer, O'Connor, 2003). The general approach to Framework Analysis is inductive in nature, but it allowed for the inclusion of both known and emergent themes. There are five distinct phases of Framework Analysis: familiarization, identifying a thematic framework, indexing, charting, and mapping and interpretation (Ritchie and Spencer, 1994; Ritchie, Spencer, O'Connor, 2003).

Procedure. The first phase of data analysis, familiarization, began with the organization of the data. This process occurred throughout the data collection phase and involved the verbatim transcription of interviews, the creation of typed lesson scripts from observations, and the labeling of artifacts.

On average, this investigator transcribed the digitally voice recorded interviews verbatim within a week of conducting the interviews. Once interviews were transcribed, they were emailed to the cases for them to review, clarify, and/or add any additional details. Once the cases were in agreement with the transcriptions, they were labeled by participant pseudonym, the term “interview,” and the date of the interview (for example LYNN Interview May 18, 2009). The email messages verifying review of the transcriptions were printed along with the transcribed interviews. These items were placed in a locked file cabinet in file folders labeled by participant pseudonym. Interviews were not analyzed until the conclusion of observations in order to prevent investigator bias during observations.

The organization of observations and artifacts involved this investigator converting written field notes and digital voice recordings into typed lesson scripts and labeling collected artifacts. Prior to observing each case’s next class session, field notes and digital voice recordings of observations were used to create typed transcripts of instructional events (see Appendix C for an example). Instructional events were based on either teacher or student initiated tasks related to each day’s objectives and the time span of the instructional segments within these events was determined based on students’ tasks; when students were required to do a different task, a new instructional time span began. These transcripts included the times that each lesson segment began, descriptive notes of what was occurring during the time span, investigator reflective notes, abbreviated themes of the instructional segment, and instructional codes for each of the segments. The generation of themes and codes for these instructional segments began during the creation of lesson scripts and continued throughout observations as themes and instructional codes evolved. Each participant’s pseudonym and the date of the observation were used as the title of the lesson scripts. For example, an observation of Lynn on October 27, 2009 was titled “LYNN 10-27-09.” Artifacts collected corresponding with the lesson began with the pseudonym and date in addition to a letter code. For example, a handout given during a lesson was labeled as “LYNN 10-27-09 A.” This label also appeared in the script to indicate where the coded document was used. Additionally, lesson plans and any other artifacts collected that were not used during lesson but were collected were given the last letters used for the script and indicated at the bottom of the script. Lessons scripts and artifacts were filed chronologically in each case’s file.

Upon the completion of observations, the investigator continued with the familiarization phase of data analysis by immersing herself in the data collected. This process included several readings of the transcripts in addition to several reviews of the lesson scripts and artifacts.

The second phase, identifying a thematic framework, began before observations and the collection of artifacts and continued throughout the analysis phase of the study. This phase involved the development and refinement of the coding framework. The thematic framework for observations and artifacts was initially conceptualized using Stuessy’s (2002) outline of forms of lesson complexity and Bonnstetter’s (1998) conceptual framework of the inquiry continuum. As the analysis phase progressed, this framework was refined as themes began to emerge from the observations and artifacts. The final categories that emerged from the themes were “Direct Instruction,” “Discussion,” “Traditional Hands-on,” “Structured Inquiry,” “Guided Inquiry,” and “Authentic Inquiry.” See Table A.1 in Appendix A for a description of the six categories of the instructional coding framework used to code observations and artifacts.

Like the collection of artifacts and completion of observations, identifying the thematic framework for the semi-structured interviews began before the interviews occurred and continued throughout the analysis phase of the study. For the SEEI and Post Interview, the development of the initial coding framework began with the reading of the interview transcripts and the recording of the investigator's thoughts and questions regarding the responses. Initial themes began to emerge including "People," "Coursework," and "Field Experiences." After two additional readings, the categories were "Learning Science," "Teaching Science," and "Professional Development." The development of these categories was based on the direct meaning of the responses provided by the cases.

The TBI was used as the thematic framework for epistemological beliefs. Once Luft and Roehrig (2007) completed the field tests and received additional reviews from experts, five categories of beliefs emerged from the interviews. These categories were those that were more teacher centered and identified as "Traditional" or "Instructive" beliefs. Those beliefs that were more behaviorist or affective in nature were considered "Transitional" beliefs. Lastly, beliefs that were more student centered were categorized as "Responsive" or "Reform-based." See Table A.2 in Appendix A for a description of these categories.

The third phase of Framework Analysis, indexing or coding, involved applying the theoretical frameworks to the data collected. The first sets of data coded were the observations and artifacts. Coding began during the creation of lesson scripts and was completed for all of the observations of each case prior to the post interview. Coding required the investigator to read the lesson scripts and review the artifacts to determine the existing and emerging themes within the lesson related to instructional practice. These abbreviated themes and their meanings are provided at the bottom of the lesson script example in Appendix C. The investigator used these themes and the instructional coding document (see Appendix A Table A.1) to code each instructional segment, defined as the instructional timeframe that involved students completing a task (the lesson segment did not change until students were required to move to a different task). Additionally, the overall lesson format was coded based on the percentage of instructional minutes for each code within the lesson; the instructional coding that occurred at the greatest percentage during the lesson was used to code the lesson.

Upon the completion of the indexing of observational and artifact data of a case, the investigator read and indexed the interviews. The SEEI was indexed using the themes that emerged from the interviews. The TBI was indexed using the descriptions (see Appendix A Table A.2) and concept maps (see Appendix B Figures B.1-B.7) provided by Luft & Roehrig (2007).

The next phase of data analysis, charting, required the development of graphical displays to represent the thematic framework of the data collected. This process began with the creation of graphical displays to represent the instructional techniques of the lessons taught by each case (see Appendix B Figure B.8 for an example). Each case's individual instructional graphs were then compiled to visually represent the instructional techniques used over the entire period of observations (see Appendix B Figures B.9-B.12 for the four graphical displays). Additionally, a thematic chart was created to represent the instructional categories evident for each case (see Chapter Four Figure 4.1 for an example). Thematic charts were also created to represent themes from the cases' SEEI and Post Interviews. The purpose of these charts were to reduce the data in order to provide an opportunity for this investigator to more clearly compare the sets of data and to note any patterns that existed.

The final phase of Framework Analysis involved the mapping and interpretation of the data collected. This involved the synthesis of the charts and graphical displays into narrative accounts of the cases' epistemological beliefs and the impact of these beliefs on their use of authentic inquiry. Table 3.4 provides a visual of this investigator's view of the correlation between epistemological beliefs and instructional practices. The

Table 3.4

The Correlation Between Instructional Strategies and Epistemological Beliefs

Instructional Strategy	View of Science	Epistemological Belief
Direct Instruction	Science as rule or fact.	Traditional
Discussion		Instructive
Traditional Hands-on Structured Inquiry	Science as consistent, connected and objective.	Transitional
Guided Inquiry		Responsive
Authentic Inquiry	Science as a dynamic structure in a social and cultural context.	Reform-based

Note. Instructional codes developed from research based on Bonnstetter (1998) and Stuessy (2002). Views of science and epistemological belief categories from "Capturing Science Teachers' Epistemological Beliefs: The Development of the Teachers Beliefs Interview" by J.A. Luft and G.H. Roehrig, 2007, *Electronic Journal of Science Education, 11*, p. 54.

narratives included descriptions of the participants' science education experiences and demographics, their epistemological beliefs, instructional practices, and the consistencies and impact of these beliefs with instructional practice. The narratives, charts, and graphical displays were used to describe patterns that existed within each case's data and among the data collected for all cases (Creswell, 2007; Ritchie and Spencer, 1994; Ritchie, Spencer, O'Connor, 2003). Once completed, this information was used to interpret how the data related to this study's initial proposition (Yin, 2003).

Study Validity and Reliability

Several techniques were used to address the study's validity and reliability. Construct validity was addressed through the use of multiple sources of evidence and by the cases reviewing and confirming the codes determined for their beliefs and instructional techniques (Yin, 2003). Through the collection of data from semi-structured interviews, direct observations, and artifacts, along with the cases' confirmation of codes generated, this investigator was able to document the science teachers' epistemological beliefs and instructional methods and how these beliefs influenced their use of authentic inquiry. Additionally, the TBI was most appropriate for determining the cases' epistemological beliefs because unlike a self developed interview protocol, the researchers who developed the TBI tested it multiple times and refined it to improve its validity and reliability (Luft & Roehrig, 2007). Also, internal validity was addressed through the use of Framework Analysis, a form pattern matching, for data analysis (Yin, 2003).

To address reliability, the investigator clearly outlined the protocol for the study that included an observation protocol (Appendix C) for the collection of data (Yin, 2003). Following this protocol, future investigators could conduct this study again. The investigator also developed a case study database to store the information collected (Yin, 2003). This database was stored in both digital and paper-based forms. The database included field notes, artifacts, interview transcriptions, lesson scripts, graphical displays, and the summarized narrative descriptions of cases.

As a qualitative study, the focus of the design was on transferability rather than generalizability. Therefore the investigator hoped that the interpretation of the data within this investigation would cause those responsible for the professional development of science teachers to reflect on methods to promote the development of teachers prepared to use inquiry-based instruction.

CHAPTER FOUR

Findings

This chapter includes the outcomes of the study as indicated by data collection and analysis. All of this study's questions are addressed for each case before the presentation of the next case's findings.

For each case, the information provided under the headings [Pseudonym's] Epistemological Beliefs and [Pseudonym's] Instructional Practices, addresses the first question of the study:

> What are the epistemological beliefs and instructional practices of one post-secondary, two secondary, and one middle school science teachers in Central Texas?

The second question of the study:

> How are the epistemological beliefs of one post-secondary, two secondary, and one middle school science teachers in Central Texas consistent with their observed science teaching practice?

is addressed for each case under the heading Consistency of [Pseudonym's] Epistemological Beliefs with Instructional Practice. The last study question:

> How do the epistemological beliefs of one post-secondary, two secondary, and one middle school science teachers in Central Texas promote student generated questions, student designed, and led investigations, and the presentation of evidence, or authentic inquiry?

is addressed under the heading Impact of [Pseudonym's] Epistemological Beliefs on Authentic Inquiry. The analysis of this impact is based on the initial study proposition that stated:

> Teachers with epistemological beliefs reflective of reformed based instruction, or Authentic Inquiry, would also incorporate opportunities for Authentic Inquiry in their classes if they additionally had experiences that led to their understanding and/or value of this method of instruction. The chapter concludes with a cross case analysis.

The Cases

Case 1: Brewer (pseudonym)

Brewer taught 8th grade science courses at a middle school within an urban public school district in Central Texas. The school's 2009 accountability rating was Academically Acceptable, unlike the district's accountability rating that was Academically Unacceptable. The school's 2009-10 student population was 49% Hispanic, 44% African-American, and 8% Caucasian, similar to the district's ethnic distribution. The school reported that for the 2008-09 school year, 88% of its students were economically disadvantaged compared to 83% of the district.

Brewer has taught science for six years. His decision to become a science teacher was based on two factors, his enjoyment of Biology and his consideration, when asked by his mother, of what he would do if money was not an issue. After considering these two factors he decided to complete a traditional certification program at a private Baptist university in Central Texas.

Brewer has taught science at his current school for four years. The school is a science and technology magnet school where students experience units called "Odysseys" each nine weeks that allow them to study real-world, hands-on applications. When asked what has been the greatest influence on how he teaches science, he indicated the professional mentor relationship he has with his principal, a former science educator, and excellent professional development opportunities.

Brewer's epistemological beliefs. Brewer's beliefs about knowledge were mostly Traditional (see Table 4.1). For example, during his Teacher Beliefs Interview (TBI) the following exchange occurred:

> Investigator (I): In the school setting, how do you decide what to teach and what not to teach?
>
> Brewer (B): TEKS. Yeah that's really it. I mean we go through and we look at a plan for vertical alignment from 6th, 7th, and 8th grade. And we really try to make sure we are focused in on teaching on our level. The TEKS are the law around here so that's a simple answer. (BREWER TBI, p. 5)

Brewer's response was classified as Traditional because his belief about what to teach was strictly based on the standards required for his grade level.

Brewer's second belief was also coded as Traditional but was not as easy to code as the first. The initial exchange was as follows:

> I: In the school setting, how do you decide what to teach and what not to teach?
>
> B: That's a great question because right now I would say that it is time based rather than learning based or I would say that time is the constant rather than learning being the constant, which is a big part of the problem. But you know typically because you are limited with time you hope that you have planned out and scaffolded as well

where they spent enough time so that the concept begins to mean something them. (BREWER TBI, p. 5)

Table 4.1

Brewer's Epistemological Beliefs

TBI Questions	Teacher Centered <----------------> Student Centered				
Beliefs About Knowledge	Trad.	Instr.	Trans.	Resp.	Reform
How do you describe your role as a teacher?			B		
In the school setting, how do you decide what to teach and what not to teach?	B				
How do you decide when to move on to a new topic in your classroom?	B				
Beliefs About Learning					
How do you maximize student learning in your classroom?			B		
How do you know when your students understand?			B		
How do your students learn science best?			B		
How do you know when learning is occurring in your classroom?			B		

Because Brewer mentioned the need to scaffold the concepts so that they mean something to his students, this investigator wondered if time was truly the factor he based his decision on, or if he took into account student understanding, an Instructive belief, or student feedback, a Transitional belief. Due to this need for clarification, the following exchange occurred during the Post Interview:

> I: You mentioned that you really hope that you plan enough time for them to know the concepts. And so I wondered, is it based on student understanding? If they are not understanding it, do you just stop and say okay we're going to continue with this no matter if I had only planned to do this unit for 5 or 7 days? Or do you kind of get student feedback?
>
> B: I mean what happens is we will plan a week of lessons and that's generally within kind of a larger plan, like six weeks or so of lessons and we realize kind of what our pace needs to be to meet that and if we get in the middle of it and realize, wow they are really not getting it, we need to take another day, we'll do that. Having said that, I couldn't honestly say that we wait until students have mastered the concept to move on. If we did that, if we truly did that, we would probably cover anywhere from a third to a half of the content…I wish I could do that, but I really don't feel like that would be honest to say that we go ahead with it until students have mastered it...
>
> (BREWER Post Interview, p. 2)

After this exchange, this investigator and Brewer agreed that the belief was Traditional. He added the comment:

> B: And I would say that is not what I wish for but certainly given the constraints that I have that's probably the more accurate representation. (BREWER Post Interview, p. 5)

Brewer only had one Transitional belief about knowledge and that belief related to his role as a teacher. In the exchange below, he emphasized both the cognitive and affective qualities of his Transitional belief:

I: How do you describe your role as a teacher?

B: I think as a teacher it is such a relational profession that it is hard to talk about being a good teacher without being able to really relate well to the kids. Not only in terms of understanding where they are in their content but just do you enjoy those kids, and do they get a feeling you enjoy them and that you are really tied emotionally to their learning. So I think the role of the teacher is to really honestly to emotionally attach yourself to the success of your students. (BREWER TBI, p. 4)

Brewer's comments reflected the importance of the teacher student relationship in addition to student understanding of content, thus reflecting a Transitional belief.

Unlike his mostly Traditional beliefs about knowledge, all of Brewer's beliefs about learning were Transitional (see Table 4.1). An example included the following exchange:

I: How do you maximize student learning in your science classroom?

B: Planning is the foundation. You've got to have a vision for and a kind of master layout of what you are going to teach and when you are going to teach it. And then your classroom experience needs to be, it needs to feel productive to the kids, it needs to feel efficient. They need to feel successful…I try to think where is this kid probably within this concept, what things does he really need to know before we really start to get into the hands-on part of it. And then what's the best way, you know we analyze the TEKS, and we look at what's the best way for them to do what that says in the TEK. To experience, not to read about, to experience what the TEK says. But yeah to me it's planning. (BREWER TBI, p. 4)

Although Brewer mentioned planning, a characteristic of Traditional beliefs, in the context of his other comments throughout the interview, this response reflected Transitional beliefs because he dealt with both the cognitive and affective qualities of learning. Cognitively, he emphasized the need for students to experience the standards. Affectively, he spoke of the importance of helping the students feel successful within the classroom environment.

Likewise, when asked about student understanding, Brewer exhibited Transitional beliefs as indicated in the exchange below:

I: How do you know when your students understand?

B: They go ooohhhh! [we laugh] They start asking more questions usually. When somebody gets it, first of all it is fun for them. But yeah, there is some sort of emotion, excitement or enjoyment and then they start asking more questions. (BREWER TBI, p. 5)

This response reflected Transitional beliefs about student understanding because it described how students respond to information presented in class on both the knowledge and affective levels. The same was true as he described how he knew learning was occurring in his classroom. He mentioned how loud it gets and how engaged the students are in the learning process.

Lastly, when asked, how do your students learn science best, Brewer responded:

B: [pauses for 15 seconds] I would have to say hands-on. So much of science is observation. Whether you are learning about physics and Newton's law and things like that, you have to-you really have to experience it…And so they definitely learn hands-on best. (BREWER TBI, p. 5)

This response was reflective of Transitional beliefs about student learning because it focused on the engagement of students in activities to promote learning.

Brewer's instructional practices. This investigator observed Brewer's third period class seven times for a total of 424 minutes. The class consisted of 21 students. Of the 424 minutes, Brewer instructed his students 89% of the observation time, or 378 minutes. The lessons consisted of four Discussions, two Traditional Hands-on activities, and one Structured Inquiry (see Appendix B Figure B.3).

All of Brewer's lessons coded as Discussion involved engaging students in note taking. During the Post Interview, Brewer and this investigator discussed this coding:

I: This first one is the one on symbiotic relationship notes. And this one has been coded … as Discussion because the greatest amount of time you spent discussing. Would you agree with that?

B: Yeah I would. I don't want to say that was generous but I think that reflects mostly what was going on. I mean it was a little bit because they were taking notes from the board, trying to get them to talk about it and not just write.

I: One of the things I will say on the outset is that most of your note taking I coded as Discussion. I don't think I coded any of it as Direct Instruction simply because you do a very good job of asking questions and prompting your students during the note taking.

B: Yeah.

I: Direct Instruction notes would be the students sitting quietly…

B: I gotcha.

I: You flipping through the slides and them writing down the information.

B: Yeah. Yeah. That makes me nervous because I don't think they are learning anything when they are not talking. [we laugh] (BREWER Post Interview, p. 6)

After this exchange, Brewer completely agreed with the coding of this lesson and lessons on Carbon Cycle and Climate, Land and Sea Breeze, and Hurricanes and El Nino as Discussion lessons.

Brewer's lessons coded as Traditional Hands-on were the Rock Cycle Webquest and Wood Block Landforms lessons. During the Post Interview, this investigator and Brewer agreed that these two lessons were Traditional Hands-on because the students worked in pairs or groups manipulating items in order to come to a specific, teacher directed outcome.

Brewer also facilitated a Structured Inquiry lesson titled Model Mountains. As we discussed his Traditional Hands-on lessons, Brewer asked for clarification for what a Structured Inquiry lesson would involve. The conversation was as follows:

B: And when you said, and I am just curious, I am not disagreeing with you or anything, but when you had the Structured Inquiry, what would Structured Inquiry look like?

I: Let me show you an example [I turn to the graphic of his Structured Inquiry lesson] It is this one. This one is when they were making the models of mountains with clay. The difference between, I see, Traditional Hands-on and Structured Inquiry is with this one basically they were given this clay and they were given instructions but they were to develop their own information that they could look at and analyze.

B: I see.

I: And so here [referring to the Rock Cycle Webquest], it was just information that they were gathering.

B: Yeah, right.

I: But here [referring to the Model Mountains lesson], that's why that day I asked you about what they were doing afterwards, the next day…

B: Oh yeah.

I: And you kind of explained to me about how they were going to make the topographic maps…And so that is why I coded that as Structured Inquiry because they went through the process of gathering the information but you weren't looking for a certain correct answer. All of their answers were different and they were responsible for analyzing it.

