PROJECT SCIENCE INQUIRY: AN EXPLORATION OF ELEMENTARY
TEACHERS’ BELIEFS AND PERCEPTIONS ABOUT SCIENCE TEACHING AND
LEARNING

by

Dawn Renee Wilcox
A Dissertation
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
in Education

Committee:

Chair

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Human Development

Date: April 25, 2008

Spring Semester 2008
George Mason University
Fairfax, VA
Project Science Inquiry: An Exploration of Elementary Teachers’ Beliefs and Perceptions about Science Teaching and Learning

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University

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Spring Semester 2008
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DEDICATION

This is dedicated to my loving husband Henry, my three wonderful children David, Laura, and Robert Henry and my dog Babe. A special dedication goes out to my grandmother who encouraged me to explore the science behind the old buttercup legend.
I would like to express my gratitude to all those who gave me the support to complete this dissertation. I would like to thank my many friends and relatives who have encouraged me to the dissertation stage of my education. My loving husband, Henry, encouraged and supported me through all of my educational endeavors. My children, who forgave me for not being able to attend all of their scouting meetings and sports events, have been a constant source of love, support, and strength. Thank you David for displaying the fervor tenacity to continually push the edge of the envelope, Laura for encouraging me to continue to make teaching and learning fun, and Robert for bringing me ice cream and tea. I am deeply indebted to Dr. Samaras whose assistance, stimulating suggestions, and encouragement helped me during the research and writing of this dissertation. Dr. Scruggs and Dr. Frazier, and the other faculty members at George Mason were of invaluable help. I extend many thanks to the teachers who participated in this research study. Finally, thanks go out to Joe for tech support and to Bob for holding the universe together.
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ABSTRACT

PROJECT SCIENCE INQUIRY: AN EXPLORATION OF ELEMENTARY TEACHERS’ BELIEFS AND PERCEPTIONS ABOUT SCIENCE TEACHING AND LEARNING

Dawn Renee Wilcox, PhD
George Mason University, 2008
Dissertation Director: Anastasia P. Samaras

This dissertation examined elementary teachers’ beliefs and perceptions of effective science instruction and documents how these teachers interpret and implement a model for Inquiry-Based (I-B) science in their classrooms. The study chronicles a group of teachers working in a large public school division and documents how these teachers interpret and implement reform-based science methods after participating in a professional development course on I-B science methods administered by the researcher. I-B science teaching and its implementation is discussed as an example of one potential method to address the current call for national education reform to meet the increasing needs of all students to achieve scientific literacy and the role of teachers in that effort. The conviction in science reform efforts is that all students are able to learn science and consequently must be given the crucial opportunities in the right environment that permits optimal science learning in our nation’s schools. Following this group of teachers
as they attempted to deliver I-B science teaching revealed challenges elementary science teachers face and the professional supports necessary for them to effectively meet science standards. This dissertation serves as partial fulfillment of the requirements for the degree of Doctor of Philosophy in Education at George Mason University.
1. Introduction

Our family was at home one evening. My elementary aged daughter, Laura, was doing her homework. She started fretting and soon became very confused. I asked her what was wrong and offered my help. She sheepishly showed me her science textbook and a picture she was trying to draw. Her assignment was to draw and label the parts of an egg. So, I began, in my best teacher talk, asking questions like, “think back to when you cracked open the egg in science class, did the teacher come around and help you identify or point out the parts of the egg? Did you look at the shape or colors of the parts to help you remember the names?” She looked at me as if I had two heads! I waited. She continued to look perplexed. So I tried to rephrase the question. She just stared blankly at me. Confused, I thought about how I could help her. She finally spoke up and said, “Mom, we never cracked open an egg. We just read the chapter in the textbook.” I was flabbergasted. I thought to myself, wow, it would have been quite simple to crack open and egg and show it to the children! Why didn’t the teacher do that?

This seemingly insignificant event triggered a series of questions or puzzlements that I still carry with me today, almost a decade later. I still wonder how often this sort of thing happens in schools? Why does the teacher use the textbook to teach concepts that would be best learned through manipulation, inquiry, or hands-on methods? Were they not taught how to do this in college? Surely they were, and if so, why is it that teachers know that a method is effective yet they choose not to use it? Do they revert to the textbook because they are not comfortable with the content? Oh, an in case you are wondering, my daughter and I went to the fridge and got out an egg.
Statement of the Problem

As a science coordinator in my school system I am frequently asked to plan and implement staff development sessions for our science teachers. I have often met resistance by teachers to change or implementation of science curriculum reform measures. This raised a major concern as to how science educators can successfully implement science standards-based reform. How will professional developers train science educators to make learning vivid, meaningful, useful, and memorable? What supports will build the passion of teachers and encourage the use of science hands-on methods? From my many years of experience as a science teacher and professional development coordinator, I have observed that professional development sessions largely consist of traditional lectures to pass on science content and the sessions typically focus on technical training in relation to teaching. Undergraduate science courses usually convey science as a group of specifics and sets of laws to be memorized, instead of as a way of knowing about the natural world. Many college science laboratories overlook the pedagogy of science as inquiry. Hands-on methods do not necessarily equate with teaching science as inquiry. What is more, teacher preparation courses and professional development training activities in methods of teaching science repeatedly put emphasis on technical skills rather than reasoning, decision-making, and theory. If standards-based reform is to be achieved, professional development activities need to include practices that engage potential and practicing teachers in active learning that fosters their comprehension, knowledge and ability (National Research Council [NRC], 1998).

The purpose of this research is to describe and document elementary teachers’ beliefs or perceptions of effective science instruction and to determine how these teachers
interpret and implement a model for inquiry-based (I-B) science in their classrooms. Throughout this investigation, my goal was to gain a deeper understanding of teacher perceptions as mental models frame these perceptions. These mental models consist of conceptions of science subject matter, and barriers related to teaching and learning. This research also includes a thick description of the process of enacting change as teachers attempt to implement I-B methods into their classrooms as opposed to teacher-centered activities. There are three stories to document through this action research study, (a) explaining or describing the Project Science Inquiry Professional Development Course and exploring what role the professional development course played in each teacher’s attempts to implement I-B methods into their classrooms, (b) presentation of the accounts of the teacher’s individual “portraits” or case studies, and (c) outlining the role played by myself and other educational leaders and reflecting on the experience as it relates to current literature on science reform and implementation of change. Implementing I-B methods is important because it is supported by research and established professional standards, promoted by professional associations, and espoused by scientists who work with both the content and the process of how the knowledge base of science can be extended. Knowing that the teachers are often resistant of changing practice, an exploration, using the action research methodology enabled me to both study the process of their change and study my practice as an educational leader facilitating a group of teachers as they attempted to implement inquiry-based methods. This study is useful to understanding what supports or hinders teachers’ adoption of applying standards based reform measures in their classrooms.
Background of the Problem

Brief History of Reform

The idea of science education reform is not a new one. The first attempt to revise science education was initiated long ago in 1892 at a National Education Association (NEA) meeting. Charles W. Eliot, then Harvard University’s President, led a task force of scholars dubbed the Committee of Ten. The members of the committee agreed that the goal of public schooling should be a smooth transition to a college level curriculum through traditional academic studies (Brazilian, 2003; Mitchell, 1981). Science education was restructured throughout the early 1900’s to accentuate its significance to society and daily living. Soon, students were stationed rigidly on to one of two tracks in science education, one for those students pursuing a college education and a second for those who were planning to obtain a job upon graduation from high school (Brazilian, 2003).

As a reaction to Sputnik in 1955 and the emergent apprehension that the United States was trailing the space race, the next phase of project reforms developed. The subsequent projects rallied attention to processes of science and incorporated laboratory procedures into course discussions. The projects, sponsored via federal government and private agencies, also highlighted and elevated cognitive skills and an awareness and knowledge of the nature of science. Unfortunately, several of these projects were terminated in the 1970’s as a result of the belief that the curriculum development programs were ineffective (Shymansky, Kyle, & Alport, 1982).

Recent Science Reform Efforts

Reports from political figures and educators coupled with studies published in the 1980’s heightened public awareness that America’s schools were not producing the
science excellence required for global economic leadership. In 1983 *A Nation at Risk* was published, calling for considerable reform in education. Results of the Third International Math and Science Study (TIMSS) conducted by the Department of Education in 1995 showed that students performed above the international average in both mathematics and science at the fourth grade level. Sadly, United States students in the eighth grade scored only slightly above the international average in science and below the international average in mathematics (Haney & Lumpe, 1998; Takahira, Gonzoles, & Salganik, 1998). Four years later the TIMSS test was administered to another group of students. The TIMSS students tested in 1995 as fourth graders and the TIMSS students tested in 1999 as eighth graders represent the same cohort at two different points in time. The TIMSS 1999 study found that the mathematics and science performance of the eighth grade students from the United States was lower than it had been for the cohort four years earlier (Gonzales et al., 2000). The science education system in place today has not changed substantially from the system that was in place one hundred years ago (Sheppard, 2006).

With our nation trailing in the international arena, there was yet another cry for education reform. The science community responded by developing innovative science curricula. By 1989 the National Governors Association, with the support of President George Bush, endorsed national education goals (Haney & Lumpe, 1998). In the United States there are currently two major national projects designed to restructure science education and encourage the development science literacy, *Project 2061: Science for All Americans* (Rutherford & Ahlgren, 1990) and the *National Science Education Standards*...
(NRC, 1998). Both projects have influenced statewide reform initiatives (Ballone & Czerniak, 2001).

Content Standards

Two national organizations, the National Resource Council (NRC, 1998) and the American Association for the Advancement of Science (American Association for the Advancement of Science [AAAS], 1993), identified content and performance standards necessary for the United States to develop a scientifically literate society and to gain an international reputation in science. The AAAS established Project 2061 which published two pivotal documents, Science for All Americans (Rutherford & Ahlgren, 1990) and Benchmarks for Science Literacy (AAAS, 1993). These documents laid the foundation for the NRC to develop the National Science Education Standards in 1996. Both organizations have identified specifically what students need to know and be able to do at grade levels kindergarten through twelve. They addressed the content of science as well as the way science should be taught. The National Science Education Standards clearly state that all students should experience quality science instruction rooted in authentic, inquiry-based (I-B) experiences (NRC, 1996). Inquiry instruction refers to any teaching method focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations and discover answers to their questions about the natural world. Students may plan systems to collect data and choose how to organize and represent the data. Inquiry models of instruction may mirror inquiry procedures of science. They are
consistent with constructivist approaches to learning and are motivational and effective in teaching science to all children (Carin, Bass, & Contant, 2004).

Significance of the Problem

Are Teachers Using Inquiry-Based Methods?

Decades later, education reform efforts have produced only modest gains in science performance (Committee on Science Learning, 2006). Research (Akerson, Flick, & Lederman, 2000; Anderson & Helms, 2001; Davis, 2002; Duschl & Gitomer, 1991; Eick & Reed, 2002; Feldman, 2000; Haury, 1993; Lachat, 2000; LaPlante, 1997; Levitt, 2001; Martin, Mullis, Gonzales, & Chrostowski, 2004) indicates that most teachers are not implementing I-B science (inquiry-based methods) as called for by the standards. Data from Findings from IEA’s Trends in International Mathematics and Science Study reveals that the textbook is frequently the basis of science instruction at both the fourth and eighth grade levels. Internationally, more than half of the fourth-grade and eighth-grade students (56%) had teachers who stated that they used a textbook as the primary foundation of their lessons. In the United States 39% of teachers reported they use a textbook as their primary basis for lessons (Martin et al., 2004). In this age of accountability and testing, teachers feel increasing stress and pressure to “cover” all of the information; instruction often gravitates towards lecture, textbook assignments, worksheets, or “drill and kill.” There is a substantial gap between knowledge (related to effective teaching methods) and practice.

Implementing Standards Based Reform

Teachers are agents of reform or change at the classroom level. The methods teachers use to engage students in the active search for knowledge varies considerably
Implementing standards based reform is a daunting task. Individuals need different kinds of support and assistance at different stages in the change process. Change is a process that takes time and persistence (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). In fact, research shows the changes requested are difficult to put into practice and when implemented they generally fall short of the mark (Anderson & Helms, 2001; Bybee, 1993, 2000; Levitt, 2001). Thesis: Implementing I-B methods is essential because it is supported by research and established professional standards, promoted by professional associations, and espoused by scientists who work with both the content and the process of how the knowledge base of science can be extended. Unfortunately, teachers are resisting.

Problem

The Quest for Knowledge

Throughout time people have created stories, song, dance, music, rituals, customs, and festivals to make sense of, and to celebrate, the world and human condition. Legends and tall tales have been part of the American culture for ages. Pecos Bill fearlessly tamed a ferocious tornado while Paul Bunyan effortlessly restrained a great river. “Such tales have been passed down from generation to generation to explain humanity, the natural world and scientific phenomenon (Hall, 2000). When tradition connects collective wisdom with innovative inspiration it sparks people’s desire to discover” (Wilcox & Sterling, 2006). Beliefs are often generalized as a result of personal experiences. Teachers are no exception to this inclination. Traditionally the teacher has been charged with the responsibility of guiding students in making sense of the world. There is a close link between teacher content knowledge in mathematics and science and student
performance in these disciplines (Darling-Hammond, 2000; Loucks-Horsley et al., 2003). If student learning is going to improve, how do we train the teacher to guide the individual successfully through this voracious quest for knowledge? There is no single approach to good teaching; however, there are general principles upon which educators can agree. These principles are actually beliefs that individuals hold about science teaching and these beliefs guide and influence the way we teach (Hassard, 2000).

Since its inception, our science education system has incessantly undergone policy change and reform (Brazilian, 2003). Administrators, professional developers and professors have struggled for creative ways to prepare teachers to meet increasing demands and standards. As instructors consider crafting professional development to their circumstances, no factor is more important to consider than teachers themselves. Many professional development efforts have plummeted unequivocally, insulting and alienating teachers because they failed to honor their knowledge, skill, cultural background or experience. Teachers often loathe staff development workshops and courses; therefore materials learned are seldom implemented. To avoid these shortcomings, professional developers are obliged to utilize time, as they plan, to discover the teachers’ background and experience, knowledge and beliefs, and goals and needs (Loucks-Horsley et al., 2003; Tate, 2004). The best way to study this problem is to investigate the footprints left as individual educators navigate the incredible journey known as the American education system. Who are these teachers? What is their background? Why do these teachers choose certain methods of teaching over others? This inquiry has uncovered patterns that influence teaching behavior. Investigations into teacher beliefs have revealed methods that encourage teachers to overcome resistance to
implementing certain teaching practices. Results will aid professional development instructors in their efforts to convince teachers to utilize best practices, which will in turn increase their capacity to teach science, based on evidence that students are learning. I propose the following thesis: teachers’ have developed and carry around an array of mental models that influence and hinder their day-to-day classroom decisions and science teaching.

Hypotheses and Research Questions

This action research study is a method of a qualitative research study as the design is emergent and data-driven. The research began with a clear direction and set of questions with anticipation that as data is collected and the analysis progress, the questions and design may shift somewhat. This shift is anticipated in action research as part of the spiraling synergism of understanding and action. The research spiral cycled over time and new questions, literature and methods emerged (Herr & Anderson, 2005). One broad question drove my research: In light of science standards based reform, what is required for elementary teachers to effectively implement inquiry-based methods in their elementary science classrooms? Several sublevel questions were asked to draw out the answer to this broad question. The sublevel questions included:

1. What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?

2. How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science
content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

3. What barriers to implementing I-B methods exist?

4. What relationships exist between teachers’ perceptions and use of I-B methods?

5. How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Importance of the Study

In keeping with recent reform project efforts, the vision of science education that was presented in the Project Science Inquiry (PSI) Professional Development Course was one in which all children have the opportunity to engage in science inquiry and to explore and construct ideas and explanations of the natural world within a supportive community of learners (Loucks-Horsley, Hewson, Love & Stiles, 1998; NRC, 1996). The realization of this vision depends on how teachers choose to teach science and which methods they choose to assess it. There is little information in the current research base on the topic of I-B professional development sessions and research regarding inquiry in the regular classroom (as opposed to a specialized ecology course for example). Also missing are studies on the topics of instruction designed by teachers, knowledge and views about the goals and purposes of implementing inquiry, and motivation for inquiry teaching (Keys & Bryan, 2001; Suters, 2004).

This study followed teachers on their quest for knowledge and understanding as they journeyed along the path of implementation of science reform efforts into their classrooms. The use of pre PSI Professional Development Course interview questions,
teacher observations, the Constructivist Learning Environment Survey (CLES), and the Science Teaching Efficacy Belief Instrument (STEBI) allowed the opportunity to determine where the teachers were in their development of cognitive instruction, inquiry methods, and skills. This information was used to guide and encourage them to build upon those skills (Loucks-Horsley et al., 2003). The teacher’s knowledge and views about the goals and purposes of implementing inquiry played a role in their motivation for inquiry teaching. I-B instruction that is designed by teachers (not prepackaged by researchers) encourages a higher fidelity of implementation (Mowbray, Holter, Teague, & Bybee, 2003).

The PSI Professional Development Course was designed to provide participants with opportunities to collaborate with colleagues and other experts in the school setting (Loucks-Horsley et al., 2003). Participants were given the opportunity to acquire new science content and concepts related to effective classroom learning and teaching, including scientific inquiry, the nature of science, problem solving, applications of knowledge, and methods to challenge and measure student learning. The PSI Professional Development Course also allowed teachers an opportunity to participate in authentic inquiry based learning experiences, which allowed the opportunity to build pedagogical and content knowledge and skills. Teachers were also given the chance to examine their own learning approach through reflection and in-depth investigation into their beliefs and teaching methods (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). The completion of this research project provided data that will help determine the focus and priority of future staff development courses as they relate to student learning, leadership, and the school community. Through participation in this project, teachers gained
important skills that they can share with their colleagues within their own schools. It takes time to successfully implement systemic change. The teachers who have chosen to participate in this project will continue to build upon their knowledge of inquiry over time. The teachers were exposed to experiences that support the their efforts to serve in leadership roles as agents of change and promoters of reform.

Definition of Key Terms

Conceptual Framework Relationship (CFR)- The term conceptual framework or cognitive framework describes the hypothetical construct referring to the organization or relationship of teacher’s concepts or mental models of himself or herself as a teacher in memory. For the purposes of this study, the relationship between each teacher’s own Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI) will be used to describe each teacher’s conceptual framework. *Who am I? What do I know? What can I do?*

Constructivism- Constructivism is a contemporary view of learning. In this view people construct new understandings and knowledge based on what they already know and believe (NRC, 2000).

Coupled Inquiry- Coupled Inquiry is inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002).

Critical Friend (CF)- A CF is someone whose opinion you value. A CF helps to critique your work and encourages you to see it in a new light (McNiff, 2002).
Fidelity of Implementation- Fidelity of Implementation involves the extent to which delivery of an intervention adheres to the protocol or program model originally developed (Mowbray et al., 2003).

Full or Open Inquiry- Full Inquiry is inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002).

Guided Inquiry- Guided Inquiry is inquiry in which the teacher develops a question and allows the student to co-construct the experimental design (Martin-Hansen, 2002).

Individual Identity (II)- The portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or personal constructs (Scribner, Hager, and Warne, 2002) is called Individual Identity.

Who am I?

Inquiry- “Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (NRC, 1998 p.23).

In-service Teacher- An in-service teacher is a practicing teacher.

Novice Teacher- A novice teacher is a new teacher within the first three to five years of teaching.

Philosophy of Teaching- A teachers’ beliefs about the nature of teaching and learning are part of her philosophy of teaching.
Portrait- A portrait is a description or vignette of each participant providing a glimpse into the period of time before, during and after the staff development course.

Professional Development- Professional Development includes all of the activities in which teachers engage to update, refine and increase their skills.

Scientific Literacy- “Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. It also includes specific types of abilities” (NRC, 1998 p.23).

Self-study- Self-study is a component of reflection in which teachers are asked to systematically and critically examine their actions and the content of those actions as a way of developing a more consciously driven mode of professional activity (Samaras & Freese, 2006, p.22).

Shared Identity (SI)- The portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents his or her role as part of the professional community is called Shared Identity. What can I do?

Structured Inquiry- Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002).

Subject Matter Knowledge (SMK)- Subject Matter Knowledge consists of the teacher’s knowledge of content matter and pedagogy (the art and science of being a teacher), and curriculum knowledge (Shulman, 1986). What do I know?

Teacher Choice (TC)- The teacher judges the merits of multiple options and selects a course of action founded on his or her own conceptual framework, including his
or her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI).

Organization of Study

This dissertation includes five chapters. Chapter One is the introductory chapter to the research study. It includes information about the background and significance of the topic, a statement of the problem, a brief overview of the research design including a description of Project Science Inquiry, the purpose of the research, an overview of the research, a list of questions, descriptions of the participants, and an outline of the methods, procedures and instruments that will be used in the study. Chapter one concludes with a definition of key terms.

Chapter Two contains a review of the relevant literature. It begins with a brief history of science education reform and an overview of present mandates in science education. The next section explores the larger theme of science education and outlines the goal of education, gives examples of teaching methods that work, and examines the role the teacher plays in this process.

Chapter Three describes the action research and multiple case study research design that was used for this study. It outlines the rationale for using action research and multiple case study design approach. Chapter three also describes the rationale for what is required to implement standards based reform and the rationale for the organization of the PSI Professional Development Course.

Chapter Four entails the findings of the study including the portraits of the individual teachers (each with an individual section). The chapter has been set up as an introduction to the case studies to portray basic demographic information, analysis of the
research questions and a participant summary for each of the participants. It also details a case analysis, a presentation of the themes developed from the interview responses and reflections. Included in this chapter is an account of the role played by myself and other educational leaders, reflecting on the experience as it relates to current literature on science reform and implementation of change. This section explains the complexity of the role of the researcher, as an insider and a facilitator; in an effort to avoid problematic and inappropriate framing that might occur if the role of the researcher as an actor or participant is ignored (Herr & Anderson, 2005).

The final chapter, Chapter Five, includes a summary, reports conclusions, discussions, implications of findings, and suggestions for further research based upon the findings of the study.
2. Literature Review

Science Education Reform

*Brief History of Reform.*

The idea of science education reform has been the focus of discussion for quite a while. The first attempt to revise science education was initiated in 1892 at a National Education Association (NEA) meeting. Charles W. Eliot, then Harvard University’s President, led a task force of scholars and educators dubbed the Committee of Ten. The members decided that a smooth transition to a college level curriculum through traditional academic studies should be the goal of public schooling. They recommended a specific sequencing order for science courses and emphasized laboratory experiences (Brazilian, 2003; Mitchell, 1981). By the early 1900’s science education had been restructured to accentuate its significance to society and daily living. As the student population continued to grow and society shifted from an agricultural to an industrial basis, it became evident that students were clearly stationed rigidly on to one of two tracks in science education; one for those students pursuing a college education and one for those who were planning to obtain a job upon graduation from high school (Brazilian, 2003).

The next phase of project reforms developed subsequent to 1955 as a reaction to Sputnik and the emergent apprehension that the United States was trailing behind the
Soviets in the space race. The projects called attention to processes of science and incorporated laboratory procedures into course discussions. The ventures also highlighted and elevated cognitive skills and an awareness and knowledge of the nature of science. The projects were sponsored via federal government and private agencies. Unfortunately, several projects were terminated in the 1970’s as a result of the belief that the curriculum development programs were ineffective (Shymansky, Kyle, & Alport, 1982).

*Present Mandates in Science Education*

Reports from political figures and educators coupled with studies published in the 1980’s heightened public awareness that America’s schools were not producing the science excellence required for global economic leadership. In 1983, *A Nation at Risk* was published, calling for considerable reform in education. Results of the Third International Math and Science Study (TIMSS) conducted by the Department of Education in 1995 showed that students performed above the international average in both mathematics and science at the fourth grade level. Sadly, United States students in the eighth grade scored only slightly above the international average in science and below the international average in mathematics (Haney & Lumpe, 1998; Takahira et al., 1998). Four years later, the TIMSS test was administered to another group of students. The nationally representative sample of TIMSS students tested in 1995 as fourth graders and the TIMSS students tested in 1999 as eighth graders represent the same cohort at two different points in time. The TIMSS 1999 study found that the mathematics and science performance of the eighth grade students from the United States was lower than it had been for the cohort four years earlier (Gonzales et al., 2000).
With our nation trailing in the international arena, there was yet another cry for education reform. The science community responded by developing innovative science curricula. By 1989 the National Governors Association, with the support of President George Bush, endorsed national education goals (Haney & Lumpe, 1998). In the United States, there are currently two major national projects designed to restructure science education and encourage the development science literacy, Project 2061: Science for All Americans (AAAS, 1993; Rutherford & Ahlgren, 1990) and the National Science Education Standards (NRC, 1998). Both projects have influenced statewide reform initiatives (Ballone & Czerniak, 2001).

The American Association for the Advancement of Science (AAAS) developed Project 2061: Science for All Americans (1993) with the intent of fostering scientific literacy as a replacement for attempting to cover more content information. The integration of science, mathematics, and technology were important goals set by the researchers, scientists, teachers and leaders from business and industry that created the plan. Science for All Americans defines scientific literacy, establishes benchmarks for science education, and creates a method to guide teacher education and material design (Rutherford & Ahlgren, 1990).

The product of years of research and collaboration between key educational organizations, The National Science Education Standards, were published in 1994 (NRC, 1998). The ideas and topics are similar to those of Science for All Americans. A look at the National Science Education Standards reveals the following:

The National Science Education Standards present a vision of a scientifically literate populace. They outline what students need to know, understand, and be
able to do to be scientifically literate at different grade levels. They describe an educational system in which all students demonstrate high levels of performance, in which teachers are empowered to make the decisions essential for effective learning, in which interlocking communities of teachers and students are focused on learning science, and in which supportive educational programs and systems nurture achievement. (p. 2)

Along with the development of new standards, Goals 2000 Educate America Act provided initial federal legislation to support the standards-based reform movement. Soon, No Child Left Behind legislature dictated that federal funding would extend only to programs that are supported by research-based evidence. In addition, the recent law requires that starting in 2007 states must assess students' progress in science no less than once in each of three grade levels (third-fifth, sixth-ninth, tenth-twelfth) each year. This reform movement based on national standards is called standards based reform (“The Facts About,” 2003).

Present science reform efforts converge on the conviction that all students are able to learn science and consequently must be given the crucial opportunities in the right environment that permits optimal science learning. These policy changes include all children, regardless of ability or interest. This includes children with special needs. Children with behavioral and emotional difficulties often have trouble reading and learning. These children are often mainstreamed into the regular classroom. Schools are encouraged to use research-based methods to teach science and to establish partnerships with universities to ensure that knowledgeable teachers deliver the best instruction in their field (Ballone & Czerniak, 2001; Welton, Smith, Owens & Adrian, 2000).
The Larger Theme Within Education

One of the primary goals of schools is to teach, train, or develop a well-educated work force. In the corporate world, today’s youth are expected to demonstrate excellence in higher-level skills such as critical thinking, teamwork, communication, and problem solving skills. General Motors Corporation and Diamond Star Motors ask that all employees from front line to management demonstrate excellence in higher-level skills such as critical thinking, teamwork, communication and problem solving (Takahira et al., 1998). Most human resource directors do not feel that today’s young adults have been adequately prepared to contribute or compete for current entry-level jobs. Large corporations are finding that entry-level applicants lack the ability to identify and solve problems. Individuals hired in entry-level positions held insufficient academic skills and were unable to work in teams, think critically, and communicate (Conference Board, Corporate Voices for Working Families, Partnership for 21st Century Skills, and the Society for Human Resource Management, 2006). Industries turn down thousands of job applicants because they lack the advanced mathematics, communications, and computer skills required to support today’s manufacturing (Takahira et al., 1998).

Can We Meet the Challenge?

How well prepared are we to meet the challenge of producing science excellence required for global economic leadership and homeland security laid out in the No Child Left Behind Act and the National Science Education Standards? The TIMSS 1999 study found that the mathematics and science performance of the eighth grade students from the United States was lower than it had been for the cohort four years earlier (Gonzales et al., 2000). What happened to this group of students between fourth and eighth grades?
Let’s examine teaching and learning practices of the older students including: homework, time in class, television and extra activities outside of school. The amount of assigned homework doesn’t appear to be a factor. United States students receive about the same amount as students in other nations. The amount of time spent in the classroom does not appear to be a factor. In fact, most United States students spend more time in mathematics and science classes than some of their international neighbors. The amount of television watched does not appear to be a factor either. United States students spend about the same amount of time watching TV or playing video games as other students around the world. Twelfth grade students in the United States are more likely to have jobs outside of school than other students. However, this still does not appear to contribute to the disappointing results of twelfth grade performance (Gonzales et al., 2000; Takahira et al., 1998).

We are spending similar amounts of time teaching and reinforcing science and mathematics skills. Content information is similar in most courses. This might lead one to the conclusion that the method of teaching could be a factor. Let’s examine how our students are taught. Unfortunately, most middle grade and high school teachers in the United States do not use the methods outlined in the National Science Standards. Most use the traditional method of teaching (Mondale & Patton, 2001). In traditional method model, students listen to lecture supplemented by audio-visual aids and textbook readings. United States students are required to use less high-level thought and solve fewer multi-step problems than classes in Japan and Germany. Students from both of these countries performed very well on the TIMSS. Teacher training is also an issue. Twenty-eight percent of high school mathematics and fifty percent of high school physics
teachers neither majored nor minored in the subjects they teach (Takahira et al., 1998). High stakes testing and pressure to cover large amounts of material is resulting in similar tendencies to use the traditional model in elementary schools (Gonzales et al., 2000).

*Why Inquiry Instruction?*

In order to meet reform efforts teachers must use inquiry instruction. The National Science Education Standards clearly state that all students should experience quality science instruction rooted in authentic, inquiry-based experiences (NRC, 1996). The vision of science education is one in which all children have the opportunity to engage in science as inquiry—to explore and construct ideas and explanations of the natural world within a supportive community of learners (Loucks-Horsley et al., 1998). *Project 2061: Science for All Americans* (AAAS, 1990) and the *National Science Education Standards* (NRC, 1996) were designed to foster learning in all children, regardless of ability or interest. In order to assist students in the achievement of scientific literacy we must consider the influence of the teacher and teacher training. Transformations in students’ roles and work will come about through efforts of teachers in classrooms. Thus, the role of teachers requires foremost consideration to better appreciate just how they can cultivate these student changes. Teacher learning is crucial to educational reform.

*Which Teaching Methods Work?*

In order to implement research based instructional practices, educators must make learning vivid, meaningful, useful, memorable, and fun. Research has shown that students learn when placed in environments that fully immerse the students in the educational experience. An example would be immersing a student in a foreign country in order for them to learn a new language. They should be receiving information within the context of
the big idea. You cannot separate the big idea from the details. Memory is a process, not a fixed or single proficiency (Sprenger, 1999; Wolfe, 2001). Teamwork and authentic problem solving situations work best for most learners (Sprenger, 1999). The learner should be free of fear, yet still feel challenged in the environment. When students understand their own learning styles they can enhance their own learning process by customizing their own environment to enhance their learning. The learner also needs to be able to consolidate and internalize the information by actively processing it, which can be done through inquiry.

What is Inquiry?

According to Suters (2004), inquiry instruction can be defined as offering students opportunities to plan and carry out their own investigations related to concepts and topics that are applicable to the curriculum. Numerous terms have been used to depict this type of science instruction, including hands-on, inquiry-based (I-B), standards-based, problem-based, activity-based, and project-based. Suters emphasizes that caution should be used, however, as activities described using one of these terms (even inquiry-based) may not actually fit the definition of inquiry instruction given above (Suters, 2004). Teachers often assume hands-on activities alone constitute I-B instruction. A better representation would be “hands-on” experiences that are also “minds-on” (NRC, 1996; Suters, 2004). The National Research Council (2000) promotes five necessary attributes that ought to be displayed as part of inquiry in the classroom. First, learners are engaged by scientifically oriented questions. Second, learners should give priority to evidence. This allows them to develop and evaluate explanations that address scientifically oriented questions. Third, learners formulate explanations from evidence to address scientifically
oriented questions. Fourth, learners evaluate their explanations in light of alternative explanations, especially those reflecting scientific understanding. Finally, learners communicate and justify their proposed explanations.