B: A little more open ended.

I: Umhm. More open ended.

B: Okay. (BREWER Post Interview, p. 6-7)

Within this conversation and others, the investigator was intrigued by Brewer's desire to know more about inquiry and how to move more towards this form of instruction. As the conversation on his instructional practice concluded, he noted, "It would be really helpful for me to see how I could do [Authentic Inquiry], so I could talk to [my principal] about professional development or something" (BREWER Post Interview, p. 8).

Consistency of Brewer's epistemological beliefs with his instructional practice. In addition to determining Brewer's epistemological beliefs and instructional practices, this investigator compared how consistent his beliefs were with his instructional practices.

Overall, Brewer's epistemological beliefs were Transitional (see Table 4.1). As noted in Appendix A Table A.2, these beliefs focus on teacher/student relationships, subjective decisions, or affective response. Additionally, these beliefs are at the midpoint between teacher centered and student centered instruction.

The method of instruction used most by Brewer was Discussion (see Appendix B Figure B.9). As noted in Appendix A Table A.1, in this form of instruction, students, in whole or small group settings, respond orally or in writing to questions posed by the teacher, guest speaker, or other students. This form of instruction is teacher focused.

For Brewer's epistemological beliefs to be consistent with his instructional practice his beliefs would need to be Instructive or his instructional techniques would need to engage students in more Traditional Hands-on and/or Structured Inquiry lessons. The instructional technique he used most, Discussion, is most aligned with Instructive beliefs because it is teacher centered and also takes into consideration the engagement of students. On the other hand, to be more consistent with his Transitional epistemological beliefs, his instruction would need to include more Traditional Hands-on and/or Structured Inquiry lessons because both Transitional beliefs and these two forms of instruction focus on the teacher guiding students to develop understanding and process skills.

Impact of Brewer's epistemological beliefs on authentic inquiry. Lastly, this investigator used this study's proposition to explore how Brewer's epistemological beliefs impacted his use of Authentic Inquiry in his science instruction. Brewer did not have Reform-based epistemological beliefs, as indicated by his TBI and he did not use Authentic Inquiry as a form of instruction, as indicated by observations. Additionally, Brewer did not have any science education experiences, as indicated by his Science Education Experiences Interview (SEEI), to promote his understanding or value of Authentic Inquiry as an instructional method.

When asked about the impact of his beliefs on his use of Authentic Inquiry, Brewer stated:

> B: Yeah. I think that question gets to the heart of why teachers get burned out…I would love to do more open ended inquiry…I don't feel like I am teaching necessarily like I believe as much as I would but mainly because I feel like just the restraints of the job, particularly dealing with the problems that come with the kind of socioeconomic situation a lot of our kids come from…I would love to do more Authentic Inquiry but I feel like given the importance of the TAKS test due to accountability reasons and finance reasons, because of a lot of the socioeconomic reasons, it is difficult. And maybe even personal reasons with family and all that kind of stuff. (BREWER Post Interview, p. 9)

Brewer was correct in that he does not teach the way he believes. Although he is at a point in his beliefs where he could transition to more student focused, inquiry lessons, he continues to teach lessons that are more teacher focused. As this investigator ended the Post Interview, the following exchange occurred:

> I: [A]fter reflecting over the period of time I observed and your science teaching experiences, what (if anything) will you change about the way you teach science in the future?
>
> B: Oh yeah, that's good. I think it just continues to confirm to me the importance of student centered intrinsic motivation. I really do think I need training in that regard

> and so I think I would continue [to] seek out that kind of professional development, and try to figure out ways to take lessons that are good and cover the content, and make them more where they are leaning towards that Authentic Inquiry. (BREWER Post Interview, p. 9)

This statement indicated Brewer's desire to teach using more authentic forms of inquiry, but also his realization of the need for experiences that would help him better understand this form of instruction.

Case 2: Lynn (pseudonym)

Lynn taught undergraduate and graduate Biology courses at a private Baptist university in Central Texas. The university was classified as a doctoral institution with an undergraduate and graduate enrollment of approximately 14,400 students. Thirty-five percent of the 2009-10 freshman class was classified as minorities. The estimated undergraduate cost of attendance for the 2009-10 school year was $18,375.

Lynn has taught science for 15 years. When asked about his decision to become a science professor he stated, "I don't think I actually decided. I just kind of ended up going that direction" (LYNN SEEI, p. 1). He discussed how he had planned to teach on the secondary level, and had even received his secondary teaching certification, but had the opportunity to work full-time on his master and Ph.D. degrees in Biology. He readily admitted that becoming a science professor was not something he had even considered until he began to work on his Ph.D.

Lynn has taught at his current university for two years. His teaching responsibilities included teaching large, freshman level and small, upper level courses. When asked what has been the greatest influence on how he teaches science, he indicated two factors:

experiences he's had as a science teacher and his mentorship relationship with a recent visiting professor. He emphasized that through his experiences as a science teacher he has learned the importance of exploration. His mentor confirmed the importance of exploration for him but also has shown him the importance of student ownership over an idea.

Lynn's epistemological beliefs. Lynn's beliefs about knowledge spanned from Traditional to Transitional (see Table 4.2). During his TBI the following exchange occurred regarding his Traditional belief:

> I: How do you decide when to move on to a new topic in your classroom?
>
> Lynn (L): [I]t is about looking at your topic, looking at the fundamentals of what that topic is-what they will need in the future. (LYNN TBI, p. 12)

This response truly reflected a Traditional belief because it was based on when fundamental concepts were covered.

Lynn's Instructive belief about knowledge related to what he decided to teach in his courses. His belief was clearly Instructive because his decision was based on what he felt his students needed to know for their next courses.

Lynn also had one Transitional belief about knowledge and that belief related to his role as a teacher. In the exchange below, he emphasized the importance of developing students' conceptual knowledge and developing them personally, characteristics of Transitional beliefs:

> L: Oh that can take on a lot of different areas there…My responsibility as a teacher is to make sure that we cover the content they will need for those next classes because it is a gateway class for the rest of Biology. So my first job as a teacher is to make

Table 4.2

Lynn's Epistemological Beliefs

TBI Questions Beliefs About Knowledge	Teacher Centered <----------------> Student Centered Trad.	Instr.	Trans.	Resp.	Reform
How do you describe your role as a teacher?			F&U-L		
In the school setting, how do you decide what to teach and what not to teach?		F&U-L			
How do you decide when to move on to a new topic in your classroom?	F&U-L				
Beliefs About Learning					
How do you maximize student learning in your classroom?	F-L	U-L			
How do you know when your students understand?		F-L		U-L	
How do your students learn science best?			U-L		
How do you know when learning is occurring in your classroom?			U-L		

Note. "F" represents beliefs related to large, freshman level courses and "U" represents beliefs related to small, upper level courses. "F&U" represents beliefs that were the same for both large and small courses.

> sure we cover the concepts and content that they need. The second job as a teacher, I try to do, is really try to give them applications to what they are learning. Meaning that what we cover in the first chapter is just as important in the last chapter as the first chapter…So really trying to give them a picture of the holistic part of the

topic…Now that's your subject material.…I look at it also as you are a mentor…Then we also have the ethical side, the ethics and the morality. As a teacher I also try to get across that in science we are looking for the truth. And how hideous the truth might be, we are looking for the truth and sometimes that requires us to have to make some tough decisions about integrity in science. So as a teacher I try to do more than just content; I try to link. Because you are by definition, standing up in front of that classroom, you are an example. They are going to model you as an example. Period. (LYNN TBI, p. 10)

Lynn's focus in this response on content, mentoring, and ethics truly emphasized the key cognitive and affective characteristics of Transitional beliefs.

Lynn's beliefs about learning for his small, upper-level classes, similar to the one this investigator observed, ranged from Instructive to Responsive (see Table 4.2). This investigator coded Lynn's beliefs about how students learn best as Transitional because he mentioned the importance of application and learning by doing. When asked about how he knows learning is occurring in his classroom, his belief was also coded as Transitional due to the following response:

L: You can just hear the eureka moments there when they figure it out…again it comes [to] that possession, they figure it out. It is not when I figure it out, when they figure it out and if it's a fish class and they can pick up a fish and they can look at it and know what it is without reading about it, then you can tell. They will pass that off and say oh that's what that is. You know they know what they're talking about. Same thing for the students we had in the spring. They didn't know what one plant was versus another plant out there. But by the time they got half way into the

> semester they knew what a bull rush was and a cattail was. They said it verbatim; I didn't know what one plant was versus another but now I know what they are. They will express that they know what's going on. (LYNN TBI, p. 13)

This response clearly demonstrated the cognitive and affective qualities of Transitional beliefs.

On each side of the instructional spectrum, more teacher centered and more student centered, was Lynn's belief about how to maximize student learning and his belief about how he knows when his students understand, respectively. When asked how he maximized student learning in the classroom, his beliefs were coded as Instructive because he spoke of how he monitored student actions and behaviors during instruction and field experiences and how he thought about and monitored student understanding. When asked how he knew when his students understood, Lynn described what would become his only Responsive belief. His comments were as follows:

> L: Now for the research course that we just finished, you can just ask them questions about why they did stuff and if they know what they are talking about, they will be able to go back through and logically process how they got to that and explain how they go to that…This is all application of what we learned in the textbook and then through labs. Then I started asking them questions. Does this water chemistry data make any sense? Is it right? Does this data here make any sense? Then the next level is, do they link, is there any linkage here? Does this plankton data; does it link to invertebrate data? Can you draw a linkage through there? Do those numbers mean something to each? As a group they did a great job explaining every number

> about what was going on and they understood what was going on… (LYNN TBI, p. 11)

Based on this response, Lynn's belief about knowledge was coded as Responsive because Lynn discussed how he wanted his students to use presented/teacher directed information and how his students defended what they learned through their experience.

This investigator noted, as outlined in Table 4.2, that Lynn often spoke of the differences between his large, freshman level General Biology course and his smaller, upper level courses, such as the research class this investigator observed and his Ichthyology class. The investigator noted that his beliefs about knowledge were the same for both larger and smaller classes but differences existed in his beliefs about learning based on the size of the class.

Lynn's instructional practices. This investigator observed Lynn's BIO 4333 course, Student Leadership: Improving Science Education, eight times for a total of 538 minutes. There were 18 students enrolled in this small, upper level course. Of the 538 minutes, Lynn instructed his students 65% of the time, or 351 minutes. The lessons consisted of three Direct Instruction lessons and four Discussions (see Appendix B Figure B.10). One of the sessions observed was not coded because it was an exam day.

All three of Lynn's Direct Instruction lessons were led by his students. Although two of the three lessons involved a significant amount of discussion, they were coded as Direct Instruction because this method of instruction occurred for the majority of the lesson. Observation five, Grant Idea Sharing, was strictly a Direct Instruction lesson for the following reasons:

> I: Then five I've coded as Direct Instruction. And this was Grant Idea Sharing, and this was basically when the students stood before the class and shared their ideas about grants. Unlike this one that was more of a discussion, this one this was strictly they just stood up and posted their stuff, and they just talked about it, so I coded that one as Direct Instruction. (LYNN Post Interview, p. 6)

Because there was minimal interaction between the students presenting and those in the class, this lesson was coded as Direct Instruction.

Most of Lynn's lessons, whether led by him, his students, or guest presenters, were Discussions or contained a significant amount of discussion. Of the four lessons coded as Discussion, Lynn led two, guest presenters at a local museum led one, and his students led one.

The two lessons Lynn facilitated included a discussion of the students' experiences while teaching a lesson in a local school and a lesson on technology in education. These lessons involved Lynn engaging students in conversations using questioning skills and prompting them for feedback.

The Discussion lesson held at the museum differed greatly from the other Discussion lessons because it also incorporated some moments of hands-on activities as students went through the museum. The investigator and Lynn mentioned this difference during the Post Interview:

> I: And then this one I coded as Discussion; it was the museum visit. And one of the things I noticed about that one is that the students spent a lot of time interacting with the presenters, so there was a lot of questions and answer there. Although there was a

little Traditional Hands-on and some Direct Instruction, it was mostly Discussion. Do you agree with that? Okay.

L: Very different. Very different ones there.

I: Yes, very different. And that was interesting to see… (LYNN Post Interview, p. 6)

The last example of a Discussion lesson was the student led Final Grant Idea Sharing lesson. It was coded as Discussion because it was purely that; the students were interacting and questioning, and Lynn and the students provided feedback.

As this investigator wrapped up the conversation regarding Lynn's instructional techniques, he posed a very interesting question regarding his teaching as indicated in the following exchange:

I: As you reflect over the period of time I observed your teaching, what were some of your most outstanding teaching moments?

L: Mine or theirs?

I: That's what's interesting in yours. I saw your students, and you might speak to that, because I am observing a lot of different teachers, and so far, out of all of the teachers I am observing, your students spend the most time engaging their classmates. And so that changed the coding that I was using, which was an interesting perspective. But although they were presenting, it was how you orchestrated because you made the decision, this is how I want this information presented. (LYNN Post Interview, p. 7)

Although Lynn facilitated most of his lessons, it was interesting that he brought up the fact that most of the lessons involved his students or guest speakers presenting or engaging his students during the lesson and because of this, he felt that I observed their teaching more so than his. He stated his reason for choosing this format of instruction:

> L: It's just something that I observed over many years of watching students. That one skill set that they need to develop is presentation, speaking to a group…It is just one of those skill sets that as a citizen that you need to be able to speak your mind. And I think the more times you do it, the better, easier it gets…And I think that is a component that a university needs to have in its courses is presentations. (LYNN Post Interview, p. 9)

Consistency of Lynn's epistemological beliefs with his instructional practice. In addition to determining Lynn's epistemological beliefs and instructional practices, the investigator compared how consistent his beliefs were with his instructional practices. Overall, Lynn's epistemological beliefs for his small, upper-level classes were Transitional (see Table 4.2). As noted in Appendix A Table A.2, these beliefs focus on teacher/student relationships, subjective decisions, or affective response. Additionally, these beliefs are at the midpoint between teacher centered and student centered beliefs.

The method of instruction used most by Lynn was Discussion (see Appendix B Figure B.10). As noted in Appendix A Table A.1, in this form of instruction, students, in whole or small group settings, respond orally or in writing to questions posed by the teacher, guest speaker, or other students. This form of instruction is teacher focused.

For Lynn's epistemological beliefs to be consistent with his instructional practice his beliefs would need to be Instructive or his instructional techniques would need to include more opportunities for Traditional Hands-on and/or Structured Inquiry lessons. He would need more Instructive beliefs because his method of teaching was mostly

Discussion, and like Instructive beliefs, this method of instruction is teacher centered but also takes into consideration the engagement of students. On the other hand, to be more consistent with his Transitional epistemological beliefs, his instruction would need to include more Traditional Hands-on and/or Structured Inquiry lessons because both Transitional beliefs these two forms of instruction focus on the teacher guiding students to develop understanding and process skills.

Impact of Lynn's epistemological beliefs on authentic inquiry. This investigator used this study's proposition to also explore how Lynn's epistemological beliefs impacted his use of Authentic Inquiry as a form of science instruction. Lynn did not have Reform-based epistemological beliefs, as indicated by his TBI, and he did not use Authentic Inquiry as a form of instruction, as indicated by observations. Additionally, Lynn did not express during his SEEI that he had any experiences to promote his understanding or value of Authentic Inquiry as an instructional method.

When asked about the impact of his beliefs on his use of Authentic Inquiry, he stated:

> L: In my undergraduate, freshman level class I am more Traditional from that stand point because I want to make sure they have that knowledge but then I want to see them kind of use that knowledge or re-examine the use of that knowledge because a lot of times they've been using science their whole lives…And so I like to try to do the content but then tie it to, Biology is an every day use of concepts. We use them every day; we just don't call it that. And I really try to draw that out…I think that's what my beliefs are, just trying to really expose them to the things that they are doing, that we talk about in class are actually going on around them. Give them a better

appreciation for Biology and what's going on around them. (LYNN Post Interview, p. 10)

When asked if there was anything he would change about his teaching or the course that this investigator observed after participating in this study, Lynn responded:

> L: I think I am…trying to figure out ways that are comfortable with me [he laughs] that I can integrate more discussion even in my freshman level Biology class than I have in the past. This class, the upper level class you observed, it is going to pretty much stay the same just adding more directed content. (LYNN Post Interview, p. 10)

This response, along with other comments noted from his interview, reflected Lynn's struggle to move beyond his comfort level of discussion based teaching to incorporate more exploration and inquiry in his teaching.

Case 3: Michelle (pseudonym)

Michelle taught 9th grade Biology and 12th grade Anatomy/Physiology at a high school within a rural public school district in Central Texas. The school's 2009 accountability rating was Recognized, unlike the district's Academically Acceptable rating. The school's 2008-09 student population was 82% Caucasian, 15% Hispanic, and 3% African-American, similar to the district's ethnic distribution. The school reported that for the 2008-09 school year, 41% of its students were economically disadvantaged compared to 58% of the district's enrollment.

Michelle was a first year science teacher. Her decision to become a science teacher was influenced by several members of her family who were teachers, her enjoyment of Biology and science, and influential teachers throughout her educational experience. Michelle completed a traditional certification program at a private Baptist university in

Central Texas. When asked what has been the greatest influence on how she teaches science, she indicated her student teaching experience.

Michelle's epistemological beliefs. Most of Michelle's beliefs about knowledge were Instructive (see Table 4.3). When asked how she decides what to teach and what not to teach, Michelle spoke a lot about her experiences as a student teacher and using those experiences to assist her with knowing what to teach. This method of decision making reflected Instructive beliefs because her decision was based on her own direction. Additionally, her decisions to move on to the next topic were Instructive because she used information, both verbal and written, provided by her students to gain feedback about their understanding.

Michelle's only Responsive belief for the study related to her thoughts regarding her role as a teacher. Originally this investigator coded her role as Instructive because during the TBI she stated:

> Michelle (M): I think as a teacher it is important to be a facilitator. To help the students with their learning but at the same time they need to be responsible for their own learning. So you're up there more as a guide than just telling them everything. It is important to remain the authority figure but the teacher's job is more to guide their learning. (MICHELLE TBI, p. 3)

As this investigator analyzed her response, she began to question what Michelle meant by guide, so the investigator aimed to clarify this during the Post Interview when the following exchange occurred:

> I: When I asked you to describe your role as a teacher, you commented that you are there to guide their learning. What do you mean by this?

Table 4.3

Michelle's Epistemological Beliefs

TBI Questions Beliefs About Knowledge	Teacher Centered <----------------> Student Centered Trad.	Instr.	Trans.	Resp.	Reform
How do you describe your role as a teacher?				M	
In the school setting, how do you decide what to teach and what not to teach?		M			
How do you decide when to move on to a new topic in your classroom?		M			
Beliefs About Learning					
How do you maximize student learning in your classroom?		M			
How do you know when your students understand?			M		
How do your students learn science best?		M			
How do you know when learning is occurring in your classroom?			M		

M: Basically that it is not just me standing up at the front talking to them every single class period, every single day. On the days that we do do notes, I try to get the students involved as well in discussing and asking questions as we go along and get them involved so I am not the only one talking. When we do labs I give them the procedures to follow but I try to let them figure it out for themselves. And I will come by and give assistance where needed or hints where needed, but I just don't stand there and set up the lab for them or anything like that. I help them where they need it but I try to let them be more independent with everything we do.

I: Okay. When you consider that response that you just gave me, do you find it more your responsibility to provide experiences for them, or to facilitate their development of understanding and skills, or do you just let them go loose and let them take charge of their own learning?

M: I think for some of my classes I think it would be kind of scary if I just let them go loose. They definitely do need some guidance, so um, I will, it depends on the lab, sometimes I will create a lab where it is very straight forward what they need to do but sometimes it is more they get to develop the procedure for it. So it really just depends on the situation. So I guess it is a little of both. (MICHELLE Post Interview, p. 1-2)

Even after this exchange, this investigator needed more clarity regarding the response, so she used the prompts from the conceptual map of this question (Appendix B Figure B.2) as a guide to verbally clarify Michelle's response. Michelle stated:

M: That would be my ultimate goal, for the students to take responsibility for their own learning. We're working on that direction, but it is not just something that can happen overnight. We've made progress throughout the year. That's my ultimate goal; for them to take responsibility for their own learning and what they do.

I: Okay. So you see that as your role as a teacher.

M: Right. (MICHELLE Post Interview, p. 4)

Then this investigator stated that she had originally coded this belief as Instructive but based on their discussion she would code it as Responsive. The investigator stated:

I: You said that you really see yourself-your ultimate goal is to get your students to take charge of their learning, which is more Responsive in nature. A Responsive teacher basically focuses on collaboration between the teacher and student. An example is that you set up your classroom so that your students can take charge of their own learning. So that is your ultimate goal. Although you feel like that is your ultimate goal, do you feel like you spent that time this school year so far getting them toward that goal?

M: Yes. (MICHELLE Post Interview, p. 4)

With this confirmation, this investigator coded Michelle's belief about her role as a teacher as Responsive.

Half of Michelle's beliefs about learning were Instructive and the other half were Transitional (see Table 4.3). When asked how she maximizes student learning, Michelle's comments centered on her need to receive responses from students and to monitor their actions and behaviors during activities, which are all characteristics of Instructive beliefs. The following comments of this investigator provided details about her second belief about learning coded as Instructive:

I: Then question six, how do your students learn science best. I've coded that as Instructive. Originally I had it as Transitional but as you talked today… you really said that demonstration is key and so that's an instructive characteristic.

(MICHELLE Post Interview, p. 5)

Michelle had two Transitional beliefs about learning. The first addressed how she knows when her students understand. Michelle explained that she does not always look for a correct answer but for her students to be able to provide explanations regarding their responses; this is a key characteristic of Transitional beliefs. The following was stated regarding her second Transitional belief about learning:

> I: And how do you know when learning is occurring in your classroom?
>
> M: I think you can kind of see kind of the light go on in some of the faces of the students. When you have their attention at least some kind of learning is going on. And so if you have the students actively engaged in the activities. (MICHELLE TBI, p. 5)

This investigator coded this response as Transitional because Michelle talked a lot in her interview about the noise level and the "aha" moments, and teachers with Transitional beliefs use these subjective responses to draw conclusions about student learning.

Michelle's instructional practices. This investigator observed Michelle's second period 9th grade Biology class nine times for a total of 396 minutes. There were 15 students in the class. Of the 396 minutes, Michelle instructed her students 76% of the time, or 300 minutes. Her lessons consisted of four Discussions, three Traditional Hands-on activities, and one Direct Instruction lesson (see Appendix B Figure B.11). One of the sessions observed was not coded because it was an exam day.

Most of Michelle's four Discussion lessons involved note taking. These lessons included note taking on Human Traits, Meiosis, and Genetic Technology. They were coded as Discussion because during note taking students had many opportunities to respond to questions and prompts and to ask questions. For example, during the Genetic Technology notes Michelle began to talk about the gene gun and the following questions came from students with Michelle's responses:

> Student 1: Could you shoot someone with that?

M: Don't know if they would feel it or not.

Student 2: So they shoot it?

M: Yeah. (MICHELLE Lesson Script 11-09-2009, p. 3)

An additional Discussion lesson was the Genetics Worksheet and Test Review. This lesson involved the students working in groups to discuss and complete a genetics review packet and test review questions.

Three of Michelle's lessons were coded as Traditional Hands-on. During the first lesson, students were responsible for cutting out DNA and RNA strands to prepare for the next day's activity. The lesson was coded as Traditional Hands-on because the students sat in groups, worked with materials, and completed a task the teacher gave them. The same was true for the two additional Traditional Hands-on lessons, the Micro-community Lab and the Mark and Recapture Activity.

Michelle's lesson titled The Practice Test was her only lesson coded as Direct Instruction. Although some discussion occurred during this lesson, a little over 50% of the time was spent in Direct Instruction. The greatest amount of Direct Instruction occurred as students quietly sat at their desks writing responses to practice questions within the PowerPoint notes. Once complete, Michelle discussed the correct responses for the questions.

At the end of the discussion regarding the coding of Michelle's lessons, the following exchange occurred:

I: One of the things that I will point out is that it is interesting how when I began there was a lot of discussion but towards the end there was a lot more Traditional Hands-on. Is there any reason why this progression has occurred?

> M: I think part of it has to do with the topic. Some topics are more, there's definitely more hands on stuff to do with them than others. And another part of it probably has to do with, since this is my first year of teaching, as I've gone through the year, I've gotten more comfortable, so I can branch out, I am comfortable with the students and I am comfortable with what I am doing, and so we are ready to take it to the next level. (MICHELLE Post Interview, p. 7-8)

Michelle's response indicated her desire to continue to move toward more reformed based instructional methods.

Consistency of Michelle's epistemological beliefs with her instructional practice. In addition to determining Michelle's epistemological beliefs and instructional practices, this investigator compared how consistent her beliefs were with her instructional practices. Overall, Michelle's epistemological beliefs were Instructive (see Table 4.3). As noted in Appendix A Table A.2, teachers with these beliefs focus on providing experiences, and these beliefs are often focused on the teacher and the decisions that she makes. Therefore these beliefs are teacher centered.

The method of instruction used most by Michelle was Discussion (see Appendix B Figure B.11). As noted in Appendix A Table A.1, in this form of instruction, students, in whole or small group settings, respond orally or in writing to questions posed by the teacher, guest speaker, or other students. This form of instruction is teacher focused.

As a whole, Michelle's epistemological beliefs were consistent with her instructional techniques. As a teacher with mostly Instructive beliefs, the use of Discussion as a primary means of instruction matched her beliefs because Discussion allowed her to provide learning experiences that engaged her students while also allowing her to provide some direction in the process.

Impact of Michelle's epistemological beliefs on authentic inquiry. This investigator used the study's proposition to also explore how Michelle's epistemological beliefs impacted her use of Authentic Inquiry as a form of science instruction. Michelle did not have Reform-based epistemological beliefs, as indicated by her TBI and she did not use Authentic Inquiry as a form of instruction, as indicated by observations. Michelle expressed during her SEEI that she had an experience to promote her understanding or value of Authentic Inquiry as an instructional method. This experience was her undergraduate science methods course. She described the experience:

> M: It was taught very inquiry based, so the course was taught in alignment with the National Science Standards and the state science standards. A lot of it was learning how to use inquiry in your own classrooms, and we got to do that by experiencing these types of experiments ourselves. Instead of just lecturing, it was much more hands on. (MICHELLE SEEI, p. 2)

When asked about the impact of her beliefs on her use of Authentic Inquiry, she stated:

> M: I know when we first started everything I was just, "Inquiry, inquiry, inquiry." And that was what my master's project had been over. And I am a firm believer in inquiry still and that it is important to get to that point. But I think my students, and some of them are ready for that point, but the majority of them, like I said earlier are still working towards responsibility for your own learning and taking charge of your own learning. So I think we are working more in that direction and that seems to be

what the data is showing, how we are moving more from the discussion to hands-on, so we are getting there. It is definitely not a process that you can throw the students into especially when they are not used to that or they've been taught a different way their whole lives and now they are in high school science and it's a lot different from middle school science and a lot more is expected of them. I think we are definitely working towards that direction, that's my ultimate goal. When we first talked, I had not had my first year of teaching and things are a lot different once you get in there and you meet your students and all of that.

I: Is it difficult to have the beliefs related to knowledge and inquiry that you have but to have to teach in a situation that does not allow you to really use those techniques to develop the knowledge and knowing of your students?

M: Yeah, it can definitely be difficult at times because I know this is the way I want to teach. I want to teach with the inquiry, but you have to work up to that point. So yeah, that can be frustrating at times but I wouldn't trade this job for anything.

(MICHELLE Post Interview, p. 10)

Michelle again addressed this discrepancy between her beliefs and instructional methods in her closing thoughts of the Post Interview:

I: After reflecting over the period of time I observed and your science teaching experiences, what if anything will you change about the way you will teach science or this course in the future?

M: Well since this is my first year I am really building up my curriculum and the activities that I want to include, so definitely keep going in the hands-on direction, even for those topics that are hard to find hands-on, figure out some kind of way to

> get those hands on activities and even move more towards the inquiry activities. Because what I want my classes to be is very little time with Direct Instruction and notes and most of the time with students collaborating, working together and discovering and so I think cause you can have the loftiest goals and the greatest ideas in the world and believe how you need to teach and all of that but each situation is different and you have to adjust to that. So sometimes your beliefs and ideas you have to put aside for a certain situation. Not in every case, not necessarily put them aside. I'm sorry, I'm kind of rambling. Not necessarily put them aside, but you are constantly having to be flexible and readjust and reflect and go back, reflect and go back on how you teach. So I think the more I teach the more easily I will be able to incorporate my ideas and beliefs. (MICHELLE Post Interview, p. 10-11)

Case 4: Yajaira (pseudonym)

Yajaira taught 10th and 12th grade Biology at a high school within an urban public school district in Central Texas. The school's 2009 accountability rating was Recognized, unlike the district's accountability rating that was Academically Unacceptable. The school's 2009-10 student population was 55% Hispanic, 30% African-American, 14% Caucasian, and 1% Asian/Pacific Islander, similar to the district's ethnic distribution. The school reported that for the 2008-09 school year, 79% of its students were economically disadvantaged compared to 83% of the district.

Yajaira has taught for five years, two of which she has taught science. Her decision to become a science teacher was influenced by her experiences related to teaching, such as serving as a tutor in college and training people in the business industry. She became particularly interested in teaching science due to her background in medical technology and working in labs, so she completed an alternative certification program through an urban school district in North Texas.

Yajaira's school was a magnet high school. The school's emphasis was on careers in engineering, business, entrepreneurship and technology. During the school year of observations, 2009-10, the school underwent renovations to improve the facility.

When asked what has been the greatest influence on how she teaches science, Yajaira mentioned that her students greatly influence how she teaches. She stated it was important for her to receive their responses and feedback and this student input caused her to reflect on how she can improve her teaching.

Yajaira's epistemological beliefs. Most of Yajaira's beliefs about knowledge were Instructive (see Table 4.4). When asked how she decides what to teach and what not to teach, her response was:

> Yajaira (Y): [W]e try to integrate the scope and sequence with the minimum requirements of the TAKS. But that's basically more our big picture, the scope and sequence, and from there on we break it down into different units so it could fit the kids' needs and our needs too. But that's the backbone, if you want to put it that way, the scope and sequence. (YAJAIRA TBI, p. 3)

This response clearly demonstrated Instructive beliefs because Yajaira mentioned that the lessons must meet the students' and teachers' needs. Plus, when asked how she decided to move on to a new topic in her classroom, Yajaira stated:

> Y: I am going to move on when time is right. When I have that feeling, be it formal or informal, that my kids are getting their stuff how they should get it; then we move

on. (YAJAIRA TBI, p. 4)

Her concern about student mastery of content demonstrates Yajaira’s Instructive belief.

Table 4.4

Yajaira’s Epistemological Beliefs

TBI Questions	Teacher Centered <----------------> Student Centered				
Beliefs About Knowledge	Trad.	Instr.	Trans.	Resp.	Reform
How do you describe your role as a teacher?			Y		
In the school setting, how do you decide what to teach and what not to teach?		Y			
How do you decide when to move on to a new topic in your classroom?		Y			
Beliefs About Learning					
How do you maximize student learning in your classroom?		Y			
How do you know when your students understand?		Y			
How do your students learn science best?			Y		
How do you know when learning is occurring in your classroom?			Y		

Yajaira only had one Transitional belief about knowledge. This belief was related to her role as a teacher. When asked about her role, she stated:

Y: We have different hats on. So it is not only the teacher that brings the content but the teacher that guides the lesson. The teacher that if you need to be a psychologist,

> we turn into a psychologist. If you need to be a mommy, you turn into a mommy. You know because the kids we serve here come from very non-structured homes, so we have different hats here. It's just not only teaching content. (YAJAIRA TBI, p. 3)

The response above reflected the cognitive and affective qualities of Transitional beliefs.

Half of Yajaira's beliefs about learning were Instructive and the other half were Transitional (see Table 4.4). When asked how she maximizes student learning in her classroom, Yajaira discussed the use of hands-on activities and graphic organizers in order to monitor the actions and behaviors of her students. These characteristics are related to Instructive beliefs. Additionally, the following exchange occurred to clarify a response from her TBI:

> I: And then question three during that interview, how do you know when your students understand? You said you like for them to tell you what they know. When they tell you what they know, are you looking for them to give a correct answer/explanation or do you expect them to talk about the information in new ways or to question?
>
> Y: Yeah. I like to try to provoke them so they can paraphrase in their own words, which is really hard. And that's what I am looking for or if they are trying to explain it to somebody else. Okay, I see, you're understanding it if you are able to explain it to a friend or if you are able to explain it to me in your own words. Those are my intentions when I am looking for comprehension. (YAJAIRA Post Interview, p. 2)

Based on her response this investigator coded this belief as Instructive because she expects her students to reiterate or demonstrate their knowledge of the information presented.

The other two beliefs Yajaira had about learning were Transitional. When asked how her students learned science best, the investigator coded her response as Transitional because she spoke of them learning using procedures and guidelines found in labs and hands-on activities. Additionally, her beliefs about how she knows when learning occurred in her classroom were Transitional. Yajaira provided the following statement:

> Y: If they're engaged within themselves and in their groups and they are asking questions related to what we are talking about…When they are asking me questions related to what we are talking about. When they are able to answer questions that I pose to them related to what we are talking about. Those type of indicators. (YAJAIRA TBI, p. 5-6)

This statement clearly reflected the subjective decisions Yajaira made about her students during the learning process, a characteristic of Transitional beliefs.

Yajaira's instructional practices. This investigator observed Yajaira's second period 10th grade Biology class six times for a total of 385 minutes. There were 23 students in this class. Of the 385 minutes, Yajaira instructed her students 57% of the observation time, or 220 minutes. The lessons consisted of five Discussions and one Direct Instruction lesson (see Appendix B Figure B.12). It is important to note that Yajaira was required to provide Accelerated Reading (AR) time every day for her students. The amount of this time varied but on average occurred for 15 minutes and was not coded within her instructional time.

Two of Yajaira's Discussion lessons were note taking and the other three were the oral completion of worksheets. The two note taking lessons were on Human Body Systems and the Lytic Cycle. The following was a segment from the Human Body Systems Discussion lesson:

> Teacher directs attention regarding integumentary system and instructs that they will take notes on their foldables regarding this system. Students get out foldables and begin to write. Teacher monitoring and leading discussion about what they are writing by questioning and student response. (YAJAIRA Lesson Script 03-01-2010, p. 4)

This segment represented Yajaira's style of note taking in which she engaged students in questions and discussion as they completed their note taking. Thus her note taking lessons were coded as Discussion. The same was true of lessons that she used worksheets to guide discussions. Either she or selected students would read parts of the handouts and either through her questions or the questions of students, discussion would occur regarding the information and questions presented on the handouts, so all of her lessons that included the use of worksheets to guide the discussion were coded as Discussion. These included worksheets on Life's Diversity, Classification, and DNA and RNA.

Yajaira's only Direct Instruction Lesson was titled The Case: Flowers for Freddy. Although designed to be a Traditional Hands-on activity, the lesson did not occur using this method. Instead, the students only experienced the introduction to the lesson that involved them listening to the teacher and students reading the introduction and purpose of the investigation, a method of Direct Instruction. The students only experienced this portion of the lesson because Yajaira ended the lesson due to their misbehavior and not following directions. From this investigator's point of view, the reason why the students were not able to behave and stay on task was due to the grouping strategy used. The following was taken from that day's lesson script:

> I wonder why she placed them at two lab pods instead of spread them out (I talked to her about this at the end of class as she approached me with a frustrated look). I expressed that I have experienced the same thing. She said she was trying to figure out what she did wrong. [She] mentioned that she told them not to touch. I suggested splitting them up more. She stated that two of the eight stations still have boxes on them and the additional two stations are set up for 7th period science fair lab. [She] doesn't want them to touch those items. I suggest either split on lab desks or have them do it at their desks. (YAJAIRA Lesson Script 01-25-2010, p. 5)

After students put up their lab goggles and returned to their desks, they were instructed that it was AR time, so the brief amount of instructional time for this day was coded as Direct Instruction due to the fact that the majority of the lesson involved the engagement of students in listening to the introduction and purpose of the activity.

The exchange above was just one example of issues related to classroom management that occurred as this investigator observed Yajaira. Yajaira was concerned about her classroom management and expressed issues related to it often. The following were examples of exchanges that occurred between this investigator and Yajaira regarding classroom management.

I: What were some of your more difficult teaching moments?

Y: [she laughs] You know. When I want to teach and I can't get them in a respectable mode so they can learn. That's really frustrating. It's really frustrating for you to feel hopeless, powerless, that you don't have control and you know you just lose it. And lose it in the sense, because you know I am not a yeller or a screamer…

I: No, you are not. I noticed that about you.

Y: Yeah. No. I just, you know. Many things travel through my mind that I cannot blurt out. That's really frustrating and it's like, okay what do I do now?

I: I saw that on that Flowers for Freddy day.

Y: Uh huh. That was one of those days. [she laughs]

I: I noted in my notes how you just…I was like, she just has this look on her face.

Y: Uh huh. [we laugh] (YAJAIRA Post Interview, p. 9)

Y: For us, this is [she states her full name] opinion, based on this is barely my fifth year of teaching, second year at high school, and what I've observed is that we can get here [referring to inquiry instruction] if we get the help that we need with the students' behavior. Because, oh my God how many things can you do with them if the behavior is manageable if the student has ownership of their learning. If the student has respect for the teacher for the learning. If we can make that change, learning can't take place if there is no change in behavior. And if we are able, I don't know how, because oh we've read books that they give us on classroom management, on the Champs that they want us to implement right now. You could go to any of the rooms and it's the same thing. So what is going on?…I feel that we don't get the help or what I've read I've tried to implement it and it doesn't work. [she laughs] You know what I mean? So I don't know if you have something to say about what I think. (YAJAIRA Post Interview, p. 7)

This investigator noted throughout conversations with Yajaira that she truly has a desire to learn how to better to manage her classes. She recognized her management issues and the issues related to her students' behavior and how they influenced her instruction. She often mentioned how these issues keep her from instructing how she would like, more inquiry based, and have led her to the point where she is considering leaving the teaching field to go back to working in the business industry.

Consistency of Yajaira's epistemological beliefs with her instructional practice. In addition to determining Yajaira's epistemological beliefs and instructional practices, this investigator compared how consistent her beliefs were with her instructional practices. Overall, Yajaira's epistemological beliefs were Instructive (see Table 4.4). As noted in Appendix A Table A.2, teachers with these beliefs focus on providing experiences, and these beliefs are often focused on the teacher and the decisions that she makes. Therefore these beliefs are teacher centered.

The method of instruction used most by Yajaira was Discussion (see Appendix B Figure B.12). As noted in Appendix A Table A.1, in this form of instruction, students, in whole or small group settings, respond orally or in writing to questions posed by the teacher, guest speaker, or other students. This form of instruction is teacher focused.

Overall, Yajaira's epistemological beliefs were consistent with her instructional techniques. As a teacher with mostly Instructive beliefs, the use of Discussion as a primary means of instruction matched her beliefs because Discussion allowed her to provide learning experiences that engaged her students while also allowing her to provide some direction in the process.

Impact of Yajaira's epistemological beliefs on authentic inquiry. This investigator used this study's proposition to explore how Yajaira's epistemological beliefs impacted her use of Authentic Inquiry in her science instruction. Yajaira did not have Reform-based epistemological beliefs, as indicated by her TBI and she did not use Authentic Inquiry as a form of instruction, as indicated by observations. Additionally, Yajaira did not express during her SEEI that she had any experiences to promote her understanding or value of Authentic Inquiry as an instructional method.