Martin-Hansen (2002) illustrates four models of inquiry that are frequently utilized for instruction consisting of full or open, guided, coupled, and structured inquiry. They range from student-centered to teacher-centered in that order. Full or Open Inquiry is described as students asking their own questions, designing investigations, and conveying results. Guided Inquiry is described as the teacher selecting a question to follow and letting the students assist in the decision as to how they might answer the question through investigation. Coupled Inquiry starts as structured inquiry or a teacher-guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control. In this model, the students are permitted to follow their own questions that have come about as a result of guided instruction. Structured Inquiry is based on teacher directed methods and usually is not considered to be an authentic inquiry experience. In this model the teacher selects the question and then leads the students through a succession of steps in the direction of a previously identified answer (Martin-Hansen, 2002; Suters, 2004).

Inquiry instruction allows for change or adjustment to the curriculum. It allows for flexibility to integrate science concepts, topics, or vocabulary words. It allows for integration into other subjects like mathematics, reading, and language arts. Inquiry learning allows students to discuss, examine, critique, explore, argue, and struggle with new ideas. Students in the middle grades are still operating at the concrete and formal operational stages of development. Inquiry learning will help these children who might
have difficulty dealing with abstract concepts (Bruner, 2001). This method of instruction meets the National Research Council’s standards by encouraging students to understand scientific concepts by “doing” science the way that professional scientists conduct experiments and analyzes data (NRC, 1998).

*How Does this Topic Fit into a Larger Theme Within Education?*

As we make advances in science and technology the need for scientific literacy becomes increasingly important to our students. Our nation is in the process of reforming our education system to meet the increasing needs of all of our students. A look at the *National Science Education Standards* (1998) reveals the following:

The intent of the *Standards* can be expressed in a single phrase: Science standards for all students. The phrase embodies both excellence and equity. The *Standards* apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science. Different students will achieve understanding in different ways, and different students will achieve different degrees of depth and breadth of understanding depending on interest, ability and context. But all students can develop the knowledge and skills described in the *Standards*, even as some students go well beyond these levels. (p.2)

These policy changes include all children, regardless of ability or interest. Children with behavioral and emotional difficulties often have trouble reading and learning. These children are often mainstreamed into the regular classroom. How will we motivate and teach children with learning, emotional and behavioral disabilities? Will we will use hands-on inquiry based science (Welton et al., 2000)?
The Teacher

*The Teachers’ Cognitive Framework: What do Teachers Believe?*

The teachers’ knowledge, goals, and beliefs are critically important determinants of what they do and why they do it. The information regarding knowledge, beliefs, and planning is abundant creating an interesting puzzle. Although beliefs and behaviors are interdependent, there is not a straightforward connection between beliefs and actions; therefore, one must assemble the pieces of the puzzle to examine precisely why teachers make particular choices at each point of instruction and precisely upon which beliefs, goals, and knowledge those decisions hinge (Schoenfeld, 1998). Teacher’s attitudes and beliefs about science are key influences on how they teach the subject. The reality of the school classroom consists of lessons in which teachers transmit science as a set of facts, laws, and data. The teachers’ principles or attitude, their tendency to respond favorably or unfavorably toward the topic, students, or other objects, determines what students will see, hear, think, and do. The teachers’ styles and principles are rooted in experience and develop into individual constructs slowly over time (Souza Barros & Elia, 1998).

*Constructivist Learning*

Learning is an active process in which learners construct new ideas or concepts based upon their current or past knowledge. We can trace this constructivist approach to learning to Dewey (1938, 1997), Piaget (1929) and Vygotsky (2006). John Dewey, an educational philosopher, proposed that experience transpires as a result of the interrelationship of two principles, continuity and interaction. Continuity refers to how each experience a person has influences one’s future, for better or for worse. Interaction refers to the situational influence on one’s experience. The individual’s present
experience is a function of the interaction between their past experiences and the present situation. No experience has a pre-destined value. Therefore, what might be a beneficial experience for one individual could be an unfavorable experience for another. In other words, "positive experiences" motivate, encourage, and enable students to go on to have more valuable learning experiences, whereas, "negative experiences" tend to lead towards a student closing off from potential positive experiences in the future. Dewey believed that learning experiences should be meaningful to each student and that teachers should step back and act as facilitators (Dewey, 1938, 1997).

The constructivist approach to how people learn focuses on providing relevant experiences and opportunities that allow students to construct knowledge (Piaget, 1929; Vygotsky, 1978). Piaget advocated the individualistic approach. This approach advocated the individual construction of knowledge in developmentally appropriate stages (Piaget, 1929; Suters, 2004). According to Vygotsky (1978), learning occurs in a socially constructivist manner where people learn from each other in social situations. In his social developmental theory, Vygotsky suggests that social interaction plays a pivotal role in cognitive development with peer collaboration exceeding what can be learned alone (Vygotsky, 1978). Social interaction is the key to enabling students to operate inside the borders of the zone of proximal development (ZPD). The ZPD is defined as “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (Vygotsky 1978, 1981). Both are based on the learner’s problem solving ability under adult guidance
or in collaboration with more capable peers. Peers and teachers are taught to help guide learners to function in their ZPD.

Building upon the work of Piaget and Vygotsky, Bruner (1997) realized the importance of the role played by teachers and peers in learning. Bruner expands on these ideas about cultural psychology in an attempt to explain how individuals make sense of the world, how they connect their thoughts with traditional systems of public beliefs, with the ideas, values, and symbols of the culture. Culture includes daily routines, art, and language. Bruner believes some aspects of culture are innate, others are learned through observation and participation. Bruner’s concept of cultures allows the learner to sort everything out through narratives or stories (Bruner, 1997).

A teacher’s cognitive framework is a hypothetical construct referring to the organization or relationship of concepts in memory. This includes the teacher’s conceptions of how children learn and her own view of effective science teaching. Understanding teachers’ cognitive frameworks related to how children learn science and teachers’ beliefs about effective science teaching is just the first piece of the puzzle needed to understand the big picture of why most teachers are resisting or not implementing inquiry science instruction.

Knowledge of Content and Teaching Methods

A teacher’s cognitive framework also includes the teacher’s knowledge of science content and teaching methods. The teacher’s conceptions of science subject matter or content knowledge includes the ideas, facts, and the concepts of a discipline (such as Earth science, physical science, and life science), as well as the relationships among those concepts, facts, and ideas. This concept also involves the knowledge of how the
discipline creates and evaluates knowledge. A teacher’s conceptions might also include knowledge of science curriculum and standards, as well as what they know about inquiry instruction. Penuel, Fishman, Yamaguchi, and Gallager (2007) note that knowledge of science content and knowledge of how to support student’s science inquiry are necessary in teachers’ professional development. Understanding teachers’ cognitive frameworks related to science content and knowledge of science teaching methods are the next piece of the puzzle needed to understand the big picture of why most teachers are resisting or not implementing inquiry instruction.

*How the Teacher Combines Knowledge with Practice: What can the Teacher Do?*

Cognitive frameworks include teachers’ conceptions of how students learn science and effective science teaching along with the teachers’ knowledge of science content and teaching methods. This is essentially what the teacher is able to do. Teaching is more than the development of a repertoire of techniques. It also includes personal judgments about when and how strategies should be used. Teaching is a “dynamic relationship that changes with different students and contexts” (Hoban, 2000, p. 165). Teachers must develop a repertoire of techniques and strategies as well as an understanding of their application. This depends on making judgments about unique contexts and unpredictable classroom moments. Teachers make decisions about teaching and learning by drawing upon not only professional knowledge and skill but also a set of personal resources that are uniquely defined and expressed by teachers’ personalities along with their individual and collective interaction with students.

Schulman (1986) proposed three categories of subject matter knowledge for teaching, (a) content knowledge, (b) pedagogical content knowledge, and (c) curriculum
knowledge. His first category, *content knowledge* includes facts and concepts in a domain, information about why these facts are true, and how knowledge is generated or structured within the discipline. The special nature of the subject matter knowledge required by teachers for effective science teaching is known as pedagogical content knowledge. Schulman introduced his second category, the notion of *pedagogical content knowledge*, in the mid-1980’s. In his definition he included familiarity with topics children find interesting or difficult, the representations most useful for teaching specific content topics, and learners’ typical errors and misconceptions. This clarification helped to inform the knowledge about qualities and resources needed for effective teaching. His third category, *curriculum knowledge*, involved awareness of ways of organizing programs of study, using curriculum resources, such as textbooks, and of how topics are used over time and within a school year (Schulman, 1986, 1987). As related directly to my thesis, Schulman’s work is useful in understanding; (a) the portion of the teacher’s cognitive framework related to science content, knowledge of science, and teaching methods and (b) a teacher’s beliefs about effective science teaching combined with (c) a teacher’s cognitive framework related to how children learn science to form the teacher’s vision of science teaching.

Specific Research Most Relevant to the Topic

*School Factors: Resources, Support for Inquiry Instruction, Accountability, and Professional Development.*

The teachers’ visions are dependent upon the teachers’ abilities to enact on their cognitive frameworks. In the real world, the teachers’ visions do not always mirror practice. Stakeholders, students, parents, colleagues, administrators, and the community all impact
teachers’ decision-making processes. Tension often occurs between conflict and consensus building as school divisions proceed with the day-to-day business of curriculum implementation, which could include programs of change. Teachers strive to maintain a balance between autonomy (Individual Identity) and their role as part of the professional community (Shared Identity) (Scribner et al., 2002). Adding one more piece to the puzzle, teachers make conscious or unconscious decisions as to what methods they will use to teach science based on their concepts of science and science teaching, knowledge of science content and teaching methods, and school factors. There is yet another piece missing, the teachers’ self-concept or self-image.

Teachers form a self-concept or self-image of their abilities based on feedback from stakeholders and their own impression of their visions of science teaching. These beliefs or principles influence teachers as they strive to create a plan that will allow them to reach each educational goal. The factors of fear, knowledge, and affect as determined by the teachers’ cognitive framework help shape the teachers’ actions. All of these factors make up a teacher’s mental model of effective science instruction. Senge defines mental models as “the images, assumptions, and stories, which we carry in our minds of our selves, other people, institutions, and every aspect of the world,” (Senge, 1990). Learners are frequently unaware of the impact of such assumptions or mental models, on their behavior, and consequently, a fundamental part of each individual’s task is to develop the ability to reflect on what one has done (Schön, 1991). Mental models permit individuals to see certain things and inhibit them from seeing others (Kuhn, 1996). Mental models govern how we interpret data. Our assumptions generally come from our mental models. Mental models are constructs using a variety of assumptions; assumptions are the
principals used to create mental models (Argyris & Schön, 1974; Senge, 1990). Teachers’ styles and principles are rooted in experience and develop into individual constructs slowly over time (Souza Barros & Elia, 1998).

There are a number of research studies related to elementary in-service teacher beliefs, knowledge, and implementation of scientific inquiry. Studies exploring teacher beliefs and knowledge related to their understanding of teaching science (Abell, 2007; Zembal-Saul, Haefner, Avraamidou, Severs, & Dana, 2002), scientific inquiry and the nature of science (Abd-El-Khalick & Lederman, 2000; Abell, Smith, & Volkmann, 2004; Colburn & Bianchini, 2000; Gess-Newsome, 2002; Schwartz, Lederman, & Crawford, 2004), and the ability to connect scientific principles to real life (Davis & Petish, 2005) outline the importance of teacher learning and understanding of the new vision of learner-centered instruction. Abell, Smith, and Volkmann (2004) explain how inquiry is used throughout the literature as an orientation to science teaching or a set of knowledge and beliefs to guide science teaching. Inquiry can be used as a way to frame our thinking about teacher education practices.

Van Zee’s (1998) study related to professional development in science training asserts that both content and pedagogy can be learned through inquiry. Akerson, Flick, & Lederman (2000) found the use of constructivist principles by some teachers is dependent on their science content knowledge. Additional studies exploring teacher beliefs related to the implementation of I-B methods include: the inquiry curriculum (Abell, & McDonald, 2004), I-B professional development (Cuevas, Lee, Hart, & Deaktor, 2005; Hewson, 2007; Lee, Hart, Cuevas, & Enders, 2004), implementing I-B science methods (Anderson & Helms, 2001; Appleton, 2007; Davis, 2002; Duschl & Gitomer, 1991; Eick
& Reed, 2002; Feldman, 2000; Haury, 1993; Lachat, 2000; LaPlante, 1997; Levitt, 2001; Martin, Mullis, Gonzales, & Chrostowski, 2004), teacher change (Keys & Bryan, 2000; Spillane, Reiser, & Reimer, 2002), and the enhancement of self-efficacy resulting from I-B science instruction (Enochs, Scharman, & Riggs, 1995; Reiff, 2002). According to Pennuel et al. (2007), standard or traditional professional development workshops are not as effective as programs designed to be directly translatable to teachers’ practice and situated in their classrooms. They also note that when classroom teachers lead reforms, those teachers may be a source of trust for other teachers. Furthermore, they note that when training involves active learning, develops from teachers’ own goals and questions, and is interactive with the professional development trainer and colleagues, it helps support a successful implementation of teachers’ professional development. Teachers face barriers, such as school schedules, resources, and competing demands, which make it difficult for them to apply what they learn through their professional development to their classroom teaching. Other researchers note that many teachers face a limited amount of instructional time (Appleton, 2007), limited subject matter knowledge and pedagogical content knowledge, and low self-efficacy (Anderson & Mitchener, 1994; Cochran & Jones, 1998). Collectively these studies tell us that professional development rooted in authentic inquiry experiences can be utilized to increase both science content and pedagogical knowledge. Use of constructivist principles by teachers will increase as their self-efficacy, knowledge of content, and pedagogical knowledge increase.

Description of Conceptual Framework

My vision or conceptual framework is framed from what we know and need to know more about in terms of teachers’ professional development in science inquiry. The
conceptual framework was designed through the use of metaphors. The overarching frame is the journey where teachers are tidal pool explorers on the beach. Components within the frame include the professional tools that teachers acquire through their studies and experiences. Each teacher sifts through an accumulation of sand, shells, stones and riches to gather their own unique set of treasures (a metaphor for their mental models) to place into their bucket as they travel along the sandy shore of educational resources. The sand, shells, stones and riches represent training, content knowledge, teaching methods, and experience. Ecological factors (Bronfenbrenner, 1979, 1995) also play a role. Factors and influences such as culture, educated-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual and style help shape the teacher’s principles or beliefs as they travel along the path. Teachers examine the shells and treasure and decide whether to keep them or place them back on the beach based on their own system of values. The discovery of treasures of big or great value has a positive influence on motivation, attitude, caring, determination and effort. The discovery of treasure with little or low value has a negative influence on motivation, attitude, caring, determination and effort. Sometimes valuable treasures are washed out to sea by educational mandates and restrictions and the opportunity to grasp them is lost forever. At other times the tide washes glittering treasures onto the shore. Some collectors have the ability to discover remarkable treasure while others may only unearth ordinary treasures. Stakeholders including students, parents, administrators, and the community judge the items treasure collectors bucket. The collector forms a self-concept or self-image of their ability based on feedback from stakeholders and their own impression of their collection. These beliefs or principles influence teachers as they strive to create a plan that will allow them to reach each educational goal. If the teacher has a
positive experience he/she is apt to repeat the decision. If the teacher has a negative experience he/she is discouraged from repeating the decision. There is a hole in the metaphor of the bucket to represent ability, knowledge or experience that is “lost” along the journey. As a teacher trainer, one would strive to create positive experiences for the teacher to place in her bucket. As the teachers reflects on their decisions, they can see several points of view, a global view of events that make up the beach and a local view details that make up the treasures-pebbles and the shells in the teachers bucket. The goal is for the teacher to see both the beach and the treasures!

Chapter Summary

This chapter explained how present science reform efforts converge on the conviction that all students are able to learn science and consequently must be given the crucial opportunities in the right environment that permits optimal science learning. It examined how well prepared are we are to meet the challenge of producing science excellence required for global economic leadership and homeland security laid out in the No Child Left Behind Act and the National Science Education Standards. This chapter has also described aspects of science literacy including defining scientific inquiry as a constructivist method. In order to meet reform efforts teachers must go beyond just teaching the skills of observing, inferring, and experimenting. They must engage students in inquiry instruction by allowing them to describe objects and events, ask questions, construct and test explanations against current scientific knowledge, and communicate those ideas to others. In order to implement research based instructional practices, educators must make learning vivid, meaningful, useful, memorable and fun. Teachers who have gathered first hand experience with inquiry will be more likely to implement
the strategy within their own classrooms. Inquiry instruction allows students to develop their own questions about content, and responds to the individual constructs, ideas, and cultures that students carry with them from their prior experiences. Professional development can provide teachers with necessary skills and personal experiences that will enable them to implement inquiry instruction in their classroom. It will also provide the tools for participants to use to mentor other teachers. The teachers’ knowledge, goals, and beliefs are critically important determinants of what they do and why they do it. Based on a social constructivist view of learning, teachers need to experience inquiry instruction themselves and professional development trainers can model the approach they encourage teachers to use by supporting teachers’ learning in that very process (Deppeler, 2007).

This is what we know about inquiry science teacher education. A new vision of science learner-centered instruction is being developed. Responses to national and international standards should focus on practicing teachers and their professional development, as this will reach a larger population of teachers within the system (Hewson, 2007). Most teachers are not implementing I-B science as called for by the standards (Mondale & Patton, 2001). Many teachers face issues related to a limited amount of instructional time dedicated to science in most elementary schools (Appleton, 2007), limited subject matter knowledge and pedagogical content knowledge, and low self efficacy (Anderson & Mitchener, 1994; Cochran & Jones, 1998).

An investigation into teacher beliefs and governing variables can uncover patterns that would encourage teachers to over come resistance or barriers to implementing certain teaching methods. Understanding the teachers’ cognitive frameworks related to inquiry,
teachers’ beliefs about inquiry teaching, and how this ties into the teachers’ daily experiences will be crucial to understanding teacher change with regard to inquiry teaching (Keys & Bryan, 2000; Spillane, Reiser, & Reimer, 2002). Thesis: Essential to our understanding of science education reform and study of how teachers’ implement I-B science instruction is an exploration of teachers’ beliefs, teachers’ choices, and school influences on science teaching because teachers have the prerogative to choose how they teach.
3. Methodology

This chapter addresses the rationale and utilization of a combination of action research and collective case study as approaches to frame the research. Information concerning the rationale for this methodology, participant selection, settings and participants, data sources and instruments/surveys administered will be addressed under the following headings:

1. Setting
2. Participants
3. Research Design
4. Data Sources
5. Data Collection Procedures: Prior to, During, and After Project Science Inquiry
6. Data Analysis Procedures
7. Assumptions of the Study
8. Limitations of the Study
Setting

School Division

Milton County Public Schools is a school division situated in a rural county that is quickly on its way to becoming a busy suburban community. The anonymity of the research participants and the division involved has been maintained through use of pseudonyms. Milton County Public Schools serves a population of over twenty-four thousand students. There are currently sixteen elementary schools in the county serving over ten thousand kindergarten through fifth grade students. The student ethnic distribution is as follows: less than one percent Native American/Alaskan, two percent Asian, nineteen percent African American, eight percent Hispanic, sixty-eight percent Caucasian American, less than one percent Native Hawaiian, and approximately one percent unspecified. Twenty percent of students are classified as economically disadvantaged. Each elementary school has unique characteristics and will be described in this section in more detail in my dissertation after I identify the participants that will take part in the study.

Participants

Participant Selection

Eight elementary in-service teachers were selected to participate in this study. They are teachers who are interested in implementing I-B science teaching into their classrooms that signed up to participate in an I-B professional development course. Participants were selected from the group of teachers who signed up for the professional development course, Project Science Inquiry (PSI), offered by Milton County Public Schools. Participants did have an opportunity to choose other workshops. PSI is just one
of four professional development courses offered to elementary teachers is the area of science. The participants also had to opportunity to choose other workshop courses offered in mathematics, reading, social studies, and arts related areas. Participants are volunteers that were recruited through personal contact by the researcher upon receipt of the class rooster. The researcher explained the research study and allowed teachers to decide if they wished to participate in the study or not. All of the participants who agreed to participate in the research signed a letter of consent (see Appendix A for the consent form). Teachers who participated in the PSI professional development course received professional development points; however, the participants were not obligated to participate in the research study. Participation was voluntary and participants were given the opportunity to withdraw form the study at any time and for any reason. If a subject decided not to participate or choose to withdraw from the study, there was no penalty or loss of benefits to which they were otherwise entitled. There was no cost to the participant or any other party. If a participant decided to withdraw from the study before data collection was completed, their data would be returned to them or destroyed upon their request.

The key components of the PSI professional development course were delivered over a two-day period, eight hours each day (sixteen hours), in June, with two subsequent two-hour sessions in October, for a total of twenty contact hours. The teachers participating in the study were interviewed and observed in their classroom prior to and at the completion of the professional development course for the purpose of gathering data on knowledge and practice at the start of the research study (Davis, 2002). The interview protocol and observation format will be described in more detail later in this chapter.
During the PSI Professional Development Course participants were asked to create and implement the I-B mini-unit that they designed themselves in their classroom.

*Participants and Participant’s Teaching Contexts*

The following accounts describe the background of each participant, the context of her science planning and teaching, and demographic information of each teacher’s classes. The background of each teacher is critical because it frames her life history and gives a broad perspective on her views of science, curriculum, and learning throughout the duration of this research study. The anonymity of the research participants involved has been maintained through use of pseudonyms. All teachers were Caucasian females teaching in a public elementary school in Milton County Public Schools with teaching experience ranging from 6 to 31 years.

*Teacher One: Ariel*

Ariel, a Caucasian American female was a veteran teacher in her twenty-seventh year of teaching during the 2007-2008 school year. She teaches a fifth grade class at an elementary school located in a midsize suburban school division in eastern Virginia. Ariel’s school serves students in kindergarten through the fifth grade, of which 4.97% receive reduced lunch pricing and 10.9% receive free lunch. The demographics of the student body are 76% Caucasian American, 18% African American, 3% Hispanic, 2% Asian, and 1% Unknown.

The demographics of the two classes that were observed for the pre PSI Professional Development Course and post PSI Professional Development Course are described in Table 4, which will be introduced in Ariel’s teacher portrait located in Chapter 4. Ariel had a total of 20 students, 13 males and 7 females, in her class during the
time of the pre PSI Professional Development Course observation. The demographics of the class are 75% Caucasian American, 15% African American, 5% Hispanic, 5% Asian, and 0% Unknown. Ariel teaches a self-contained class. Students remain in her classroom most of the day for all subject areas with the exception of art, music, and library. Her schedule rotates between science, social studies and health. She spends about two or three weeks on science in a nine-week grading period. Science is generally taught from 2:15 until 2:45 in the afternoon. During the 2007-2008 school year, Ariel had a total of 20 students, 11 males and 9 females, in her class during the time of the post PSI Professional Development Course observation. The demographics of the class are 85% Caucasian American, 15% African American, 0% Hispanic, 0% Asian, and 0% Unknown.

The mini unit project that Ariel designed and implemented was a component of the PSI Professional Development Course. During the PSI Professional Development Course, Ariel’s Critical Friend (CF) was Jo. A Critical Friend is defined as someone whose opinion is valued. A Critical Friend helps to critique the teacher’s work and encourages the teacher to see it in a new light (McNiff, 2002). They both teach the fifth grade at the same school and planned their mini unit together. During the PSI Professional Development Course, Ariel spent about four hours on preparation and planning time for the mini unit. She spent about two hours prepping for each class.

*Teacher Two: Jo*

Jo, a Caucasian American female was a veteran teacher in her twenty-seventh year of teaching during the 2006-2007 school year. She teaches the fifth grade at an elementary school located in a midsize suburban school division in eastern Virginia. Jo’s school serves students in kindergarten through the fifth grade, of which 4.97% receive
reduced lunch pricing and 10.9% receive free lunch. The demographics of the student body are 76% Caucasian American, 18% African American, 3% Hispanic, 2% Asian, and 1% Unknown.

The demographics of the two classes that were observed for the pre PSI Professional Development Course and post PSI Professional Development Course are described in Table 8, which will be introduced in Jo’s teacher portrait located in Chapter 4. Jo had a total of 22 students, 13 males and 9 females, in her class during the time of the pre PSI Professional Development Course observation. The demographics of the class are 68% Caucasian American, 18% African American, 9% Hispanic, 0% Asian, and 4% ELL, a student from Africa. During the 2006-2007 school year, Jo taught a self-contained class. Students remain in her classroom most of the day for all subject areas with the exception of art, music, and library. Her schedule rotates between science, social studies, and health. She spends about two or three weeks on science in a nine-week grading period. Science is generally taught from 2:15 until 2:45 in the afternoon. During the 2007-2008 school year, Jo has a total of 19 students, 9 males and 10 females. The demographics of the class are 74% Caucasian American, 26% African American, 0% Hispanic, 0% Asian, and 0% ELL, a student from Africa.

The mini unit project that Jo designed and implemented was a component of the PSI Professional Development Course. During the PSI professional development course, Jo’s Critical Friend was Ariel. They both teach the fifth grade at the same school and planned their mini unit together. Jo spent about four hours on preparation and planning time for the mini unit. She spent about two hours prepping for each class.
Teacher Three: Liz

Liz, a Caucasian American female was a veteran teacher in her twenty-third year of teaching during the 2007-2008 school year. She teaches a fourth grade class at an elementary school located in a midsize suburban school division in eastern Virginia. Liz’s school serves students in kindergarten through the fifth grade students, of which 7.02% receive reduced lunch pricing and 12.74% receive free lunch. The demographics of the student body are 83% Caucasian American, 11% African American, 4% Hispanic, 1% Asian, and 1% Unknown.

The demographics of the two classes that were observed for the pre PSI Professional Development Course and post PSI Professional Development Course are described in Table 12, which will be introduced in Liz’s teacher portrait located in Chapter 4. Liz had a total of 24 students, 14 males and 10 females, in her class during the time of the pre PSI Professional Development Course observation. The class demographics are 83% Caucasian American, 13% African American, 0% Hispanic, and 4% Asian. During the 2006-2007 school year, Liz taught a primarily self-contained class. Students remain in her classroom most of the day and she teaches most subject areas to her students with the exception of social studies, art, music, and library. She teaches another teacher’s students science while that teacher teaches her class social studies. She spends about 45 minutes with each class per day on science. During the 2007-2008 school year, Liz had a total of 24 students, 13 males and 11 females. The class demographics for the post PSI Professional Development Course are 87% Caucasian American, 13% African American, 0% Hispanic, 0% Asian, and 0% Unknown.
During the PSI Professional Development Course, Liz’s Critical Friend was Lucy. Liz and Lucy do not teach at the same school. Lucy teaches the third grade. Liz spent about three hours on preparation and planning time for the mini unit in addition to the time spent during the PSI Professional Development Course.

*Teacher Four: Hailey*

Hailey, a Caucasian American female was an experienced teacher in her sixth year of teaching during the 2007-2008 school year. She teaches a fifth grade class at an elementary school located in a midsize suburban school division in eastern Virginia. Hailey’s school serves students in kindergarten through the fifth grade, of which 6.87% receive reduced lunch pricing and 19.48% receive free lunch. The demographics of the student body are 68% Caucasian American, 22% African American, 5% Hispanic, 2% Asian, and 3% Unknown.

The demographics of the two classes that were observed for the pre PSI Professional Development Course and post PSI Professional Development Course are described in Table 16, which will be introduced in Hailey’s teacher portrait located in Chapter 4. Hailey had a total of 24 students, 12 males and 12 females, in her class during the time of the pre PSI Professional Development Course observation. The demographics of the class are 79% Caucasian American, 17% African American, 4% Hispanic, 0% Asian, and 0% Unknown. During the 2006-2007 school year, Hailey taught a self-contained class. Students remain in her classroom most of the day for all subject areas with the exception of art, music, and library. During the 2007-2008 school year Hailey and another teacher, Shelby, began team teaching. This means that they switch students for science and history instruction. Hailey teaches science and Shelby teaches history.
During the 2007-2008 school year, Hailey has a total of 23 students, 13 males and 10 females in her class during the time of the post PSI Professional Development Course observation. The demographics of the class are 65% Caucasian American, 26% African American, 9% Hispanic, 0% Asian, and 0% Unknown.

The mini unit project, which Hailey designed and implemented, was a component of the PSI Professional Development Course. During the PSI professional development course, Hailey’s Critical Friend was Robin. They both teach the fifth grade at the same school and planned their mini unit together. Robin and Hailey both teach science to the students on their own team. Hailey spent about four hours on preparation and planning time in designing the mini unit project. She spent an additional two hours planning for each science lesson and about 30 minutes on set-up and preparation during the mini unit project.

Teacher Five: Robin

Robin, a Caucasian American female was a seasoned teacher in her eighteenth year of teaching during the 2007-2008 school year. She has always taught the fifth grade. She currently teaches a fifth grade class at an elementary school located in a midsize suburban school division in eastern Virginia. Robin’s school serves students in kindergarten through the fifth grade, of which 6.87% receive reduced lunch pricing and 19.48% receive free lunch. The demographics of the student body are 68% Caucasian American, 22% African American, 5% Hispanic, 2% Asian, and 3% Unknown.

The demographics of the two classes that were observed for the pre PSI Professional Development Course and post PSI Professional Development Course are described in Table 20, which will be introduced in Robin’s teacher portrait located in
Chapter 4. Robin had a total of 23 students, 10 males and 13 females, in her class during the time of the pre PSI Professional Development Course observation. During the 2006-2007 school year, Robin taught a self-contained class. Students remain in her classroom most of the day for all subject areas with the exception of art, music, and library. The demographics of the class are 70% Caucasian American, 26% African American, 4% Hispanic, 0% Asian, and 0% Unknown. During the 2007-2008 school year Robin and another teacher, Melissa, began team teaching. This means that they switch students for science and history instruction. Robin teaches science and Melissa teaches history. Robin has a total of 22 students, 9 males and 13 females in her class during the time of the post PSI Professional Development Course observation. The demographics of the class are 82% Caucasian American, 18% African American, 0% Hispanic, 0% Asian, and 0% Unknown.

The mini unit project, which Robin designed and implemented, was a component of the PSI Professional Development Course. During the PSI Professional Development Course, Robin’s Critical Friend was Hailey. They both teach the fifth grade at the same school and planned their mini unit together. Robin and Hailey both teach science to the classes on their own team. Robin spent about four hours on preparation and planning time in designing the mini unit project. She spent an additional hour planning for each science lesson and about 30 minutes on set-up and preparation during the mini unit project.

Teacher Six: Lucy

Lucy, a Caucasian American female was a seasoned teacher in her ninth year of teaching during the 2007-2008 school year. She teaches a third grade class at an elementary school located in a midsize suburban school division in eastern Virginia.
Lucy’s school serves students from kindergarten through the fifth grade, of which 4.17% receive reduced lunch pricing and 28.95% receive free lunch. The demographics of the student body are 74% Caucasian American, 20% African American, 3% Hispanic, 1% Asian, and 2% Unknown.

The demographics of the two classes that were observed for the pre PSI Professional Development Course and post PSI Professional Development Course are described in Table 24, which will be introduced in Lucy’s teacher portrait located in Chapter 4. Lucy had a total of 24 students, 11 males and 13 females, in her class during the time of the pre PSI Professional Development Course observation. The class demographics are 87.5% Caucasian American, 12.5% African American, 0% Hispanic, and 0% Asian. During the 2006-2007 school, year Lucy taught a primarily self-contained class. Students remain in her classroom most of the day and she teaches most subject areas to her students with the exception of social studies, art, music, and library. She teaches another teacher’s students science while that teacher teaches her class social studies. Lucy spends between 20 and 60 minutes with each class every day on science. She might spend more time on science one day because of an experiment or an involved activity. On other days she might spend more time on math. During the 2007-2008 school year, Lucy had a total of 21 students, 13 males and 8 females. The class demographics for the post PSI Professional Development Course are 81% Caucasian American, 14% African American, 5% Hispanic, 0% Asian, and 0% Unknown.

The mini unit project that Lucy designed and implemented was a component of the PSI Professional Development Course. During the PSI Professional Development Course, Lucy’s Critical Friend was Liz. Lucy and Liz do not teach at the same school.
Liz teaches the fourth grade. Lucy spent 12 hours on preparation and planning time for the mini unit. She spent about 30 minutes setting up and 45 minutes cleaning up for each lesson.