When asked about the impact of her beliefs on her use of Authentic Inquiry, she stated:

> Y: I totally believe in student centered learning environment to take place. I totally believe in this, getting them to this level. Probably that's why I am in between Instructive and Transitional. I can feel me, myself struggling to get here because I am conscious that this is the highest gain that our students can obtain in the learning environment. However, I would like to know how can I move from there to get them to this level. But at the same time I answer myself again, but [Yajaira] you know to get them to this level, you have to have this mastered because the classroom management is the ownership from your students and if we have this mastered, classroom management, ownership from the students, respectfulness, that willingness, all those nice words. If I have that I have no doubt that I would be at this level with my students. No doubt. (YAJAIRA Post Interview, p. 10)

Yajaira continued to express her concerns relative to her beliefs about knowledge and knowing and how concerns about classroom management and student behavior hinder her from moving towards inquiry instruction. The following exchange occurred as the Post Interview ended:

> I: After reflecting over the period of time I observed and your science teaching experiences, what (if anything) will you change about the way you teach science (or this course) in the future?
>
> Y: Oh, well that's a tough one. I mean, what would drive me. Once again, I end up saying the same thing. What would drive me to make the changes that I need to take place is if I knew how to make that change in the students. If I knew how to make that inner change in the students it would totally help me improve my lessons because I'm like how can [I] improve my lessons when the lessons are not going to get in them if I don't have that change from them. I don't know how to do that. So if I'm able to find how to make our students have that willingness to learn and all of those elements that they need, it would completely drive my instruction into a more reform-based because I would have that in place. But in the meantime, I am at the middle level, stuck there, stuck there. I can't move on, I can't move on because I don't have this mastered and it's frustrating. That's why I'm like, I don't know if I am the teacher that should be in here because I've cried too much at home. I've cried too much. I've shed too many tears. [she begins to cry] I'm going to get sentimental. I am just tired.
>
> I: Yeah, I know.
>
> Y: I'm really tired. (YAJAIRA Post Interview, p. 10-11)

Cross Case Analysis

The previous section described each of the cases in this study using narrative and graphical displays. As this investigator wrote about and reflected on the cases, themes emerged from the analysis. These themes were first noted from the creation of within-case graphical displays. Themes that guided the within-case findings provided a framework that this investigator used to compare across cases. The following are the trends that emerged from cross case analysis.

Patterns in Epistemological Beliefs

Table 4.5 shows the distribution of beliefs about knowledge and learning, or epistemological beliefs, for all of this study's cases. The distribution was determined using responses from the TBI, and the analysis by examining these responses along with other comments made during the SEEI and Post Interview. There were several patterns that emerged from examining these beliefs:

- Transitional beliefs occurred most during the study. Forty-six percent of the beliefs mentioned by the cases were Transitional beliefs. Brewer and Lynn both had mostly Transitional beliefs but Michelle and Yajaira had mostly Instructive beliefs. What was interesting about Brewer, Michelle, and Yajaira is that they each noted at some point in their interviews that they wanted to teach using inquiry, which they said was more along with their beliefs, but as indicated by their interviews, they did not have the Responsive or Reform-based beliefs that would be associated with inquiry instruction. These comments may demonstrate the cases' lack of understanding regarding the influence their determined beliefs have on their use of inquiry instruction.

- The cases with the least amount of science teaching experience, Michelle and Yajaira, had more teacher centered beliefs than the cases with the most science

Table 4.5

The Epistemological Beliefs of All Cases

TBI Questions	Teacher Centered <----------------> Student Centered				
Beliefs About Knowledge	Trad.	Instr.	Trans.	Resp.	Reform
How do you describe your role as a teacher?			B, L, Y	M	
In the school setting, how do you decide what to teach and what not to teach?	B	L, M, Y			
How do you decide when to move on to a new topic in your classroom?	B, L	M, Y			
Beliefs About Learning					
How do you maximize student learning in your classroom?		L, M, Y	B		
How do you know when your students understand?		Y	B, M	L	
How do your students learn science best?		M	B, L, Y		
How do you know when learning is occurring in your classroom?			B, L, M, Y		

Note. "B" represents Brewer, "L" represents Lynn, "M" represents Michelle, and "Y" represents Yajaira.

teaching experience, Brewer and Lynn. This may demonstrate how over time the cases' beliefs about knowledge and learning may become more behaviorist or affective with more years of experience as a science teacher. Additionally, quality professional development as a science teacher may also play a role. Both Brewer and Lynn mentioned excellent professional development opportunities that they have experienced as science teachers. They both also mentioned mentors they have in the field. Neither Michelle nor Yajaira mentioned quality professional development as science teachers or relationships they have with mentors.

- The most student centered belief about knowledge was the cases' belief about their role as a teacher. As the cases responded to the question, how do you describe your role as a teacher, the responses were much more "idealized" than their other responses related to knowledge. This pattern may demonstrate the influence of what the cases know to be "best practice" in the field of science education for science teachers.
- Beliefs about knowledge were more teacher centered than beliefs about learning. This pattern may demonstrate the influence of accountability mandates on the cases' beliefs about knowledge. It may also demonstrate how their experiences and interests as K-16 and/or graduate students influenced their beliefs about learning.
- The cases on the extreme ends, middle school (Brewer) and post-secondary (Lynn), had beliefs that were more student centered than the beliefs indicated by the high school teachers. This may demonstrate the perceived need from the middle and post-secondary cases to provide experiences that address both the cognitive and affective needs of their students whereas on the secondary level the

perceived needs might be more cognitive in nature.

- None of the cases had the Reform-based beliefs necessary, as set forth by the study's proposition, for Authentic Inquiry to occur in their teaching. This may demonstrate the cases' lack of experiences to assist with their understanding and appreciation of inquiry oriented beliefs.

Patterns in Instructional Practices

Table 4.6 shows the instructional practices of the cases during this study. This distribution of instructional practice was determined by the observations that occurred during this study, and the analysis by the instructional scripts created from observations

Table 4.6

The Instructional Practices of All Cases

	Teacher Focused <--					> Student Focused
Observation	DI	DIS	THO	SI	GI	AI
1	L	B, Y	M			
2	M	B, L, Y				
3	Y	L, M	B			
4		L, M, Y		B		
5	L	M, Y	B			
6		B, L, M, Y				
7	L	B	M			

Note. "B" represents Brewer, "L" represents Lynn, "M" represents Michelle, and "Y" represents Yajaira.

along with information provided by the cases during their Post Interview. There were several patterns that emerged from examining their instructional practices:

- Discussion was the form of instruction that occurred most; it was used by the cases 61% of the time. All of the cases used this form of instruction as their primary means of lesson delivery. This pattern may demonstrate their desire to move past Traditional, Direct Instruction they were all familiar with from their post-secondary science courses.
- The amount of student focused instruction was highest at the lowest grade level and began to decrease as the grade level increased. Brewer, as the middle school science teacher, used the most student focused instruction, and then Michelle, a 9^{th} grade science teacher, Yajaira, a 10^{th} grade science teacher, and the least student centered instruction occurred with Lynn, the post-secondary science teacher. This trend may represent the cases' desired goals for instruction. Brewer noted that he hoped to move toward more inquiry instruction, Michelle wanted to incorporate more hands-on learning, Yajaira wanted to improve her classroom management in order to teach in a more reform-based manner, and Lynn wanted to incorporate more discussion.
- Brewer and Michelle varied their instructional techniques the most, using instructional techniques closer to student focused instruction, whereas Lynn and Yajaira used most of the same methods that were teacher focused. This pattern may represent Brewer and Michelle's preferences regarding how they learn science best through labs, application, and hands-on methods unlike Lynn who mentioned that he did not have opportunities until late in graduate school to have

learning experiences that allowed him to develop his own projects and do field and lab experiences. The same was true for Yajaira who mentioned that she learned science through traditional methods such as note taking and reading textbooks.

- Direct Instruction occurred more with Lynn than the other cases. Lynn was the only case to mention a concern regarding teaching science the way he was taught. This instance of him using Direct Instruction the most may represent the influence of Traditional learning experiences on science teaching.
- The only instance of inquiry teaching occurred when Brewer used Structured Inquiry. Brewer was also the case that emphasized the most his desire to learn how to use inquiry as a method of science teaching.

Patterns in the Consistency of Epistemological Beliefs with Instructional Practice

Table 4.7 provides information regarding the consistency of the cases' beliefs with their instructional practice. The pattern that emerged was that Michelle and Yajaira both demonstrated beliefs and instructional practices that were consistent whereas Brewer and Lynn had beliefs that were beyond their observed instructional practices. Michelle and Yajaira had the least amount of science teaching experience, so this pattern might demonstrate that early in a science teaching career teachers are more apt to teach according to their beliefs. Having the most amount of science teaching experience, Brewer and Lynn might demonstrate that with more years of experience there is a greater struggle between knowing about and/or wanting to teach using reform-based instruction and the realities of implementing that instruction. This investigator also noted that Brewer and Lynn stated specific reasons for why they teach science, whereas Michelle and Yajaira did not state an overarching goal for their science teaching. Additionally, this investigator wondered if gender, Brewer and Lynn were both male and Yajaira and Michelle were female or grade level, Michelle and Yajaira both taught at the high school level, played a role in the consistency of their beliefs.

Table 4.7

Cases' Consistency of Epistemological Beliefs with Instructional Practice

Case	Belief	Instruction	Consistency
Brewer	Transitional	Discussion	Beliefs beyond instructional technique used
Lynn	Transitional	Discussion	Beliefs beyond instructional technique used
Michelle	Instructive	Discussion	Beliefs consistent with instructional technique used
Yajaira	Instructive	Discussion	Beliefs consistent with instructional technique used

Patterns in the Impact of the Cases' Epistemological Beliefs on Authentic Inquiry

This study's proposition was:

> Teachers with epistemological beliefs reflective of reformed based instruction, or Authentic Inquiry, would also incorporate opportunities for Authentic Inquiry in their classes if they additionally had experiences that led to their understanding and/or value of this method of instruction.

None of the cases within this study had Reform-based beliefs nor did they use Authentic Inquiry. Only one of the cases, Michelle, had an experience to develop an understanding and appreciation for inquiry instruction. This pattern may demonstrate how Reform-based beliefs impact the use of Authentic Inquiry in science teaching.

Summary

This study was designed to explore the impact of science teachers' epistemological beliefs on their use of authentic inquiry. After the careful examination of the individual cases, several patterns emerged. The cross case analysis revealed that the cases epistemological beliefs were mostly Transitional and the method of instruction used most was Discussion. Two of the cases exhibited consistent beliefs and instructional practices whereas the other two exhibited beliefs beyond their instructional practices. Overall, the cases demonstrated that without Reform-based beliefs and experiences to develop their understanding and/or value of Authentic Inquiry, opportunities for Authentic Inquiry in instruction would not occur.

CHAPTER FIVE

Discussion and Implications

Teachers' beliefs are one of many factors that influence their instructional practices. Experiences influencing these beliefs occur as early as when teachers are students, and these beliefs are continually influenced during their time as preservice and inservice teachers. One form of beliefs, epistemological beliefs, reveals teachers' thoughts and values regarding knowledge and learning. This investigator examined epistemological beliefs and their influence on instruction. She did so in order to provide an interpretation of the data that would cause those responsible for the professional development of science teachers to reflect on methods to promote the development of teachers better prepared to use inquiry-based instruction.

Gaps in the research exist regarding epistemological beliefs and science education. There are studies in science education that identified and analyzed science teachers' epistemological beliefs (Aguirre et al., 1990; Boulton-Lewis et al., 2001; Tsai, 2002), investigations regarding the impact of epistemological beliefs on curriculum selection and implementation (Benson, 1989; Cronin-Jones, 1991), and studies that focused on the influence of beliefs about the Nature of Science (NOS), or epistemology of science, on teaching strategies (Abd-El-Khalick et al., 1998; Bell et al., 2000; Brickhouse, 1989; Gallagher, 1991; Lederman, 1999). Most of these studies focused on preservice and inservice secondary teachers and the subject area of science in general. Few studies examined teacher beliefs on the post-secondary level. Additionally, studies have not focused on the influence of epistemological beliefs on Authentic Inquiry. Therefore, through this study this investigator examined the epistemological beliefs of four science teachers at the middle, secondary and post-secondary levels, in Central Texas and how their beliefs about knowledge and learning impacted their science instruction. In particular, this investigator analyzed how their epistemological beliefs influenced students experiencing Authentic Inquiry.

This multiple-case study included the collection of data from five cases. The first case, Elizabeth, was used in a pilot study that later informed this study's research questions and observation protocol. The four remaining cases, Brewer, Lynn, Michelle, and Yajaira, were used for the main study. These teachers were chosen because they represented a range of science teachers from middle to post-secondary, and because they were teachers who actively engaged their students during science lessons.

This chapter includes a summary of the findings from Chapter Four, along with a description of the agreement of the findings with the study's initial proposition. This investigator also provides a review of the literature that supports and/or counters the findings, in addition to the implications and limitations of this study.

Discussion

The primary research question for this study was:

> How do the epistemological beliefs of science teachers impact their use of authentic inquiry in science instruction?

This question was addressed by researching three sub-questions. The first question was:

> What are the epistemological beliefs and instructional practices of one post-secondary, two secondary, and one middle school science teachers in Central Texas?

The cross case analysis revealed that the cases' epistemological beliefs were mostly

Transitional and the method of instruction used most was Discussion. Brewer and Lynn both had Transitional beliefs but Michelle and Yajaira had Instructive beliefs. All of the cases used discussion as their primary form of lesson delivery.

Epistemological Beliefs: In Transition

As preservice teachers enter their teacher education programs, they do so with well established belief systems (Kagan, 1992; Richardson, 1996). Kagan noted in her review of educational research that these belief systems are often "the filter and foundation of new knowledge" (p. 75). In order to influence these beliefs, teacher education programs "must require [preservice teachers] to make their preexisting personal beliefs explicit;…must challenge the adequacy of those beliefs; and…must give novices extended opportunities to examine, elaborate, and integrate new information into their existing belief systems" (Kagan, 1992, p. 77). Richardson noted that for this to occur, it is essential for preservice teachers to experience an excellent student teaching element within their program in order to counteract the power of experiences preservice teachers had as students and will have as teachers.

During the Post Interview, as this investigator reviewed and confirmed the results of the Teacher Beliefs Interview (TBI), all of the cases were amazed with this investigator's ability to correctly identify and code their epistemological beliefs. It was obvious throughout the interviews that the cases never had opportunities to identify and examine their beliefs as preservice or inservice teachers. Brewer, Michelle and Yajaira even mentioned that they wish they could teach more along the lines of their student centered beliefs, but as indicated by their interviews, they did not have the Responsive or Reform-based beliefs classified as student centered beliefs. These comments and others related to the cases' lack of understanding of epistemological beliefs were due to the lack of experiences they had to assist them with their understanding and appreciation of these beliefs.

Other than opportunities to examine beliefs as preservice teachers, inservice teachers must also have professional development opportunities that allow them to examine their beliefs. In her review article, Richardson (1996) noted the significant impact inservice teacher professional development had on the modification of beliefs. Others also agreed with the significant role of professional development (Fang, 1996; Luft and Roehrig, 2007). Both Brewer and Lynn had the most student centered beliefs, and both mentioned the excellent professional development opportunities they have experienced as science teachers. They both also mentioned mentors they had in the field and how these mentors improved their ideas about teaching. Neither Michelle nor Yajaira mentioned quality professional development as science teachers or relationships they had with mentors, and they both had more teacher centered beliefs. These commonalities demonstrate the affect of quality professional development opportunities on these science teachers' epistemological beliefs.

Additionally, when discussing teachers' beliefs, one must take into consideration the context in which these beliefs occur. "Factors such as differing student abilities and classroom management make the classroom a more complex place for the enactment of beliefs" (Roehrig & Luft, 2004, p. 19). The cases on the extreme ends, the middle school (Brewer) and post-secondary teachers (Lynn), had beliefs that were more student centered than the beliefs indicated by the high school teachers (Michelle and Yajaira). This difference demonstrated what the teachers perceived as needs related to student ability. The middle and post-secondary teachers provided experiences that addressed both the cognitive and affective needs of their students, whereas on the secondary level the perceived needs were more cognitive in nature. Also, with less years of science teaching experience, Michelle and Yajaira both noted issues regarding student abilities and classroom management that they had to address as teachers more often than Brewer and Lynn. These needs and issues, in the context of the classroom setting, influenced the types of beliefs demonstrated by these science teachers.

Overall, the beliefs the cases exhibited the most were Transitional beliefs. These beliefs are at the midpoint of teacher centered and student centered beliefs. These beliefs not only emphasize the cognitive aspects of knowledge and learning but also begin to take into consideration the affective qualities. As science teachers with mostly Transitional beliefs, this study's cases struggled with whether to transition to more student focused instructional techniques or to continue to teach using more teacher focused methods.

Instructional Practice: The Roles of Experience, Beliefs and Goals

As early as the 1960s, Schwab (1960) warned of the effects of teachers who experience science in Traditional rather than inquiry-oriented methods. Schwab emphasized that when taught in a Traditional manner, science teachers would not be prepared to teach science as inquiry. Barrow (2006) noted that "[t]eachers need to have inquiry modeled for them because they need to see the benefit for their future students. For the vast majority of future science teachers, this is not their personal experience" (Barrow, 2006, p. 271). Research synthesized by Welch et al. (1981) also emphasized the importance of engaging future science teachers in training sessions using inquiry.

Although Welch et al. noted that the desired state of teacher training is that teachers would be trained through the use of inquiry, they found that teachers had science classes that did not include inquiry experiences.

This lack of inquiry experiences was evident as the cases reflected over their science education experiences. They all mentioned some form of Traditional science experiences in their past and did not mention any inquiry experiences, except for Michelle who mentioned her inquiry experiences in her preservice science methods course. This lack of inquiry experiences in science classes and more Traditional experiences reflects why all of the cases used Discussion, a teacher focused approached, as their primary method of instruction rather than more student focused, inquiry approaches. Barrow (2006) warned that “[u]nless science teacher preparation programs provide an inquiry orientation to both their education and science courses, there will not be a major impact on seeing inquiry in K-12 classrooms” (p. 275). The findings of this study reflect Barrow’s concern.

There were two cases that demonstrated extremes in instructional practices. Direct Instruction occurred more with Lynn than the other cases. Additionally, Lynn was the only case to mention a concern regarding teaching science the way he was taught, in a Traditional format. Brewer’s use of Structured Inquiry for one of his lessons caused him to be the case to use the most student focused form of instruction among the cases studied. Although Brewer mentioned experiences regarding Traditional methods of teaching, unlike Lynn, he did not mention that these Traditional lessons influenced his teaching. Instead, he mentioned the influence of labs, whether as a student or teaching them himself, and how these hands-on experiences influenced his teaching. Neither Lynn nor Brewer mentioned experiences as students with inquiry lessons. This instance of

Brewer using more student focused instruction and Lynn using Direct Instruction the most represented the influence of learning experiences on their science teaching. Although Brewer used more student focused instruction, neither of the cases primarily used nor had experienced student focused, inquiry lessons.

Brewer was the case that emphasized the most his desire to learn how to use inquiry as a method of science teaching. He also was the only case to use a form of inquiry instruction. Brewer, like the National Research Council (2000), understood that in order to use more inquiry in his teaching, he needed to understand more about the purpose of inquiry and how to use it in his classroom.

Other than experiences influencing instructional practices, beliefs also played an interesting role. A substantial body of evidence supports the idea that epistemological beliefs held by teachers strongly influence the decisions they make regarding classroom instruction (Hashweh, 1996; Lederman, 2004; Luft & Roehrig, 2004; Smith, 2005; Wallace & Kang, 2004). In their study of 14 beginning secondary science teachers, Roehrig and Luft (2004) explored constraints experienced by teachers as they attempted to implement inquiry-based lessons. Roehrig and Luft found that the four teachers who successfully conducted student focused inquiry lessons, such as Guided Inquiry and Authentic Inquiry, all had predominately student centered beliefs and those that implemented Structured Inquiry and other more Traditional forms of instruction had less student centered beliefs than their peers who implemented the inquiry lessons. This study confirmed what was discovered during this investigator's study; the cases either had teacher centered beliefs or Transitional beliefs that were neither teacher centered nor student centered. All of the teachers also used Discussion, a teacher focused method of instruction, as their primary instructional technique. Without the more student centered beliefs, the teachers did not use inquiry instruction as their primary instructional method.

Like the influence of epistemological beliefs on instruction, there are also trends related to how teachers' goals influence instruction. Weiss et al. (2003) found within nationally observed science lessons that only 15% or less of the instructional time in K-12th grades was spent on content regarding inquiry as science. By the 9th-12th grades, only 2% of the content focused on this. Like Weiss et al.'s study, the amount of student focused instruction was highest at the lowest grade level and began to decrease as the grade level increased. Brewer, as the middle school science teacher, used the most student focused instruction, and then Michelle, a 9th grade science teacher, Yajaira, a 10th grade science teacher, and the least student centered instruction occurred with Lynn, the post-secondary science teacher. This trend represents the cases' desired goals for instruction. Brewer noted that he hoped to move toward more inquiry instruction, Michelle wanted to incorporate more hands-on learning, Yajaira wanted to improve her classroom management in order to teach in a more reform-based manner, and Lynn wanted to incorporate more discussion. Wallace and Kang (2004) noted the influence of private goals of teachers on instructional decisions. The goals these cases had for their instruction directly influenced their instructional practices.

All of the cases in this study used Discussion as their primary means of instruction. Although instructional techniques varied from one extreme, Direct Instruction, to another, Structured Inquiry, on average the instructional practices of the cases were teacher focused. The reasons for the use of this instructional technique were clear; they were based on the experiences, or lack thereof, that these cases had with student focused, inquiry oriented instruction as students and preservice and inservice teachers, their beliefs about knowledge and learning, and the goals they had for the type of instruction they wanted to implement in their classrooms.

Consistency of Beliefs with Practice: On and Beyond the Target

The second sub-question was:

> How are the epistemological beliefs of one post-secondary, two secondary, and one middle school science teachers in Central Texas consistent with their observed science teaching practices?

Two of the cases exhibited consistent beliefs and instructional practices, whereas the other two exhibited beliefs beyond their instruction.

It is not uncommon for inconsistencies to exist between teachers' beliefs and their instructional practices. Fang (1996) presented a review of research studies that indicated these inconsistencies. Fang noted in the review that contextual factors influence both teachers' beliefs and their classroom practice and at times caused inconsistencies between the two. These contextual factors included teacher-student respect, classroom management, student ability levels, and school and district mandates. Fang also noted that some school contexts provided more of an opportunity for implementing beliefs than others.

The pattern that emerged regarding the consistency of epistemological beliefs with instructional practices was that Michelle and Yajaira both demonstrated beliefs and instructional practices that were consistent, whereas Brewer and Lynn had beliefs that were beyond their observed instructional practices. What was interesting about the pattern that emerged from this study was that Michelle and Yajaira exhibited consistency that was teacher focused. Although their school contexts differed, they expressed similar concerns regarding student abilities and willingness to conduct inquiry instruction. They also commented regarding the management of their classrooms; Michelle had concerns as a first year teacher about establishing herself as an effective teacher, and Yajaira had concerns about her management style and the behavior of her students.

On the other hand, Brewer and Lynn, although in different school contexts, did not speak as much about contextual factors, but they both demonstrated the same inconsistencies in their beliefs. Having the most amount of science teaching experience, Brewer and Lynn demonstrated that with more years of experience they had a greater struggle between knowing about and/or believing in reform-based instruction and the realities of implementing that instruction. Michelle and Yajaira had the least amount of science teaching experience. This pattern demonstrated that early in a science teaching career these teachers are more likely to teach according to their beliefs. This pattern contradicts what Lederman (1999) found in his examination of secondary teachers' view of the NOS and their relationship to classroom practice. Of the five high school biology teachers in Lederman's study, only two had reformed-based views regarding the NOS and instructional practices that matched these views. The two with consistent views and instructional practices were the two most experienced teachers. Lederman ultimately concluded that it was the teachers' instructional intentions that significantly affected their classroom practice.

This investigator also noted that Brewer and Lynn stated specific reasons for why they teach science, whereas Michelle and Yajaira did not state an overarching goal for their science teaching. Barrow (2006) noted the importance of these personal goals and how at times they conflict with the goals or mandates of the school context. Both Brewer and Lynn addressed this conflict. Brewer noted that the conflict between wanting to teach a certain way and having to teach using a different method often causes teachers to burn out. Lynn stated that although he has a personal desire to do more exploration, he must take the context of the students' current and future needs as Biology majors in to consideration.

The cases in this study either demonstrated beliefs and instructional practices that were consistently teacher centered or Transitional beliefs that were beyond their teacher centered instructional methods. The two factors that influenced these trends the most were the experiences and beliefs of the cases. These experiences and beliefs ultimately influenced the cases' use of Authentic Inquiry.

Authentic Inquiry and Reformed Based Beliefs: Connecting the Whys

The third sub-question was:

> How do the epistemological beliefs of one post-secondary, two secondary, and one middle school science teachers in Central Texas promote student generated questions, student designed and led investigations, and the presentation of evidence, or authentic inquiry?

This investigator drew upon both research on general epistemological beliefs (Hashweh, 1996) and research on the epistemology of science (Abd-El-Khalick et al., 1998; Bell et al., 2000; Brickhouse, 1989; Gallagher, 1991; Lederman, 1999) to generate the study proposition. The study's proposition was that teachers with epistemological beliefs reflective of reform-based instruction, or Authentic Inquiry, would also incorporate opportunities for Authentic Inquiry in their classes, if they additionally had experiences that led to their understanding and/or value of this method of instruction.

The epistemological beliefs reflective of reform-based instruction, Responsive and Reform-based beliefs (see Chapter 3 Table 3.4 for correlations) are the most student centered forms of beliefs. Overall, the cases demonstrated that without these beliefs and experiences to develop their understanding and/or value of Authentic Inquiry, opportunities for Authentic Inquiry in instruction would not occur. As the cases were interviewed, they noted concerns and needs relevant to their lack of the use of reform-based instructional techniques.

Accountability. From testing to fewer opportunities for exploration, the cases all discussed concerns relevant to accountability and their lack of the use of reform-based instruction. The cases in this study were not the first to note these concerns. Jones, Jones, and Hargrove (2003) in their book *The Unintended Consequences of High-stakes Testing* noted several positive and negative consequences of accountability in the field of education. The consequences experienced by teachers included a decrease in teacher autonomy, less balance between teacher and student focused instruction, and less student and teacher creativity exhibited during lessons. McNeil and Valenzuela (2000) echoed these concerns in their essay regarding high stakes testing in Texas. McNeil and Valenzuela noted the pressure teachers experience to change their instructional techniques to raise test scores. Often these instructional techniques were teacher focused and did not leave room for more student focused instruction.

These same consequences were mentioned by the cases in this study. Brewer mentioned the restraints he felt due to accountability. He felt as if the content requirements were too large and this was specifically due to the requirements for testing. Yajaira also mentioned the high amount of accountability and the fact that she felt as if testing drove learning. She, like Lynn, noted the lack of the fun of exploration and discovery in science lessons, and Yajaira noted that it has been replaced with the drilling of students.

Professional development. All of the cases in this study either mentioned, or demonstrated the need for, professional development as it relates to developing an understanding and value for inquiry techniques and the ability to teach inquiry lessons. A review of the literature also indicated this need.

Professional development in inquiry should occur for both preservice and inservice science teachers in order for them to have a clear understanding of what it means to use inquiry in the science classroom (Barrow, 2006; Welch et al., 1981). For inservice teachers, this might be in the form of induction programs for new teachers (Roehrig & Luft, 2004), and for preservice teachers, carefully crafted discussions and activities in their science methods courses (Bell, Lederman & Abd-El-Khalick, 2000).

Only one of the cases had an experience that allowed her to develop a better understanding of inquiry. Michelle's experience was as an undergraduate student in her preservice science methods course. Brewer mentioned that due to his lack of experiences with inquiry, he would like to experience trainings that would help him to teach using Authentic Inquiry. Yajaira also expressed that she wanted to learn how to move from discussion to inquiry techniques. Brewer, Lynn, and Yajaira all acknowledged that they were not prepared to teach in a way that would promote their use of inquiry in science teaching.

Students. A last area discussed by the cases was the students they taught. Brewer mentioned concerns regarding the low socioeconomic status of his students and the issues this presented for his classroom instruction. Yajaira had the same concern as she spoke of the issues her students faced at home and how this translated into her class with their lack of supplies for class and lack of engagement in the course. Michelle mentioned the difficulty of teaching inquiry-based lessons because her students did not know the true NOS. She also emphasized that her students needed to learn how to take responsibility for their learning. Yajaira had similar concerns as she discussed how her students did not take advantage of the learning opportunities provided to them.

All of the cases expressed issues or needs that negatively influenced their ability to implement inquiry instruction. Based on their comments and the literature reviewed by this investigator, several implications emerged.

Delimitations and Limitations of the Investigation

This investigator imposed restrictions or boundaries on the study. The first was the delimitation of the study to Central Texas. For the convenience of the investigator and her travel during the study, all participants were within a 30-mile radius from the investigator. Additionally, the participants were delimited to the middle, secondary and postsecondary levels due to the examination of authentic inquiry and the developmental appropriateness of this form of instruction.

A limitation of the study was time. The investigator was limited by time because she was required to investigate the participants in the study during the time frames established by the schools, so even if the generation of new themes continued, the length of time she could observe was limited to the amount of time the teachers had to teach the courses observed. Time was also a factor because the investigator taught on Friday, therefore preventing observations on this day of the week. Time was a greater factor during the spring semester observations due to practice tests for the state's accountability testing and inclement weather days.

Implications and Suggestions for Future Research

The findings of this study have important implications regarding factors to consider when developing teachers prepared to use reform-based instruction. Due to the qualitative nature of this multiple-case study, the implications and suggestions for future research stem from the interpretations made from the four cases in the study, and the potential for the transferability of what was discovered to future research studies. The following are this investigator's final thoughts regarding the study:

- *Science teachers must have opportunities to develop an understanding for and experience inquiry instruction.* As indicated by this study, when teachers are not presented with these opportunities at either the preservice or inservice levels, they are not likely to implement inquiry instruction in their classrooms. These opportunities should not only occur during their teacher education programs, but their science courses.
- *Science teachers should have opportunities to identify and critically evaluate their beliefs.* Often science teachers are not presented with the opportunity to identify and evaluate their beliefs about knowledge and learning, epistemological beliefs, and their beliefs about the NOS, epistemology of science. Because they are not presented with these opportunities, they are not aware of the tremendous impact these beliefs have on the instructional techniques they use. Science

teachers should have opportunities to identify, evaluate and develop these beliefs as preservice and inservice teachers. By doing so, they will become more aware of how these beliefs influence their instructional practices and hopefully use this awareness to improve their instructional practice.

- *Science teachers should have opportunities to address any concerns they have regarding the contexts in which they teach.* Contextual factors play an important role in influencing beliefs and instruction. For this reason, science teachers should have the support they need to work through frustrations that may occur when contextual factors hinder their ability to teach according to their beliefs. Brewer noted that often these contextual factors lead science teachers to becoming burned out. Yajaira noted her own concerns regarding her inability to teach using inquiry due to student ability levels, classroom management issues, and district mandates. When support is not there to help teachers work through their concerns, it can lead to science teachers leaving the profession, as Yajaira did a month after this study ended.
- *Districts must begin to bring science teachers together across grade levels to plan effective instructional experiences for their students.* As the investigator of this study, it was interesting to observe science teachers at three different levels. By doing so, this investigator was able to compare the beliefs and instructional practices at the different levels. It was interesting to discover that within these four cases, the amount of student centered instruction began to decrease as the grade level increased. Lynn, the post-secondary science teacher, often mentioned how the fun of exploration and discovery no longer exist in science classes, but

> he readily admitted that post-secondary teachers perpetuate this. This was true because he had the least amount of student focused instruction, but what was also interesting was his assumption that lower grade levels did also, which among the teachers in this study was not the case. Additionally, the teachers seemed to live in this "I have to prepare them for the next level" bubble, so often they were thinking ahead to a state test that they had to prepare students for or how to better prepare them for their next level of school; it rarely seemed as if the teachers considered that day, that moment and what and why it was important for the students to personally gain the knowledge and skills the teachers were teaching.

Due to the findings of this investigation, there are several suggestions this investigator has for future research studies. First, this investigator suggests the investigation of the influence of instructional leadership in schools on the use of reform-based teaching in science instruction. This suggestion stems from this investigator's observation of Brewer and the professional relationship he had with his principal, who he referred to as and excellent instructional leader. He often spoke of the instructional guidance she provided to the science department, and the planning that she allowed for the core subject areas in which she emphasized her desire for them to implement more hands-on, reformed-based instruction. The influence of school-based instructional leadership is definitely worth examining because it had a tremendous positive influence on how Brewer taught and his desire to continue to learn.

Secondly, this investigator suggests further research in the area of epistemological beliefs and Authentic Inquiry. This study only touched the surface of issues that could be gleaned from the topic. A particularly interesting study would include the investigation of this study's proposition with a group of teachers who already possess Responsive and Reform-based epistemological beliefs. Additionally, it would be interesting to conduct a longitudinal study to discover if epistemological beliefs and instructional practices remain the same or if they change over time.

A last suggestion for future research is a study examining teachers who effectively implement inquiry instruction in spite of the contextual factors often present in public school settings. It would be interesting to know the stories of these teachers and how their determination to teach according to their beliefs and preferred instructional methods outweighed any outside factors.

Conclusion

This study contributes to the literature regarding teacher beliefs about knowledge and learning. Most interesting about this study is the examination of these beliefs at the middle, secondary and post secondary levels and the study's focus on a specific aspect of science education, Authentic Inquiry. The findings of this study support the literature on the influence of contextual factors and professional development on teacher beliefs and practice. The findings support and contradict literature relevant to the consistency of teacher beliefs with instruction. This study's findings revealed that the use of reform-based instruction, or Authentic Inquiry, does not occur when science teachers do not have the beliefs and experiences necessary to implement this form of instruction. It is this investigator's hope that future studies will continue to provide insight into these beliefs and how to develop science teachers prepared to provide the types of reform-based instruction necessary to develop students with inquiring minds.

APPENDICES

APPENDIX A

Tables Related to Data Analysis

Table A.1

Descriptions and Examples of Instructional Codes

Instructional Strategy	Description of Strategy	Example(s)
Direct Instruction	Students are directed to listen as the teacher, guest speaker, or another student talks to the entire group. Students are directed to read or do seat work quietly.	Lecture, silent reading, note taking, independent practice, and seat work.
Discussion	In the whole or small group setting, students respond orally or in writing to questions posed by the teacher, guest speaker, or other students.	Teacher led-recitation, interactive note taking, written group work, question and answer, and discussion led by teacher.
Traditional Hands-on	Students in pairs or in small groups work together under the teacher's supervision to discuss and complete tasks given by the teacher. All groups conduct the same task with the same expected results.	Student discussion in groups, task completion, verification laboratories, and cooperative learning.
Structured Inquiry	Students in pairs or small groups work on a teacher designed laboratory experience that allows students to reach their own conclusions based on evidence they collect.	Student completion of laboratory activities with the collection of data for group analysis.
Guided Inquiry	Teacher selects topic, question, and materials but students in pairs or small groups design and carry out their own investigations in order to develop their own conclusions.	Student designed laboratory activity.
Authentic Inquiry	Teacher might only provide the general topic and assist with questioning. Otherwise, students in pairs or individually, develop questions, materials, design, analysis and conclusions of their own investigation.	Student research projects.

Note. Instructional codes developed from research based on Bonnstetter (1998) and Stuessy (2002).

Table A.2

Teacher Beliefs Interview Categories with Examples

Category	Example	View of Science
Traditional: Focus on information, transmission, structure, or sources.	I am an all-knowing sage. My role is to deliver information.	
Instructive: Focus on providing experiences, teacher-focus, or teacher decision.	I want to maintain a student focus to minimize disruptions. I want to provide students with experiences in laboratory science (no elaboration).	Science as rule or fact.
Transitional: Focus on teacher/student relationships, subjective decisions, or affective response.	I want a good rapport with my students, so I do what they like in science. I am responsible for guiding students in their development of understanding and process skills.	Science as consistent, connected and objective.
Responsive: Focus on collaboration, feedback, or knowledge development.	I want to set up my classroom so that students can take charge of their own learning.	
Reform-based: Focus on mediating student knowledge or interactions.	My role is to provide students with experiences in science, which allows me to understand their knowledge and how they are making sense of science. My instruction needs to be modified accordingly so that students understand key concepts in science.	Science as a dynamic structure in a social and cultural context.

Note. From "Capturing Science Teachers' Epistemological Beliefs: The Development of the Teachers Beliefs Interview" by J.A. Luft and G.H. Roehrig, 2007, *Electronic Journal of Science Education*, *11*, p. 54.

APPENDIX B

Figures Related to Data Analysis

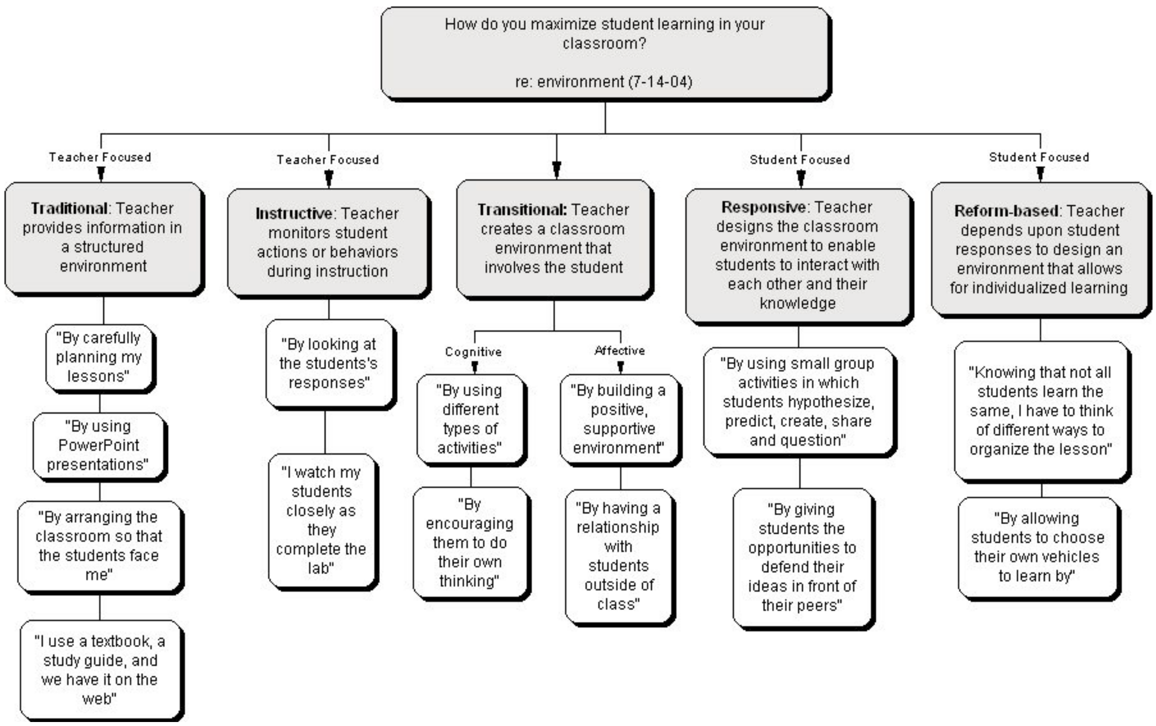

Figure B.1. Teacher Beliefs Interview (Luft and Roehrig, 2007) Question 1 map used for indexing.