Teacher Seven: Anna

Anna, a Caucasian American female was an experienced teacher in her thirty-first year of teaching during the 2007-2008 school year. She teaches the first grade at an elementary school located in a midsize suburban school division in eastern Virginia. Anna’s school serves students in kindergarten through the fifth grade, of which 5.92% receive reduced lunch pricing and 31.64% receive free lunch. The demographics of the student body are 64% Caucasian American, 24% African American, 6% Hispanic, 2% Asian, 1% American Indian, and 3% Unknown. The demographics of the two classes that were observed for the pre PSI Professional Development Course and post PSI Professional Development Course are described in Table 28, which will be introduced in Anna’s teacher portrait located in Chapter 4.

During the 2006-2007 school year, Anna taught in a self-contained classroom, which consists of 20 students, 13 males and 7 females. The class demographics were 75% Caucasian American, 15% African American, 5% Hispanic, and 5% Asian. Currently, Anna teaches in a self-contained classroom, which consists of 20 students, 11 males and 9 females. The class demographics were 85% Caucasian American, 15% African American, 0% Hispanic, and 0% Asian. Because it is a self-contained classroom, students remain in her classroom most of the day and she teaches all subject areas to her students with the exception of art, music, P.E. and library. Her schedule rotates between science, social studies, and health. She spends about three or four weeks on science in a nine-
week grading period. Science is generally taught during the last half of the day. Anna spends about 30 minutes on science each day. Occasionally, Anna will extend science up to an hour and a half for special projects or activities.

The mini unit project that Anna designed and implemented was a component of the PSI Professional Development Course. Anna spent approximately eight hours on preparation and planning time for her mini unit. During the PSI professional development course, Anna’s Critical Friend was Megan. Although Megan has chosen to take time off from her work as a classroom teacher, Megan participated in the PSI Professional Development Course as a part of her commitment to continuous learning and growth obtain credit for license renewal requirements. She occasionally visits Anna’s classroom and helps with instruction, particularly with hands-on activities.

Teacher Eight: Julia

Julia, a Caucasian American female was a veteran teacher in her twentieth year of teaching during the 2007-2008 school year. She teaches the first grade at an elementary school located in a midsize suburban school division in eastern Virginia. Julia’s school serves students in kindergarten through the fifth grade students, of which 7.02% receive reduced lunch pricing and 12.74% receive free lunch. The demographics of the student body are 83% Caucasian American, 11% African American, 4% Hispanic, 1% Asian, and 1% Unknown.

The demographics of the two classes that were observed for the pre PSI Professional Development Course and post PSI Professional Development Course are described in Table 32, which will be introduced in Julia’s teacher portrait located in Chapter 4. Julia had a total of 22 students, 11 males and 11 females, in her class during
the time of the pre PSI Professional Development Course observation. The demographics of the class are 91% Caucasian American, 9% African American, 0% Hispanic, 0% Asian, and 0% Unknown. During the 2006-2007 school year, Julia taught a self-contained class. Students remain in her classroom most of the day for all subject areas with the exception of art, music, P.E., Spanish, and library. Her schedule rotates between science and social studies. She spends about four weeks on social studies in a nine-week grading period. The rest of the time is spent on science. Julia and her 2007-2008 class are just beginning a new cycle of looping. Looping is the practice of advancing a teacher from one grade level to the next along with his or her class. Julia will work with her new class for two years. During the 2007-2008 school year, Julia had a total of 21 students, 12 males and 9 females, in the pre PSI Professional Development Course. The demographics of the class are 95% Caucasian American, 5% African American, 0% Hispanic, 0% Asian, and 0% Unknown.

The mini unit project that Julia designed and implemented was a component of the PSI Professional Development Course. During the PSI professional development course, Julia’s Critical Friend was Sara. They both teach first grade at the same school and planned their mini unit together. Julia spent approximately four hours on preparation and planning time for her mini unit. She spent approximately thirty minutes preparing for each class.

Research Design

This research investigation explored how and why elementary teachers make certain decisions and take specific actions as they engage in planning and implementation for I-B instruction in science. The emergent design for this qualitative study utilized
action research methodology and collective case study applications. An action research approach allowed the participants themselves to control the research and act as participants in the design and methodology of the research. The action research design allowed me, the researcher to reflect on the research process as well as the findings (Herr & Anderson, 2005). Specifically, the researcher examined teachers’ beliefs about how children learn science as well as teachers’ beliefs about teaching methods, nature and knowing of science, and science education reform. The researcher dug deeper into teachers’ frameworks for understanding science content, to reveal how teachers describe their abilities to produce desired or intended results in the classroom, their visions for science teaching. My research was based around a specially designed professional development course, outlined later in this chapter. A case-study approach allowed me to give an intensive description and analysis of this course and the individual teacher’s attempts to implement the I-B mini unit (Merriam, 1998). Though action research the researcher gathered information to, (a) explain or describe the professional development course and explore what role the professional development course played in the teacher’s attempts to implement inquiry science into their classrooms, (b) outline the role played by myself and other educational leaders and reflect upon the experience as it relates to current literature on science reform and implementation of change, (c) present the accounts of the teacher’s individual “portraits” or case studies.

Data Sources

The researcher obtained informed consent of the participants (Appendix A: Informed Consent Form for Project Science Inquiry). The researcher first explained the research study to the school principal (principals). Next, the researcher discussed the
research procedures, risks, benefits, confidentiality, participation, alternative participation, contact information, and consent information with the subjects. The researcher handed the subject a copy of the informed consent form and allowed ample time for the participant to read the form. After the form was signed, the researcher handed each subject a copy of the consent document. Subjects were not compensated for their participation. Collection of the data occurred primarily through (a) surveys administered before and after the professional development course, (b) interviews with teachers, (c) informal classroom observations conducted before and after the professional development course, and (d) teachers’ Partner Portfolios for Professional Development, which included participant reflections during implementation of I-B science methods.

Participants were asked to complete two surveys/questionnaires before the first and on the last day of the course, i.e., (a) the Science Teaching Efficacy Belief Instrument, and (b) the Constructivist Learning Environment Survey. The teachers were interviewed before (April/May) and after (October) they participated in the course. The interviews were audio taped and transcribed. The interviews were held at the participant’s school site. The amount of time for each interview consisted of approximately 45 minutes in duration. Each participant was observed as he/she taught class before (April/May) and after (October) they participated in the course. Observations occurred over a week of instruction during a class specified by the participant (during science instruction for elementary teachers). The focus of the observation was teacher behavior, not students. Teachers’ classrooms were not audio taped or videotaped. The participants completed a portfolio of their professional development with feedback from their critical friend. Teachers took part in activities that provided practice in exploring one’s teaching and
learning using reflection as a critical dimension (e.g., journaling, personal history papers, and goal statements) and included those activities in a portfolio. The teachers completed at least six reflections or journal entries over the duration of the course. Each entry was about one page of double-spaced type or handwritten script. The entries were also included in the portfolio.

**STEBI (Science Teaching Efficacy Belief Instrument)**

The Science Teaching Efficacy Belief Instrument (Appendix C) was designed by Riggs (1988) and Riggs and Enochs (1990) for elementary in-service teachers and is used to assess attitudes and beliefs toward science. The STEBI is made up of twelve negatively written item statements and thirteen positively written item statements with response items in a Likert-style format. The item statements are labeled as “personal self-efficacy” and “outcome expectancy.” The STEBI was constructed based upon Bandura’s (1986) cognitive dimensions. A detailed description of this instrument will be outlined later in this chapter. The STEBI was utilized as an additional source for gathering data related to the participant’s attitudes and beliefs toward science instruction.

**CLES (Constructivist Learning Environment Survey)**

Llewellyn (2002) asserts that it is important to develop the proper philosophical mind-set that accompanies inquiry to become an I-B teacher. The principles of constructivism lay the foundation for understanding inquiry for many teachers. The researcher chose to use the Salish I Research Project’s Constructivist Learning Environment Survey (CLES) Science Teacher Form (Appendix D) because I-B science methods are based on the constructivist theory of learning. I gathered data related to evaluation and monitoring of teaching environments, as teachers using the CLES Science
Teacher Form perceive them. This form, created by Taylor, Fraser, and Fisher (1997), contains forty-two Likert-style items. It contains six scales. Scale one is called the Personal Relevance Scale (PR) and it can be used to determine the relevance of science instruction to students, as the teacher perceives it. Scale two, the Scientific Uncertainty Scale (SU) may be used to assess the extent to which students are provided opportunities to experience scientific knowledge arising from inquiry related to human experience and values, again, as the teacher perceives. The third scale, the Critical Voice Scale (CV) looks at the extent to which the teacher perceives students feel it is legitimate and beneficial to express their concerns and question the teacher’s plans and methods within the established social climate. The Shared Control Scale (SC), number four, deals with teacher perceptions of students’ invitation to share control of the learning environment with the teacher. The fifth scale, the Student Negotiation Scale (SN), assesses teacher perception of the opportunities for students to listen, reflect upon, explain and justify newly developing ideas. Scale number six is the Attitude Scale (AT). It measures how the teacher views the way that students perceive and understand the activities completed in class (Taylor, Fraser, & Fisher, 1997). A detailed description of this instrument will be outlined later in this chapter. This instrument served as an additional data source for learning about the teacher created environment.

*Interview Questions for Science Teachers*

The teachers were interviewed before and after they participated in the PSI Professional Development Course. The interviews were audio taped and transcribed. Appendix B: Interview Questions for Science Teachers was used as a guide for the initial interview. It was developed from an interview protocol that the researcher piloted in a
qualitative research study. The original protocol was modified through research and feedback. Questions were added modeled upon the work of Suters (2004). She completed her dissertation by studying the impact of an inquiry-based professional development course. The interview served as one source of data collection to uncover teacher beliefs. A semi-structured face-to-face interview allowed teachers the opportunity to discuss or reflect on their choice of instructional practices and factors that impacted their choice of implementation or use.

Classroom Observation Protocol

Each participant was observed as she taught class before and after participation in the PSI Professional Development Course. Demographic information was recorded for the classes observed for the pre PSI Professional Development Course observation and the post PSI Professional Development Course observation The Classroom Observation Protocol (Appendix E) is modeled after a protocol created by Johnson (2003) for her mixed methods study about barriers influencing the implementation of the National Science Education Standards in the middle school classroom. The open-ended nature of the first section of the protocol allowed the researcher to gather information to provide a picture of what is happening in the schools. The structured check list on the second page focuses the researcher on aspects of a standards-based instructional practices.

Confidentiality was maintained at all times. The data in this study was kept confidential and stored securely. Pseudonyms were used when referring to individual surveys and questionnaire results in written reports, (a) the participants names were not included on the surveys and other collected data, (b) a code or pseudonym were placed on the surveys and other collected data, (c) through the use of an identification key, the
researcher was able to link the participants survey to their identities, and (d) only the researcher has access to the identification key. There were no potential physical, psychological, social, or legal risks to the participants. Pseudonyms were used in the transcriptions of the audiotapes of the individual teacher interviews and the audiotapes were erased after transcription. Individual teacher interviews were audio taped and transcribed. The documents were kept confidential and stored securely. Participants were not misinformed and/or uninformed about the true nature of the study.

Data Collection Procedures: Prior to, During, and After Project Science Inquiry

Procedures and Strategies

The teachers were purposefully selected (Maxwell, 1996) to provide information because they are all teachers of elementary science. The participants were involved in a standards-based curriculum project, designed to promote inquiry as presented in science reform initiatives. This research endeavored to determine how, and to what extent, a predetermined number of elementary teachers attending staff development in science, designed to introduce those reform initiatives, subsequently interpret and use I-B science in their classrooms. Since qualitative research is concerned with the perceptions of the participants and with process rather than outcomes or products (Bogdan & Biklen, 1992; Marshall & Rossman, 2006), this design served as an appropriate methodology to utilize to define inquiry as it is perceived and used.

Data collection strategies were used to discover the natural flow of process events, as well as how participants interpret them (McMillan & Schumacher, 1989). Maxwell lists five purposes for doing qualitative research: (a) understanding the meaning, i.e., cognition, affect and intentions, (b) understanding the context in which participants
act and the influence this has on their actions, (c) identifying unanticipated phenomena and influences and generating new theories, (d) understanding the process by which events and actions take place, and (e) developing causal explanations, i.e., how x plays a role causing y (Maxwell, 1996).

Data Collected Prior to the PSI Professional Development Course

I began my study with a series of on-site visits and teacher interviews. At this time I administered the STEBI to gather information related to teacher attitudes and beliefs about science and the CLES to gather information about the participants view of the learning environment related to the lesson(s) observed. This allowed me to gather data of knowledge and practice at the start of the research (Davis, 2002).

STEBI

The most pervasive and central mechanism of personal agency controlling human motivation, action, and affect is self-efficacy. Bandura (1986) states that efficacy differs from other types of self-appraisal, including self-esteem and self-concept. The principles of self-efficacy operate on behavior through motivational, cognitive, and affective mediating processes (Bandura, 1986). Riggs (1988) and Riggs and Enochs (1990) devised the Science Teaching Efficacy Belief Instrument (Appendix C) to measure science teaching self-efficacy and outcome expectancy in elementary in-service teachers based on Bandura’s (1977, 1986) work in self-efficacy and Gibson and Dembo’s (1984) work in measurement of efficacy. Since this time, this instrument has been used in studies to measure science teaching self-efficacy (de Laat, & Watters, 1995; Duran, Ballone, Haney, & Beltyukova, 2006; Enochs, Posnanski, Hagedorn, 1999; Suters, 2004). Results of a study by Riggs and Enochs (1990) indicate that:
The STEBI is a valid and reliable tool for studying elementary teachers’ beliefs toward science teaching and learning. With this tool, a more complete perspective of elementary science teaching is possible, since it allows investigation of teacher belief systems to supplement the existing research base, which includes study of teachers’ attitude and behaviors in the area of science teaching. The STEBI as a measurement tool can lead to further understanding of teacher behavior, which in turn can facilitate the development of strategies which may assist in teacher preparation and teacher in-service designed to improve elementary science teaching. The STEBI might easily serve as a needs assessment for future in-service or pre-service training. (p. 636)

In keeping with on Bandura’s (1977, 1986) two-factor theory, the STEBI was designed with two standardized scales titled the Personal Science Teaching Efficacy Scale (PSTE) and the Science Teaching Outcome Expectancy Scale (STOE). The PTSE measures personal self-efficacy, a measure of the degree to which a teacher of science believes they can succeed in teaching the subject of science. STOE measures outcome expectancy, the measure of the degree to which a teacher of science expects their students’ outcome to succeed as a result of their teaching. The STEBI is designed for use with in-service teachers. The instrument is made up of twelve negatively written item statements and thirteen positively written item statements with response items in a Likert-style format (Riggs & Enochs, 1990).

Bandura (1997) states that knowledge of self-efficacy beliefs can have the ability to predict behavior. Based upon Bandura’s (1977) theory of social learning, the researcher asserts that a teacher who possesses a high sense of self-efficacy is more likely
to use student-centered, constructivist teaching practices than teachers who have a low
sense of self-efficacy. The STEBI instrument will allow the researcher to gather data
about teachers’ sense of efficacy as a possible factor to the behavior patterns of
elementary science teachers (Riggs, 1988; Riggs & Enochs, 1990). The researcher will
use the STEBI as an additional source for gathering data related to the participant’s
attitudes and beliefs toward science instruction before and after participation in the PSI
professional development course.

The STEBI scores for each participant were calculated according to the scoring
guidelines before and after participation in the PSI Professional Development Course (see
Appendix C for the instrument and C2 for scoring instructions and calculations). The
Personal Science Teaching Efficacy (PSTE) scale has a range of scores from 13 to 65
points. For the purposes of this study this range was divided into categories. If the score
fell into a range from 13-30 points it was labeled as a low PSTE score. If the score fell
into a range from 31-48 points it was labeled as an average PSTE score. If the score fell
into a range from 49-65 points it was labeled as a high PSTE score. The Outcome
Expectancy (OE) scale has a range of scores from 12 to 60 points. This OE scores were
also divided into categories. If the score fell into the range of 12-28 points it was labeled
as low OE. If the score fell into the range of 29-44 points it was labeled as average OE. If
the score fell into the range of 45-60 points it was labeled as high OE (Suters, 2004).
When the STEBI has been used in larger studies (Enochs & Riggs, 1990), resulting
standard deviations fell into the range of 5.6 to 7.7. Based upon this, a change of four or
more points, pre to post, equates to more than one half of one standard deviation point.
For the purposes of this study, a change of four or more points on the STEBI instrument will be counted as notable (Suters, 2004).

**CLES**

The researcher gathered data related to evaluation and monitoring of teaching environments, as teachers using the Salish I Research Project’s Constructivist Learning Environment Survey (CLES) Science Teacher Form (see Appendix B) perceive them. This form contains forty-two Likert-style items. It contains six scales. Scale one is called the Personal Relevance Scale (PR) and it can be used to determine the relevance of science instruction to students, as the teacher perceives it. Scale two, the Scientific Uncertainty Scale (SU) may be used to assess the extent to which students are provided opportunities to experience scientific knowledge arising from inquiry related to human experience and values, again, as the teacher perceives. The third scale, the Critical Voice Scale (CV) looks at the extent to which the teacher perceives students feel it is legitimate and beneficial to express their concerns and question the teacher’s plans and methods within the established social climate. The Shared Control Scale, number four, deals with teacher perceptions of students’ invitation to share control of the learning environment with the teacher. The fifth scale, the Student Negotiation Scale (SN), assesses teacher perception of the opportunities for students to listen, reflect upon, explain and justify newly developing ideas. Scale number six is the Attitude Scale (AT). The CLES contains 30 items in all, with six items occurring in each of the five scales. It measures how the teacher views students perceive and understand the activities completed in class. The response alternatives for each of the items are Almost Always, Often, Sometimes,
Seldom, and Almost Never (Taylor et al., 1997). This instrument serves as an additional data source for learning about the teacher created environment (Suters, 2004).

Taylor and Fraser created the original version of the CLES in 1991. Since that time the CLES was been used in numerous studies including the Australian component of the Third International Mathematics and Science Study (TIMSS) conducted in secondary schools during 1994. A few years later, Taylor, Fraser, and Fisher (1997) examined the viability of the new CLES for monitoring constructivist transformations to the epistemology of school science and mathematics classrooms. They discovered cultural restraints that might counteract the development of constructivist learning environments. For example, teachers might hold beliefs in powerful cultural myths that were rooted in the histories of science or mathematics and of schooling. They made appropriate changes in the CLES and conducted a series of qualitative and quantitative studies. In their study, “Monitoring Constructivist Classroom Learning Environments,” Taylor, Fraser, & Fisher (1997) concluded:

This combination of small-scale qualitative and large-scale quantitative studied has provided substantial evidence that the Constructivist Learning Environment Survey can be used to monitor the development of constructivist learning environments in school science in Western cultures. A major advantage of this use of multiple methodologies is the enhanced viability of the CLES that allows it to be used across a range of grain-sizes, from case studies of individual classrooms to state-wide reform initiatives. (p. 298)

The plausibility of the CLES was established in small-scale classroom based qualitative studies like those outlined in this research study, Project Science Inquiry.
**Teacher Interviews and Observations**

On-site visits to the schools of each teacher participating in the study consisted of a teacher interview and an observation of a lesson. The individual teacher interview was audio taped and transcribed. The amount of time for each interview consisted of 45 minutes in duration. Appendix B: Interview Questions for Science Teachers was used as a guide for the initial interview. It was developed from an interview protocol that the researcher piloted in a qualitative research study. The original protocol was modified through research and feedback. Questions were added modeled upon the work of Suters (2004). She completed her dissertation by studying the impact of an I-B professional development course. The interview served as one source of data collection to uncover teacher beliefs. A semi-structured face-to-face interview allowed teachers the opportunity to discuss or reflect on their choice of instructional practices and factors that impact their choice of implementation or use.

Each participant was observed as she taught class before and after participation in the PSI Professional Development Course. Demographic information was recorded for the classes observed for the pre PSI Professional Development Course observation and the post PSI Professional Development Course observation. Gathering of data occurred using a Classroom Observation Protocol (see Appendix E for the Classroom Observation Protocol). Each participant was observed as she taught class before participation in the PSI Professional Development Course. Observations occurred over a week of instruction during a class specified by the participant. The Classroom Observation Protocol was modeled after a protocol created by Johnson (2003) for her mixed methods study about barriers influencing the implementation of the National Science Education Standards in
the middle school classroom. The open-ended nature of the first section of the protocol allowed the researcher to gather information to provide a picture of what is happening in the schools. The structured check list on the second page focused the researcher on aspects of standards-based instructional practices. Transcribing of teacher interviews and teacher observations began immediately upon collection to ensure accuracy and to prevent possible distortion of data by confusing this data collection session with the interviews and observations of other participants.

*Partner Portfolios for Professional Development*

Each participant created a Partner Portfolio for Professional Development by assembling a collection of structured activities designed based upon the work of Samaras and Freese (2006). Through the creation of a portfolio, the teachers are offered an opportunity to reflect and manage their thoughts and behaviors through strategic processing (Hawley & Valli, 1999; Keller, 2004). The partner portfolio also allows teachers to inquire into their practice with critical friends or colleagues who can help them reframe thinking about teaching and learning. This strategy can provides support as well as feedback that will enable participants to improve their practice and student learning (Samaras & Freese, 2006) (see Appendix I for the Partner Portfolio for Professional Development Invitation to Practice). The following items are part of the Partner Portfolio for Professional Development: Goal Statement, Invitation to Practice: Personal History (Samaras & Freese, 2006), Invitation to Practice: Mapping My Classroom (Samaras & Freese, 2006), Lesson Plans, Exit Slips, and various journal entries. The journal entries consist of Quick Writes (Samaras & Freese, 2006), reflections, notes, and other data entries completed by the participants related to the
process of implementing I-B science methods into their classroom. The components of
the Partner Portfolio for Professional Development will be discussed in more detail in the
section titled *Multiple Case Study Methodology*.

**Collaboration with Administrators**

As the teachers attempt to implement inquiry science into their classrooms, the
researcher encouraged their collaboration with the school principal and other building
administrators. It is crucial that they are supportive of the process and encouraging of the
change to new or unfamiliar methods (Richardson & Placier, 2001; Keller, 2004). This
also set the researcher up to collaborate with others, although not typical in dissertation
work, this element is acceptable in the action research dissertation (Herr & Anderson,
2005) and is essential to the successful change process (Davis, 2002).

**Project Science Inquiry**

*Creating Project Science Inquiry*

The Project Science Inquiry Professional Development Course was developed for
elementary science teachers. Adopting lessons and activities based upon readings and on
the following experiences created Project Science Inquiry:

1. Science Methods Class - The researcher co-taught a masters level elementary
   science methods course with a professor and a colleague at George Mason
   University. In this course, emphasis was placed on the National Science
   Education Standards (NRC, 1998), the 5E Model of science teaching (Bybee,
   1993, 2000; Carin et al., 2004), the Nature of Science (AAAS, 1993; NRC,
   1998), and meeting the needs of all students (NRC, 1998). The course
   presents and draws on an understanding of inquiry and provides a framework
that builds in accountability for science content learning, encourages use of
inquiry-based activities, and allows teachers to create and manage productive
engaging science classrooms (Carin et al., 2004).

2. Content Teaching Academy- The researcher served her internship at the 2006
Standards of Learning Content Teaching Academy in Science as Inquiry with
a professor at James Madison University. The academy course is designed to
increase teachers’ knowledge of content and improve instructional delivery of
that content. The course is delivered in an interactive, hands-on/minds-format,
inclusive of lecture, demonstration, and individual group activities. The focus
is on the teacher development of classroom inquiry planning, instruction, and
assessment. Three separate strands operated concurrently –Earth Science,
Physical Science, and Life Science. Participants work in each of these areas
also work longitudinally across middle and high school levels, with the
intention of facilitating sustained science inquiry instruction.

3. Self-Study Course- The researcher participated in a self-study course at
George Mason University where she conducted a research project to study her
own practice as a science teacher and staff development provider, gather
information about how others study their own teaching practice, and to help
frame her dissertation study. This course introduced her to the self-study
research methodology and included a comprehensive review and synthesis of
the self-study literature; including guidelines and invitations to practice. It
allowed her to examine five central areas of self-study research: purposes,
foundations, nature, methodology, and support for incorporating self-study into her research.

The framework (Darling-Hammond, Hammerness, Grossman, Rust, & Schulman, 2005) for the I-B instruction in the PSI Professional Development Course was developed through readings (Bybee, 1997; Callahan, Hall, O’Brien, & Kitchell, 1998; Hassard, 2000; Johnson, 2003; Llewellyn, 2002; Martin-Hansen, 2002; NRC, 2000; Suters, 2004) and the researcher’s experiences in the science methods class and the content teaching academy. Incorporation of activities and knowledge into the course was based on activities in the methods, academy and self-study courses and readings related to teacher beliefs (Anderson, 1996; Davis, 2002; Tate, 2004), self-study (Samaras & Freese, 2006), action research methodology (Herr & Anderson, 2005; Lewin, 1948), and the change process (Keller, 2004; Richardson & Placier, 2001). The researcher used the methods learned in the self-study course to help frame a system that would allow teachers to examine their own beliefs and practices while providing data for her research study at the same time. From these experiences, she developed activities and lessons for the PSI Professional Development Course. The activities were piloted in Milton County over the course of one school year through teacher workshops. Based on feedback and suggestions from teachers, the activities were modified and organized into the framework for Project Science Inquiry.

*Overview of the PSI Professional Development Course*

Through their experiences in the PSI Professional Development Course, teachers examined their own professional knowledge, practice and training, observe models of effective science teaching, design and implement an inquiry based mini unit, and have the
opportunity to collaborate with peers and professionals (Davis, 2002). The course included self-reflective activities, surveys, readings with teacher-led and peer-led discussion, and peer work (see Appendix K for a detailed description of the twenty-hour professional development course). Teachers began a series of activities including: (a) a self-reflective personal history exercise (Samaras & Freese, 2006) that encouraged teachers to investigate their own personal knowledge (Davis, 2006), (b) investigation into their knowledge of practice through use of STEBI (Riggs & Enochs, 1990), and (c) an experience and training through use of the CLES instrument (Taylor et al., 1997). Teachers designed their own mini unit with opportunities to collaborate with their critical friend and other professionals and access professional administrative support (Davis, 2002). Participants had the opportunity to read and discuss several chapters from their textbook, *Inquire Within: Implementing Inquiry-Based Standards* (Llewellyn, 2002).

Through the course of the PSI Professional Development Course instruction participants developed an understanding of the following topics: What is inquiry, learning through inquiry, developing a mind for constructivism, constructivism, how children learn, designing inquiry-based classrooms, integrating I-B activities, the scientific method, learning cycles, skills and knowledge of I-B teachers, questioning, and they also participated in examples of inquiry based lessons.

*During and After the PSI Professional Development Course*

During the PSI Professional Development Course teachers set goals (Hammerness et al., 2005), explored science education reform and standards (Loucks-Horsley et al., 2003), became familiar with I-B science methodology (Llewellyn, 2002), and designed their own mini units. Designing their own units gives the participants a sense of
ownership and increased the potential fidelity of implementation of the reform initiatives. Fidelity can be defined as the extent to which the delivery of an intervention follows or sticks to the procedure or program model developed originally (Mowbray et al., 2003). Throughout the course teachers were given the opportunity to reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Assuming that teachers are not always able to fully carry out their science teaching vision, the researcher examined possible threats to fidelity or barriers to use of I-B instruction. This was accomplished through classroom observation and interviews. This process enabled the researcher to identify connections or relationships between teachers’ perceptions and use of inquiry instruction (Davis, 2002).

Documenting the quality of the delivery promoted the external validity of the PSI Professional Development Course and the teachers’ mini units, and provided records or guidelines for replication (Mowbray et al., 2003). Multiple sources of evidence were used since this triangulation method allowed for the development of converging lines of inquiry, which in turn allowed the investigator to address a broader range of historical, attitudinal, and behavioral issues (Yin, 2003). Collection of follow-up data consisted of teacher interviews, and on-site visits, and reflections. The teachers were interviewed following the implementation of their mini unit, after they participated in the PSI Professional Development Course. The interviews were audio taped and transcribed (Merriam, 1998). The Post PSI Professional Development Course Interview Question Protocol was used for the exit interview. This question protocol was made through modification by the researcher to serve as a post observation protocol by creating a series
of follow-up questions modeled after the Classroom Observation Protocol (Johnson, 2003) questions used prior to the PSI Professional Development Course (see Appendix E for the Classroom Observation Protocol and Appendix F for the Post PSI Professional Development Course Interview Question Protocol). The Post PSI Professional Development Course interview served as one source of data collection to uncover teacher beliefs and practices. This semi-structured fact-to-face interview allowed teachers the opportunity to discuss or reflect on their experiences in the PSI Professional Development Course and on the process involved in implementation of the mini unit.

Data Analysis Procedures

Multiple Case Study Methodology

Along with action research methodology, collective or multiple case study methodology was utilized for this study. The study consisted of an exploration of multiple cases over a period of time involving specific in-depth data collection of context rich information sources (Creswell, 1998; Merriam, 1998). In order to fully understand the decisions teachers make with regard to science instruction the investigator must uncover examples of authentic experiences for science instruction. “Any finding or conclusion in a case-study is likely to be much more convincing and accurate if it is based on several different sources of information, following a corroboratory mode” (Yin, 2003, p. 98). Triangulation of multiple data sources provides for multiple measures of the same phenomenon. This method addresses any potential problems with construct validity. Data analysis occurred, using a pattern matching technique where a link between themes and concepts from interviews, observations, and field notes was obtained through a number of onsite visits over a period of seven months (Yin, 2003). This exploration
generated the compilation of a register of methods or options available to the science teacher. The purpose of this investigation was to explore what motivates or inhibits a teacher to use certain methods of science instruction.

The following pieces of data were analyzed: each teacher’s STEBI (pre and post), each teacher’s CLES (pre and post), each teacher’s interviews (pre and post), classroom observations including the arrangement of the room and lessons taught (pre and post), and the data from the Partner Portfolio for Professional Development.

1. Science Teaching Efficacy Belief Instrument (STEBI) (Riggs & Enochs, 1990)—This instrument was used prior to the PSI Professional Development Course to assess participant beliefs and then repeated following the PSI Professional Development Course to examine changes that might have occurred (see Appendix C for the instrument and C2 for scoring instructions and calculations). The STEBI scores were calculated according to the scoring guidelines for each subject before and after PSI Professional Development Course participation. A graph was created for each scale using data collected from all participants for cross-case analysis (Riggs & Enochs, 1990; Suters, 2004).

2. Constructivist Learning Environment Survey (CLES) (Taylor, Fraser, & White, 1994)—This instrument was used prior to the PSI Professional Development Course to evaluate and monitor the teaching environment and then repeated following the PSI Professional Development Course to examine changes that might have occurred (see Appendix D for the instrument and D2 for detailed scoring instructions and calculations). The scales measuring constructivist approaches (PR, CV, SC, SN, and AT) were used to provide insights into changes
in each teacher’s beliefs and attitudes toward science instruction after participation in the PSI Professional Development Course and following the implementation of their mini-unit (Suters, 2004).

3. Interviews—Each participant was interviewed prior to and following the PSI Professional Development Course (see Appendix B for the Interview Questions for Science Teachers and Appendix F for the Follow-up Interview Questions for Science Teachers).

4. Classroom Observations—Each participant was observed prior to and following the PSI Professional Development Course (Davis, 2002). The researcher observed both the lesson taught and the arrangement of the classroom (see Appendix E for the Classroom Observation Protocol).