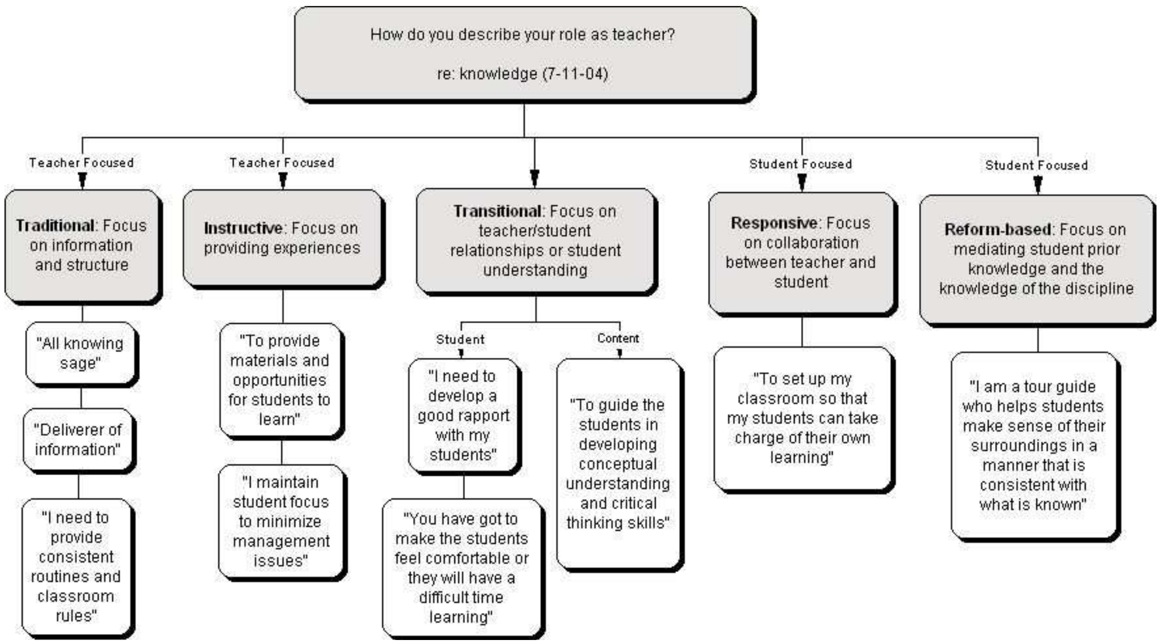

Figure B.2. Teacher Beliefs Interview (Luft and Roehrig, 2007) Question 2 map used for indexing.

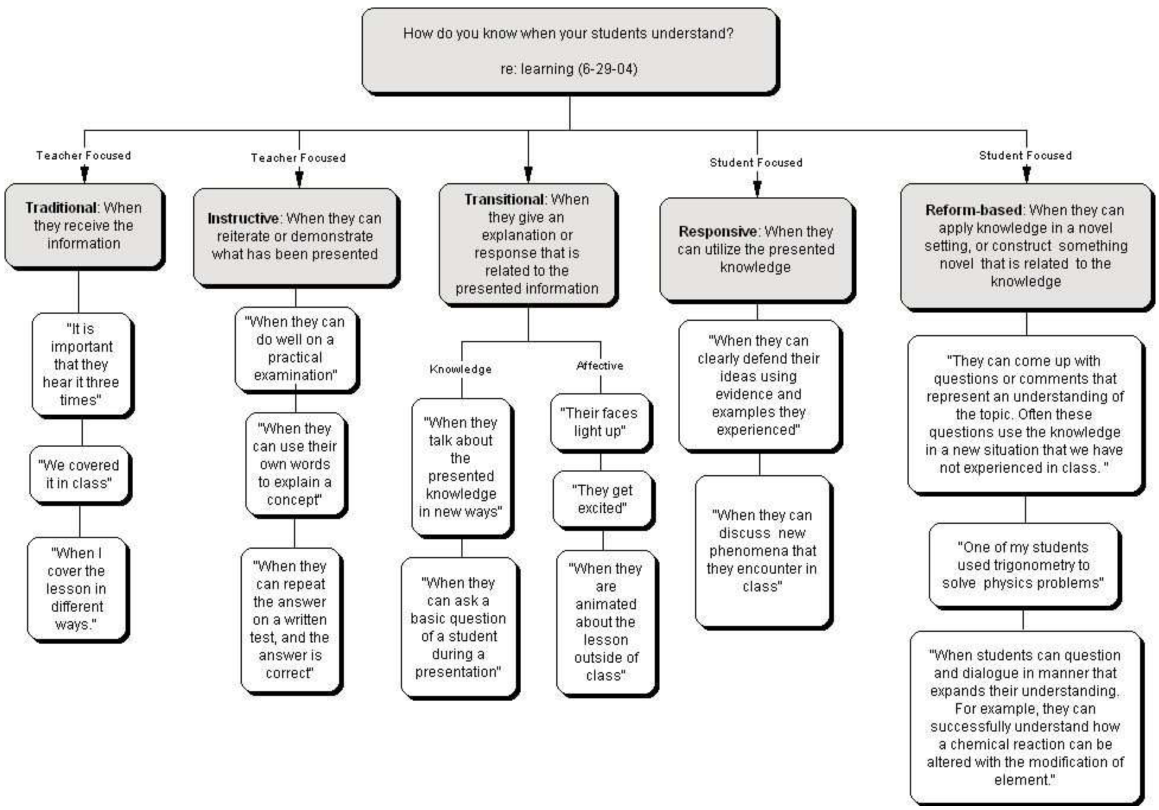

Figure B.3. Teacher Beliefs Interview (Luft and Roehrig, 2007) Question 3 map used for indexing.

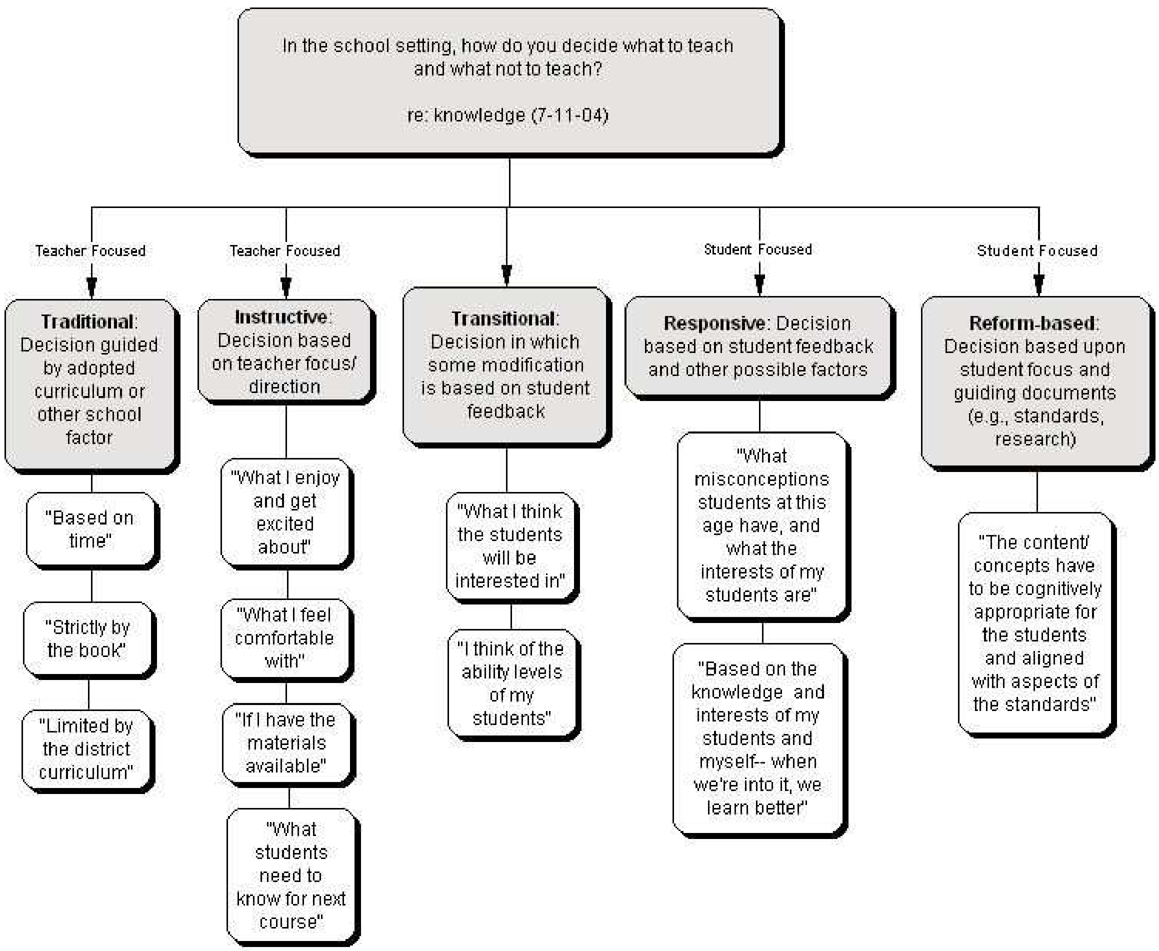

Figure B.4. Teacher Beliefs Interview (Luft and Roehrig, 2007) Question 4 map used for indexing.

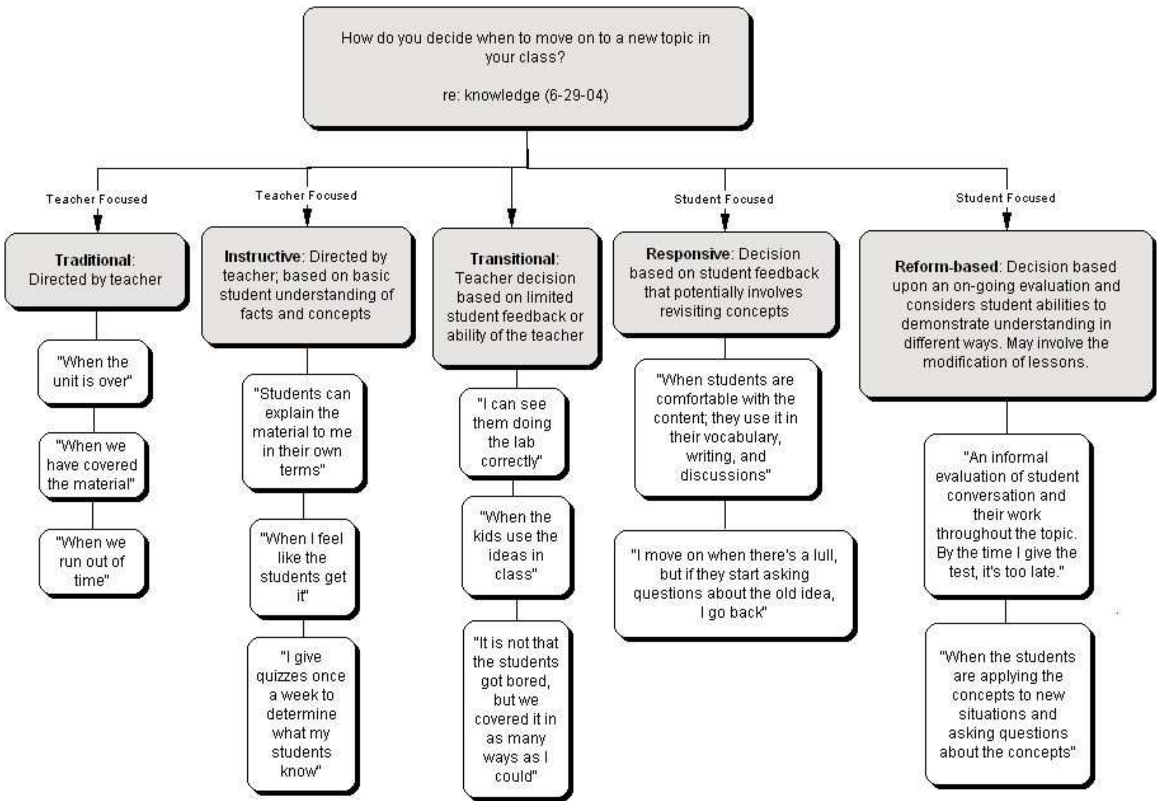

Figure B.5. Teacher Beliefs Interview (Luft and Roehrig, 2007) Question 5 map used for indexing.

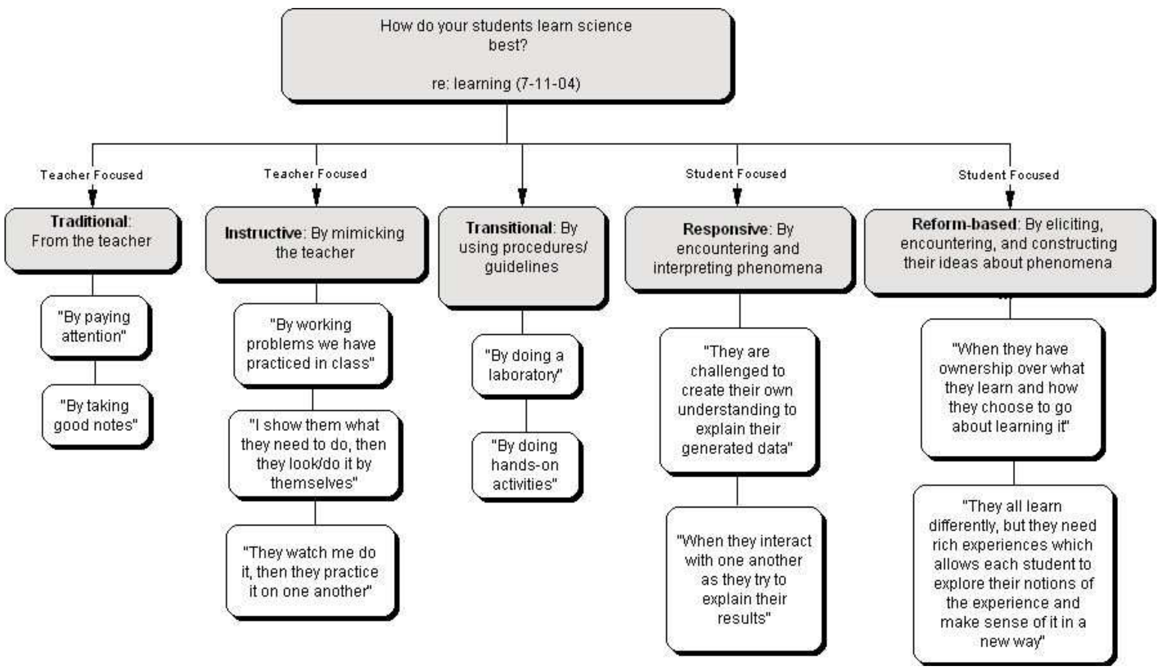

Figure B.6. Teacher Beliefs Interview (Luft and Roehrig, 2007) Question 6 map used for indexing.

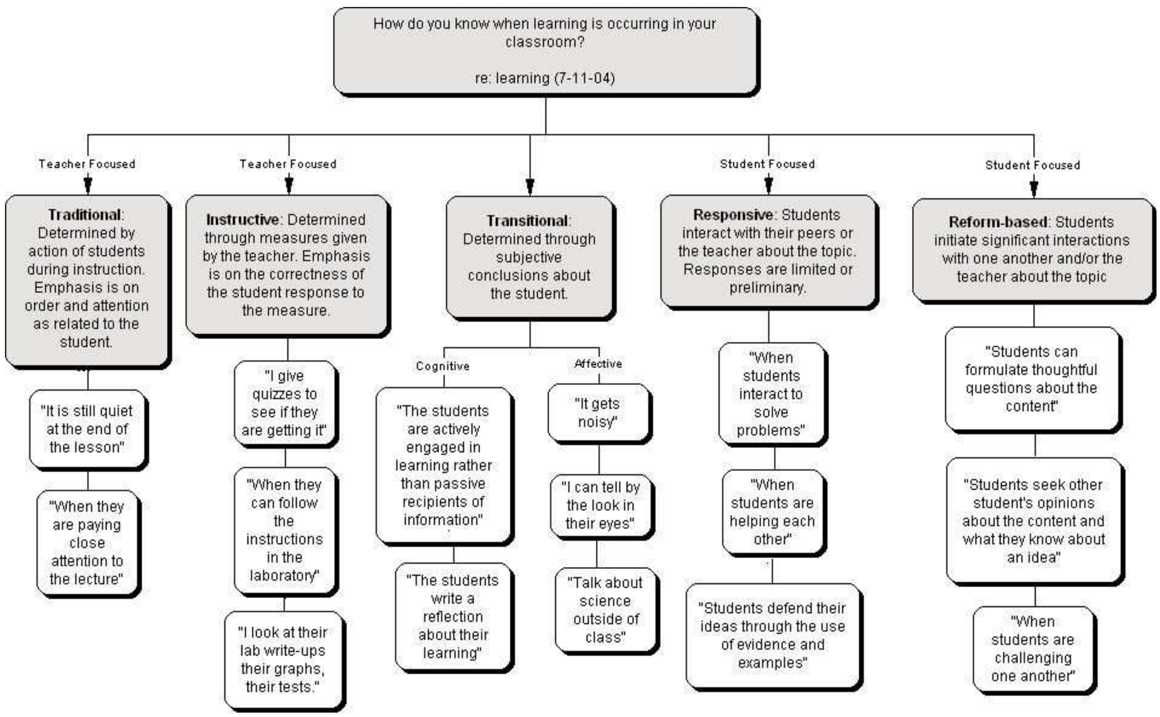

Figure B.7. Teacher Beliefs Interview (Luft and Roehrig, 2007) Question 7 map used for indexing.

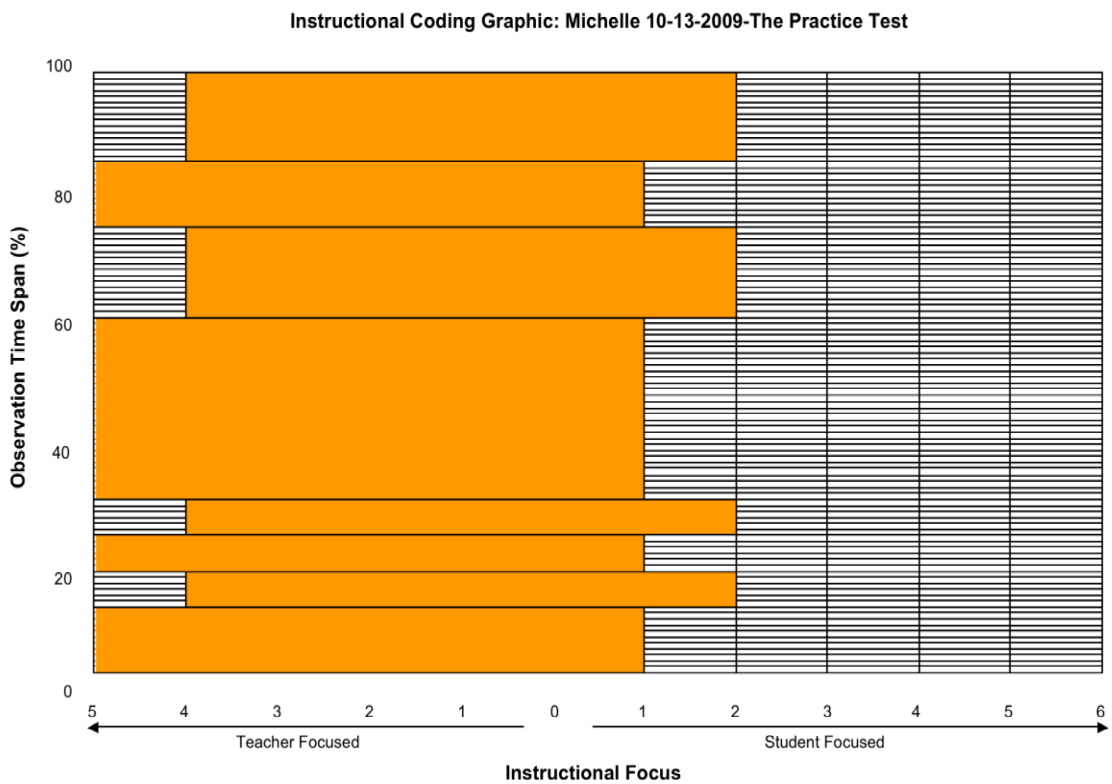

Figure B.8. Example of a graphical display of a lesson

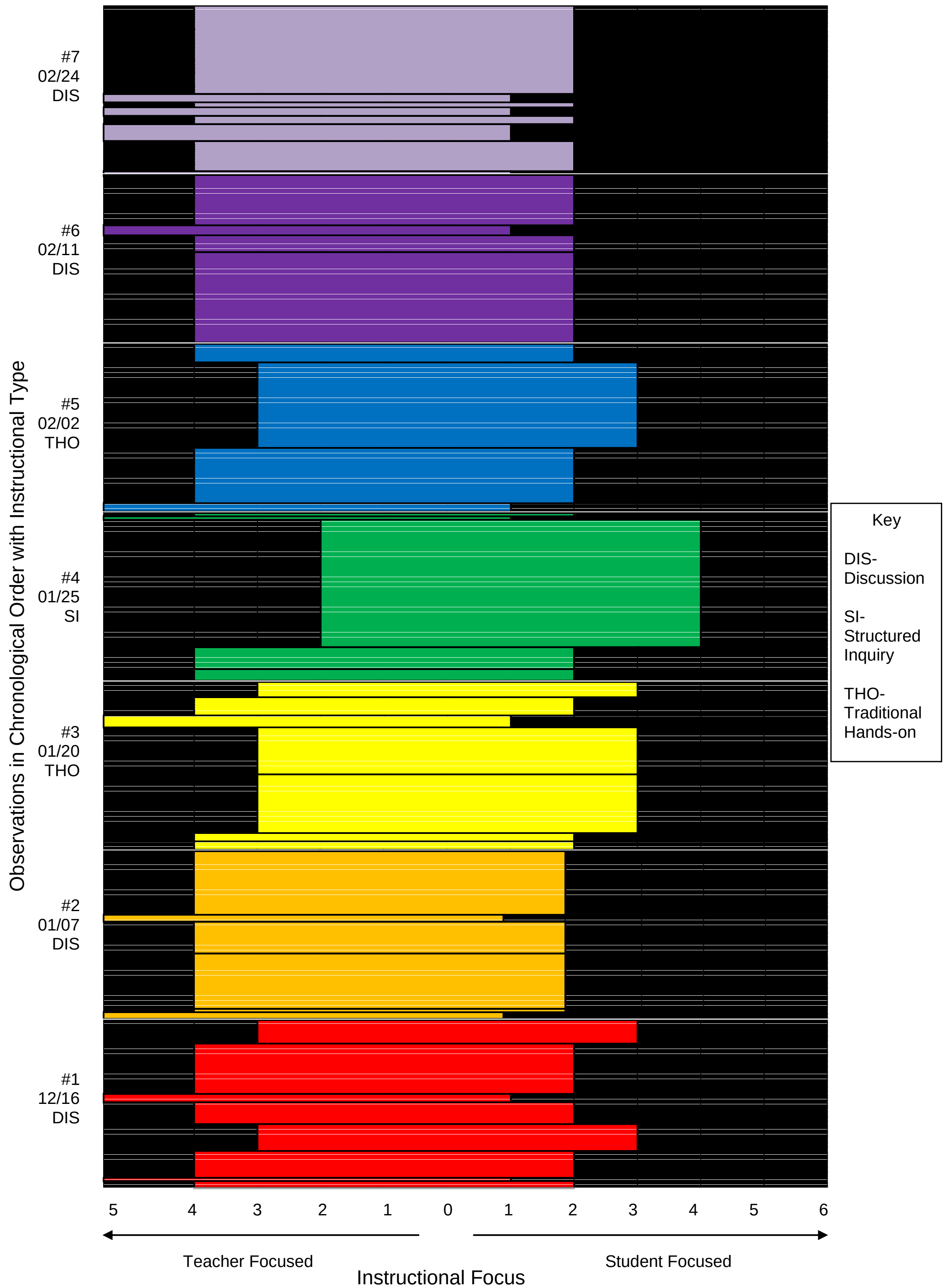

Figure B.9. Graphical display of Brewer's instructional techniques.

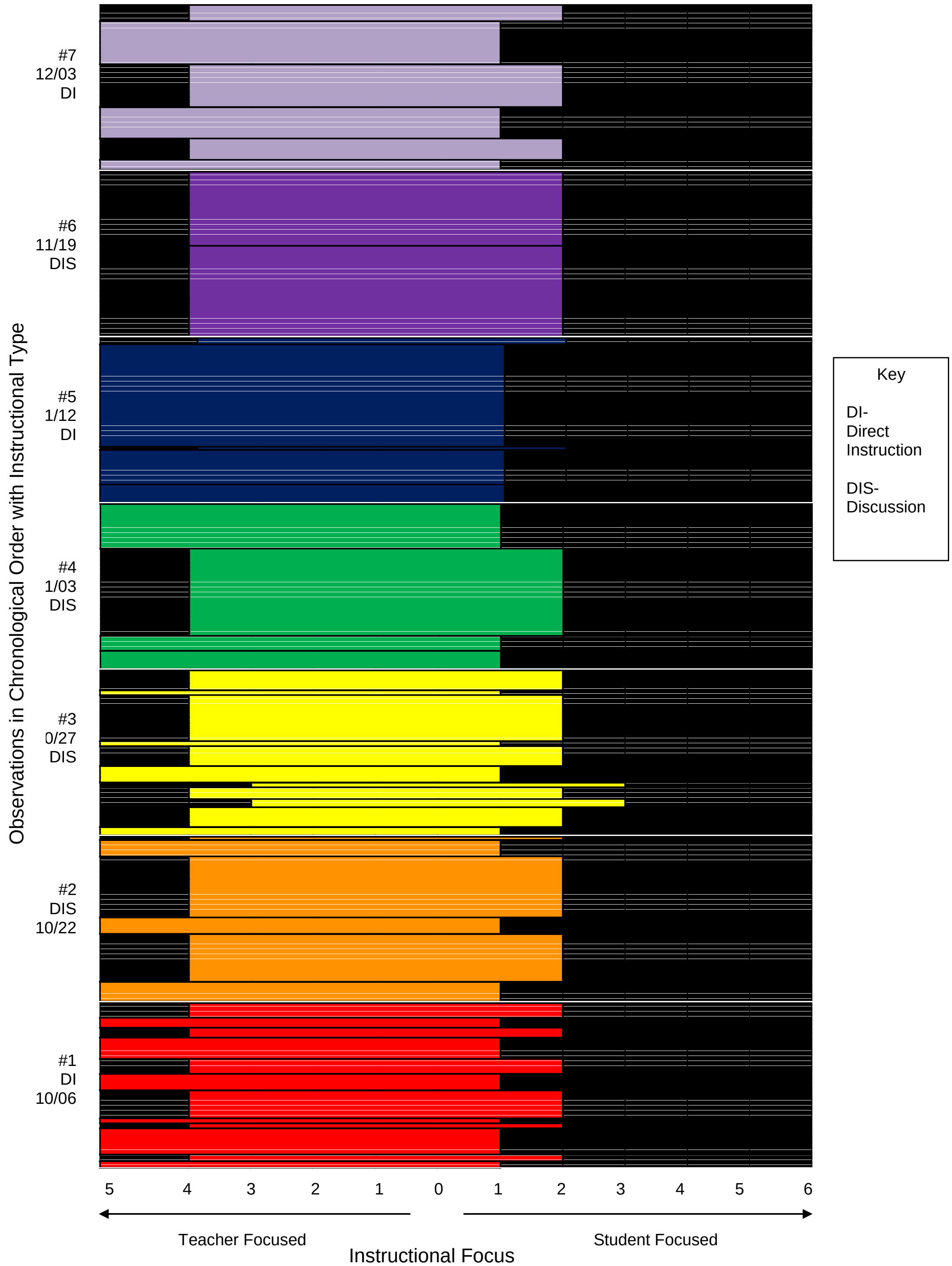

Figure B.10. Graphical display of Lynn's instructional techniques.

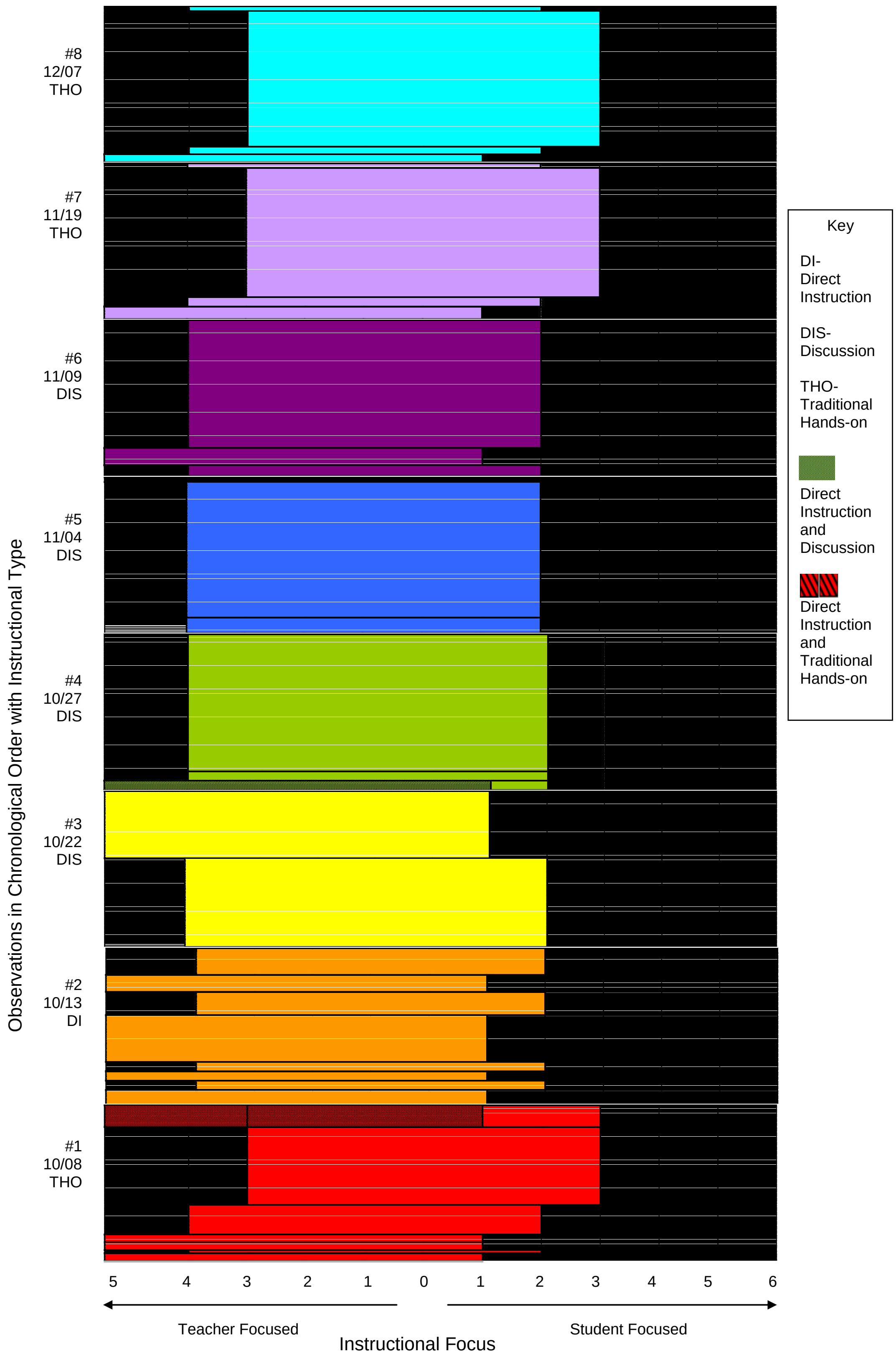

Figure B.11. Graphical display of Michelle's instructional techniques.

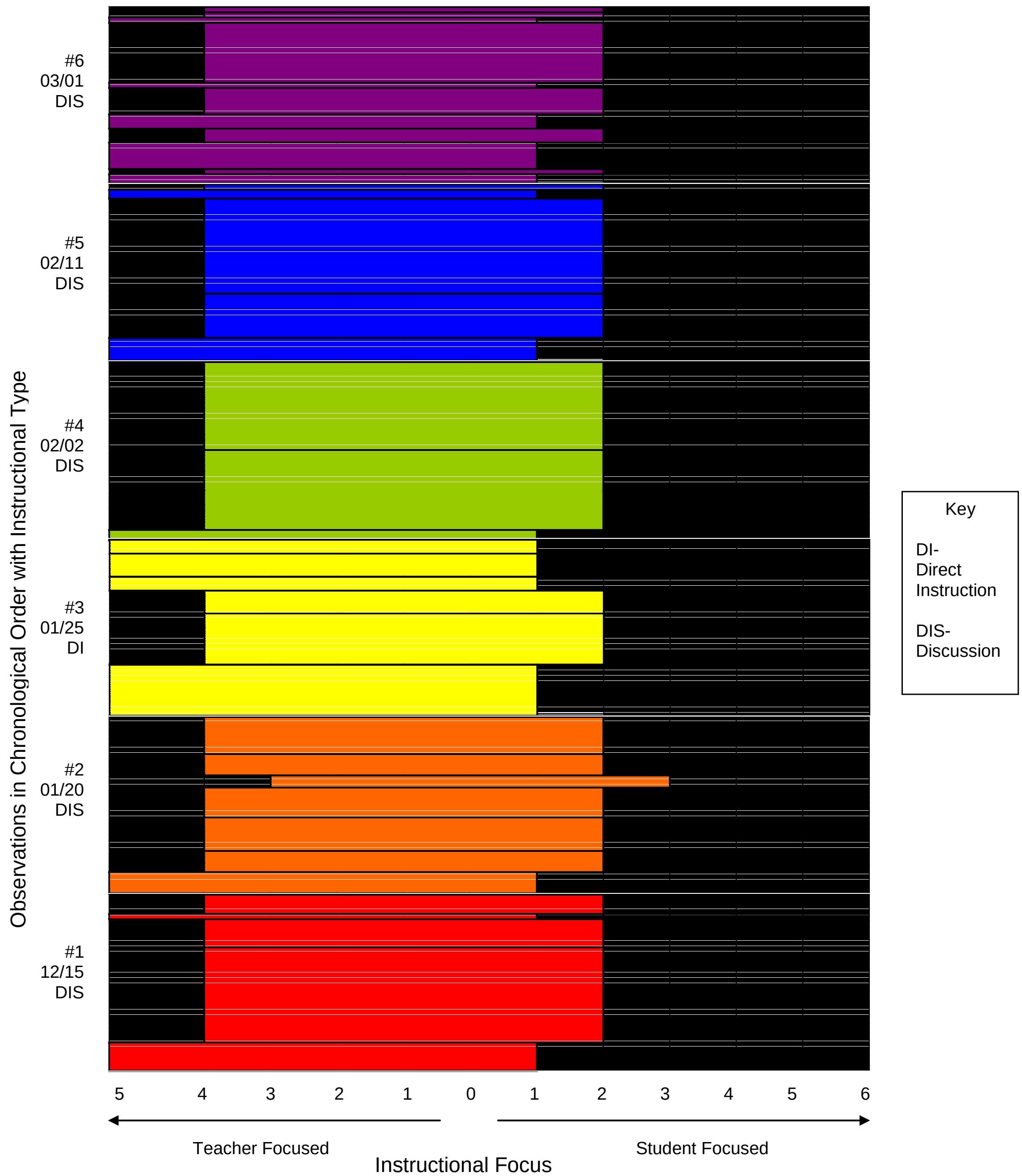

Figure B.12. Graphical display of Yajaira's instructional techniques.

APPENDIX C

Observation Protocol

Field Note Template for Observations

D.B. JACKSON FIELD NOTES FOR CASE:

DAY: **DATE:** **START TIME:** **END TIME:** **PAGE:**

DESCRIPTIVE NOTES	REFLECTIVE NOTES	THEME	INSTRUCTIONAL CODING

Detailed Description of Observation Protocol

1. Participants not observed during the first round of observations received the following email message:

   Dear (Participant First and Last Name Used),

   I hope that the start of your new school year has gone well. As promised at the completion of our interview last semester, I am contacting you regarding the second phase of my data collection, observations.

   I am currently observing two of the other participants. My plan is to begin observing you either in December or January. Please let me know if your ability to participate in this study and/or your teaching assignment has changed. If you are still able to participate, I will contact you a week prior to observations to discuss this phase of the research and address any questions you might have.

   Thanks again for your participation in my study. I truly appreciate your assistance.

   Sincerely,
   Dionne Jackson

2. Contact participant by email at least a week prior to the beginning of observations to confirm their continued participation in the study and their current teaching assignment. The following email message was used:

   Dear (Participant First and Last Name Used),

   I hope that the start of your new school year has gone well. As promised at the completion of our interview last semester, I am contacting you to begin the second phase of my data collection, observations. I would like to set up a brief meeting with you this week in order to discuss the observation phase and address any questions you might have. Please let me know if there is a time you are available to meet this (Insert day(s) convenient for the researcher).

   If your ability to participate in this study and/or your teaching assignment has changed, please let me know. Thanks again for your participation in my study. I truly appreciate your assistance.

   Sincerely,
   Dionne Jackson

3. Once confirmation received, meet with the teachers to discuss the protocol for observations, address any questions they have, and to let them know which week to anticipate the first observation.

4. Observations followed the following patterns:

Week	Middle and Secondary	Post Secondary
1	Thursday	Tuesday
2	Tuesday	Thursday
3	Wednesday	Thursday
4	Monday	Tuesday
5	Thursday	Tuesday
6	Tuesday	Thursday
7	Wednesday	Thursday
8	Monday	Tuesday

If there was a known conflict that existed for the day of an observation (holiday, school assembly, investigator teaching responsibilities, etc.), the investigator skipped to the next observation day without a conflict according to the observation schedule. If all days within a week did not work for the participant and/or investigator, the original day of observation was used for the following week.

5. When the investigator arrived at the participant's class, she greeted the teacher and took her place at the area of the classroom designated for observations.

6. When the teacher began to interact with the students, the investigator turned on the digital voice recorder and left it on until all students from the class left the room.

7. The investigator used field note forms to document observations and reflections during the class session.

8. Either during or at the end of each class session, the investigator collected artifacts (lesson plans, lesson handouts, examples of student work, PowerPoints) related to the day's lesson. Any documents not collected at this time were collected at a later date.

9. If there were questions regarding the observation, they were addressed by an email exchange with the teacher.

10. At the conclusion of observations, teachers were informed that they would be contacted at a later date to schedule their post interview.