5. Partner Portfolios for Professional Development—This strategy allows the participant to reflect and manage their thoughts and behaviors through strategic processing (Hawley & Valli, 1999; Keller, 2004). This technique of exploring our professional development is tailored from the work of Samaras and Freese (2006). The partner portfolio allows the teacher to inquire into their practice with critical friends or colleagues who can assist them in reframing their thinking about teaching and learning. This strategy can provide support as well as feedback that will enable participants to improve their practice and student learning (Samaras & Freese, 2006) (see Appendix I for the Partner Portfolio for Professional Development Invitation to Practice). The following items are part of the Partner Portfolio for Professional Development:
a. Goal Statement—At the start of the PSI Professional Development Course the participants identified a goal or vision related to the implementation of I-B science instruction into their classroom (Hammerness et al., 2005). Participants recorded their own personal definitions of the concepts of science, inquiry, and the nature of science. This served as data on knowledge and practice at the start of the study (Davis, 2002).

b. Invitation to Practice: Personal History—The Personal History Invitation to Practice was used to gather data related to each subjects own personal knowledge beliefs and practices at the start of the study start (Davis, 2002). This self-study strategy was developed by Samaras and Freese (2006) and modified by the researcher to fit the theme of science inquiry. It is one way to explore how each participant’s personal experiences shape their professional practice and inform their teaching (Samaras & Freese, 2006) (see Appendix G for the Personal History Invitation to Practice).

c. Invitation to Practice: Mapping My Classroom—The Mapping My Classroom Invitation to Practice was used to gather knowledge of practice at the start of the study and to create a structure or framework for the participants (Darling-Hammond, 2000; Samaras & Freese, 2006). This strategy allows the participants the opportunity to reflect and manage their thoughts and behaviors through strategic processing (Hawley & Valli, 1999; Keller, 2004). This approach was developed by Samaras and Freese (2006) and adapted by the researcher to match the topic of science inquiry. It is a concept map or a visual representation of what the participant
knows and what they want to learn more about. It is an arts-based self-study method that promotes and provokes critical analysis, self-reflection and dialogue about improving one’s teaching through the arts (Samaras & Freese, 2006) (see Appendix H for the Mapping My Classroom Invitation to Practice).

d. Lesson Plans—Each participant created and implemented a mini unit as part of their professional development training. The lesson plans were analyzed using a pattern matching technique that identified outcomes within the newly created lesson plan (Yin, 2003).

e. Exit Slips—The Exit Slip is a reflective writing tool that allowed the participant to reflect and manage their thoughts and behaviors through strategic processing (Hawley & Valli, 1999; Keller, 2004). It was used after or following an event or activity to gather feedback.

f. Journal Entries—The journal entries consist of Quick Writes (Samaras & Freese, 2006), reflections, notes, and other data entries completed by the participants related to science teaching, learning, the process of implementing I-B methods into their classrooms. The Quick Write served as a model and allowed for reflection (Davis, 2002). Specifically, participants learned to reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). This reflective strategy was developed by Samaras and Freese (2006) and personalized by the researcher to fit the theme of science inquiry. The Quick Write allows
the participant to quickly jot down their thinking about a topic or area of study.

*Clarifying the Project Science Inquiry Questions*

Research Question 1, “What do teachers believe about teaching science? What are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?” was clarified employing an array of instruments. Selected interview questions served as the principal source of data. Supporting data compiled from the STEBI and CLES instruments and the Partner Portfolio for Professional Development was utilized, documents included the teacher’s Goal Statement, Invitation to Practice: Personal History, Invitation to Practice: Mapping My Classroom activity (Samaras & Freese, 2006), lesson plans for the mini unit, classroom observation notes, and journal entries. The journal entries consist of Quick Writes (Samaras & Freese, 2006), reflections, notes, and other data entries completed by the participants related to science teaching, learning, and the process of implementing I-B methods into their classrooms. The following data proved useful in providing insights about Research Question 1: (a) each teacher’s pre PSI Professional Development Course interview (questions 1, 2, and 3 as listed in Table 1), (b) STEBI instrument, (c) CLES instrument, (d) each teacher’s Partner Portfolio for Professional Development, and (e) each teachers’ post PSI Professional Development Course interview. This information was utilized to examine the teacher’s beliefs in an effort to uncover patterns that influence teaching behavior as it relates to autonomy or individual identity. In other words, the researcher has assembled the pieces to answer the teacher’s query, “*Who am I?*”
Research Question 2, “How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?” was clarified employing an array of instruments. Interview analysis (see Appendix B for instrument) for Research Question 2 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, and 8 listed in Table 1, (b) post PSI Professional Development Course interview questions 3 and 4, (c) Classroom Observation analysis (see Appendix E for the Classroom Observation Protocol), (d) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), (e) CLES analysis (see Appendix D1 for instrument and D2 for scoring instructions), and the (f) Partner Portfolio for Professional Development which contained the teacher’s Goal Statement, Invitation to Practice: Personal History, Invitation to Practice: Mapping My Classroom activity (Samaras & Freese, 2006), lesson plans for the mini unit, classroom observation notes, and journal entries. The journal entries consist of Quick Writes (Samaras & Freese, 2006), reflections, and other data entries completed by the participants related to science teaching, learning, and the process of implementing I-B methods into their classrooms. Information was drawn on to describe the each teacher’s knowledge of subject matter and pedagogy. In other words, the researcher has assembled the pieces to answer the teacher’s query, “How does the teacher describe her abilities to produce desired or intended results in her science classrooms? What does the teacher believe about her science content knowledge and their pedagogical science knowledge? What does the teacher understand about I-B methods?”
Research Question 3, “What barriers to implementing I-B methods exist?” was clarified employing an array of instruments. Interview analysis (see Appendix B for instrument) includes examination of the teacher’s Goal Statement, and selected pre and post interview questions listed in Table 1. To build credibility, information was compiled through (a) STEBI analysis, (b) CLES analysis, (c) direct observation of the participant’s teaching, and the (d) Partner Portfolio for Professional Development, which included lesson plans for the mini-unit, Invitation to Practice: Mapping My Classroom activity, Exit Slips, and journal entries including, Quick Writes (Samaras & Freese, 2006), reflections, notes, and other data entries completed by the participants related to science teaching, learning, and the process of implementing I-B methods into their classrooms. The researcher made use of this data to study the teacher’s mental models to uncover patterns that shape teaching behavior as it relates to her Shared Identity (SI), the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents his or her role as part of the professional community. In other words, we have assembled the pieces to answer the teacher’s query, “How does the teacher describe her abilities to produce desired or intended results in her science classroom as it relates to barriers to implementation of I-B science methods?”

Research Question 4, “What relationships exist between teachers’ perceptions and use of I-B methods?” was clarified employing an array of instruments. Interview analysis (see Appendix B for instrument) for Research Question 4 includes the examination of (a) post PSI Professional Development Course interview questions 2, 3, 6, and 7 listed in Table 1, (b) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (c) STEBI analysis (see
Appendix C1 for instrument and C2 for scoring instructions), and (d) Partner Portfolio for Professional Development. Influences such as the teacher’s culture, educated-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual and style help mold the her beliefs about I-B methods. Teachers’ have developed and carry around an array of mental models that influence and hinder their day-to-day classroom decisions. Information was used to examine the teachers Conceptual Framework Relationship (CFR), the relationship that exists between the teachers’ cognitive frameworks related to inquiry, teachers’ beliefs about inquiry teaching, and how this ties into the teachers’ daily experiences.

Research Question 5, “How do teachers choose to use I-B methods as opposed to teacher-centered activities?” was clarified employing an array of instruments. Interview analysis (see Appendix B for instrument) includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, 8 and 9 listed in Table 1, (b) post PSI Professional Development Course interview question 6, (c) post PSI Professional Development Course classroom observation analysis (see Appendix E), and (d) the Partner Portfolio for Professional Development. This information was utilized to examine Teacher Choice (TC) in an attempt to disclose methods that encourage teachers to overcome resistance to implementing I-B teaching practices. This information was used to examine Teacher Choice (TC) in an effort to reveal methods that encourage teachers to overcome resistance to implementing I-B teaching practices.

*Project Science Inquiry Interview Protocol*

The Project Science Inquiry interview questionnaire was utilized to address the research questions as described in Table 1. The interview questions were coded into five
categories within the nine research questions. For the purposes of this study, interview
questions one, two, and three were coded as II (Individual Identity), interview questions
four, five, seven, and eight were coded as SMK (Subject Matter Knowledge), interview
questions seven, eight, and nine were coded as SI (Shared Identity), interview questions
one through nine were coded as CFR (Conceptual Framework Relationship), and
interview questions four, seven, eight, and nine were coded as TC (Teacher Choice).
Definitions of the coding terms II, SMK, SI, CFR, and TC were provided in Chapter 1
within the Definition of Key Terms.

Based upon Schoenfeld’s (1998) theory of teaching-in-context, Shulman’s (1986)
categories of subject matter knowledge, and Scribner, Hager, and Warne’s work related
to autonomy and professional community; the researcher formed three categories of study
to identify a teacher’s Conceptual Framework Relationship (CFR). A teacher’s
Conceptual Framework Relationship (CFR) is composed of his or her:

1. Individual Identity (II), the portion of the their conceptual or cognitive
   framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents
   autonomy or personal constructs (Scribner, Hager, and Warne, 2002);
2. Subject Matter Knowledge (SMK), her knowledge of content matter and
   pedagogy (the art and science of being a teacher) and curriculum knowledge
   (Shulman, 1986); and
3. Shared Identity (SI), the portion of her conceptual or cognitive framework
   (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared
   identity or role as part of the professional community.
The teacher judges the merits of multiple options and selects a course of action founded on his or her own conceptual framework Relationship (CFR) made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI). The researcher has labeled this term Teacher Choice (TC).

Table 1

*Project Science Inquiry Interview Questions Aligned with Research Questions*

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Project Science Inquiry Interview Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 II (Individual Identity)</td>
<td>1. Tell me an example of yourself as a science student…I’d like to hear an example of a science lesson/activity that helped you learn a science concept. Do you try to model that teaching/learning situation in your classroom? Why or why not?</td>
</tr>
<tr>
<td></td>
<td>2. Tell me how you were trained to teach science. Can you tell me about your teacher training/preparation? Can you tell me about specific content training/instruction? (In the past and most recent)</td>
</tr>
<tr>
<td></td>
<td>3. Tell me about yourself as a teacher. (Number of years teaching, grade levels) How would you describe yourself as a classroom teacher? In what areas would you like to improve as a teacher? In what ways do you manipulate the educational environment (classroom, school, etc.) to maximize student understanding?</td>
</tr>
<tr>
<td>#2 SMK (Subject Matter Knowledge)</td>
<td>4. Tell me about science content and curriculum. How do you decide what to teach and what not to teach? What science concepts do you believe are the most important for your students to understand by the end of the school year? Are there any things at the local/school/state levels that influence the way you teach? Please give some examples.</td>
</tr>
<tr>
<td></td>
<td>5. What do you think of when someone says “science?” What do you think of when someone says inquiry science?</td>
</tr>
<tr>
<td></td>
<td>7. Tell me about the methods which you generally use to teach science? What motivates you to use the above-mentioned methods? (Motivations) What inhibits you from using the above-mentioned methods? (Barriers) What motivates you to keep going in the face of ___?</td>
</tr>
<tr>
<td></td>
<td>8. Are there methods that you do not use to teach science? Tell me about them. Why do you choose not to use them? (Barriers)</td>
</tr>
<tr>
<td>#3 SI (Shared Identity)</td>
<td>7. Tell me about the methods which you generally use to teach science? What motivates you to use the above-mentioned methods? (Motivations) What inhibits you from using the above-mentioned methods? (Barriers) What motivates you to keep going in the face of ______? 8. Are there methods that you do not use to teach science? Tell me about them. Why do you choose not to use them? (Barriers) 9. In what ways has your team influenced your choice of science teaching methods? In what ways do you feel your administrators have influenced your choice of science teaching methods? In what ways do you feel your administrators have influenced your choice of science teaching methods? In what ways have your students influenced your choice of teaching methods? Have there been any other influences on your choice of science teaching method?</td>
</tr>
<tr>
<td>#4 CFR (Conceptual Framework Relationship)</td>
<td>Questions 1-9 (see Appendix B for instrument)</td>
</tr>
<tr>
<td>#5 TC (Teacher Choice)</td>
<td>4. Tell me about <strong>science content and curriculum</strong>. How do you decide what to teach and what not to teach? What science concepts do you believe are the most important for your students to understand by the end of the school year? Are there any things at the local/school/state levels that influence the way you teach? Please give some examples. 7. Tell me about the methods which you generally use to teach science? What motivates you to use the above-mentioned methods? (Motivations) What inhibits you from using the above-mentioned methods? (Barriers) What motivates you to keep going in the face of ______? 8. Are there methods that you do not use to teach science? Tell me about them. Why do you choose not to use them? (Barriers) 9. In what ways has your team influenced your choice of science teaching methods? In what ways do you feel your administrators have influenced your choice of science teaching methods? In what ways do you feel your administrators have influenced your choice of science teaching methods? In what ways have your students influenced your choice of teaching methods? Have there been any other influences on your choice of science teaching method?</td>
</tr>
</tbody>
</table>
Action Research Methodology

A series of vignettes was assembled using data gathered from the participants. The nature of this portion of the study follows the action research methodology. Usually, action research follows the path of interactive cycles that include plan-act-observe-reflect (Lewin, 1948). Analysis of the information was ongoing, as was the review of the literature. The literature review and the methodology sections shifted slightly from the proposal stage as the dissertation was written (Herr & Anderson, 2005). The STEBI and the CLES instruments along with the reflection exercises were used to identify changes in teacher beliefs or teaching practices.

Assumptions of the Study

The following assumptions underlie the study:

1. Instruction within the schools in the county is highly textbook and worksheet driven. Most content information is delivered through the traditional teaching approach (personal observation).

2. The teachers selected for this study were inexperienced in the area of I-B learning and therefore may benefit from participation in an I-B professional development course.

3. The teachers were able to develop and implement an I-B mini unit as a result of taking the PSI Professional Development Course.

4. It is appropriate to use I-B instruction in a rural classroom because it is culturally relevant and constructivist by nature.

5. Participants provided honest, accurate responses to interviews, questionnaires, and reflections.
6. The CLES and STEBI instruments were coded accurately according to the procedures provided for each document.

Limitations of the Study

The following limitations underlie the study:

1. Participants were limited to rural, K-6 teachers that teach science. There were a small number of teachers participating in the study (approximate range 4-10).

2. The preliminary interviews and observations were compiled close to the end of one school year with one group of students while the follow-up interviews and observations were compiled at the start of the next school year with a new group of students.
4. Findings Overview

Organization of the Chapter

This Chapter is organized into three sections and contains:

1. A presentation of the organization of the within-case analysis for each teacher participant arranged by the five research questions.

2. A presentation of cross-case analysis of the eight teacher participants arranged by the five research questions followed by a section that presents themes developed from interview questions and the Partner Portfolio for Professional Development.

3. Summary of key findings of the eight case studies.

Within-Case Analysis

Introduction

For the purposes of this study, each participant or teacher was looked upon as a case. Stake (2006) writes:

The case researcher needs to generate a picture of the case and then produce a portrayal of the case for others to see. In certain ways, the case is dynamic. It operates in real time. It acts purposefully, encounters obstacles, and often has a strong sense of self. It interacts with other cases, playing different roles, vying and complying. It has stages of life—only one of which may be observed, but the sense of history and future are part of the picture. (p. 3)
As the case researcher, the researcher gathered data and assembled it into a portrait or a narrative documentary. Information was collected and analyzed for each teacher and included: (a) teacher interviews, (b) STEBI survey, (c) CLES survey, and the (d) Partner Portfolio for Professional Development. Data instruments were purposefully designed and administered to obtain information pertaining to each research question from different and multiple sources. The researcher present the data to answer the query, “In light of science standards based reform, what is required to implement inquiry-based methods in elementary science classrooms?” Several sublevel questions were asked to draw out the answer to this broad question. The sublevel questions included:

1. What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?

2. How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

3. What barriers to implementing I-B methods exist?

4. What relationships exist between teachers’ perceptions and use of I-B methods?

5. How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Each case (teacher portrait) was divided into five sections using the following outline for each teacher participant. The outline references the sections of Chapter III and/or the appendix that can be referred to for more detailed descriptions of the methods used.
I. Research Question 1 analysis – “What do teachers believe about teaching science? What are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?”

A. Pre PSI Professional Development Course Interview Analysis (see Appendix B for instrument) – analysis of questions 1, 2, and 3 listed in Table 1 Project Science Inquiry Interview Questions Aligned with Research Questions

B. STEBI Analysis (see Appendix C1 for instrument and C2 for scoring instructions)

C. CLES Analysis (see Appendix D1 for instrument and D2 for scoring instructions)

D. Partner Portfolio for Professional Development

II. Research Question 2 analysis – “How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?”

A. Interview Analysis (see Appendix B for instrument) – analysis of questions 4, 5, 7, and 8 listed in Table 1 Project Science Inquiry Interview Questions Aligned with Research Questions

B. Classroom Observation Analysis (see Appendix E for the Classroom Observation Protocol)

C. STEBI Analysis (see Appendix C1 for instrument and C2 for scoring instructions)

D. CLES Analysis (see Appendix D1 for instrument and D2 for scoring instructions)
E. Partner Portfolio for Professional Development

III. Research Question 3 analysis – “What barriers to implementing I-B methods exist?”

A. Pre and Post PSI Professional Development Course Interview Analysis
   (see Appendix B for instrument)– analysis of questions 7, 8, and 9 listed in Table 1 Project Science Inquiry Interview Questions Aligned with Research Questions

B. Goal Statement Analysis

C. Classroom Observation Analysis (see Appendix E for the Classroom Observation Protocol)

D. STEBI Analysis (see Appendix C1 for instrument and C2 for scoring instructions)

E. CLES Analysis (see Appendix D1 for instrument and D2 for scoring instructions)

F. Partner Portfolio for Professional Development

IV. Research Question 4 analysis – “What relationships exist between teachers’ perceptions and use of I-B methods?”

A. Pre and Post PSI Professional Development Course Interview Analysis
   (see Appendix B for instrument)– analysis of questions 1 through 9 listed in Table 1. Project Science Inquiry Interview Questions Aligned with Research Questions

B. Classroom Observation Analysis (see Appendix E for the Classroom Observation Protocol)
C. STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions)

D. CLES analysis (see Appendix D1 for instrument and D2 for scoring instructions)

E. Partner Portfolio for Professional Development

V. Research Question 5 analysis – “How do teachers choose to use I-B methods as opposed to teacher-centered activities?”

A. Pre PSI Professional Development Course Interview Analysis (see Appendix B for instrument)– analysis of questions 7, 8, and 9 listed in Table 1 Project Science Inquiry Interview Questions Aligned with Research Questions

B. Post PSI Professional Development Course Interview Analysis

C. Classroom Observation Analysis (see Appendix E for the Classroom Observation Protocol)

D. Partner Portfolio for Professional Development
I next present the data to answer the query, “Who is Ariel?” This teacher portrait is described as it aligns with each research question. Data that yields information related to each question was analyzed. A discussion of the findings for each question is presented.

Research Question 1 Analysis

What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?

Ariel’s Interview Analysis: Pre and Post Professional Development Course

The following information was found useful in providing insights about Research Question 1: (a) Ariel’s pre PSI Professional Development Course interview (questions 1, 2, and 3 as listed in Table 1), (b) STEBI survey, (c) CLES survey, (d) Ariel’s Partner Portfolio for Professional Development, and (e) Ariel’s post PSI Professional Development Course interview. This information was utilized to examine Ariel’s beliefs in an effort to uncover patterns that influence her teaching behavior as it relates to her Individual Identity (II). Individual Identity (II) is defined as the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfield, 1998) that represents autonomy or personal constructs (Scribner et al., 2002). Ariel’s Pre and post PSI Professional Development Course Interview Codes and Transcript Statements for Research Question 1 are located in Table 2.
Table 2

*Interview Codes and Transcript Statements for Ariel (T1) Pre and Post – Research Question 1.*

<table>
<thead>
<tr>
<th>Ariel’s Experiences: Beliefs About Learning and Teaching Science</th>
<th>Beliefs About How Children Learn Science</th>
<th>Beliefs About Science Teaching Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: I remember dissecting the frog. I guess I did that in high school. So I remember that lesson. I don’t remember a lot of what the teacher told us to do. I just remember doing it, the frog, and I thought it was gross. I remember pinning back certain parts of the frog and going into and seeing all of the organs and things inside of the frog. So, that stands out. (See &amp; Do)</td>
<td>Post: Investigating questions and finding answers that are important to them as far as making science something they can relate to in their lives. (Investigating) (Relate to)</td>
<td>Pre: I like it organized. I like it structured, for the most part. I do go off, like what we did the other day. I like that kind of thing. I just have to make sure I can tolerate it, the kind of noise. Sometimes it gets a little chaotic with the kids, making sure everybody is on task. That’s hard in that kind of situation. But, I do like to do that. I get more excited when I’m going to teach that kind of lesson. Post: I try to use different methods to hopefully reach all students. I use the interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments. (Organization) (Actively Involved) (Emotions) (Variety of Methods)</td>
</tr>
<tr>
<td>Pre: I do remember the anatomy class because I do remember seeing cats. I am a cat person and I see all of the cats and I did not want to do that. And the chemistry, I don’t remember doing a lot in there except I was surprised because I did so much better in that than I did in high school. I realize I probably talked a lot in high school during the class. Do you know what I’m saying? And didn’t do what I was supposed to. I was more focused in college at that point. I remember anatomy and thinking it was very hard. I had to remember all of the bones of the human body. I just remember struggling with that. (See &amp; Do) (Struggles with Science)</td>
<td>Post: I think the students enjoyed the activity and I like to see that they were involved, even excited about learning. (Emotions) (Actively Involved)</td>
<td></td>
</tr>
</tbody>
</table>

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Ariel has limited training experience in the area of science. In college, Ariel took one course in each of the following subjects: chemistry, anatomy, and biology. Several years before this study, Ariel and her critical friend, Jo, participated in a professional development session that gave teachers the opportunity to go outside near a river and join in a science game that included searching for items in nature. Ariel noted that she made things in the session that she really didn’t use with her classes; however, she feels that it was a good experience. In the following interview excerpt Ariel tells us that only one high school experience really stood out or played a role in the shaping of her beliefs related to science teaching and learning.

I remember dissecting the frog. I guess I did that in high school. So I remember that lesson. I don’t remember a lot of what the teacher told us to do. I just remember doing it, the frog, and I thought it was gross. I remember pinning back certain parts of the frog and going into and seeing all of the organs and things inside of the frog. So, that stands out.

Another excerpt from the pre PSI Professional Development Course interview emphasizes an idea that Ariel remembers as an example of several classroom experiences that allowed her to become engaged in her learning.

I do remember the anatomy class because I do remember seeing cats. I am a cat person and I see all of the cats and I did not want to do that. And the chemistry, I don’t remember doing a lot in there except I was surprised because I did so much better in that than I did in high school. I realize I probably talked a lot in high school during the class. Do you know what I’m saying? And didn’t do what I was supposed to. I was more focused in college at that point. I remember anatomy and thinking it was very hard. I had to remember all of the bones of the human body. I just remember struggling with that.

Ariel remembered learning when she was “seeing” and “doing” or when her teachers used a constructivist approach. The constructivist approach to how people learn focuses
on providing relevant experiences and opportunities that allow students to construct knowledge (Piaget, 1929; Vygotsky, 1978).

A teacher’s principles or attitude, her tendency to respond favorably or unfavorably toward a topic, students or other objects, determines what her students will see, hear, think, and do (Souza Barros & Elia, 1998). This excerpt from Ariel’s pre PSI Professional Development Course interview reveals how she describes herself as a classroom teacher.

I like it organized. I like it structured, for the most part. I do go off, like what we did the other day. I like that kind of thing. I just have to make sure I can tolerate it, the kind of noise. Sometimes it gets a little chaotic with the kids, making sure everybody is on task. That’s hard in that kind of situation. But, I do like to do that. I get more excited when I’m going to teach that kind of lesson.

Ariel arranges what her students will see, hear, think, and do in an organized and structured manner. In her post PSI Professional Development Course interview excerpts Ariel shares that she believes it is important for students to understand how to go about “investigating questions and finding answers that are important to them as far as making science something they can relate to in their lives.” In the post PSI Professional Development Course interview data more of Ariel’s beliefs are revealed. Ariel shares a list of examples that she believes illustrates her beliefs about science teaching methods and how children learn science and states, “I try to use different methods to hopefully reach all students. I use the interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments.” Ariel likes to see her students motivated about learning. The following excerpt shows her feelings. Ariel explains, “I think the students enjoyed the activity and I like to see that they were involved, even excited about learning.”
In summary, data from the pre PSI Professional Development Course interview revealed information about Ariel’s conceptual framework for science teaching. The researcher analyzed data in an attempt to discover what Ariel believes about how children learn science and science teaching methods. This includes Ariel’s conceptions of how children learn and her own view of effective science teaching. Ariel learns by seeing and doing. Ariel attempts to reach all students and encourages them to investigate questions, find answers, and relate science concepts to their own lives. She prefers structure, but will permit occasional chaos if it enables students to become involved and excited about learning.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

Ariel’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments increased notably, with 45 (average efficacy) points and 52 (high efficacy) points respectively (max=65 points) (see Figure 1). This indicates that she became more comfortable with her ability to teach science following the PSI Professional Development Course. Ariel’s STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased slightly, from 40 points to 36 points respectively (max=60 points); however, both scores were in the average expectancy category indicating that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).
Constructivist Learning Environment Survey – CLES Analysis Pre and Post

The CLES Personal Relevance scale relates to students’ experience of the personal relevance of school science as perceived by teachers (Suters, 2004; Taylor et al., 1997). Ariel’s Personal Relevance scores increased notably from a low intermediate agreement level for the pre assessment (20) to a high intermediate agreement level for the post assessment (26) (see Figure 2). Ariel did not score one of the items in the pre assessment instrument, this could account for the large jump in this score. Taking this information into consideration the score could still indicate an increase; a sign that before the PSI Professional Development Course Ariel did not feel comfortable inviting students to engage in opportunities to experience the relevance of school science to their everyday interests and activities or to use their everyday experiences as a meaningful context for the development of their formal scientific knowledge. After the PSI Professional
Development Course she placed more emphasis on linking school science with students’ everyday experiences.

The Scientific Uncertainty scale relates to students’ perceptions of science as a fallible human activity as perceived by teachers (Suters, 2004; Taylor et al., 1997). Ariel’s pre (27) and post (22) Scientific Uncertainty scores were in the high intermediate agreement range, which indicated that she often, but not always, emphasized engaging students in opportunities to learn to be skeptical and critical about the value and nature of science. In particular, Ariel often but not always emphasized engaging students in opportunities to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. The scores decreased indicating that in the 2007-2008 class she provided a smaller number of occasions for students to engage in opportunities that would allow them to learn to be skeptical and critical about the value and nature of science.

The Critical Voice scale relates to students development as autonomous learners, through creation of a social climate in which students feel that their learning is legitimate and beneficial (Suters, 2004; Taylor et al., 1997). Ariel’s pre (28) and post (27) Critical Voice scores decreased slightly from a high to a high intermediate agreement range. This indicated that after Ariel’s participation in the PSI Professional Development Course she provided slightly fewer opportunities for students to question her plans and methods and express concerns about impediments to their learning.

The Shared Control scale also relates to student autonomy. This scale is concerned with students sharing control of the classroom-learning environment with their teacher (Suters, 2004; Taylor et al., 1997). Ariel’s pre (20) and post (20) Shared Control
scores were identical, both in the low intermediate agreement range. This is an indication that her students are sometimes invited to participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom.

The Student Negotiation scores speak about teacher beliefs as they relate to student interaction with other students (Suters, 2004; Taylor et al., 1997). Ariel’s Student Negotiation scores increases slightly from the pre assessment (28) to the post assessment (30). Both scores were in the high agreement category, which indicated that she placed a high emphasis on providing opportunities for students to explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas.

Last, the Attitude Scale scores provide a measure of the concurrent validity of the CLES. This scale is used to measure teachers’ interpretations of students’ attitudes towards the classroom environment (Suters, 2004; Taylor et al., 1997). Ariel’s pre (30) and post (28) Attitude Scale scores were in the high agreement range which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, understood the activities, and enjoyed the activities (see Appendix D1 for instrument and D2 for scoring instructions).
Figure 2. Ariel’s CLES Scores

Ariel’s Partner Portfolio for Professional Development Analysis

Teachers were given the opportunity to reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006) throughout the PSI Professional Development Course. The researcher examined five products produced by Ariel: (a) Invitation to Practice: Science Learning Personal History, (b) Invitation to Practice: Collaboration, (c) pre PSI Professional Development Course lesson observation, (d) personal goal for the PSI Professional Development Course, and (e) journal entries to confirm the previously mentioned data findings from interview sessions. Data reported in the section titled Ariel’s Partner Portfolio for Professional Development Analysis findings, along with the STEBI and CLES data serves as triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).
A framework for organization is based upon Ariel’s interview excerpts related to her beliefs about teaching science. Ariel’s interview excerpts showed that she learns by “seeing” and “doing.” An excerpt from the Invitation to Practice: Science Learning Personal History (see Appendix G) activity supported the idea that Ariel believes that she needs to see or visualize her learning.

During a college anatomy course, we had to learn all the names of the bones in the body. I thought I would never be able to do that. I had to use different methods to achieve this goal. We not only had to name them but also be able to label them correctly on a diagram of the body. As a learner myself, I think I am more of a visual learner. I need to be able to see whatever it is we are learning about. So to learn the names of the bones, I wrote them down many, many times. Then to label, I used a blank diagram, practiced writing the names of the bones on the diagram.

In her own teaching, Ariel notes that she applies methods that helped her as a student. In one of her Partner Portfolio for Professional Development journal entries she explains that she allows her students to see, write, and practice. In post PSI Professional Development Course interview data Ariel shows that she uses a variety of teaching methods including: interactive notebooks, hands-on activities, demonstrations, whole class teaching, partner work, and small group experiments. Her CLES Attitude Scale scores were in the high agreement range, pre (30) and post (28), which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, understood the activities, and enjoyed the activities (Suters, 2004; Taylor et al., 1997).

Data collected revealed information about Ariel’s beliefs about how children learn science. Her post PSI Professional Development Course interview excerpts show that after the PSI Professional Development Course Ariel indicated that she believes it is important for students to understand how to go about “investigating questions and finding
answers that are important to them as far as making science something they can relate to in their lives.” Data from the CLES supports this idea. Ariel’s Personal Relevance scores, pre (20) and post (26), increased notably indicating that before the PSI Professional Development Course she did not feel comfortable inviting students to engage in opportunities to experience the relevance of school science to their everyday interests and activities and to use their everyday experiences as a meaningful context for the development of their formal scientific knowledge. After the professional development course she placed more emphasis on linking school science with students’ everyday experiences (Suters, 2004; Taylor et al., 1997). Ariel’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (45) and post (52) assessments increased notably indicating that after participating in the professional development course she became more comfortable with her ability to teach science (Riggs, 1988; Riggs & Enochs, 1990).

Last, data analysis was conducted to investigate Ariel’s beliefs about science teaching methods. Ariel’s interview excerpts revealed that she likes structure and organization. Data from her Invitation to Practice: Collaboration supported this idea as an excerpt showed that she and her CF are both very structured. Although she likes it organized and structured, for the most part, she will occasionally “go off” and allow students freedom to explore and investigate. Her CLES Shared Control scores, pre (20) and post (20), supported this statement as it indicated that her students are sometimes invited to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom (Suters, 2004; Taylor et al., 1997). An example of Ariel allowing students to venture away from the normal structured
routine was noted in Ariel’s pre PSI Professional Development Course lesson observation when she allowed her students to explore and create their own instruments out of tissue boxes and rubber bands. Ariel’s goal for the PSI Professional Development Course was to “better implement experiments and scientific process into her classroom” and to learn “how to use the inquiry process in the classroom.” Ariel’s goal statement, located in her Partner Portfolio for Professional Development, revealed her willingness to improve knowledge of science teaching methods.

*Summary of Ariel’s Results for Research Question 1*

Research Question 1 solicits an answer to the following: “What do teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?” Ariel’s interview excerpts disclosed knowledge about her conceptual framework for science teaching. Ariel discovered that she learns by “seeing” and “doing.” Ariel strives to reach all students and encourages them to investigate questions, find answers, and relate science concepts to in their own lives. She likes structure, but tolerates chaos from time to time to allow students an opportunity to become involved and excited about learning. Ariel’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments increased notably, pre (45) and post (52), showing she became more comfortable with her ability to teach science. Ariel’s STEBI Outcome Expectancy subscale scores for the pre (40) and post (36) assessments indicated that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enoch, 1990).
Research Question 2 Analysis

How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

Interview analysis (see Appendix B for instrument) for Research Question 2 includes the examination of: (a) pre PSI Professional Development Course interview questions 4, 5, 7, and 8 listed in Table 1, (b) post PSI Professional Development Course interview questions 3 and 4, (c) Classroom Observation analysis (See Appendix E for the Classroom Observation Protocol), (d) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), (e) CLES analysis (see Appendix D1 for instrument and D2 for scoring instructions), and the (f) Partner Portfolio for Professional Development. The researcher utilized this data in order to examine the way in which Ariel perceives herself or describes her own abilities to produce desired or intended results in her science classroom. This information was also drawn upon to describe Ariel’s Subject Matter Knowledge (SMK). Subject Matter Knowledge (SMK) is defined as the teacher’s knowledge of content matter and pedagogy (the art of being a teacher), along with her curriculum knowledge (Shulman, 1986). Last, the researcher analyzed the data to reveal information related to Ariel’s understanding of I-B methods. In other words, the researcher has assembled the pieces to answer the teacher’s query, “How does Ariel describe her abilities to produce desired or intended results in her science classrooms? What does Ariel believe about her science content knowledge and her pedagogical science knowledge? What does Ariel understand about I-B methods?”
Ariel’s Interview Analysis: Pre and Post Professional Development Course

The researcher analyzed pre PSI Professional Development Course interview data, which proved to be useful in describing Ariel’s framework for understanding science as well as her ability to produce desired results according to her beliefs and self-efficacy. In the pre PSI Professional Development Course interview Ariel defines science as “investigation, questioning everything I have to teach, SOL tests, applying science concepts to their lives.” Research shows that there is a close link between teacher content knowledge in mathematics and science and student performance in these disciplines (Darling-Hammond, 2000; Loucks-Horsley et al., 2003). Keeping this in mind, the researcher examined the data to learn more about Ariel’s knowledge of science content information. This information about Ariel’s knowledge of science content information was revealed through Research Question 1 data analysis. During this investigation, the researcher learned that Ariel has limited training experience in the area of science content. Ariel explained that she took just one class in each of the following science subjects while completing her college coursework: chemistry, anatomy, and biology.

To create a picture describing Ariel’s framework for understanding science and her ability to produce desired results according to her beliefs and self-efficacy, data analysis includes: an examination of Ariel’s description of her own efficacy, an examination of Ariel’s description of her own framework for understanding science content and teaching methods, and a description of her own framework for understanding I-B science methods. Interview codes and transcript statements for Ariel’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions for Research Question 2 are listed in Table 3.
Table 3

*Interview Codes and Transcript Statements for Ariel (T1) Pre and Post – Research Question 2.*

**Self-Efficacy Related to:**

<table>
<thead>
<tr>
<th>Understanding of Science Content</th>
<th>Teaching Methods</th>
<th>Definition of science and Inquiry science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: “Ariel has limited training experience in the area of science. In college, Ariel took one course in each of the following subjects: chemistry, anatomy, and biology in college.” (Sit n’ Git)</td>
<td>Pre: “I try to use different methods to hopefully reach all students. I use the interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments.” (Methods)</td>
<td>Pre: Ariel defines Science as “investigation, questioning everything I have to teach, SOL tests, applying science concepts to their lives.” (Components-Science) (World View)</td>
</tr>
<tr>
<td>Pre: “Science would be one [fear] and math another. I never really liked math and so I think it might come through unconsciously. I do because I don’t feel comfortable in math, or as much in science as I do in history and reading.” (Negative Emotions)</td>
<td>Pre: “I do a lot of hands-on, not experiments that they design themselves, but like building things like the atom. I would hope they would say it was fun and they learned a lot. I think I have a long way to go with that too.” (Methods)</td>
<td>Pre: Ariel defines inquiry science as “questioning, looking into something more thoroughly, and lots of questions, more observing.” (Components-Inquiry)</td>
</tr>
<tr>
<td></td>
<td>Pre: “I want it to be interesting to them and learn why they are supposed to learn. You try different ways. I don’t want them to be bored.” (Motivation)</td>
<td>Post: (Science definition) “…answering questions about what goes on in the world.” (Components-Science) (World View)</td>
</tr>
<tr>
<td></td>
<td>Pre: “I have a lot of those kids, LD and kids with autism. I use hands-on, shorter assignments, and give them more time to complete assignments. If they can’t write well, I allow them to use pictures for their evaluation. I break down the content so that it is appropriate for their level. I put them with another student who understands and will help them.” (Reach All)</td>
<td>Post: (Inquiry definition) questioning, investigating, figuring out answers, exploring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post: Ariel noted that she probably avoids “giving them something and letting them discover on their own,” The reason she does not “do as much of that” is because she doesn’t “feel comfortable doing that.” (POV) (Emotions)</td>
</tr>
</tbody>
</table>
Data analysis started with an examination of Ariel’s description of her own efficacy and ability to produce a desired or intended result. During this analysis, we learned that Ariel does not feel comfortable with science and worries that her feelings might be exposed through her actions. The factors of fear, knowledge, and affect as determined by a teacher’s cognitive framework help shape a teacher’s actions (Senge, 1990). This excerpt from Ariel’s pre PSI Professional Development Course interview showed her fears when she talked about how she would like to improve as a teacher.

Science would be one [fear] and math another. I never really liked math and so I think it might come through unconsciously. I do because I don’t feel comfortable in math, or as much in science as I do in history and reading.

During Ariel’s post PSI Professional Development Course interview she defined science as, “answering questions about what goes on in the world.” In summary, Ariel defines science as investigation, questioning, exploring the world. She includes the Virginia SOL, the curriculum she is required to teach, in her definition of science. She believes in applying science concepts to the lives of her students.

Data analysis continued with an examination of Ariel’s description of her own framework for understanding science content and teaching methods. In the pre PSI Professional Development Course interview Ariel reveals details about her teaching methods. One excerpt lists examples of the methods Ariel generally uses to teach science. She explains that she likes to use “…talk, lecture some, group activities, partner activities, discuss. I talk about the next day. What did you learn? What were you supposed to get out of the lesson? Discuss, I don’t lecture for hours.” The excerpt that follows reveals details about the methods Ariel uses and gives an indication that she is willing to gain more knowledge about science teaching methods.
I do a lot of hands-on, not experiments that they design themselves, but like building things like the atom. I would hope they would say it was fun and they learned a lot. I think I have a long way to go with that too.

Ariel further discloses the reason she varies her teaching methods. She says, “I want it to be interesting to them and learn what they are supposed to learn. You try different ways. I don’t want them to be bored.” Ariel instructs a lot of special needs students. Ariel accommodates students with special needs in her classroom. An excerpt from her pre PSI Professional Development Course interview outlines those accommodations.

I have a lot of those kids, LD and kids with autism. I use hands-on, shorter assignments, and give them more time to complete assignments. If they can’t write well, I allow them to use pictures for their evaluation. I break down the content so that it is appropriate for their level. I put them with another student who understands and will help them.

The excerpt that follows describes how Ariel knows that her students understand a concept. She explains that she knows they understand when “…they can tell me what we have learned, when they can show me what we have learned, when they can give me an example of what we have learned, when they can actively show me something in the lesson.”

In summary, Ariel varies her teaching methods. She uses all of the following: lecture, partner and group activities, discussion, hands-on activities, and projects that allow students the opportunity to build things. She includes all students and modifies instruction for special needs students. She knows her students have learned a concept when they can show or give an example of their understanding.

Next, data analysis focused on Ariel’s description of her own framework for understanding I-B methods. In her pre PSI Professional Development Course interview, Ariel defines inquiry science as “questioning, looking into something more thoroughly,
and lots of questions, more observing.” In her post PSI Professional Development Course interview she defined inquiry science as, “questioning, investigating, figuring out answers, and exploring.” Ariel noted that she probably avoids “giving them something and letting them discover on their own,” The reason she does not “do as much of that” is because she doesn’t “feel comfortable doing that.” In summary, prior to the PSI Professional Development Course Ariel’s definition of inquiry included questioning and observing. She did not feel comfortable letting students discover things by themselves.

_Ariel’s Classroom Observation Analysis: Pre and Post Professional Development Course_

Researcher observations were completed May 16, 2007 and October 12, 2007. The demographics of the two classes observed for the pre PSI Professional Development Course and post PSI Professional Development Course observations are described in Table 4. Ariel had a total of 20 students in each of the pre PSI Professional Development Course and post PSI Professional Development Course observations.

**Table 4**

_Ariel’s Class Demographics Pre and Post Observations (T1)_

<table>
<thead>
<tr>
<th>Race</th>
<th>Pre (20)</th>
<th>Post (20)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>African American</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Caucasian American</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Asian</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>13</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>
Data analysis includes a review of Ariel’s interview and observation data followed by presentation of evidence related to the implementation of the forms of inquiry as described by Martin-Hansen (2002). A review of the pre PSI Professional Development Course observation data supports the pre PSI Professional Development Course interview data and suggests that Ariel used multiple methods while teaching one lesson. A brief synopsis of the pre PSI Professional Development Course lesson is illustrated in this paragraph. In her lesson plan for the pre PSI Professional Development Course observation Ariel engaged students by asking them to sit quietly and write down the sounds that they hear. They shared their ideas with each other as a whole class. The next section of the lesson consisted of teacher led activities where students tapped on the desk and listened first while sitting up and then while leaning their ear on the desk. Ariel called on students to discuss their prior knowledge and to offer explanations related to the activity. The class was directed to make connections to real life situations that involved sound. Students next worked with a partner and they followed directions to create a rubber band banjo. They made observations and recorded the data. Ariel circulated, helped students, and asked questions.

During the pre PSI Professional Development Course observation lesson the students were observed following directions to create a rubber band banjo, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). During the pre PSI Professional Development Course observation, Ariel asked students to follow specific directions. This data from the pre PSI Professional Development Course observation verifies data from the pre PSI Professional
Development Course interview that showed that Ariel doesn’t “feel comfortable” giving students “something and letting them discover on their own.”

During the post PSI Professional Development Course observation Ariel continued to employ a variety of teaching methods into her lessons. Ariel used a variety of methods including: reading books (incorporating literature), a KWL chart (a graphical organizer, the letters KWL are an acronym for “what we know,” “what we want to know,” and “what we learned”) use of manipulatives, journaling, interactive notebooks, use of technology (subject related web sites), partner work, and creation of dioramas. As demonstrated in Ariel’s lesson plans and pre observation data, she had already successfully implemented one form of inquiry as described by Martin-Hansen (2002), Structured Inquiry. Throughout her mini unit plan, Ariel gradually moved from Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design, to Coupled Inquiry, inquiry that starts as Structured Inquiry or teacher Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control. Ariel gradually lessened teacher control. Ariel has slowly started using the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). Ariel allowed students the opportunity to discover the answers to many of their questions on their own as they moved through the unit. In summary, the researcher observed some evidence of Full or Open inquiry in the post PSI Professional Development Course observation as students used a KWL chart to gather information and generate questions that they utilized to guide their investigations as they moved through the unit.
Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post

As noted in Research Question 1 analysis, Ariel’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments increased notably. This increase indicated that she became more comfortable with her ability to teach science following the PSI Professional Development Course. Ariel’s STEBI Outcome Expectancy subscale scores decreased slightly; however, both scores were in the average expectancy category indicating that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Ariel’s Partner Portfolio for Professional Development Analysis.

Constructivist Learning Environment Survey – CLES Analysis Pre and Post

Ariel’s CLES Personal Relevance scores increased notably from a low intermediate agreement level for the pre assessment (20) to a high intermediate agreement level for the post assessment (26). Ariel did not score one of the items in the pre assessment instrument, this could account for the large jump in this score. Taking this information into consideration the score would still indicate an increase, this would indicate that before the PSI Professional Development Course she did not feel comfortable inviting students to engage in opportunities to experience the relevance of school science to their everyday interests and activities and to use their everyday experiences as a meaningful context for the development of their formal scientific knowledge. After the professional development course she placed more emphasis on
linking school science with students’ everyday experiences. Her pre (27) and post (22) CLES Scientific Uncertainty scores were in the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. The scores decreased indicating that in the 2007-2008 class she provided fewer opportunities for students to engage in opportunities to learn to be skeptical and critical about the nature and value of science. Her pre (28) and post (27) CLES Critical Voice scores decreased slightly from a high to a high intermediate agreement range. This indicated that after Ariel’s participation in the professional development course she provided slightly fewer opportunities for students to question her plans and methods and express concerns about impediments to their learning. Her pre (20) and post (20) CLES Shared Control scores were identical, both in the low intermediate agreement range, which indicated that her students are sometimes invited to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom. Ariel’s CLES Student Negotiation scores increases slightly from the pre assessment (28) to the post assessment (30). Both scores were in the high agreement category, which indicated that she placed a high emphasis on provided opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. Ariel’s pre (30) and post (28) CLES Attitude Scale scores were in the high agreement range which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed
the activities (see appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Ariel’s Partner Portfolio for Professional Development Analysis*.

*Ariel’s Partner Portfolio for Professional Development Analysis*

The Partner Portfolio for Professional Development was used to hold teacher reflections and permitted the opportunity for participants to manage their thoughts and behaviors through strategic processing, reflection, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Ariel’s (a) Goal Statement, (b) Exit Slips, and (c) journal entries were analyzed to confirm the earlier mentioned data findings. This examination offers a triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).

Data analysis for points of triangulation started with an examination of Ariel’s description of her own efficacy and ability to produce a desired or intended result. Pre PSI Professional Development Course interview data shows that prior to the PSI Professional Development Course, Ariel was not always comfortable with science or mathematics, and feared her discomfort might be visible to her students. Ariel’s Personal Science Teaching Efficacy Belief subscale scores, from the STEBI analysis, increased notably, indicating that after the PSI Professional Development Course she became more comfortable with her ability to teach science.

Data analysis for points of triangulation was also conducted to examine Ariel’s description of her own framework for understanding science content and teaching methods. Pre PSI Professional Development Course interview data showed that Ariel
would like to improve as a science teacher. The following excerpt from Ariel’s Goal Statement in her Partner Portfolio for Professional Development supported the idea that Ariel would like to improve as a science teacher. She writes that she would like to learn “how to better implement experiments and scientific process in my classroom.” She would also like to learn “how to use the inquiry process in the classroom.” An excerpt from an Exit Slip in Ariel’s Partner Portfolio for Professional Development further supports the idea that Ariel would like to improve as a science teacher. Ariel wrote, “I would like to learn more about Inquiry Science and to create lessons.” In summary, Ariel is interested in improving as a science teacher by learning more about implementing experiments, the scientific process, and the inquiry process as it applies to teaching science in her classroom.

Ariel uses a variety of methods to teach science, including: talking or lecture, hands-on activities, group activities, partner activities, and discussion. Ariel’s CLES Student Negotiation scores, pre (28) and post (30), showed a slight increase. Both of Ariel’s scores fell into the high agreement category, which indicated that she placed a high emphasis on provided opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas (Suters, 2004; Taylor et al., 1997).

Last, data analysis for points of triangulation was conducted to examine Ariel’s description of her own framework for understanding I-B science methods. Pre PSI Professional Development Course interview data revealed that she doesn’t “feel comfortable” just “giving them something and letting them discover on their own.” This idea was supported by the pre PSI Professional Development Course observation data.
During the science lesson the students followed Ariel’s directions to create a rubber band banjo. This observation serves as evidence of the use of Structured Inquiry. Structured Inquiry is defined as inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). Interview data from Ariel’s post PSI Professional Development Course interview reveals the reason there was little evidence of use of inquiry in her classroom prior to the PSI Professional Development Course. Ariel reported that, “before the in-service, I had no idea what inquiry based science was all about.” Ariel’s STEBI Outcome Expectancy subscale scores, pre (40) and post (36), decreased slightly; however, both scores were in the average expectancy category indicating that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Ariel’s post PSI Professional Development Course observation data showed that although she was a little uncomfortable about “letting them discover on their own,” she was experiencing some success while implementing Guided Inquiry into her classroom. Ariel was gaining confidence and working towards implementation of Full or Open Inquiry, inquiry in which students ask their own questions, design their own scientific investigations, and convey the results of the scientific investigations (Martin-Hansen, 2002), into her science lessons. In one of her journal entries, Ariel excitedly relates her feelings about implementing one of the lessons in her mini unit, “I think it went pretty well, kids seemed to be interested!”
Summary of Ariel’s Results for Research Question 2

Research Question 2 seeks information to explain the following: “How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?”

To offer an explanation, one must understand that Ariel’s cognitive framework incorporates her knowledge of science content and teaching methods. Her conceptions of science subject matter or content knowledge include the ideas, facts, and the concepts of the discipline, as well as the relationships among those concepts, facts, and ideas. Information related to Ariel’s cognitive framework was revealed through data analysis. The researcher learned that Ariel does not feel “confident” with science or mathematics, and fears her discomfort “might come through unconsciously” to her students. Ariel is interested in improving as a teacher by learning more about implementing experiments and the scientific process, and through learning more about the inquiry process. Ariel employs a variety of methods to teach science, including: talking or lecture, hands-on activities, group activities, partner activities, and discussion. Pre PSI Professional Development Course interview data revealed that she didn’t feel comfortable giving students ideas or concepts and letting them discover on their own. Prior to the PSI Professional Development Course, Ariel had “no idea what inquiry-based science was.” Post PSI Professional Development Course interview and post PSI Professional Development Course observation data indicated that Ariel was slowly and increasingly able to implement lessons using Guided Inquiry and is slowly moving on towards Full or Open Inquiry as defined by Martin-Hansen (2002).
Research Question 3 Analysis

What barriers to implementing I-B methods exist?

Interview analysis (see Appendix B for instrument) for Research Question 3 includes examination of Ariel’s Goal Statement and selected pre and post interview questions as listed in Table 1. To build credibility, information was compiled through (a) STEBI surveys, (b) CLES surveys, (c) direct observation of the participant’s teaching, and (d) Partner Portfolio for Professional Development, including lesson plans, Invitation to Practice: Mapping My Classroom activity, Exit Slips, Quick Writes, and journal entries. The researcher made use of this data to study the teacher’s mental models in an effort to uncover patterns that shape teaching behavior as it relates to her Shared Identity (SI), the portion of a teacher’s conceptual framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community. In other words, we have assembled the pieces to answer the teacher’s query, “How does Ariel describe her abilities to produce desired or intended results in her science classroom as they relate to barriers to implementation of I-B science methods?”

Ariel’s Goal Statement Analysis

A teacher’s attitudes and beliefs about science are key influences on how they teach the subject. The reality of the school classroom consists of lessons in which teachers transmit science as a set of facts, laws, and data. The teachers’ principles or attitude, their tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do. The teachers’ styles, principles, are rooted in experience and develop into individual constructs slowly over
time (Souza Barros & Elia, 1998). During the PSI Professional Development Course, Ariel set her own goal for I-B instruction (Hammerness et al., 2005). Ariel’s goal for the PSI Professional Development Course read as follows: “I want to be able to implement the Inquiry process into my classroom and the other things under [the section] “What I Want to Learn.” Those “other things” for Ariel include the phrases: “how to better implement experiments and scientific process” and “how to use the Inquiry process in the classroom.” Looking at Ariel’s goal allowed the researcher to study her attitude towards implementation of I-B methods into her classroom. This goal reveals that Ariel is interested in learning how to implement experiments, the scientific process, and I-B methods into her classroom.

* Ariel’s Interview Analysis: Pre and Post Professional Development Course *

Interview analysis for Research Question 3 included the analysis of the pre PSI Professional Development Course interview questions numbered 4, 7, 8, and 9. This allowed the researcher to gather information to provide a picture of what was happening in Ariel’s classroom and school, thus providing information related to Ariel’s knowledge and practice at the beginning of the research (Davis, 2002). Data analysis started with an examination of interview excerpts that focused on the themes of strategies and teaching methods. Pre PSI Professional Development Course interview analysis showed that Ariel used the following strategies in her classroom prior to the PSI Professional Development Course: lecture, group activities, partner activities, and discussion. Interview codes and transcript statements for Ariel’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions are listed in Table 5.
Table 5

Interview Codes and Transcript Statements for Ariel (T1) Pre and Post – Research Question 3.

**Barriers to Implementation of I-B Methods**

<table>
<thead>
<tr>
<th>Time for Science Instruction and Time Related to Curriculum Guidelines</th>
<th>Support</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: “I watch the pacing guide. I also pace according to the curriculum. I also would like them to show me that they learned and understand. But, you know we have to split it with health so time is also a factor unfortunately.” (Pacing)</td>
<td>Post: “Time and materials being available” inhibit her from using I-B methods. (Time to teach) (Materials)</td>
<td>Pre: “Sometimes I feel I don’t know as much as I should, in depth knowledge.” (Teacher knowledge)</td>
</tr>
<tr>
<td>Post: “Time and materials being available” inhibit her from using I-B methods. (Time to teach) (Materials)</td>
<td>Post: “They can express the concept in words that are meaningful to them. Again, the way it is, not necessarily the way I want it to be; they perform well on benchmarks, et cetera. I move to the next concept when I feel the kids have grasped that concept. Also, realistically, you have to move on to the next nine weeks to make sure you cover everything for the SOL test.” (Standards) (Pacing) (Testing) (Teacher relationship with students)</td>
<td>Post: “They can express the concept in words that are meaningful to them. Again, the way it is, not necessarily the way I want it to be; they perform well on benchmarks, et cetera. I move to the next concept when I feel the kids have grasped that concept. Also, realistically, you have to move on to the next nine weeks to make sure you cover everything for the SOL test.” (Standards) (Pacing) (Testing) (Teacher relationship with students)</td>
</tr>
<tr>
<td>Post: “I understand the method, but the implementing of it is going very slowly. I find myself having to reread the 5E strategy often. Again, time constraints, the fact that there are so many new things we have to do this year [a new computer system, C.O.W.’s, Elmo’s, SMART Boards, et cetera]. They’re all good; they just all take time to implement.” (Share with other subjects)</td>
<td>Post: “The curriculum map, curriculum framework, benchmarks, and Virginia SOL tests.” Ariel felt that the amount of subject matter to be covered in a limited amount of time served as a barrier to implementation of I-B methods.” (Time to teach) (Standards) (Pacing) (Testing)</td>
<td>Post: “The curriculum map, curriculum framework, benchmarks, and Virginia SOL tests.” Ariel felt that the amount of subject matter to be covered in a limited amount of time served as a barrier to implementation of I-B methods.” (Time to teach) (Standards) (Pacing) (Testing)</td>
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<td>Post: “They can express the concept in words that are meaningful to them. Again, the way it is, not necessarily the way I want it to be; they perform well on benchmarks, et cetera. I move to the next concept when I feel the kids have grasped that concept. Also, realistically, you have to move on to the next nine weeks to make sure you cover everything for the SOL test.” (Standards) (Pacing) (Testing) (Teacher relationship with students)</td>
<td>Post: She may not have implemented many I-B “extension activities” is “because of time constraints.” (Time to teach) (Pacing)</td>
<td>Post: She may not have implemented many I-B “extension activities” is “because of time constraints.” (Time to teach) (Pacing)</td>
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Research supports that it is important that administrators and teammates are supportive of teachers while they are implementing the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). Data analysis of the interview excerpts focused on the theme of support from Ariel’s administrators and teammates. Her teaching team at her school consisted of her CF, Jo, and three other fifth grade teachers. The excerpt that follows illustrates the level of support Ariel feels that she has received from her team. Ariel explains, “Jo and I have been teaching together since 1988. She influences me. When talking to the others, we share ideas on lessons that worked for them. This influences me to try something different.” Ariel states that her administration has “encouraged us to use hands-on science kits.” She further indicates that they have provided “any material we want. They will listen to our request and try to get the materials.” Ariel continues by assuring that her administration has “been very supportive.” In summary, data from the pre PSI Professional Development Course interview analysis showed that Ariel is receiving the support she needs from teammates and administrators in order to successfully implement I-B science methods into her classroom.

Although Ariel possesses the desire to implement I-B methods, feels confidence in her teaching ability, and believes her CF, colleagues and administration support her; there may be other barriers that inhibit Ariel to fully carry out her science teaching vision. Accordingly, the researcher next examined possible threats to fidelity or barriers to use of I-B instruction besides lack of administrative and peer support. This was accomplished through interviews and classroom observation. This process permitted the researcher to
identify connections or relationships between Ariel’s perceptions and use of I-B instruction (Davis, 2002).

Analysis of the pre PSI Professional Development Course interview questions revealed that Ariel did face a number of barriers as she went about the process of teaching science in her classroom, including: time to teach; sharing time teaching other subjects; the amount of subject matter she is required to cover, this is related to curriculum guidelines, including the curriculum framework, curriculum map, Virginia SOL, and county benchmark tests; and her knowledge of subject matter. Ariel finds that the factor of time, both sharing time teaching other subjects and the amount of time she is required to spend to cover the required subject matter, is a concern she feels when planning to teach science in her classroom. This excerpt from the pre PSI Professional Development Course interview illustrates Ariel’s beliefs.

I watch the pacing guide. I also pace according to the curriculum. I also would like them to show me that they learned and understand. But, you know we have to split it with health so time is also a factor unfortunately.

Analysis of pre PSI Professional Development Course interview data revealed that Ariel believes that her knowledge of subject matter might also prove to be a possible barrier to implementation of IB methods. Ariel stated, “Sometimes I feel I don’t know as much as I should, in depth knowledge.”

Interview analysis for Research Question 3 also included the analysis of the post PSI Professional Development Course interview questions numbered 3, 4, 6, and 7. Data analysis continued with the assumption that Ariel might have encountered possible threats to fidelity or barriers to use of I-B instruction. This process allowed for further identification of connections or relationships between Ariel’s perceptions and use of
inquiry instruction (Davis, 2002). Analysis of the post PSI Professional Development Course interview questions also revealed that Ariel did face a number of barriers as she went about the process of implementing I-B science in her classroom, including: time to implement methods; the amount of subject matter she is required to cover in a given amount of time, this is related to curriculum guidelines including the curriculum framework, curriculum map, Virginia SOL, and county benchmark tests; and materials being available. In other words, these barriers remain despite the professional development course and administrator and peer support. Ariel explains that “time and materials being available” inhibit her from using I-B methods. Ariel outlines some of her struggles with finding enough time to implement I-B in the following excerpt from the post PSI Professional Development Course interview.

I understand the method, but the implementing of it is going very slowly. I find myself having to reread the 5E strategy often. Again, time constraints, the fact that there are so many new things we have to do this year [a new computer system, C.O.W.’s, Elmo’s, SMART Boards, et cetera]. They’re all good; they just all take time to implement.

Ariel notes that the way she teaches is influenced by “the curriculum map, curriculum framework, benchmarks, and Virginia SOL tests.” Ariel felt that the amount of subject matter to be covered in a limited amount of time served as a barrier to implementation of I-B methods. This is illustrated in the following excerpt in which Ariel discusses pacing or moving on to a new concept as it relates to student learning.

They can express the concept in words that are meaningful to them. Again, the way it is, not necessarily the way I want it to be; they perform well on benchmarks, et cetera. I move to the next concept when I feel the kids have grasped that concept. Also, realistically, you have to move on to the next nine weeks to make sure you cover everything for the SOL test.
Ariel notes the reasons she may not have implemented many I-B “extension activities” is “because of time constraints.”

In summary, analysis of the pre PSI Professional Development Course interview questions revealed that Ariel did face a number of barriers as she went about the process of implementing I-B science in her classroom including: time to teach, this is related to sharing time teaching other subjects; the amount of subject matter she is required to cover, this is related to curriculum guidelines including the curriculum framework, curriculum map, Virginia SOL, and county benchmark tests; and knowledge of subject matter. In post PSI Professional Development Course interview questions Ariel explained that the barriers she faced included time to implement I-B methods, time to gather materials, and materials being available. Again, these barriers remain despite the professional development course and administrator and peer support.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

Ariel’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (45) and post (52) assessments increased notably, an indication that she felt more at ease with her ability to teach science. Ariel’s Outcome Expectancy subscale scores, pre (40) and post (36), decreased slightly; however, both scores were in the average expectancy category demonstrating that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Details of the STEBI results were noted in Research Question 1 analysis. This data serves as a source for triangulation of multiple data sources and also provides for multiple measures of the same phenomenon.
(Yin, 2003). Results will be reported in the section titled *Ariel’s Partner Portfolio for Professional Development Analysis.*

*Constructivist Learning Environment Survey – CLES Analysis Pre and Post*

Details of Ariel’s CLES scores were noted in Research Question 1 analysis. Data analysis showed Ariel’s Personal Relevance scores increased notably, pre (20) and post (26). This is an indication that before the PSI Professional Development Course she did not feel comfortable inviting students to engage in opportunities to experience the relevance of school science to their everyday interests and activities nor in inviting them to use their everyday experiences as a meaningful context for the development of their formal scientific knowledge. Further, scores indicated that after the professional development course Ariel placed more emphasis on linking school science with students’ everyday experiences. Her Scientific Uncertainty scores were in the high intermediate agreement range, pre (27) and post (22). This indicates that Ariel often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science. She often but not always emphasized to students that scientific knowledge is: evolving and provisional, shaped by cultural and social influences, and arises from human interests and values. Ariel’s scores declined in the post PSI professional development test indicating that after the PSI Professional Development Course she offered a reduced amount of occasions for students to become involved in opportunities to learn to be skeptical and critical about the value and nature of science. Ariel’s Critical Voice scores decreased slightly, pre (28) and post (27), showing that after her participation in the professional development course she provided a reduced amount of chances for students to question her plans and methods or to express concerns about
obstructions to their learning. Her Shared Control scores, pre (28) and post (27), were both recorded in the low intermediate agreement range. This showed that Ariel sometimes invited her students to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom. Her Student Negotiation scores, pre (28) and post (30), showed a slight increase with both scores falling into the high agreement category. This is an indication that Ariel placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. Ariel’s Attitude Scale scores, pre (30) and post (28), fell into the high agreement range. This is and indication that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (see Appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003). Results will be reported in the section titled Ariel’s Partner Portfolio for Professional Development Analysis.

Ariel’s Partner Portfolio for Professional Development Analysis

Throughout the PSI Professional Development Course teachers were allowed the opportunity to reflect and take charge of their thoughts and behaviors through reflection, planned processing, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). To confirm the previously mentioned data findings as triangulation of multiple data sources provided for multiple measures of the same phenomenon (Yin, 2003) the following data were analyzed: (a) the Invitation to Practice: Mapping My Classroom activity, (b) the Invitation to Practice: Collaboration activity, (c) Exit Slips,
(d) Quick Writes, and (e) journal entries. Analysis of the pre PSI Professional Development Course and post PSI Professional Development Course interview questions disclosed that Ariel confronted numerous barriers as she went about the course of implementing I-B science in her classroom, including: time to teach, this relates to sharing time teaching other subjects; the amount of subject matter she is required to cover, this relates to curriculum guidelines including the curriculum framework, curriculum map, Virginia SOL, and county benchmark tests; knowledge of subject matter; time to implement methods; time to gather materials; and materials being available.

Post PSI professional development interview data revealed that Ariel understands “the method, but the implementing of it is going very slowly.” This delay was confirmed and explained further as Ariel reflected in her journal that she has not implemented “some parts of the Inquiry lesson plan because I have not had time to implement all of the “E’s [from the 5E Model of science teaching (Bybee, 1993, 2000; Carin et al., 2004)].” Post PSI professional development interview data also revealed that Ariel felt that “time and materials being available” inhibit her from using I-B methods in her science classroom. This statement was supported by the Invitation to Practice: Collaboration activity. Ariel and her CF, Jo, both agreed that they “…find it difficult to get all of the materials together for certain experiments.”

During the Invitation to Practice: Mapping My Classroom activity, Ariel planned changes that would have to take place in her classroom in order for her to implement I-B science. The excerpt that follows outlines her plans. Ariel notes, “I would need an area for exploration and investigation. Possibly put tables together where my desk was this
year. Also could use area where the two old computers were.” Data gathered from CLES scores indicated that after the professional development course Ariel placed more emphasis on linking school science with students’ everyday experiences. She placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. This supports Ariel’s intent to provide more space for exploration and investigation. In the post PSI Professional Development Course interview Ariel shared that she “made sure students were sitting in groups to make it easier to work together and discuss ideas.”