Excerpt of a Lesson Script

D.B. JACKSON INSTRUCTIONAL SCRIPT FOR CASE: MICHELLE

DAY: Monday DATE: 11-09-2009 START TIME: 8:55 AM END TIME: 9:39 AM
TT: 44 minutes PAGE: 2

TIME	DESCRIPTIVE NOTES	REFLECTIVE NOTES	THEME	INSTRUCTIONAL CODING
8:59 9:00	Teacher reads warm up and questions students openly. Students respond orally as a whole group. Teacher asks for a student to provide a summary of Jurassic Park. One student provides summary, then all students begin to summarize with the teacher's assistance. Teacher tells them about the movie clip they are about to watch.	15 students present today.	TQ, SL, ST, TT TQ, SL, ST, TT, SL	Discussion
9:01	Teacher starts video clip. Students watching and listening.	Good use of technology at this level Clip is of the DNA movie shown to those visiting the park and how at the park they harvest dinosaur blood from preserved mosquitoes from long ago to create dinosaurs	M, SW, SL	Direct Instruction
9:04	Teacher stops video and briefly talked about what the clip represented as she transitions to PowerPoint notes "Genetic Technology" Chp. 13 (Michelle 11-09-2009 A)	Very smooth transition. (notes coded as discussion because they have blanks and require interaction during the notetaking process)	M, TT, SL	

M= Manage PQ=Presenter questions PT=Presenter talks R=Review SHO= Student hands on
SL=Students listen SWR= Students write ST=Student(s) talk SQ=Student(s) question
SW=Students watch THO=Teacher hands-on TL=Teacher listens TM=Teacher Monitors
TQ=Teacher questions TT=Teacher talks TWR=Teacher writes V=Video

APPENDIX D

Interview Protocol

Science Education Experiences Interview Questions

Science Education Experiences Semi-Structured Interview: Middle and Secondary

1. Why did you decide to become a science teacher?

2. As a student, how did you learn science best?

- **A.** Do you have a degree in science? If so, what is the subject area?
- **B.** How were your science courses taught?

3. Please describe your teacher education program.

- **A.** Did you complete a traditional or alternative certification program?
- **B.** Did you take a science methods course? If so, how was this courses taught?
- **C.** Please describe your student teaching experience.

4. How would you describe the professional development opportunities you have participated in since receiving your certification, such as in-service, conferences/institutes or additional college courses?

5. What has been the greatest influence on how you teach science?

Science Education Experiences Interview: Post Secondary

1. Why did you decide to become a science professor?

2. As a student, how did you learn science best?

- **A.** Do you have a degree in science? If so, what is the subject area?
- **B.** How were your science courses taught?

3. Please describe any experiences you had that were specifically designed to prepare you to become a science professor.

4. How would you describe the professional development opportunities you have participated in since becoming a science professor, such as in-service, conferences/institutes or additional college courses?

5. What has been the greatest influence on how you teach science?

Note. Questions based on interview questions from Smith (2005).

Teacher Beliefs Interview Questions

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

Note. From "Capturing Science Teachers' Epistemological Beliefs: The Development of The Teachers Beliefs Interview by J.A. Luft and G.H. Roehrig, 2007, *Electronic Journal of Science Education, 11,* p. 43. Permission to use interview questions granted by Dr. Luft. See Appendix E for permission statement.

Post Interview Questions

Semi-structured Interview After Field Observations

The general questions below were structured to address themes that arose from the observations conducted.

1. As you reflect over the period of time I observed your teaching, what were some of your most outstanding teaching moments? What were some of your more difficult teaching moments?

2. Why did you use this technique to teach this topic? Did you consider other approaches to teach this topic?

3. Do you have any clarifications to make for the themes or categories generated?

4. Now that you have seen the themes and categories generated from my observations, what are your overall thoughts regarding how your epistemological beliefs impact your engagement of students in posing questions and engaging in student generated investigations?

5. After reflecting over the period of time I observed and your science teaching experiences, what (if anything) will you change about the way you teach science (or this course) in the future?

APPENDIX E

Informed Consent and Permission Documents

Informed Consent Form

Baylor University
Certification of Informed Consent
Principal Investigator: Dionne B. Jackson, Doctoral Candidate
Department of Curriculum and Instruction

This form asks for your consent to participate in education research. This study will investigate the science teaching philosophies of science teachers. For this study you will be asked to respond to questions during an interview prior to and after the investigation and allow the investigator to observe your science teaching. The initial and final interviews will each take approximately one to two hours and the observations will be conducted approximately one hour once a week during the fall semester.

There will be no physical risks at any time. You may elect, either now or at any time during the study, to withdraw your participation, with no penalty or loss of benefits. You have been selected to participate in this study based on your employment. You should understand that your compliance is completely voluntary and that your participation, or lack of participation, in this study will not affect your employment.

A pseudonym will be used to identify each school and the information collected from each participant so you are guaranteed complete confidentiality. All participants' information will be kept in a locked file cabinet in the investigator's office.

This study meets the American Psychological Association's standards for "Minimal Risk" and poses no major risks or dangers for you as a participant.

Information gathered from the investigation will be analyzed and used to help the investigator understand science teaching philosophies in order to improve the professional development opportunities provided to science teachers. A summary of the study will be available for you to review, should you wish to see the outcome. A copy of this consent form is available for participants.

The principal investigator is a graduate student so all inquires should be directed to the chair of her dissertation committee, Dr. Betty J. Conaway, Department of Curriculum and Instruction, School of Education, Baylor University, P.O. Box 97314, Waco, TX 76798-7314. Dr. Conaway may also be reached at 254-710-6115.

If you have any questions regarding your rights as a participant, or any other aspect of the research as it relates to you as a participant, please contact the Baylor University committee for the Protection of Human Subjects, Dr. Matthew S. Stanford, Chair, Baylor University, P.O. Box 97344, Waco, TX 76798-7344. Dr. Stanford may also be reached at 254-710-2236.

I have read and understood this form, am aware of my rights as a participant, and have agreed to participate in this study.

______________________________ _________________________

NAME (SIGNATURE) DATE

Demographic Information Forms

Middle and Secondary Teacher Demographic Information

First and Last Name: ____

What is your race? (circle)

African-American Asian Hispanic Native American

White/Caucasian Other ____________

What is your age range? (circle)

21-30 31-40 41-50 51+

What is your sex? (circle)

Male Female

How many years have you taught? __________

How many years have you taught science? __________

How many years have you taught science at your current school? __________

What grade level(s) and course(s) do you currently teach?

____

____

____

Have you taught any subjects other than science? If so, what subjects and at what grade levels and districts?

____

____

____

For Researcher Use Only:
Teacher Pseudonym ___________ School Pseudonym __________ Date __________

Post-Secondary Teacher Demographic Information

First and Last Name: ____

What is your race? (circle)

African-American   Asian   Hispanic   Native-American

White/Caucasian   Other ____________

What is your age range? (circle)

21-30   31-40   41-50   51+

What is your sex? (circle)

Male   Female

How many years have you taught? __________

How many years have you taught science? __________

How many years have you taught science at your current school? __________

What courses do you currently teach? Are these courses undergraduate or graduate courses?

____

____

____

Have you taught any subjects other than science? If so, what subjects and at what level and university?

____

____

____

For Researcher Use Only:
Teacher Pseudonym ___________ School Pseudonym __________ Date __________

Permission Statement from Dr. Julie A. Luft

Sent: Thursday, May 07, 2009 5:49 AM
To: Jackson, Dionne
Attachments:

HI;

You are welcome to use this -- and if you have questions, let me know.

julie

****
Julie A. Luft, Ph.D.
Professor, Science Education
Director of Research, National Science Teachers Association
PI, NSF Induction Program
College of Education
Arizona State University
Tempe, Arizona 85287-0911
480-965-8463 (office)
480-727-6558 (fax)
****

____

From: Jackson, Dionne [mailto:Dionne_Jackson@baylor.edu]
Sent: Tue 5/5/2009 1:14 PM
To: Julie Luft
Subject: Teacher Beliefs Interview

Dr. Luft,

Hello. I am currently working on my dissertation, and I am interested in using your Teacher Beliefs Interview questions published in the Electronic Journal of Science Education. My study involves the examination of the epistemological beliefs of science teachers (both secondary and post secondary) and how these beliefs impact their use of authentic inquiry.

Thanks in advance for your consideration.

Sincerely,

Dionne Jackson

****
Dionne Jackson
Instructor and Doctoral Candidate
Baylor School of Education
One Bear Place #97314
Waco, TX 76798
Office: 254.710.4238

WORKS CITED

Abd-El-Khalick, F., Bell, R.L., & Lederman, N.G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education, 82*(4), 417-436.

Abd-El-Khalick, F., Boujaoude, S., Duschl, R., Lederman, N. G., Mamlok-Naaman, R., Hofstein, A., Niaz, M., Treagust, D., & Tuan, H. (2004). Inquiry in science education: International perspectives. *Science Education*, *88*(3), 397-419.

Abelson, R. (1979). Differences between belief systems and knowledge systems. *Cognitive Science, 3*, 355-366.

Abruscato, J. (2004). *Teaching children science: A discovery approach, 6th edition*. Boston: Pearson.

Aguirre, J.M., Haggerty, S.M., & Linder, C.J. (1990). Student-teachers' conceptions of science teaching and learning: A case study in preservice science education. *International Journal of Science Education, 12*(4), 381-390.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

Barman, C.R. (2002). Guest editorial: How do you define inquiry? *Science and Children, 40*(2), 8-9.

Barrow, L.H. (2006). A brief history of inquiry: From Dewey to standards. *Journal of Science Teacher Education, 17*, 265-278.

Baxter Magolda, M.B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development.* San Francisco: Jossey-Bass Publishers.

Belenky, M.F., Clinchy, B.M., Goldberger, N.R., & Tarule, J.M. (1986). *Women's ways of knowing: The development of self, voice, and mind.* New York: Basic Books, Inc., Publishers.

Bell, R.L., Lederman, N.G., & Abd-El-Khalick, F. (2000). Developing and acting upon one's conception of the nature of science: A follow-up study. *Journal of Research in Science Teaching, 37*(6), 563-581.

Benson, G.D. (1989). Epistemology and science curriculum. *Journal of Curriculum Studies, 21*(4), 329-344.

Bonnstetter, R.J. (1998). Inquiry: Learning form the past with an eye on the future. *Electronic Journal of Science Education, 3*(1).

Boulton-Lewis, G.M., Smith, DJ.H, McCrindle, A.R., Burnett, P.C., & Campbell, K.J. (2001). Secondary teachers' conceptions of teaching and learning. *Learning and Instruction, 11*, 35-51.

Brickhouse, N.W. (1989). The teaching of the philosophy of science in secondary classrooms: Case studies of teachers' personal theories. *International Journal of Science Education, 11*(4), 437-449.

Brownlee, J., Boulton-Lewis, G., & Purdie, N. (2002). Core beliefs about knowing and peripheral beliefs about learning: Developing an holistic conceptualization of epistemological beliefs. *Australian Journal of Educational & Developmental Psychology, 2*, 1-16.

Bybee, R.W. (1997). *Achieving scientific literacy: From purposes to practices.* Portsmouth, NH: Heinemann.

Center for Science, Mathematics, and Engineering Education. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, D.C: National Academy Press.

Chiappetta, E.L. & Adams, A.D. (2004). Inquiry-based instruction: Understanding how content and process go hand-in-hand with school science. *The Science Teacher, 71*(2), 46-50.

Chinn, C.A. & Malhotra, B.A. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education, 86*(2), 175-218.

Creswell, J.W. (2007). *Qualitative inquiry & research design: Choosing among five approaches.* London: Sage Publications.

Cronin-Jones, L.L. (1991). Science teacher beliefs and their influence on curriculum implementation: Two case studies. *Journal of Research in Science Teaching, 28*(3), 235-250.

DeBoer, G. (1991). *A History of ideas in science education: Implications for practice.* New York: Teachers College Press.

Duschl, R. A., Shouse, A. W., & Schweingruber, H. A. (2007). What research says about K-8 science learning and teaching. *Principal, 87*(2), 16-22.

Etheredge, S. & Rudinitsky, A. (2003). *Introducing students to scientific inquiry: How do we know what we know?* Boston: Pearson Education, Inc.

Fang, Z. (1996). A review of research on teacher beliefs and practices. *Educational Research, 38*(1), 47-65.

Fletcher, S. S. (2006). *Exploring the beliefs and practices of five preservice secondary science teachers from recruitment through induction in a university preparation program: A longitudinal study*. Ph.D. dissertation, The University of Texas at Austin. Retrieved April 17, 2009, from Dissertations & Theses: Full Text. (Publication No. AAT 3266826).

Gallagher, J.J. (1991). Prospective and practicing secondary school science teachers' knowledge and beliefs about the philosophy of science. *Science Education, 75*(1), 121-133.

Germann, P.J., Haskins, S., & Auls, S. (1996). Analysis of nine high school biology laboratory manuals: Promoting scientific inquiry. *Journal of Research in Science Teaching, 33*(5), 475-499.

Hashweh, M.Z. (1996). Effects of science teachers' epistemological beliefs in teaching. *Journal of Research in Science Teaching, 33*(1), 47-63.

Hewson, P.W. & Hewson, M.G. (1987). Science teachers' conceptions of teaching: Implications for teacher education. *International Journal of Science Education, 9*(4), 425-440.

Hofer, B.K. (2002). Personal epistemology as a psychological and Educational construct: An Introduction. In B.K. Hofer & P.R. Pintrich (Eds.) *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 3-14). Mahwah, N.J.: L. Erlbaum.

Hofer, B.K. & Pintrich, P.R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67*(1), 88-140.

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27*(1), 65-90.

King, P.M. & Kitchener, K.S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults.* San Francisco: Jossey-Bass Publishers.

Hansen, L. (2002). Defining inquiry: Exploring the many types of inquiry in the science classroom. *The Science Teacher, 69*(2), 34-37.

Lederman, N.G. (1992). Students' and teachers conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*(4), 331-359.

Lederman, N.G. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate and impede the relationship. *Journal of Research in Science Teaching, 36*(8), 916-929.

Lederman, N. (2004). Scientific inquiry and science education reform in the United States. In E. Krugly-Smolska and P.C. Taylor (Eds.), *Inquiry in science education: International perspectives* (pp. 402-404). *Science Education, 88*(3).

Leonard, W.H. & Penick, J.E. (2009). Is the inquiry real. *The Science Teacher, 76*(5), 40-43.

Llewellyn, D. (2005). *Teaching high school science through inquiry: A case study approach.* Thousand Oaks, CA: Corwin Press, 2005.

Loucas, L., Elby, A., Hammer, D., & Kagey, T. (2004). Epistemological resources: Applying a new epistemological framework to science instruction. *Educational Psychologist, 39*(1), 57-68.

Luft, J.A. & Roehrig, G.H. (2007). Capturing science teachers' epistemological beliefs: The development of the teachers beliefs interview. *Electronic Journal of Science Education, 11*(2), 38-63.

Martin-Hanson, L. (2002). Defining inquiry: Exploring the many types of inquiry in the science classroom. *The Science Teacher, 69*(2), 34-37.

McNeil, L. & Valenzuela, A. (2000). *The harmful impact of the TAAS system of testing in Texas: Beneath the accountability rhetoric.* Houston, TX. (ERIC Document Reproduction Service No. ED443872)

Mellado, V., Bermejo, M.L., Blanco, L.J., & Ruiz, C. (2007). The classroom practice of a prospective secondary biology teacher and his conceptions of the nature of science and of teaching and learning science. *International Journal of Science and Mathematics Education, 6*, 37-62.

Merriam, S.B. (1998). *Qualitative research and case study application in education.* San Francisco: Jossey-Bass.

Michaels, S., Shouse, A.W., Schweingruber, H.A. (2008). *Ready, set, science!: Putting research to work in K-8 science classrooms.* Washington, D.C.: National Academies Press.

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform.* Retrieved April 1, 2010 from http://www2.ed.gov/pubs/NatAtRisk/index.html.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academies Press.

National Research Council. (2000). *Inquiry and the national science education standards.* Washington, D.C.: National Academies Press.

National Society for the Study of Education. (1947). *Science education in American schools.* Chicago, IL: University of Chicago Press.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies*, *19*(4), 317-328.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

Perry Jr., W.G. (1970). *Forms of intellectual and ethical development in the college years: A scheme.* New York: Holt, Rinehart and Winston, Inc.

Raphael, L.M., Pressley, M., & Mohan, L. (2008). Engaging instruction in middle school classrooms: An observational study of nine teachers. *The Elementary School Journal*, *109*(1), 61-81.

Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula (Ed.), *The handbook of research in teacher education 2nd edition* (pp. 102-119). New York: Macmillan.

Ritchie, J. & Spencer, L. (1994). Qualitative data analysis for applied policy research. In A. Bryman & R.G. Burgess (Eds.), *Analyzing qualitative data* (pp. 173-194). New York: Routledge.

Ritchie, J., Spencer, L., & O'Connor, W. (2003). Carrying out qualitative analysis. In J. Ritchie & J. Lewis (Eds.), *Qualitative research practice: A guide for social science Students* (pp. 119-262). London: Sage Publications.

Roehrig, G.H. & Luft, J.A. (2004). Constraints experienced by beginning secondary science teachers in implementing scientific inquiry lessons. *International Journal of Science Education, 26*(1), 3-24.

Schommer-Aikin, M. (2002). An evolving theoretical framework for an epistemological belief system. In B.K. Hofer & P.R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 103-118). Mahwah, N.J.: L. Erlbaum.

Schommer-Aikin, M. (2004). Explaining the epistemological belief system: Introducing the embedded systemic model and coordinated research approach. *Educational Psychologist, 39*(1), 19-29.

Schommer, M. (1990). Effects of beliefs about nature of knowledge on comprehension. *Journal of Educational Psychology, 82*(3), 498-504.

Schommer, M. & Walker, K. (1995). Are epistemological beliefs similar across domains? *Journal of Educational Psychology, 87*(3), 424-432.

Schwab, J.J. (1960). Enquiry, the science teacher, and the educator. *The Science Teacher, 27*(6), 6-11.

Schwab, J.J. (1962). The teaching of science. Cambridge, MA: Harvard University Press.

Smith, L.K. (2005). The impact of early life history on teachers' beliefs: In-school and out-of-school experiences as learners and knowers of science. *Teachers and Teaching: Theory and Practice, 11*(1), 5-36.

Smith, M.U. (2004). Knowing, believing and understanding: What goals for science education? *Science & Education, 13*, 553-582.

Southerland, S.A., Sinatra, G.M., & Matthews, M.R. (2001). Belief, knowledge, and science education. *Educational Psychology Review, 13*(4), 325-351.

Stake, R. E. (1995). *The art of case study research.* Thousand Oaks, CA: Sage Publications.

Stuessy, C.L. (2002). Visualizing complexity in science classroom learning environments. In D. Colton, M.J. Payne, N. Bhatnagar, and C.R. Woratscheck (Eds.). Proceedings from ISECON 2002: *The 29th Information Systems Educators Conference.* Chicago, IL: AITP Foundation for Information Technology Education.

Stuessy, C., Parrot, J., & Foster, A. (2005, April). *Looking inside: Videotape analysis of classroom learning environments.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, Dallas, TX.

Tatto, M.T. (1999). The socializing influence of normative cohesive teacher education on teachers' beliefs about instructional choice. *Teachers and Teaching: Theory and Practice, 5*(1), 95-118.

Tobin, K., Elmesky, R., & Seiler, G. (Eds.). (2005). *Improving urban science education: New roles for teachers, students, & researchers.* Lanham: Littlefield Publishing Group.

Trowbridge, L., Bybee, R., & Powell, J. (2000). *Teaching secondary school science: Strategies for developing scientific literacy.* Upper Saddle River, NJ: Prentice Hall.

Tsai, C.-C. (2002). Nested epistemologies: Science teachers' beliefs of teaching, learning and science. *International Journal of Science Education, 24(8),* 771-783.

Wallace, C.S. & Kang, N. (2004). An investigation of experienced secondary science teachers' beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching, 41*(9), 936-960.

Weiss, I.R., Pasley, J.D., Banilower, E.R., & Heck, D.J. (2003). *Looking inside the classroom: A study of K-12 mathematics and science education in the United States.* Chapel Hill, NC: Horizon Research.

Welch, W.W., Klopfer, L.E., Aikenhead, G.S., & Robinson, J.T. (1981). The role of inquiry in science education: Analysis and recommendations. *Science Education, 65*(1), 33-50.

Yin, R.K. (2003). *Case study research: Design and methods, 3rd edition.* London: Sage Publications.