Although Ariel acted to arrange her classroom to facilitate I-B instruction, she was not able to implement all of her ideas as planned. However, after the PSI Professional Development Course Ariel reflected on her plans. This excerpt details her progress toward carrying out her plans.

I made a round table in one corner of my classroom to hopefully use for small groups. I have not used the area where the old computers were. I just have a Purple COW [a machine that is contains a technology based program or Curriculum on Wheels] sitting in that space.

Ariel indicated that she has the space, but has not utilized it as of October 15, 2007, which is seven weeks into the new school year. Journal entries and observations revealed that part of the reason for the delay in getting to I-B science is because classroom time is split between her teaching of science and social studies.

Analysis of pre PSI Professional Development Course interview data revealed that Ariel believed that her knowledge of subject matter might also prove to be a possible barrier to implementation of I-B methods. Ariel stated, “Sometimes I feel I don’t know as
much as I should, in depth knowledge.” In post PSI Professional Development Course interview discussion Ariel listed time to implement I-B methods, time to gather materials, and materials being available. In the excerpt that follows Ariel reveals that her knowledge of subject matter was not an influence on her decision to use I-B methods in her science classroom.

Did a lack of knowledge of subject matter or a lack of confidence have any influence on my decision to use the Inquiry method? Not really! I am always open to new ideas and methods, and so, am willing to try most anything!

Ariel’s STEBI Personal Science Teaching Efficacy Belief subscale scores indicated that she became more comfortable with her ability to teach science. This score seemed to conflict with Ariel’s CLES Critical Voice scores. Ariel’s CLES Critical Voice scores decreased slightly showing that after her participation in the professional development course she provided a reduced amount of chances for students to question her plans and methods or to express concerns about obstructions to their learning (Suters, 2004; Taylor et al., 1997). This conflict might be explained by Ariel’s pre PSI Professional Development Course interview comment where she noted that she probably avoids “giving them something and letting them discover on their own.” The reason she gives for this is that she does not “do as much of that” is because she doesn’t “feel comfortable doing that.”

Ariel’s Classroom Observation Analysis: Pre and Post Professional Development Course

As noted in Research Question 1 analysis, Ariel’s lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Structured Inquiry into her classroom. In Ariel’s post PSI Professional Development Course lesson it was evident that she was in the process of
implementing further use of I-B methods into her classroom. Ariel’s post PSI Professional Development Course lesson addressed the Virginia SOL related to Earth history and fossil evidence. Ariel engaged the students by reading a story about digging up dinosaurs and helping students access prior knowledge through completion of a KWL chart. The students were given the opportunity to formulate questions. This activity began as Ariel used Coupled Inquiry, inquiry that starts as Structured Inquiry or Teacher Guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002). Ariel indicated that students would be given the opportunity to discover the answers to many of their questions on their own as they moved through the unit, thus showing that Ariel will slowly begin implementing the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). As the fossil lesson continued, the students were then given the opportunity to explore, investigate, and organize collected information through an activity. The activity was student centered. The teacher acted as a facilitator. Students dug and unearthed fossils and other objects. They sorted the items into categories of their own choosing. The lesson had students actively engaged and served as an introduction for further study. Lessons that followed would include: interactive science notebook sessions, I-B searches using technology and books, journaling, hands-on I-B activities examining fossil records, and work with partners or small groups to create dioramas. In Ariel’s reflections about her fossil lesson she excitedly relates that she “used the lesson plan Jo and I made up this summer. I think it went pretty well, kids seemed to be interested!”
Summary of Ariel’s Results for Research Question 3

Ariel’s professional development goal revealed that she was interested in learning how to implement science experiments, the scientific process, and I-B science methods into her science classroom. During the PSI Professional Development Course Ariel worked with her CF, Jo, to create and implement a series of I-B lesson plans, on the topic of Investigating Fossils, into each of their science classrooms. Classroom observation data following the PSI Professional Development Course showed that Ariel made use of several forms of inquiry as defined by Martin-Hansen (2002), including Guided Inquiry and Coupled Inquiry. As Ariel continued with the lessons she created the researcher observed that she was slowly beginning to implement the model of Full or Open Inquiry, inquiry in which students ask their own questions, design their own investigations, and convey results of those investigations (Martin-Hansen, 2002), into her classroom.

Analysis of the data revealed that Ariel confronted a number of barriers as she went about the process of implementing I-B science in her classroom, including: time to teach, this relates to sharing time teaching other subjects; time to implement methods; time to gather materials; materials being available; and the amount of subject matter she is required to cover, this relates to curriculum guidelines including Milton County’s curriculum framework, Milton County’s curriculum map, Milton County’s benchmark tests, and the Virginia SOL. Ariel thought a lack of knowledge of subject matter might become a barrier to implementation of I-B methods, but she later explained that this proved not to be the case.
Research Question 4 Analysis

What relationships exist between teachers’ perceptions and use of I-B methods?

Information was analyzed to address the query, “What relationships exist between Ariel’s perceptions and use of I-B methods?” Interview analysis (see Appendix B for instrument) for Research Question 4 includes the examination of (a) post PSI Professional Development Course interview questions 2, 3, 6, and 7 listed in Table 1, (b) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (c) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (d) Partner Portfolio for Professional Development. Influences such as Ariel’s culture, education-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual, and style help mold her beliefs about I-B methods. The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI).

John Dewey (1938, 1997) proposed that experience transpires as a result of the interrelationship of two principles, continuity and interaction. Continuity refers to how each experience a person has influences one’s future, for better or for worse. Interaction refers to the situational influence on one’s experience. The individual’s present experience is a function of the interaction between their past experiences and the present situation. No experience has a pre-destined value. Therefore, what might be a beneficial experience for one individual could be an unfavorable experience for another. In other words, "positive experiences" motivate, encourage, and enable students to go on to have
more valuable learning experiences, whereas, "negative experiences" tend to lead towards a student closing off from potential positive experiences in the future. Dewey believed that learning experiences should be meaningful to each student and that teachers should step back and act as facilitators (Dewey, 1938, 1997).

Going back to the bucket metaphor described in the researcher’s conceptual framework, Ariel examined the shells and treasures introduced at the PSI Professional Development Course and made a decision to either keep each one and place it in her bucket, or place it back on the beach based on her own system of values. The unearthing of treasures of considerable value produced a positive influence on Ariel’s motivation, attitude, caring, determination and effort. The discovery of treasure with modest value had a negative influence on Ariel’s motivation, attitude, caring, determination and effort. This information was drawn on to illustrate Ariel’s cognitive framework related to inquiry, her beliefs about inquiry teaching, and how this ties into her daily experiences. This information is vital to understanding teacher change related to inquiry (Keys & Bryan, 2000; Spillane et al., 2002).

*Ariel’s Interview Analysis: Pre and Post Professional Development Course*

Interview analysis for Research Question 4 includes the analysis of the post PSI Professional Development Course interview questions numbered 2, 3, 6, and 7. A qualitative research design served as an appropriate methodology to utilize to examine any relationships the might exist between Ariel’s perceptions and use of I-B methods, seeing as qualitative research is concerned with the perceptions of the participants and with process rather than outcomes or products (Bogdan & Biklen, 1992; Marshall &
Rossman, 2006). This design serves as an appropriate methodology to utilize to define inquiry as it is perceived and used by Ariel.

This information was drawn on to first illustrate Ariel’s cognitive framework related to inquiry. Prior to the PSI Professional Development Course, Ariel stated that she defines science as “investigation, questioning, everything I have to teach, SOL tests, and applying science concepts to their lives.” She defines inquiry science as “questioning, looking into something more thoroughly, lots of questions, and more observing.” Ariel was willing to try to implement I-B methods into her classroom. In fact, she had to get special permission from her administrators to participate in the PSI Professional Development Course. She shares her reasons for signing up to take the PSI Professional Development Course in the excerpt below.

Jo and I [decided] together, [our science] benchmark scores came out lower in science than we expected. To improve scores, [we signed up for the professional development course] to learn new teaching methods. We had to justify it to the principal. There was a math class they wanted us to take.

Post PSI Professional Development Course interview data showed that before the PSI Professional Development Course Ariel did not know about I-B science. She explains that, “before the in-service, I had no idea what inquiry based science was.” In summary, Ariel’s cognitive framework for understanding inquiry prior to the PSI Professional Development Course was minimal. She knew that it had something to do with questioning and observing.

The next step in data analysis for Research Question 4 included investigating data about Ariel’s beliefs about inquiry teaching. Given that pre PSI Professional Development Course interview data showed that Ariel “had no idea what inquiry based
science was,” supplementary data sources were used to enhance analysis for this portion of the question in the section labeled *Ariel’s Partner Portfolio for Professional Development.*

As a final point, data from the pre PSI Professional Development Course interview was examined to determine how Ariel’s cognitive framework related to inquiry and her beliefs about inquiry teaching tied into her daily experiences. Keeping in mind that Ariel “had no idea what inquiry based science was,” an examination of Ariel’s beliefs related to classroom learning gives us a glimpse into her thoughts related to teaching in general. Ariel believes that students are learning when they are “listening, participating, asking questions,” she envisions them “discussing what we’re teaching with students around them, focused and involved in the lesson.” Ariel explains what she believes her students’ value most from her class in this excerpt from her pre PSI Professional Development Course interview.

I hope they say because that was fun, because they got to do a lot. I do a lot of hands-on, not experiments that they would design themselves, but like building things like the atom. I would hope they would say it was fun and they learned a lot. I think I have a long way to go with that too.

This excerpt highlights that prior to the PSI Professional Development Course Ariel was using hands-on activities, but not implementing I-B science activities in her science classroom.

In summary, before the PSI Professional Development Course Ariel explained that she did not know about I-B science at all. She used hands-on activities, experiments, discussion, and questioning in her lessons. Ariel did not allow the students to design their
own experiments. Ariel was not implementing inquiry; however, she was willing to learn.

*Ariel’s Goal Statement Analysis*

Ariel’s goal for the PSI Professional Development Course read as follows: “I want to be able to implement the Inquiry process into my classroom and the other things under the What I Want to Learn [section].” Those “other things” include the statements: “How to better implement experiments and scientific process” and “How to use the Inquiry process in the classroom.” Ariel’s goal statement shows that she is eager to learn about and implement I-B methods into her science classroom and is able to choose which methods she employs in her classroom.

*Science Teaching Efficacy Belief Instrument - STEBI Analysis Pre and Post*

Details of Ariel’s STEBI results were noted in Research Question 1 analysis, *Science Teaching Efficacy Belief Instrument – STEBI analysis* (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Ariel’s STEBI data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003). Ariel’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (45) and post (52) assessments increased notably, which is an indication that she felt more at ease with her ability to teach science. Ariel’s STEBI Outcome Expectancy subscale scores, pre (40) and post (36), decreased slightly; however, both scores were in the average expectancy category demonstrating that she had some confidence in her teaching ability to create desirable outcomes. This data supports Ariel’s goal statement, which shows that she is eager to
learn about and implement I-B methods into her science classroom and feels that she is able to choose which methods she employs in her classroom.

*Ariel’s Partner Portfolio for Professional Development*

Ariel took part in activities that allowed her to reflect upon and manage her thoughts and behaviors through strategic processing, reflection and collaboration throughout the PSI Professional Development Course (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Ariel’s portfolio data provided additional pieces that were used to solve the query, “*What relationships exist between Ariel’s perceptions and use of I-B methods?*” Analysis focused on relationships connecting Ariel’s perceptions as they connected to her practice. Emic accounts, descriptions of behaviors in terms meaningful to the teacher, were used because these accounts are culture specific or are found in the context of the teacher’s classroom (Stake, 2006). The researcher completed three steps in analyzing the Partner Portfolio for Professional Development. First, Ariel’s definition of inquiry, Ariel’s methods of instruction, and the definition of inquiry used during the PSI Professional Development Course were reviewed for comparison. Second, a review of the findings from Ariel’s Interview analysis, Goal Statement analysis, and STEBI analysis was conducted. Third, emic accounts were compared to excerpts from Ariel’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). Each of these steps is discussed next.

First, the researcher examined Ariel’s definition of inquiry. During the PSI Professional Development Course Ariel defined inquiry as “questioning, curiosity,
discovering, wondering, thinking, and learning.” Throughout the duration of the PSI instruction, Ariel was given the opportunity to develop an understanding of the following topics: What is inquiry, learning through inquiry, developing a mind for constructivism, constructivism, how children learn, designing I-B classrooms, integrating I-B activities, the scientific method, learning cycles, skills and knowledge of I-B teachers, questioning. Ariel also participated in sample I-B lessons that were modeled during the PSI Professional Development Course (a complete detailed description of the twenty-hour professional development course is located at Appendix K). In an Exit Slip journal entry after the first day of the PSI Professional Development Course Ariel says, “I would like to learn more about inquiry science to create lessons.” In Ariel’s post PSI Professional Development Course interview she added “investigating, figuring out answers, and exploring” to her definition of inquiry.

Next, the researcher looked at Ariel’s methods of instruction. This excerpt from post PSI Professional Development Course interview data illustrates Ariel’s beliefs about science teaching methods and how children learn science. “I try to use different methods to hopefully reach all students. I use the interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments.” In her post PSI Professional Development Course mini unit lessons Ariel started implementing the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). During the mini unit, the students were then given the opportunity to explore, investigate, and organize collected information through an activity.
As data analysis continued, the definition of inquiry used during the PSI Professional Development Course was reviewed for comparison with Ariel’s definition of inquiry and choice of teaching methods. During the PSI Professional Development Course, inquiry instruction was defined as referring to any teaching method focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations and discover answers to their questions about the natural world. Students may plan systems to collect data and choose how to organize and represent the data (Carin et al., 2004). The National Research Council (1998) defines scientific inquiry as:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world” (p. 23)

In her portfolio, Ariel defined inquiry as “questioning, curiosity, discovering, wondering, thinking, and learning” and “investigating, figuring out answers, and exploring.” Her definition of inquiry is aligned with the definition used in the PSI Professional Development Course. In her classroom, she uses “different methods” including “interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments.” Ariel’s choice of methods allow for integration or use of I-B methods.
The next step in placing the pieces of the puzzle to solve the query, “What relationships exist between Ariel’s perceptions and use of I-B methods?” consisted of a review of the findings from Ariel’s (a) Interview analysis, (b) Goal Statement analysis, and (c) STEBI analysis. Beginning with her pre PSI Professional Development Course interview, Ariel believes she is learning when she is “seeing” and “doing” or when her teachers use a constructivist approach, they provided relevant experiences and opportunities that allowed teachers to construct knowledge (Piaget, 1929; Vygotsky, 1978). Ariel likes structure, but tolerates chaos from time to time to allow students an opportunity to become involved and excited about learning. In post PSI Professional Development Course interview excerpts, Ariel shares her beliefs about teaching and learning. She explains, “I try to use different methods to hopefully reach all students.” Ariel further explains to us that she believes it is important for students to understand how to go about “investigating questions, finding answers that are important to them as far as making science something they can relate to in their lives.” Ariel’s goal statement shows that she is eager to learn about and implement I-B methods into her science classroom and is able to choose which methods she employs in her classroom. Ariel’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (45) and post (52) assessments increased notably, an indication that she felt more at ease with her ability to teach science. Ariel’s STEBI Outcome Expectancy subscale scores, pre (40) and post (36), decreased slightly; however, both scores were in the average expectancy category demonstrating that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). In summary, Ariel is eager to learn about and
implement I-B methods and the PSI Professional Development Course helped her to feel more at ease with her ability to teach science.

Last, in assembling the pieces of the puzzle to solve the query, “What relationships exist between Ariel’s perceptions and use of I-B methods?” Emic accounts from Ariel’s (a) Interview analysis, (b) Goal Statement analysis, and (c) STEBI analysis were compared with excerpts from Ariel’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). A teacher’s attitudes and beliefs about science are key influences on how they teach the subject (Souza Barros & Elia, 1998). Ariel’s Partner Portfolio for Professional Development data analysis revealed more about her attitudes and beliefs about science teaching and learning. For example, in an Exit Slip journal entry, Ariel shares her positive attitude about trying new things. She passes on her thoughts, “I don’t think I will find it difficult, just different, but I am looking forward to trying what I have learned.” Data from Ariel’s Partner Portfolio for Professional Development supports both her goal statement and her STEBI scores, which illustrate that she is looking forward to learning about and implementing I-B methods into her science classroom, and that she is capable of choosing which methods she uses in her science classroom. Ariel’s attitude had a positive influence on her decision to choose to implement I-B science methods into her science classroom.

As noted in Research Question 2 analysis, throughout her mini unit plan, Ariel gradually moved from Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design, to Coupled Inquiry,
inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an
inquiry making use of a reduced amount of teacher control. Ariel gradually lessened
teacher control during her science lesson. Data analysis from Ariel’s post PSI
Professional Development Course lesson it was evident that she was in the process of
implementing further use of I-B methods into her science classroom. Ariel notes the
reasons she may not have implemented many I-B science “extension activities” is
“because of time constraints.”

Summary of Ariel’s Results for Question 4

Research question 4 asked the question “What relationships exist between
teachers’ perceptions and use of I-B methods?” The researcher examined the teacher’s
Conceptual Framework Relationship (CFR), the relationship between her Individual
Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI). Data
analysis for Research Question 4 showed that Ariel was willing to learn about and willing
to try to implement I-B methods into her science classroom. The perception that I-B
methods have significant value for students’ understanding of science had a positive
influence on Ariel’s motivation, attitude, caring, determination and effort during
implementation of the methods in her science classroom. Ariel’s definition and vision of
inquiry matches her choice of methods for science instruction. Ariel likes structure, but
tolerates chaos from time to time to allow students an opportunity to become involved
and excited about science learning. This belief might explain why Ariel’s implementation
of I-B methods into her science classroom followed a gradual and careful path.
Research Question 5 Analysis

How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Interview analysis (see Appendix B for instrument) for Research Question 5 includes the examination of: (a) pre PSI Professional Development Course interview questions 4, 5, 7, 8 and 9 listed in Table 1, (b) post PSI Professional Development Course interview question 6, (c) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), and (d) the Partner Portfolio for Professional Development. This information was utilized to examine Teacher Choice (TC) in an attempt to disclose methods that encourage teachers like Ariel to overcome resistance to implementing I-B teaching practices. When a teacher, like Ariel, makes a choice she critically assesses the value of available options and chooses a course of action built on her own conceptual framework. Data analysis for Research Question 5 was completed through of a study of Ariel’s conceptual framework composed of: her Individual Identity (II), the portion of the Ariel’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or personal constructs (Scribner et al., 2002); Ariel’s Subject Matter Knowledge (SMK), Ariel’s knowledge of content matter and pedagogy (the art and science of being a teacher) and curriculum knowledge (Shulman, 1986); and Ariel’s Shared Identity (SI), the portion of the Ariel’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community.
Ariel’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 5 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 5, 7, 8 and 9 as well as post PSI Professional Development Course interview question 6. Teacher Choice (TC) is influenced by mental models, “the images, assumptions, and stories, which we carry in our minds of our selves, other people, institutions, and every aspect of the world” (Senge, 1990). Interview analysis gave the researcher a glimpse of Ariel’s Individual Identity (II). Ariel describes her teaching style as “structured” and “organized.” In the following interview excerpt Ariel details the methods uses in her classroom. Ariel notes, “I try to use different methods to hopefully reach all students. I use the interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments.” When Ariel thinks about teaching science to students she thinks about her own children. When asked what influences her teaching in the pre PSI Professional Development Course interview she said she thinks about, “…my own kids, thinking about what they would enjoy as they went through the fifth grade.”

Interview analysis also gave the researcher a glimpse into Ariel’s early Subject Matter Knowledge (SMK). Undergraduate science courses usually convey science as a group of specifics and sets of laws to be memorized, instead of as a way of knowing about the natural world (NRC, 1998). Ariel’s experiences support this statement. She remembers “I took chemistry in college, I took anatomy, I think I took biology maybe my freshman year.” Ariel continues, “I remember anatomy and thinking it was very hard.” Ariel recalls that she “had to remember all of the bones of the human body.” She notes that, “I just remember struggling with that.” Ariel also remembers, “dissecting the frog”
in high school and “seeing the cats” in her college anatomy class. Ariel reported that she
doesn’t feel confident in math “or as much in science” as she does in “history and
reading.” In her own teaching Ariel leads her students in activities similar to the frog
dissection she remembers so well. An excerpt from her pre PSI Professional
Development Course interview shows this.

Not frogs or pigs, but we do owl pellets. I guess that would be as close. We do
look at worms when we are studying animals, vertebrates and invertebrates. So
we do the worms and we just do a few basic things with them, like do they prefer
the wet to the dry? Or light to dark? Or where do they stay? We look at how they
move. We try to pick out just the basic part, external part of the worm. But, we
don’t dissect the worm.

Interview analysis also gave the researcher a glimpse of Ariel’s Shared Identity
(SI). Ariel acknowledged that her CF, her teammates, her students, and county and state
curriculum standards influenced her choice of science teaching methods. Ariel believed
support from her administration and grade level team was positive. Ariel’s Pre PSI
Professional Development Course interview data showed that her CF and her teammates
influence her. The following interview excerpt relates what Ariel explains as the role her
CF and her teammates play in influencing her choice of teaching methods. Ariel notes,
“Jo and I have been teaching together since 1988. She influences me. When talking to the
others, we share ideas on lesson that worked for them. This influences me to try
something different.”

Ariel’s students also have an influence on her choice of teaching methods. Ariel
also feels influenced by her students’ reactions to her teaching. Pre PSI Professional
Development Course interview data showed that Ariel is motivated to choose teaching
methods because she wants “it to be interesting to them and learn what they are supposed
to learn.” She tries “different ways” because she doesn’t “want them to be bored.” In her pre PSI Professional Development Course interview Ariel stated that she doesn’t want her students to “sit there and just look at me talking, with that look on their faces. I don’t want it to be mundane, dull all of the time.” Ariel’s post PSI Professional Development Course interview data supported these ideas. In her post PSI Professional Development Course interview Ariel stated that she is motivated to choose an activity because, “I think the students enjoyed the activity and I like to see that they were involved, even excited about learning.” Ariel also thinks of, “…My own kids, thinking about what they would enjoy as they went through the fifth grade” when deciding which science teaching methods to use in her classroom.

Following the staff development Ariel reported that “the curriculum map, curriculum framework, benchmarks, and Virginia SOL tests” influence both what she teaches and the way she teaches it. She believes that the most important concepts for students to understand by the end of the school year are “investigating questions, finding answers that are important to them as far as making science something they can relate to in their lives.” These ideas are reinforced as Ariel relates the reason she signed up for the PSI Professional Development Course in her pre PSI Professional Development Course interview outlined in the following excerpt.

Jo and I together, benchmark scores came out lower in science than we expected. To improve scores, to learn new teaching methods. We had to justify it to the principal. There was a math class they wanted us to take.

Ariel is motivated to keep going when she faces disappointments related to science teaching because she wants “the kids to learn.”
In summary, Interview data revealed that Ariel makes choices about which methods to use to teach science based on the influences of her CF and her teammates, her students, and county and state curriculum standards influenced her choice of science teaching methods. She “enjoys” what she is doing. She wants “the kids to learn.” She exclaims that she does it all “for them!”

*Ariel’s Partner Portfolio for Professional Development*

To provide triangulation of multiple data sources (Yin, 2003), the researcher studied pieces from Ariel’s Partner Portfolio for Professional Development including Ariel’s (a) post PSI Professional Development Course lesson plan, (b) Invitation to Practice: Science Learning Personal History, (c) the post PSI Professional Development Course lesson plan, and (d) the journal entry titled “What is Inquiry?” This study leads to a more meaningful understanding of Ariel’s perceptions as they connect to Teacher Choice (TC) framed by her mental models, conceptions of science subject matter, and barriers she faced related to teaching and learning. Throughout the course of this study Ariel made use of on her own science education and teaching experiences, analyzed what she learned during the staff development training and made a decision whether or not to implement the ideas based on her own system of values. Following the pattern for data analysis used for the pre PSI Professional Development Course interview analysis, this portion of the data analysis consisted of a study of Ariel’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI).

First, interview analysis gave the researcher a view of Ariel’s Individual Identity (II). Ariel describes her teaching style as “structured” and “organized.” Ariel noted in her
pre PSI Professional Development Course interview that she thought about her own children and what they would have enjoyed when they were in the fifth grade as she planned lessons for her science classroom. Ariel tries “to use different methods to hopefully reach all students.” She uses “the interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments.” Data showed that Ariel’s teaching style is reflective of the way she learns. Data from Ariel’s Partner Portfolio for Professional Development, located in her Science Learning Personal History, supports Ariel’s belief that she learns when she is “seeing” and “doing,” when her teachers use a constructivist approach. The following excerpt shows how Ariel views herself as a learner.

During a college anatomy course, we had to learn all the names of the bones in the body. I thought I would never be able to do that. I had to use different methods to achieve this goal. We not only had to name them but also be able to label them correctly on a diagram of the body. As a learner myself, I think I am more a visual learner. I need to be able to see whatever it is we are learning about. So, to learn the names of the bones, I wrote them down many, many times. Then, to label, I used a blank diagram and practiced writing the names on the diagram.

When learning, Ariel uses multiple methods, including “seeing” and “writing.” Ariel uses many of the methods that helped her learn in her own teaching. As noted in Research Question 4 analysis, this excerpt from post PSI Professional Development Course interview data illustrates Ariel’s beliefs about science teaching methods and how children learn science. Ariel explains, “I try to use different methods to hopefully reach all students. I use the interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments.” Ariel also feels, “I care about what I am doing and about the kids.” She feels it was important for her students to enjoy learning science.
Next, Partner Portfolio analysis supported and extended previous findings related to Ariel’s Subject Matter Knowledge (SMK). Excerpts from Ariel’s pre PSI Professional Development Course interview analysis revealed that Ariel does not feel “confident” with science or mathematics, and fears her discomfort “might come through unconsciously” to her students. Ariel is interested in improving as a science teacher through the implementation of experiments and the scientific process, and by learning more about the inquiry process. Would this lack of knowledge of subject matter have an influence on Ariel’s implementation of I-B methods into her classroom? Ariel noted that her knowledge of subject matter was not an influence on her decision to use I-B methods in her science classroom. In the excerpt that follows Ariel stated that her knowledge of subject matter was not an influence on her decision to use I-B methods in her science classroom.

Did a lack of knowledge of subject matter or a lack of confidence have any influence on my decision to use the Inquiry method? Not really! I am always open to new ideas and methods, and so, am willing to try most anything!

Last, data analysis was conducted to investigate findings related to Ariel’s Shared Identity (SI). Interview analysis revealed that Ariel believed her administration and grade level team had an influence on her choice of science teaching methods. Ariel writes during her Invitation to Practice: Collaboration activity that she feels she can help her CF in the area of science instruction by “sharing ideas and things that I have tried that worked.” In turn, she feels that her CF can help her to “team teach on certain topics.” Ariel notes that she “found it very helpful to work with my critical friend and plan a lesson.”

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Another large motivator or influence on Ariel’s choice of teaching methods is her students. In her post PSI Professional Development Course interview Ariel stated that she felt motivated to choose an activity because “I think the students enjoyed the activity and I like to see that they were involved, even excited about learning.” In her journal entries, Ariel indicates that she has added “a new science lesson on investigating fossils” to her bucket of science treasures. She has “used the lesson plan Jo and I made up this summer.” She believes “it went pretty well” because the “kids seemed to be interested!” These ideas are further enforced by Ariel’s statement in the post PSI Professional Development Course interview that she is motivated to overcome barriers “to make it an enjoyable learning experience for the children.”

*Summary of Ariel’s Results for Research Question 5*

Information was used to examine Ariel’s choices in an effort to reveal methods that encourage teachers like her to overcome resistance to implementing I-B teaching practices in her science classroom. Ariel made decisions about her choice of science teaching methods by assessing the value of the options available to her and deciding upon a course of action based on her own conceptual framework. Data analysis for Research Question 5, “How do teachers choose to use I-B methods as opposed to teacher-centered activities?” consisted of an examination of Ariel’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI). Partner Portfolio analysis supported previous findings related to Ariel’s Individual Identity (II). Excerpts from Ariel’s pre PSI Professional Development Course interview analysis, supported by secondary data, showed that Ariel describes her science teaching style as “structured” and “organized.” She thinks about her own children when planning
science lessons. Ariel tries “to use different methods to hopefully reach all students.” She uses “the interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments.” Ariel’s Partner Portfolio for Professional Development analysis clarified previous findings related to her Subject Matter Knowledge (SMK) where it was revealed that Ariel does not feel “confident” with science or mathematics, and fears her discomfort “might come through unconsciously” to her students. Following the implementation of her mini-unit Ariel made it clear that she felt that her knowledge of science subject matter was not an influence on her decision to use I-B methods in her science classroom. Data from interview analysis related to Ariel’s Shared Identity (SI) revealed that she believed support from her administration and grade level team was positive and that they, in fact, had a large influence on her choice of science teaching methods. In conclusion, Ariel acknowledged that her CF and her grade level teammates, her students, Milton County and Virginia state curriculum standards all influenced her choice of science teaching methods.
I next present the data to answer the query, “Who is Jo?” This teacher portrait is described as it aligns with each research question. Data that yields information related to each question was analyzed. A discussion of the findings for each question is presented.

**Research Question 1 Analysis**

What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?

**Jo’s Interview Analysis: Pre and Post Professional Development Course**

The following information was found useful in providing insights about Research Question 1: (a) Jo’s pre PSI Professional Development Course interview, (b) STEBI survey, (c) CLES survey, (d) Jo’s Partner Portfolio for Professional Development, and (e) Jo’s post PSI Professional Development Course interview. This information was utilized to examine Jo’s beliefs in an effort to uncover patterns that influence her teaching behavior as it relates to her Individual Identity (II). Individual Identity (II) is defined as the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfield, 1998) that represents autonomy or personal constructs (Scribner et al., 2002). Jo’s Interview Codes and Transcript Statements for Research Question 1 are located in Table 6.
Table 6

Interview Codes and Transcript Statements for Jo (T2) Pre and Post – Research Question 1.

<table>
<thead>
<tr>
<th>Jo’s Experiences: Beliefs About Learning and Teaching Science</th>
<th>Beliefs About How Children Learn Science</th>
<th>Beliefs About Science Teaching Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: Dad was a big influence too, because he was an orthodontist. He was real into math and science. He was a big influence, and so was mom, with the baking. Dad’s hobby was color photography and in the basement he had a darkroom….He explained to me that because of all of the electricity running in the neighborhood,…I would ask, “What?” So, I’d pull up a stool next to him and he would try to explain. That was really neat. (Memory) (See &amp; Do)</td>
<td>Pre: I think that I stick to a schedule. I feel that I provide the children with that safety net that there are bounds, there are limitations and they pretty much know by the second week of school those boundaries. I just feel that it’s very important to keep that structure because it’s needed. They need those boundaries and to know that it is a safe… (CZ)</td>
<td>Pre: I tend to be, quite a mix actually. I tend to be very structured and I can also be very flexible. It is important to keep a sense of humor…I think I tend to be strict but my way of disciplining is that I use more of a sense of humor way to deal with, showing the ridiculous rather than the negative. I try to be positive rather than negative. I try to do it that way. (Organization)</td>
</tr>
<tr>
<td>Pre: I liked to collect rocks. I learned a lot, really, from my parents, even way before I entered school. I’d bring rocks home. I learned from cooking and baking. Cooking was different from baking. Baking was more like doing a science experiment. (See &amp; Do)</td>
<td>Post: Jo believes her students will say, “We got to play!” She feels they value the opportunity to engage in “hands-on and sharing out their thinking.” Jo enjoys the transition from “when they are clueless at the beginning of a lesson and then —ah ha- the light comes on!” (Variety of Methods) (Actively Involved)</td>
<td>Pre: If the kids are really into it, let them go with it rather than try to stick with a set schedule. If we go over the flexibility of allowing if there is another question to let them go towards that question and try to go as far as they can with it. (Organization)</td>
</tr>
<tr>
<td>Pre: I just remember my sixth grade teacher. She had all kinds of hands-on things like barometers. We’d watch the barometer and check it to how the weather was. Then in middle school it was starting to go towards looking through microscopes at slides and things like that. (See &amp; Do)</td>
<td>Post: A good learner shows “enthusiasm, curiosity, and perseverance.” A good learner “will question misunderstand information.” (Emotions) (Investigating)</td>
<td></td>
</tr>
</tbody>
</table>
As a child Jo learned a lot about science from her parents. She would bring home rocks, cook, and bake. She learned that baking was similar to doing a science experiment. Her father’s hobby was color photography and he would often spend time explaining the science behind what he was doing to Jo. She remembers using a real barometer to check the weather in the sixth grade. In college, Jo describes her training in the area of science as poor. Jo was basically given a textbook. She does not remember anything hands-on. She was told to read and then she was tested. Several years before this study, Jo participated in an integrated math science class at a local community college. She recalls making light shadows and learning a lot about the difference between experimentation and a scientific observation.

Interview analysis for Research Question 1 began with the examination of interview questions 1, 2, and 3 in an effort to learn what influences Jo’s teaching behavior as it relates to her autonomy or her Individual Identity (II). This excerpt from the pre PSI Professional Development Course interview reveals what Jo explains as playing a role in shaping her beliefs related to students and learning.

I liked to collect rocks. I learned a lot, really, from my parents, even way before I entered school. I’d bring rocks home. I learned from cooking and baking. Cooking was different from baking. Baking was more like doing a science experiment.

Jo believes she learned a lot about science by cooking and baking with her mom. This excerpt from the pre PSI Professional Development Course interview reinforces this belief and reveals more about what Jo explains as playing a role in shaping her beliefs related to students and learning.

Dad was a big influence too, because he was an orthodontist. He was real into math and science. He was a big influence, and so was mom, with the baking.
Dad’s hobby was color photography and in the basement he had a darkroom. He would sit down there after dark and after dinner and he would be trying to get the light and the color correct. He explained to me that because of all of the electricity running in the neighborhood, it would mess up the chemicals. So that was really awesome to me. I would ask, “What?” So, I’d pull up a stool next to him and he would try to explain. That was really neat.

Another excerpt from the pre PSI Professional Development Course interview emphasizes the idea that Jo remembers activities in which she participated in hands-on activities throughout the learning process.

I just remember my sixth grade teacher. She had all kinds of hands-on things like barometers. We’d watch the barometer and check it to how the weather was. Then in middle school it was starting to go towards looking through microscopes at slides and things like that.

Jo remembered learning when she was actively engaged or participated in hands-on activities throughout the learning process. The constructivist approach to how people learn focuses on providing relevant experiences and opportunities that allow students to construct knowledge (Piaget, 1929; Vygotsky, 1978).

A teacher’s principles or attitude, her tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do (Souza Barros & Elia, 1998). This excerpt from the pre PSI Professional Development Course interview reveals more about how Jo views herself as a classroom teacher.

I tend to be, quite a mix actually. I tend to be very structured and I can also be very flexible. It is important to keep a sense of humor. I love it that the kids, everyday they walk through that door. They’re different everyday they walk through that door. Which keeps it alive and exciting for me. I think I tend to be strict but my way of disciplining is that I use more of a sense of humor way to deal with, showing the ridiculous rather than the negative. I try to be positive rather than negative. I try to do it that way. When you do it so many years it’s hard to think of all of the theory type things.
Jo believes her science classroom should have structure and boundaries. She believes her students should feel safe. This excerpt from the pre PSI Professional Development Course interview reveals how Jo describes herself as a classroom teacher.

I think that I stick to a schedule. I feel that I provide the children with that safety net that there are bounds, there are limitations and they pretty much know by the second week of school those boundaries. I just feel that it’s very important to keep that structure because it’s needed. They need those boundaries and to know that it is a safe environment. Not having any children of my own I feel like those are my own, my babies. I probably would even if I did have kids. But, I’m the main teacher. They’re mine.

Although Jo encourages structure and boundaries, she will stray from the schedule if the students are still asking questions or investigating. The following supports her feelings.

If the kids are really into it, let them go with it rather than try to stick with a set schedule. If we go over the flexibility of allowing if there is another question to let them go towards that question and try to go as far as they can with it.

In her post PSI Professional Development Course interview excerpts Jo shares what she believes are the characteristics of a good learner. A good learner shows “enthusiasm, curiosity, and perseverance.” A good learner “will question misunderstand information.” The methods teachers use to engage students in the active search for knowledge vary considerably (Haury, 1993). In the post PSI Professional Development Course interview data more of Jo’s beliefs are revealed. She believes children learn through use of hands-on activities and by sharing out their thinking. Jo shares an example that illustrates her beliefs about which teaching methods her students’ value. Jo believes her students will say, “We got to play!” She feels they value the opportunity to engage in “hands-on and sharing out their thinking.” Jo enjoys the transition from “when they are clueless at the beginning of a lesson and then –ah ha- the light comes on!”
In summary, data from the pre PSI Professional Development Course interview revealed information about Jo’s conceptual framework for science teaching. The researcher analyzed data in an attempt to discover what Jo believes about how children learn science and science teaching methods. This includes Jo’s conceptions of how children learn and her own view of effective science teaching. There is no single approach to good teaching; however, there are general principles upon which educators can agree. These principles are actually beliefs that individuals hold about science teaching and these beliefs guide and influence the way we teach (Hassard, 2000). Jo learned when she was actively engaged or when she participated in hands-on activities throughout the learning process. She believes she learned a lot about science by cooking and baking with her mom, examining rocks, and experimenting with photography chemicals in her basement with her dad. Jo likes structure and boundaries in her science classroom so that children feel safe. She often allows her students to have fun and will stray from the schedule if the students are still asking questions or investigating. She believes children learn through use of hands-on activities and by sharing out their thinking.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

Jo’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments increased notably, with 42 (average efficacy) points and 54 (high efficacy) points respectively (max=65 points) (see Figure 3). Therefore, she was comfortable with her ability to teach science. Jo’s STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased slightly, with 49 points to 46 points respectively (max=60 points); however, both scores were in the high expectancy category.
indicating that she had confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

![Figure 3. Jo’s STEBI Scores](image)

**Constructivist Learning Environment Survey – CLES Analysis Pre and Post**

The CLES Personal Relevance scale relates to students’ experience of the personal relevance of school science as perceived by teachers (Suters, 2004; Taylor et al., 1997). Jo’s pre (32) and post (35) Personal Relevance scores showed a slight increase, both were in the high agreement range. This is an indication that she placed a high emphasis on linking school science with students’ everyday experiences (see Figure 4).

The Scientific Uncertainty scale relates to students’ perceptions of science as a fallible human activity as perceived by teachers (Suters, 2004; Taylor et al., 1997). Jo’s
pre (26) and post (28) Scientific Uncertainty scores increased slightly from a high intermediate agreement score to a high agreement score, which indicated that after participating in the PSI Professional Development Course she placed more emphasis on engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values.

The Critical Voice scale relates to students development as autonomous learners, through creation of a social climate in which students feel that their learning is legitimate and beneficial (Suters, 2004; Taylor et al., 1997). Jo’s Critical Voice scores were identical with both falling in the high agreement range, pre (35) and post (35). This indicates that she placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediments to their learning.

The Shared Control scale also relates to student autonomy. This scale is concerned with students sharing control of the classroom-learning environment with their teacher (Suters, 2004; Taylor et al., 1997). Jo’s pre (23) and post (24) Shared Control scores were in the high intermediate agreement range. This is an indication that her students often but not always are invited to: participate in designing their own activities, determine assessment criteria, and negotiate the norms of the classroom.

The Student Negotiation scores relate to teacher beliefs as they relate to student interaction with other students (Suters, 2004; Taylor et al., 1997). Jo’s Student Negotiation scores increases slightly from the pre PSI Professional Development Course assessment (29) to the post PSI Professional Development Course assessment (32). Both
scores were in the high agreement category, which indicated that she placed a high emphasis on providing opportunities in her science classroom for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas.

Last, the Attitude Scale scores provide a measure of the concurrent validity of the CLES. The Attitude Scale is used to measure teachers’ interpretations of students’ attitudes towards the science classroom environment (Suters, 2004; Taylor et al., 1997). Jo’s pre (29) and post (30) Attitude Scale scores were also in the high agreement category which indicated that she felt students: anticipated the activities within her science classroom, found the activities worthwhile, and understood and enjoyed the activities.

![Figure 4. Jo’s CLES Scores](image-url)

*Figure 4. Jo’s CLES Scores*
Jo’s Partner Portfolio for Professional Development Analysis

At various stages of the PSI Professional Development Course, teachers were offered the chance to think about and direct their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). The researcher examined the (a) Invitation to Practice: Science Learning Personal History, (b) Invitation to Practice: Mapping My Classroom, (c) Jo’s Goal Statement, and (d) journal entries to confirm the previous data findings. The STEBI and CLES data also served as triangulation of multiple data sources, providing for multiple measures of the same phenomenon (Yin, 2003).

A framework for organization is based upon Jo’s interview excerpts related to her beliefs about teaching science. Jo’s interview excerpts showed that she learns when she is actively engaged or participating in hands-on activities. An excerpt from the Invitation to Practice: Science Learning Personal History (see Appendix G) activity supported the idea that Jo believes that participating in visual and hands-on activities and making connections to her life are important aspects that define her as a learner.

I took a class, integrated science and math, at a local community college one summer. One of the sessions was on white light. We were asked what the primary colors were—a-ha- we all said the colors, but they were the primary pigment colors not light primary colors. My dad’s hobby was photography and developing film, color. I remember him monkeying to get color right. Anyway, I found it fascinating to learn how we see color, making color shadows, colors in white light, primary and secondary. I discovered the name for my favorite color was cyan, visible spectrum, et cetera. We did an activity called “color analyzer.” We had to color by number several design sheets and look through the color analyzer and voila! I saw a word or image. I learned because it was visual and hands-on.

In her own teaching Jo applies methods that helped her as a student, participating in visual and hands-on activities and making connections to her life. In her goal statement
Jo explains that she believes getting the students activity engaged will increase retention. She says, “I want to learn how to implement inquiry in my science teaching to get all the kids engaged and enjoying the activities to increase retention of the lessons objectives.” This excerpt reveals that Jo believes students should enjoy the activities. Jo replicates this thought in her Invitation to Practice: Mapping My Classroom (see Appendix H) activity. Jo wants to create a learning culture that inspires “wonder and excitement” in her students. Her CLES Attitude Scale scores, pre (29) and (30), were in the high agreement range, which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities. This data confirms the previously reported findings from Jo’s interview analysis. An example was presented that illustrates Jo’s beliefs about which teaching methods her students’ value. Jo believes her students will say, “We got to play!” She feels they value the opportunity to engage in “hands-on and sharing out their thinking.” Jo enjoys the transition from “when they are clueless at the beginning of a lesson and then –ah ha- the light comes on!” Data from the CLES also supports these ideas. Jo’s Personal Relevance scores, pre (32) and post (35), showed a slight increase, both were in the high agreement range, which indicated that she placed a high emphasis on linking school science with students’ everyday experiences (Suters, 2004; Taylor et al., 1997).

Data analysis was conducted to investigate Jo’s beliefs about science teaching methods. Jo’s interview excerpts revealed that she encourages structure and boundaries, but will stray from the schedule if the students are still asking questions or investigating. CLES Shared Control scores, pre (23) and post (24), supported this statement as results indicated that her students often but not always are invited to: participate in designing
their own activities, determine assessment criteria, and negotiate the norms of the classroom (Suters, 2004; Taylor et al., 1997). In her Invitation to Practice: Collaboration activity, Jo and her CF both saw themselves as “very structured.” Data from her Invitation to Practice: Mapping My Classroom activity reveals that she feels others see her “as a facilitator leading students across bridges making discoveries along the way.” Jo’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (42) and post (54) assessments increased notably, indicating that after participating in the PSI Professional Development Course, Jo felt more comfortable with her ability to teach science (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

Summary of Jo’s Results for Research Question 1

Research Question 1 solicits an answer to the following: “What do teachers believe about science teaching? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?” Jo’s interview excerpts disclosed knowledge about her conceptual framework for science teaching. STEBI results, CLES results, and excerpts from the Partner Portfolio for Professional Development supported interview data. Jo discovered that she learns when she is actively engaged or participating in hands-on activities throughout the learning process. Jo feels confident in her ability to teach science. Jo strives to apply methods that helped her as a student, participating in visual and hands-on activities and linking school science with students’ everyday experiences. In summary, although Jo see herself as very structured, she will lead her children in investigations that allow them to stray from the routine to explore on their own. She is confident in her ability to teach science.
Research Question 2 Analysis

How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

Interview analysis (see Appendix B for instrument) for Research Question 2 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, and 8 listed in Table 1, (b) post PSI Professional Development Course interview questions 3 and 4, (c) classroom observation analysis (See Appendix E for the Classroom Observation Protocol), (d) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), (e) CLES analysis (see Appendix D1 for instrument and D2 for scoring instructions), and the (f) Partner Portfolio for Professional Development. The researcher utilized this data in order to examine the way in which Jo perceives herself or describes her own abilities to produce desired or intended results in her science classroom. This information was also drawn upon to describe Jo’s Subject Matter Knowledge (SMK). Subject Matter Knowledge (SMK) is defined as the teacher’s knowledge of content matter and pedagogy (the art of being a teacher), along with her curriculum knowledge (Shulman, 1986). Last, the researcher analyzed the data to reveal information related to Jo’s understanding of I-B methods. In other words, the pieces have been assembled to answer the query, “How does Jo describe her abilities to produce desired or intended results in her science classrooms? What does Jo believe about her science content knowledge and her pedagogical science knowledge? What does Jo understand about I-B methods?”
Jo’s Interview Analysis: Pre and Post Professional Development Course

The researcher analyzed pre PSI Professional Development Course interview data to create a picture that would describe Jo’s framework for understanding science and her ability to produce desired results according to her beliefs and self-efficacy. In the pre PSI Professional Development Course interview, Jo defines inquiry science as “questioning, answers to puzzles.” There is a close link between teacher content knowledge in mathematics and science and student performance in these disciplines (Darling-Hammond, 2000; Loucks-Horsley et al., 2003). Information about Jo’s knowledge of content information was revealed in Research Question 1 analysis. The researcher learned that Jo believes she learned a lot about science when she was engaged in cooking and baking with her mom and photography with her dad. Jo learned best when she was engaged in hands-on activities, collecting things, and able to ask questions. Interview codes and transcript statements for Jo’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions for Research Question 2 are listed in Table 7.
Table 7.

**Interview Codes and Transcript Statements for Jo (T2) Pre and Post – Research Question 2.**

**Self-Efficacy Related to:**

<table>
<thead>
<tr>
<th>Understanding of Science Content</th>
<th>Teaching Methods</th>
<th>Definition of science and Inquiry science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: Jo believes she learned a lot about science by cooking and baking with her mom and photography with her dad. (Positive Influences)</td>
<td>Pre: “I manipulate all the time. Sometimes I find it better to group them together and we focus on that. Other times I focus on, mix it up, where you’ve got somebody that’s strong visually, strong with hands-on, put them together to work and give them the job that they are strong in and then come back together as a group.” (Methods) (Reach All)</td>
<td>Pre: (Science definition) Cooking, baking “Also dad was a big influence too because he was an orthodontist so he was real into math and science and he was a big influence…his hobby was color photography …So that was really awesome to me, ‘what?’ So I’d pull up a stool next to him and he would try to explain. That was really neat.” (World View-implied) Components-Science-implied) (Emotions)</td>
</tr>
<tr>
<td>Pre: “They were very poor, to be honest with you. I was basically given a textbook. I don’t remember doing any hands-on. It was basically read and you’re going to be tested. Read, you’re going to be tested. It was very poor.” (Sit n’ Git)</td>
<td>Pre: “When they can apply it to something else. That’s in all subject areas, especially in math and science. When they can carry it over into something else and say, “hmmm, it worked for that, maybe it’ll work for this, let’s try it.” (Motivation) (Apply or Connect)</td>
<td>Pre: Jo defines inquiry science as “questioning, answers to puzzles.” (Components-Inquiry)</td>
</tr>
<tr>
<td>Pre: “I would like to be a better science teacher. That’s why I signed up for this course…I think I was better with science before, I hate to say this, but before we had the SOL. I feel like I now have a time limitation…and now I feel like I’ve got to cut everything short. I feel like that’s a limitation…” (Make Better)</td>
<td>Pre: “The way I teach? Well, you’re going to laugh, but the food channel, the food network. Alton Brown, I love him. In fact, I even had my kids watch him…” (Methods) (Motivation)</td>
<td>Post: Jo defines science as “exploring, questioning, and experimenting to discover the reasons things are what they are or why they happen.” (Components-Science)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post: Jo defines inquiry science in the following excerpt, “Inquiry science is a combination of scientific method and further exploration to figure out the ‘How’s?’ It is a chance to wonder about life and ‘play,’ to maybe make sense of it all.” (Method)</td>
</tr>
</tbody>
</table>
Data analysis started with an examination of Jo’s description of her own efficacy and ability to produce a desired or intended result. Jo feels comfortable manipulating the educational environment to maximize student understanding. An excerpt form her pre PSI Professional Development Course interview outlines examples of how she manipulates according to student learning styles and strengths.

I manipulate all the time. Sometimes I find it better to group them together and we focus on that. Other times I focus on, mix it up, where you’ve got somebody that’s strong visually, strong with hands-on, put them together to work and give them the job that they are strong in and then come back together as a group.

The excerpt that follows describes how Jo feels she knows when her students understand a concept.

When they can apply it to something else. That’s in all subject areas, especially in math and science. When they can carry it over into something else and say, “hmmm, it worked for that, maybe it’ll work for this, let’s try it.

In summary, Jo feels comfortable manipulating the environment to meet student needs. She feels students are learning when they can apply the concept learned to another situation.

Data analysis continued with an examination of Jo’s description of her own framework for understanding science content. During this analysis, we learned that Jo feels comfortable with science. Her training experiences consist of a mixture that ranges from “poor” to “awesome.” Jo’s tells about her teacher preparation courses in science in the following excerpt.

They were very poor, to be honest with you. I was basically given a textbook. I don’t remember doing any hands-on. It was basically read and you’re going to be tested. Read, you’re going to be tested. It was very poor.

This excerpt shows that most of Jo’s science training experiences were very poor.
As noted in Jo’s Partner Portfolio for Professional Development Analysis section of Research Question 1, Jo relates science learning experiences she had at the local community college with light and color as “awesome” and “really neat.” The factors of fear, knowledge, and affect as determined by the teachers’ cognitive framework help shape the teachers’ actions (Senge, 1990). One of Jo’s fears is her “own lack of knowledge” about science topics. This fear inhibits her. She feels she is “just not prepared as well as I’d like to be.” This excerpt from Jo’s pre PSI Professional Development Course interview supports her comment that she believed she had weaknesses in the area of science teaching. Jo talked about how she would like to improve as a teacher in the excerpt that follows.

I would like to be a better science teacher. That’s why I signed up for this course. I feel like my strength is in math and I think that’s because I like math. I think I was better with science before I hate to say this, but before we had the SOL. I feel like I now have a time limitation, for example, if I want to carry on a science experiment. I’m thinking about back when I taught the fourth grade. When I taught fourth, I could do science all day long, you know, with the kits and the AIMS activities and things like that. And now I feel like I’ve got to cut everything short. I feel like that’s a limitation. I guess I would like to learn a better use of time for that kind of thing. I would like to be able to do that same sort of thing but within the time frame we have to do it.

This excerpt revealed details about the science teaching methods that Jo uses in her science classroom and also gives an indication that she is willing to gain more knowledge about science teaching methods. This leads us to our next step, piecing together pre PSI Professional Development Course interview data to create a picture to describe Jo’s framework for understanding science-teaching methods. In the pre PSI Professional Development Course interview, Jo reveals details about her science teaching methods. One excerpt lists examples of the methods Jo generally uses to teach science in her
classroom. She explains, “I try to use all of them, everything from textbook or old school, to hands-on and experimentation. We use the computer, the computer lab, and technology.”

Data analysis continues as Jo discloses another influence on her science teaching methods. An excerpt from her pre PSI Professional Development Course interview outlines an example of someone from television that influences the way she teaches.

The way I teach? Well, you’re going to laugh, but the food channel, the food network. Alton Brown, I love him. In fact, I even had my kids watch him. I looked to see what he was doing and he was describing why something, maybe why water does certain things like surface tension. He got into the water molecules and all of that. The gas is expanding and the molecules moving apart and why things work. That’s true though.

This excerpt ties back into Jo’s earlier learning experiences with cooking and baking that were revealed in her interview analysis.

In summary, during her pre PSI Professional Development Course interview, Jo describes her framework for understanding science content and teaching methods in a mixed fashion. Jo’s science training experiences consist of a mixture that ranges from “poor” to “awesome.” On one hand, Jo feels that her “own lack of knowledge” about science topics inhibits her. She feels she is “just not prepared as well as I’d like to be.” On the other hand, Jo describes many of her experiences with science as “awesome” and “really neat.” Jo states that she feels comfortable with all methods of teaching science and with manipulating the educational environment in her science classroom to maximize student understanding.

Next, data analysis focused on Jo’s description of her framework for understanding I-B science teaching methods. The excerpts that follow describe how Jo
defines inquiry science prior to the PSI Professional Development Course. Jo believes that inquiry science involves “questioning.” It is finding “answers to puzzles.” Prior to the PSI Professional Development Course, Jo explains that she “wasn’t sure how it [inquiry science] is different from experimental design.” Following the PSI Professional Development Course, Jo defines science in her post PSI Professional Development Course interview as, “Exploring, questioning, and experimenting to discover the reasons things are what they are or why they happen.” Jo defines inquiry science in the excerpt that follows. Jo explains, “Inquiry science is a combination of scientific method and further exploration to figure out the ‘How’s?’ It is a chance to wonder about life and ‘play,’ to maybe make sense of it all.” In her definition of inquiry science, Jo emphasized wonder, play, and making sense of the science concepts. This data from the interview analysis is utilized in the section titled Jo’s Partner Portfolio for Professional Development Analysis and serves as a source for triangulation of multiple data sources (Yin, 2003).

**Jo’s Classroom Observation Analysis: Pre and Post Professional Development Course**

Researcher observations in Jo’s classroom were completed on May 16, 2007 and on October 12, 2007. The demographics of the two science classes that were observed for the pre PSI Professional Development Course and post PSI Professional Development Course observations are described in Table 8. Jo had a total of 22 students during the pre PSI Professional Development Course observation and 19 students during the post PSI Professional Development Course observation.
Data analysis includes a review of Jo’s interview and observation data followed by presentation of evidence related to the implementation of the forms inquiry as described by Martin-Hansen (2002). A review of the pre PSI Professional Development Course observation data supports the pre PSI Professional Development Course interview data and suggests that Jo incorporates a range of activities or methods into each lesson. She manipulates the learning environment depending on student “strengths and weaknesses.” A brief synopsis of Jo’s pre PSI Professional Development Course lesson is illustrated in this paragraph. In her lesson plan for the pre PSI Professional Development Course observation Jo engaged students by reviewing a series of definitions for the concepts of mixtures and solutions. Jo informed the students that they would be acting as scientists. Then she gave the students directions for stations, assigned partners, and reviewed safety procedures. The next section of the lesson consisted of students rotating through stations in small groups. As the students worked, Jo circulated and asked...
questions to the students like “Why is it?” and “Why do you think so?” Students next cleaned up and returned to their seats quietly. Students worked individually to create a Venn-Diagram graphic organizer. Jo brought the class together once again and students shared information from their experience using the overhead projector. Closure included a discussion about the lesson.

During the pre PSI Professional Development Course observation lesson the students rotated through stations in small groups. Jo circulated and asked questions to the students like “Why is it?” and “Why do you think so?” This observation serves as evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). Data from the pre PSI Professional Development Course observation verifies data from the Pre PSI Professional Development Course interview that showed that Jo “wasn’t sure how it [inquiry science] is different from experimental design.” Prior to the PSI Professional Development Course Jo did not fully understand inquiry and was not using Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), in her classroom.

Post PSI Professional Development Course observation data showed that Jo continued to employ a variety of teaching methods into her lessons, methods included: questioning, discussion, incorporation of technology, group and partner work, hands-on activities, and experimentation. The lesson that the researcher observed following Jo’s participation in the PSI Professional Development Course addressed the Virginia SOL related to Earth history and fossil evidence. A brief synopsis of the lesson is illustrated in
this paragraph. Jo started her lesson by posing a question, “How old is old?” Students watched a video clip of a scientist handling artifacts. The scientist was wearing white gloves. Jo asked students several questions about why the scientist was wearing white gloves. This shows evidence of Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design (Martin-Hansen, 2002). Next, she directed the lesson towards the completion of a KWL chart (a graphical organizer, the letters KWL are an acronym for “what we know,” “what we want to know,” and “what we learned”). The students generated questions about what they wanted to know. They wrote in their notebooks on their wonder page. The students would refer back to the questions later in the unit. After addressing safety issues and giving directions, the students were ready to become archeologists. The researcher observed several forms of inquiry as described by Martin-Hansen (2002). Students were engaged in Coupled Inquiry, inquiry that starts as Structured Inquiry or teacher Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control. Jo began by guiding the students as they uncovered fossils buried in the sand. Students then sorted their fossils according to their own classification system. Last, Jo pulled kids back together, asked question and concluded the lesson. This activity was a precursor for future activities in which the students pursued a number of the questions that they had created in their KWL chart at the beginning of the lesson. Lessons that followed would include: examples of activities interactive science notebook sessions, I-B searches using technology and books, journaling, hands-on I-B activities examining fossil records, and work with partners or small groups to create dioramas. This indicated that Jo was moving towards implementation of Full or Open Inquiry.
In summary, throughout her mini unit plan Jo gradually implemented several forms of inquiry as described by Martin-Hansen (2002). She moved from Guided Inquiry to Coupled Inquiry. Jo has slowly started using the model of Full or Open Inquiry. Jo allowed students the opportunity to discover the answers to many of their questions on their own as they moved through the unit. The researcher observed evidence of Full or Open inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), in the post PSI Professional Development Course observation as students used a KWL chart to gather information and generate questions that they utilized to guide their own investigations as they moved through the unit.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

As noted in Research Question 1 analysis, Jo’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments increased notably, with 42 (average efficacy) points and 54 (high efficacy) points respectively (max=65 points). Therefore, she was comfortable with her ability to teach science. Jo’s STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased slightly, with 49 points to 46 points respectively (max=60 points); however, both scores were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Jo’s Partner Portfolio for Professional Development Analysis.*
Constructivist Learning Environment Survey – CLES Analysis Pre and Post

As noted in Research Question 1 analysis, Jo’s pre (32) and post (35) CLES Personal Relevance scores showed a slight increase, both were in the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences. Her pre (26) and post (28) CLES Scientific Uncertainty scores increased slightly from a high intermediate agreement score to a high agreement score, which indicated that after participating in the PSI Professional Development Course she placed more emphasis on engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. Her CLES Critical Voice scores were identical with both falling in the high agreement range, pre (35) and post (35). This indicates that she placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediments to their learning. Her pre (23) and post (24) CLES Shared Control scores were in the high intermediate agreement range, which indicated that the students often but not always are invited to: participate in designing their own activities, determine assessment criteria, and negotiate the norms of the classroom. Her CLES Student Negotiation scores increases slightly from the pre assessment (29) to the post assessment (32). Both scores were in the high agreement category, which indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. Her pre (29) and post (30) CLES Attitude Scale scores were also in the high agreement category which indicated that she felt students,
anticipated the activities within her classroom; found the activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Jo’s Partner Portfolio for Professional Development Analysis.

**Jo’s Partner Portfolio for Professional Development Analysis**

Pre PSI Professional Development Course interview data shows that prior to the PSI Professional Development Course Jo, describes her own framework for understanding science content and teaching methods in a mixed fashion, ranging from “poor” to “awesome.” Jo also explains that she feels comfortable with all methods of teaching science. Jo notes that she manipulates the educational environment “all the time” to maximize student understanding. The Partner Portfolio for Professional Development was assembled during the PSI Professional Development Course in order to organize and hold teacher reflections. Jo was and given opportunity to manage her thoughts and actions through collaboration, strategic processing, and reflection (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Jo’s (a) Goal Statement, (b) Exit Slips, and (c) journal entries were analyzed to confirm the earlier mentioned data findings. This examination offers a triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).

Data analysis for points of triangulation started with an examination of Jo’s description of her own efficacy and ability to produce a desired or intended result. Pre PSI Professional Development Course interview data showed that Jo would like to improve as a science teacher. The following excerpt from Jo’s Goal Statement in her
Partner Portfolio for Professional Development supported the idea that she would like to improve as a science teacher. Jo writes that she would like to, “learn how to implement inquiry in my science teaching to get all the kids engaged and enjoying the activities to increase retention of the lessons objectives.” An excerpt from an Exit Slip in Jo’s Partner Portfolio for Professional Development further supported the thought that Jo would like to improve as a teacher, specifically in the area of science content related to the study of matter. Jo wrote, “I would still like to learn how to better teach the concept of matter.” In summary, Jo is interested in improving as a science teacher through learning about implementation of inquiry, student engagement, and expansion of her science content knowledge.

Pre PSI Professional Development Course interview data shows that prior to the PSI Professional Development Course, Jo describes her own framework for understanding science content and teaching methods in a mixed fashion, ranging from “poor” to “awesome.” Jo states that she feels comfortable with all methods of teaching science, she explains that she “tries to use them all.” Jo implements a wide variety of methods when she is teaching science, she notes, “I try to use all of them, everything from textbook or old school, to hands-on and experimentation. We use the computer, the computer lab, and technology.” Jo’s CLES Student Negotiation scores indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students; make sense of other students’ ideas; and reflect on the viability of their own ideas (Suters, 2004; Taylor et al., 1997). This data supports Jo’s STEBI Personal Science Teaching Efficacy Belief subscale scores, pre (42) and post (54), which showed she was comfortable with her ability to teach science and she had confidence in her
teaching ability to create desirable outcomes (Riggs, 1988; Riggs & Enochs, 1990). An excerpt from an Exit Slip in Jo’s Partner Portfolio for Professional Development further backed the idea that Jo felt comfortable utilizing a wide variety of activities in her science classroom. She notes that she will use the following methods presented at the PSI Professional Development Course in her classroom: suggestions on how to help students choose investigable questions; lessons planned using the 5 E model of science instruction; interactive centers that can be stored easily on hangers; books on a variety of science topics; meaningful 10-minute science activities; inquiry themed mix-up the steps laboratories; and “uncookbook” labs. In her pre PSI Professional Development Course interview, Jo notes that she feels that she is manipulating the educational environment “all the time” to maximize student understanding. This supports data from her CLES Critical Voice scores, which indicated that she placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediments to their learning (Suters, 2004; Taylor et al., 1997). In summary, Jo has been exposed to a wide variety of science teaching strategies and methods throughout the course of teacher training opportunities she has participated during the course of her teaching career. She presently utilizes a wide variety of teaching methods and strategies in her science classroom. Although she already has participated in a wide range of science training, Jo is willing to try new ideas and science teaching methods.

Continuing analysis for Research Question 2, the researcher investigated the question, “How does Jo describe her own framework for understanding I-B methods?” Interview data from Jo’s post PSI Professional Development Course interview supports evidence that Jo used Structured Inquiry in her science lessons in her classroom prior to
the PSI Professional Development Course. Jo reported that before the in-service, I “wasn’t sure how it [Inquiry] differed from experimental design.” This idea was supported by Jo’s pre PSI Professional Development Course observation data. During the pre PSI Professional Development Course observation lesson Jo instructed her students to rotate through stations in small groups. The students participated in a variety of hands-on activities located at each center as directed by the teacher. Jo circulated and asked questions to the students like “why is it?” and “why do you think so?” This lesson example serves as evidence of the use of Structured Inquiry. Jo’s STEBI Outcome Expectancy subscale scores, pre (49) and post (46), showed she had confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

Following the PSI Professional Development Course, Jo made progress towards the implementation of I-B methods in her science classroom. Jo’s post PSI Professional Development Course observation data showed evidence of Full or Open inquiry, inquiry in which students ask their own questions, design their own investigations, and convey results about those investigation (Martin-Hansen, 2002). In the post PSI Professional Development Course observation Jo’s students used a KWL chart to gather information and generate questions that they utilized to guide their investigations. Jo allowed students the opportunity to discover the answers to many of their questions on their own as they moved through the unit. The researcher observed that Jo was experiencing some success while working towards implementation of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), into her lessons. In her post PSI Professional Development Course
interview, Jo excitedly states that she is motivated because of “the students, they are so in to ‘it’!”

Summary of Jo’s Results for Research Question 2

Research Question 2 seeks information to explain the following: “How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?” To present an explanation, it important to appreciate that Jo’s cognitive framework includes her knowledge of science content and teaching methods. Her conception of science subject matter or content knowledge includes the ideas, facts, and the concepts of the discipline, as well as the relationships among those concepts, facts, and ideas. Data analysis exposed information related to Jo’s cognitive framework. Jo has gained knowledge of wide variety of science teaching strategies and methods. She is willing to try new ideas and science teaching methods. Jo would like to improve as a science teacher through implementation of inquiry, student engagement, and expansion of science content knowledge. Prior to the PSI Professional Development Course Jo “wasn’t sure how it [inquiry] differed from experimental design.” Jo’s post PSI Professional Development Course interview and post PSI Professional Development Course observation data support this finding. Post PSI Professional Development Course observation data showed that Jo was able to slowly implement some lessons using Full or Open Inquiry, inquiry in which students ask their own questions, design their own science investigations, and convey results of those investigations (Martin-Hansen, 2002), into her science classroom.
Research Question 3 Analysis

What barriers to implementing I-B methods exist?

Interview analysis (see Appendix B for instrument) for Research Question 3 includes examination of Jo’s Goal Statement and selected pre and post interview questions listed in Table 1. To build credibility, information was compiled through (a) STEBI surveys, (b) CLES surveys, (c) direct observation of the participant’s teaching, and (d) Partner Portfolio for Professional Development, including lesson plans for the mini-unit, Invitation to Practice: Mapping My Classroom activity, Exit Slips, Quick Writes, and journal entries. The researcher made use of this data to study the teacher’s mental models to uncover patterns that shape teaching behavior as it relates to her Shared Identity (SI), the portion of her conceptual framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community. In other words, we have assembled the pieces to answer the teacher’s query, “How does Jo describe her abilities to produce desired or intended results in her science classroom as they relate to barriers to implementation of I-B science methods?”

Jo’s Goal Statement Analysis

Teacher’s attitudes and beliefs about science are key influences on how they teach the subject. The reality of the school classroom consists of lessons in which teachers transmit science as a set of facts, laws, and data. A teacher’s attitude, her tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do. A teacher’s styles, principles, are rooted in experience and develop into individual constructs slowly over time (Souza Barros & Elia,
1998). Jo’s inclination to respond positively or negatively towards her students or a science topic has an influence on what her students will see, hear, think, and do. These tendencies make up her principles or attitude. Jo set her own goal during the PSI Professional Development Course (Hammerness et al., 2005). Jo’s goal read as follows: “I want to learn how to implement inquiry in my science teaching to get all the kids engaged and enjoying the activities to increase retention of the lessons objectives.” Looking at Jo’s goal allowed the researcher to study her attitude towards implementation of I-B methods into her classroom. This goal reveals that Jo responds favorably and is interested in learning how to implement inquiry into her science teaching.

*Jo’s Interview Analysis: Pre and Post Professional Development Course*

Interview analysis for Research Question 3 includes the analysis of the pre PSI Professional Development Course interview questions numbered 3, 4, 7, 8, and 9. This allowed the researcher to gather information to provide a picture of what was happening Jo’s classroom and school, thus providing information related to Jo’s knowledge and practice at the beginning of the research (Davis, 2002). The pre PSI Professional Development Course interview analysis data supported Jo’s goal that she is interested in learning how to implement inquiry into her science teaching. Jo stated that she “would like to be a better science teacher.” Pre PSI Professional Development Course interview analysis also revealed that Jo uses a variety of methods. Jo notes, “I try to use all of them, everything from textbook or old school, to hands-on and experimentation. We use the computer, the computer lab, and technology.” Interview codes and transcript statements for Jo’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions are listed in Table 9.
Table 9.

*Interview Codes and Transcript Statements for Jo (T2) Pre and Post – Research Question 3.*

**Barriers to Implementation of I-B Methods**

<table>
<thead>
<tr>
<th>Time for Science Instruction and Time Related to Curriculum Guidelines</th>
<th>Support</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: “We were trying to incorporate those hands-on science kits without following the curriculum map. But then the benchmarks come out, we didn’t teach that and they’re tested on it. So next year, I’m going to follow the map. That pretty much tells me what to teach and when to teach for this county.” (Standards) (Pacing) (Time to teach)</td>
<td>Pre: When asked about barriers she faced, Jo stated in her pre PSI Professional Development course interview, “my own lack of knowledge. That would be a major one, just not prepared as well as I’d like to be.” Jo was also unhappy with her students test scores. She shares, “I was unhappy with the Benchmark scores so I knew that my methods are failing, so I need to do something to improve that.” (Teacher)</td>
<td></td>
</tr>
<tr>
<td>Pre: “I think I was better with science before I hate to say this, but before we had the SOL. I feel like I’ve got a time limitation if I want to carry on a science experiment. (I’m back when I taught the fourth grade.) When I taught fourth, I could do science all day long. You know with the kits and the AIMS activities and things like that. And now I feel like I’ve got to cut everything short. I feel like that’s a limitation.” (Standards) (Pacing) (Time to teach)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post: Analysis of the post PSI Professional Development Course interview questions showed that Jo notes that the way she teaches is influenced by “the curriculum map, curriculum framework, benchmark tests, and past SOL data.” (Standards) (Pacing) (Testing)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Jo’s teaching team at her school consisted of her CF, Ariel, and three other fifth grade teachers. The following excerpt illustrates the level of support Jo indicates that she feels she has received from her teaching team. “We share ideas. Ariel and I share a lot. We plan activities together.” Jo feels supported by her administrators. Jo states that her administrators, “pretty much let us do and trust that we do what we feel will best help the children learn.” It is important that Jo feels supported by her administrators and teammates while she is implementing the I-B process. Research supports that it is important that administrators and teammates are supportive of teachers while they are implementing the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). In summary, data from the pre PSI Professional Development Course interview analysis showed that Jo is receiving the support she needs from teammates and administrators in order to successfully implement I-B science methods into her classroom.

Although Jo possesses the desire to implement I-B methods, feels confident in her teaching ability, and believes her CF, colleagues and administration support her; there may be other barriers that inhibit Jo to fully carry out her science-teaching vision. Appropriately, the researcher next looked at likely threats to fidelity or barriers to use of I-B instruction besides lack of administrative and peer support. This task was completed using data gathered from interviews and classroom observation, thus allowing the researcher to identify connections or relationships between Jo’s perceptions and use of I-B instruction (Davis, 2002).

Analysis of the pre PSI Professional Development Course interview questions revealed that Jo did face a number of barriers as she went about the process of teaching
science in her classroom, including: content knowledge; time for instruction; and curriculum guidelines, including Virginia SOL, Milton County curriculum maps, and benchmark tests. Jo feels that curriculum guidelines, including the Milton County curriculum maps and benchmark tests govern what she teaches and when she teaches it.

This excerpt from the pre PSI Professional Development Course interview illustrates Jo’s frustration with planning.

We were trying to incorporate those hands-on science kits without following the curriculum map. But then the benchmarks come out, we didn’t teach that and they’re tested on it. So next year, I’m going to follow the map. That pretty much tells me what to teach and when to teach for this county.

In the excerpt that follows Jo shares what she feels are limitations to her science planning because of curriculum guidelines, including the Virginia SOL and time for instruction, or time to fit all of the material into the school day.

I think I was better with science before I hate to say this, but before we had the SOL. I feel like I’ve got a time limitation if I want to carry on a science experiment. (I’m back when I taught the fourth grade.) When I taught fourth, I could do science all day long. You know with the kits and the AIMS activities and things like that. And now I feel like I’ve got to cut everything short. I feel like that’s a limitation.

Analysis of pre PSI Professional Development Course interview data revealed that Jo believed that her science content knowledge might also prove to be a possible barrier to implementation of IB methods. When asked about barriers she faced, Jo stated, “my own lack of knowledge. That would be a major one, just not prepared as well as I’d like to be.” Jo was also unhappy with her students’ science test scores. She shares, “I was unhappy with the benchmark scores so I knew that my methods are failing, so I need to do something to improve that.” In summary, during the pre PSI Professional Development Course interview Jo viewed the following as possible barriers to
implementing I-B science: content knowledge; time for instruction; and curriculum guidelines, including the Virginia SOL, county curriculum maps and county benchmark tests.

Interview analysis for Research Question 3 continued with the analysis of the post PSI Professional Development Course interview questions numbered 3, 4, 6, and 7. Data analysis resumed assuming that Jo could have come across potential threats to fidelity or barriers to implementation of I-B instruction. This method allowed for additional identification of connections or relationships between Jo’s perceptions and use of inquiry instruction (Davis, 2002). Analysis of the post PSI Professional Development Course interview questions showed that Jo notes that the way she teaches is influenced by “the curriculum map, curriculum framework, benchmark tests, and past SOL data.” In other words, these barriers remain despite the professional development course and administrator and peer support.

In summary, analysis of the post PSI Professional Development Course interview questions confirmed pre PSI Professional Development Course interview data, which indicated that Jo viewed time for science instruction as a barrier to implementing I-B methods. The researcher also discovered that curriculum guidelines, including the Virginia SOL, curriculum maps and benchmark tests also emerged as possible barriers to implementing I-B science. Jo did not mention the factor of content knowledge as a barrier in her post PSI Professional Development Course interview comments. Again, these barriers remain despite the professional development course and administrator and peer support.
Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post

Jo’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments increased notably, with 42 (average efficacy) points and 54 (high efficacy) points respectively, indicating she was comfortable with her ability to teach science. Jo’s STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased slightly, with 49 points to 46 points respectively; however, both scores were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Details of the STEBI results were noted in Research Question 1 analysis, Science Teaching Efficacy Belief Instrument – STEBI Analysis. This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Jo’s Partner Portfolio for Professional Development Analysis.

Constructivist Learning Environment Survey – CLES Analysis Pre and Post

As noted in Research Question 1 analysis, Jo’s pre (32) and post (35) CLES Personal Relevance scores increased slightly, both scores fell within in the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences (see Figure 4). Her pre (26) and post (28) CLES Scientific Uncertainty scores showed that following participation in the PSI Professional Development Course she heightened emphasis on engaging students in opportunities to learn to be skeptical and critical about the nature and value of science. Jo’s CLES Critical Voice scores, pre (35) and post (35), both fell in the high agreement range. This indicated that she placed a high emphasis on supporting students in efforts to
question her plans and methods and express concerns about obstacles to their learning. Jo’s CLES Shared Control scores, pre (23) and post (24), showed that the students in her class often but not always are called upon to: take part in designing their own activities, establish assessment criteria, and confer on the norms of the classroom. Jo’s CLES Student Negotiation scores, pre (29) and post (32), indicated that she placed a high emphasis on providing opportunities for students in her class to: explain their ideas to others, make sense of other students’ ideas, and reflect on the feasibility of their own ideas. Jo’s CLES Attitude Scale scores, pre (29) and post (30), showed that she felt that her students: looked forward to the activities within her classroom, felt the activities were worthwhile, and understood and enjoyed the activities in her classroom (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources (Yin, 2003) in the section titled Jo’s Partner Portfolio for Professional Development Analysis.

Jo’s Partner Portfolio for Professional Development Analysis

Jo was given the opportunity to reflect and take command of her thoughts and behaviors through reflection, planned processing, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006) throughout the PSI Professional Development Course. Documents were kept in Jo’s Partner Portfolio for Professional Development. To confirm the previously mentioned data findings as triangulation of multiple data sources (Yin, 2003) the following data were analyzed: (a) Invitation to Practice: Mapping My Classroom activity, (b) the Invitation to Practice: Collaboration activity, (c) Exit Slips, (d) Quick Writes; and (e) journal entries. Analysis of the pre PSI Professional Development Course and post PSI Professional Development Course
interview questions disclosed that Jo confronted a number of barriers as she went about the course of implementing I-B science in her classroom. During the pre PSI Professional Development Course interview Jo viewed the following as possible barriers to implementing I-B science: content knowledge; time for instruction; curriculum guidelines, including the Virginia SOL, county curriculum maps, county benchmark tests, and the amount of content information to be covered. Analysis of the post PSI Professional Development Course interview questions confirmed pre PSI Professional Development Course interview data, which indicated that Jo viewed the amount of time available for instruction as a barrier to implementing I-B methods. Curriculum guidelines, including the amount of content information to be covered within the standards and results of student test scores related to the Virginia SOL, county curriculum maps, and county benchmark tests also emerged as possible barriers to implementing I-B science. Jo did not mention the factor of content knowledge as a barrier in her post PSI Professional Development Course interview comments.

During the Invitation to Practice: Mapping My Classroom activity Jo planned changes that would have to take place in her classroom in order for her to implement I-B science. The excerpt that follows outlines her plans.

Next year I will: create space for materials and center activities, design a “quick fix” desk arrangement, pull library resources, create an Inquiry bulletin board with questions and pictures, have a box for journals, create an area for storage of materials, and use concept maps and thinking maps.

Data gathered from CLES scores showed that Jo’s Student Negotiation scores, pre (29) and post (32), indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students; make sense of other students’ ideas; and
reflect on the viability of their own ideas (Suters, 2004; Taylor et al., 1997). This supports Jo’s intent to arrange desks to facilitate students communicating and working towards I-B learning and make resources available for the students. Jo’s idea to implement concept maps and thinking maps allows students to think and reflect on their ideas.

What really happened? Was Jo able to implement her plan as written? Following the implementation of the mini unit into her classroom, Jo reflected on her accomplishments during the follow-up portion of The Invitation to Practice: Mapping My Classroom activity. Jo listed it items from her plan to implement I-B science. In the excerpt that follows Jo shares her accomplishments.

I have a science station for investigation materials. I created a box or container for journals. I set aside an area for related literature. The desks are currently in groups of four with one group of three. I have posted thinking maps on the wall.

In an Exit Slip Jo wrote that she might have a difficult time “organizing the classroom, finding and creating the space. This thought was supported by the Invitation to Practice: Collaboration activity. Jo and her CF, Ariel, both agreed that they “find it difficult to get all of the materials together for certain experiments.” Jo noted during the follow-up portion of The Invitation to Practice: Mapping My Classroom activity that she did not post an “inquiry bulletin board” because she forgot about it. She is still working on an “on going quick fix desk arrangement solution.”

Although Jo made plans to arrange her science classroom to facilitate I-B instruction, she was not able to implement all of her ideas as planned. After the PSI Professional Development Course, Jo reflected on her plans. In the post PSI Professional Development Course interview, Jo shared that she was able to improve as a science
teacher by learning “how to take a cookbook experiment and turn it into an inquiry lesson.” She stated that she also learned “ideas to incorporate the kids multiple intelligences.” This excerpt from a journal entry details her progress toward carrying out her plans. Jo writes, “I began the mini-unit on fossils that we began planning for this summer and used ‘I Wonder’ journals. I am taking ‘baby steps.’ I have used the first and second E’s [from the 5E Model of science teaching (Bybee, 1993, 2000; Carin et al., 2004)].” Jo will use the “E’s” titled Explain and Elaborate at the end of the week of October 15, 2007. She has not used extension activities in her science classroom yet this school year, but plans to do so at the end of this week. However, she explains that “time will tell” and is “hopeful” that she will accomplish her goal. This shows further support to the idea that time for instruction and sharing time with other subjects are barriers for Jo’s implementation of I-B instruction. In an Exit Slip Jo wrote that she thought she might have difficulty with “time management.” She knows she “will want the kids to take all the time they need but that is not always possible with the schedule.” Journal entries and observations revealed that part of the reason for the delay in getting to I-B science also includes the fact that classroom time is split between science and social studies.

Analysis of pre PSI Professional Development Course interview data revealed that Jo believed her knowledge of science subject matter might also prove to be a possible barrier to implementation of I-B science methods. As Jo talked about barriers she feels she might face while trying to implement I-B methods into her classroom, she explains, “my own lack of knowledge. That would be a major one, just not prepared as well as I’d like to be.” In a journal entry excerpt that follows Jo explains that her
knowledge of subject matter was not an influence on her decision to use I-B methods in her classroom.

My memory of knowledge gained in the past often fails me. Therefore, I often have to go back and relearn the material before I teach certain academic areas. When planning the mini unit I had the opportunity to “refresh” my memory so it was not a barrier. Plus, I am really into fossils so it was minimal refreshing!

Jo held prior knowledge related to the science topic of fossils, therefore, knowledge of subject matter was not a barrier that Jo faced when implementing I-B methods related to her mini-unit into her science classroom.

In summary, Jo revealed that she faced a number of barriers as she planned and worked towards the implementation of I-B methods into her science classroom. Jo found the following were barriers to implementation: time for instruction; sharing time with other subjects; curriculum guidelines, including, the Virginia SOL, county curriculum maps, Milton County School’s benchmark tests, and the amount of science content information to be covered. Jo was able to overcome the barrier of covering all of the Virginia SOL objectives and follow the curriculum map by manipulating time and sharing materials, like science kits, with other teachers. After the implementation of benchmark testing in Milton County, Jo was no longer able to keep that flexibility in her schedule. During the pre PSI Professional Development Course interview session, Jo felt that lack of subject knowledge might prove to be a barrier. During the process of implementing her mini-unit, Jo explained that she learned that content knowledge was not a barrier that she faced while attempting to implement I-B science methods into her science classroom.
Jo’s Classroom Observation: Pre and Post Professional Development Course

As noted in Research Question 1 analysis, data from Jo’s lesson plans and pre PSI Professional Development Course observation illustrated that she was successfully implementing Structured Inquiry into her science classroom. In Jo’s post PSI Professional Development Course lesson it was evident that she was in the process of implementing further use of I-B methods into her science classroom. The lesson Jo chose for her post PSI Professional Development Course observation addressed the Virginia SOL related to Earth history and fossil evidence. Jo engaged the students in her class by posing a question, “How old is old?” Students then watched a video clip of a scientist wearing white gloves handling artifacts. Jo next asked students several questions about why they believed the scientist was wearing white gloves and allowed them to discuss possible answers to the question, thus showing evidence of Guided Inquiry. The students were given the opportunity to formulate questions through the use of a KWL chart, thus shifting to the use of Coupled Inquiry. Coupled Inquiry is inquiry that starts as Structured Inquiry or Teacher Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002). Jo explained that she will slowly begin implementing the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), as she gradually allows students the opportunity to discover the answers to many of their questions on their own as they move through the unit. Students will participate in lessons that follow this one, examples of activities include: interactive science notebook sessions, I-B searches using technology and science books, journaling, hands-on I-B activities examining fossil records, and work with partners or small groups to create dioramas.
Summary of Jo’s Results for Research Question 3

Jo’s professional development goal revealed that she was interested in learning how to implement inquiry into her science teaching. She wrote her goal stating, “I want to learn how to implement inquiry in my science teaching to get all the kids engaged and enjoying the activities to increase retention of the lessons objectives.” During the PSI Professional Development Course Jo worked with her CF, Ariel, to create and implement an I-B science mini unit, Investigating Fossils, into each of their classrooms. Classroom observation data showed that Jo had already made use of several forms of inquiry as defined by Martin-Hansen (2002), including Guided Inquiry and Coupled Inquiry. Jo was slowly beginning to implement the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), into her classroom. During the pre PSI Professional Development Course interview Jo viewed the following as possible barriers to implementing I-B science: time for instruction; sharing time with other subjects; curriculum guidelines, including, the Virginia SOL, county curriculum maps, county benchmark tests, and the amount of content information to be covered. Analysis of the data revealed that Jo confronted a number of barriers as she went about the process of implementing I-B science in her classroom. The amount of content information to be covered within the curriculum guidelines, which include Virginia SOL and results of student test scores related to the Virginia SOL, curriculum maps and benchmark tests also emerged as possible barriers to implementing I-B science. Jo thought a lack of knowledge of subject matter might become a barrier to implementation of I-B science methods but this proved not to be the case.
Research Question 4 Analysis

What relationships exist between teachers’ perceptions and use of I-B methods?

Information was analyzed to address the query, “What relationships exist between Jo’s perceptions and use of I-B methods?” Interview analysis (see Appendix B for instrument) for Research Question 4 includes the examination of (a) post PSI Professional Development Course interview questions 2, 3, 6, and 7 listed in Table 1, (b) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (c) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (d) Partner Portfolio for Professional Development. Influences such as Jo’s culture, educated-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual and style help mold the her beliefs about I-B methods. The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI).

John Dewey (1938, 1997) proposed that experience transpires as a result of the interrelationship of two principles, continuity and interaction. Continuity refers to how each experience a person has influences one’s future, for better or for worse. Interaction refers to the situational influence on one’s experience. The individual’s present experience is a function of the interaction between their past experiences and the present situation. No experience has a pre-destined value. Therefore, what might be a beneficial experience for one individual could be an unfavorable experience for another. In other words, "positive experiences" motivate, encourage, and enable students to go on to have
more valuable learning experiences, whereas, "negative experiences" tend to lead towards a student closing off from potential positive experiences in the future. Dewey believed that learning experiences should be meaningful to each student and that teachers should step back and act as facilitators (Dewey, 1938, 1997).

Returning to the bucket metaphor described in the researcher’s conceptual framework, Jo examined the shells and treasures presented during the PSI Professional Development Course and decided to either keep each one and place it in her bucket, or place it back on the beach based on her own system of values. The exposure of treasures of considerable value created a positive influence on Jo’s motivation, attitude, caring, determination and effort. The discovery of treasure with modest value had a negative influence. This information is vital to understanding teacher change related to inquiry (Keys & Bryan, 2000; Spillane et al., 2002) as it was used to exemplify Jo’s cognitive framework related to inquiry, her beliefs about inquiry teaching, and connections related to her daily experiences.

Jo’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 4 includes the analysis of the post PSI Professional Development Course interview questions numbered 2, 3, 6, and 7. A qualitative research design serves as an appropriate methodology to utilize to examine any relationships the might exist between Jo’s perceptions and use of I-B methods, seeing as qualitative research is concerned with the perceptions of the participants and with process rather than outcomes or products (Bogdan & Biklen, 1992; Marshall & Rossman, 2006). This design serves as an appropriate methodology to utilize to define inquiry as it is perceived and used by Jo. This information was drawn on to first illustrate Jo’s
cognitive framework related to inquiry. Jo defined inquiry science as “questioning,” finding “answers to puzzles” in her pre PSI Professional Development Course interview session. Jo says that she “wasn’t sure how it [inquiry science] is different from experimental design” prior to the PSI Professional Development Course.

Next, post PSI Professional Development Course interview information was drawn on to reveal Jo’s beliefs about inquiry teaching. After participating in the PSI Professional Development Course, Jo defined science in her post PSI Professional Development Course interview as “exploring, questioning, and experimenting to discover the reasons things are what they are or why they happen.” Jo shared her definition of inquiry science in the following excerpt. Jo explains, “Inquiry science is a combination of scientific method and further exploration to figure out the ‘How’s?’ It is a chance to wonder about life and ‘play,’ to maybe make sense of it all.”

As a final point, the interview information was examined to determine how Jo’s cognitive framework related to inquiry and her beliefs about inquiry teaching tie into the her daily experiences. Jo feels comfortable manipulating the educational environment to maximize student understanding. Pre PSI Professional Development Course interview data shows that she manipulates according to student learning styles and strengths. Jo was willing to try to implement I-B methods into her classroom because she feels it is a way “to improve the way I teach.” She believes that her students will “remember the hands-on things.” She shares, “those are the kinds of things I remember. The activities that we did.” Jo chooses the methods that helped her learn and applies them in her own classroom.
Jo’s Goal Statement Analysis

Jo’s goal for the PSI Professional Development Course read as follows: “I want to learn how to implement inquiry in my science teaching to get all the kids engaged and enjoying the activities to increase retention of the lessons objectives.” Jo’s goal statement and pre PSI Professional Development Course interview comments show that she is eager to learn about and implement I-B methods into her science classroom, is interested in engaging the students, and she is able to choose which methods she employs in her classroom.

Science Teaching Efficacy Belief Instrument - STEBI Analysis Pre and Post

Details of Jo’s STEBI results were noted in Research Question 1 analysis, Science Teaching Efficacy Belief Instrument – STEBI Analysis. Jo’s STEBI serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003). Jo’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (42) and post (54) assessments increased notably, indicating she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores for the pre (49) and post (46) assessments decreased slightly, however, both scores were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes in her science classroom (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data supports Jo’s goal statement and pre PSI Professional Development Course interview data, which shows that she is eager to learn about and implement I-B methods into her science classroom and is able to choose which methods she employs in her science classroom.
Jo’s Partner Portfolio for Professional Development

Throughout the PSI Professional Development Course, Jo participated in exercises that led her to reflect upon and manage her thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Jo’s Partner Portfolio for Professional Development data provides additional pieces that were used to solve the query, “What relationships exist between Jo’s perceptions and use of I-B methods?” Data analysis focused on relationships connecting Jo’s perceptions as they are related to her practice. Emic accounts, descriptions of behaviors in terms meaningful to the teacher, were used because these accounts are culture specific or are found in the context of the teacher’s science classroom (Stake, 2006). The researcher completed three steps in analyzing the Partner Portfolio for Professional Development. First, Jo’s definition of inquiry, Jo’s methods of instruction, and the definition of inquiry used during the PSI Professional Development Course were reviewed for comparison. Jo’s definition of inquiry and choice of science teaching methods was examined. Second, a review of the findings from Jo’s Interview analysis, Goal Statement analysis, and STEBI analysis was conducted. Third, emic accounts were compared to excerpts from Jo’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003).

First, the researcher examined Jo’s definition of inquiry. During the PSI Professional Development Course Jo defined inquiry in her Partner Portfolio for Professional Development. Jo’s definition is shown in the excerpt that follows.
Inquiry is questioning why something does what it does. It involves experimentation on that something to find out the possible *whys*, ultimately leading to more questions and puzzlements followed by experimentation, data collection, and comparing data. Then the cycle expands and continues.

Throughout the duration of the PSI instruction, Jo was given the opportunity to develop an understanding of the following topics: What is inquiry, learning through inquiry, developing a mind for constructivism, constructivism, how children learn, designing I-B classrooms, integrating I-B activities, the scientific method, learning cycles, skills and knowledge of I-B teachers, and questioning. Jo also participated in sample I-B lessons that were modeled during the PSI Professional Development Course (a complete detailed description of the twenty-hour professional development course is located at Appendix K). In Jo’s post PSI Professional Development Course interview she added “exploring, questioning, and experimenting to discover the reasons things are what they are or why they happen” to her definition of inquiry.

Next, the researcher looked at Jo’s methods of science instruction. This excerpt from post PSI Professional Development Course interview data illustrates Jo’s beliefs about science teaching methods and how children learn science. “I try to use all of them, everything from textbook or old school, to hands-on and experimentation. We use the computer, the computer lab, and technology.” Classroom observation data showed that Jo had already made use of several forms of inquiry as defined by Martin-Hansen (2002), including Guided Inquiry and Coupled Inquiry. In her post PSI Professional Development Course mini unit lessons, Jo gradually moved from Guided Inquiry to Coupled Inquiry. She was slowly beginning to implement the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results.
(Martin-Hansen, 2002), into her science classroom by allowing students the opportunity to discover the answers to many of their questions on their own as they progressed through the science unit.

Then, a comparison was made between of the definition of inquiry used during the PSI Professional Development Course and Jo’s definition of inquiry, which included an examination of her choice of science teaching methods. During the PSI Professional Development Course Inquiry instruction was defined as referring to any teaching method focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations and discover answers to their questions about the natural world. Students may plan systems to collect data and choose how to organize and represent the data (Carin et al., 2004). The National Research Council (1998) defines scientific inquiry as:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work.
Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world” (p.23)

Jo defined inquiry in the excerpt that follows.

Inquiry is questioning why something does what it does. It involves experimentation on that something to find out the possible whys, ultimately leading to more questions and puzzlements followed by experimentation, data collection, and comparing data. Then the cycle expands and continues.
A review of Jo’s definition of inquiry shows that it is aligned with the definition used in the PSI Professional Development Course as it includes students working collaboratively to pose questions, make observations, and discover answers. In her classroom she uses “all” methods. Jo explains, “I try to use all of them, everything from textbook or old school, to hands-on and experimentation. We use the computer, the computer lab, and technology.” Jo’s flexibility in trying all methods allows for integration or use of I-B methods.

The next step in placing the pieces of the puzzle to solve the query, “What relationships exist between Jo’s perceptions and use of I-B methods?” consisted of a review of the findings from Jo’s (a) Interview analysis, (b) Goal Statement analysis, and (c) STEBI analysis. Beginning with her pre PSI Professional Development Course interview, Jo believes she remembers best when she was actively engaged or participated in hands-on activities throughout the learning process. In her Invitation to Practice: Science Learning Personal History activity, Jo writes that she learns when the activities are “visual and hands-on.” Jo learns best when her teachers use a constructivist approach, when they provide relevant experiences and opportunities that allow her to construct knowledge (Piaget, 1929; Vygotsky, 1978). She believes she learned a lot about science by cooking and baking with her mom in the kitchen, collecting and examining rocks outside of her home, and experimenting with photography chemicals her basement with her dad.

A summary of the pre and post PSI Professional Development Course interview data from Research Question 1 reveals information about Jo’s science teaching style. The researcher learned that Jo likes structure and boundaries in her science classroom so that
children feel safe. She often allows her students to have fun, straying from the schedule if the students are still asking questions or investigating about science concepts. Post PSI Professional Development Course interview data shows that Jo believes children learn through use of “hands-on” activities and by “sharing out their thinking.” Jo’s goal statement and interview data show that she is eager to learn about and implement I-B methods into her classroom and that she is able to choose which methods she employs. Jo’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (42) and post (54) assessments increased notably, an indication that she felt more at ease with her ability to teach science. Jo’s STEBI Outcome Expectancy subscale scores, pre (49) and post (46), decreased slightly; however, both scores were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). In summary, the PSI Professional Development Course helped Jo to feel more at ease with her ability to teach science and she is eager to learn about and implement I-B methods into her science classroom.

Last, in assembling the pieces of the puzzle to solve the query, “What relationships exist between Jo’s perceptions and use of I-B methods?” Emic accounts from Jo’s Interview analysis, Goal Statement analysis, and Science Teaching Efficacy Belief Instrument - STEBI analysis were compared with excerpts from Jo’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003).
A teacher’s beliefs and attitudes about science are key influences on how they teach the subject (Souza Barros & Elia, 1998). In an Exit Slip journal entry, Jo shares her positive attitude and beliefs related to experimenting and trying new things. In her Invitation to Practice: Mapping My Classroom notes, she passes on her thoughts saying that she sees herself “as a facilitator leading students across bridges making discoveries along the way.” She further shares that she wants to create “wonder and excitement” with her students. Jo’s Partner Portfolio for Professional Development data supports both her goal statement and her STEBI scores, which illustrate that she wants to learn about I-B science and more about how to implement I-B methods into her science classroom, and she is capable of choosing which methods she uses in her classroom. Jo’s positive attitude had an influence in her decision to choose to implement I-B methods into her science classroom.

As noted in Research Question 2 analysis, Jo used Guided Inquiry in the mini-unit that she created during the PSI Professional Development Course. Jo gradually lessened teacher control to implement Coupled Inquiry into her science classroom. In Jo’s post PSI Professional Development Course lesson, it was evident that she was in the process of implementing further use of I-B methods into her science classroom. Jo notes the reasons she may have been slow to implement all of the I-B methods she learned about in the PSI Professional Development Course dealt with the factor of time. Jo explains that “time will tell” and is “hopeful” that she will accomplish her goal of fully implementing I-B science methods.
Summary of Jo’s Results for Question 4

Research Question 4 asked the question “What relationships exist between teachers’ perceptions and use of I-B methods?” The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI). Data analysis for Research Question 4 showed that Jo was willing to try to implement I-B methods into her classroom. The perception that I-B methods hold large or great value had a positive influence on Jo’s motivation, attitude, caring, determination and effort. Jo’s definition and vision of inquiry matches her choice of methods for instruction. She is willing to use all teaching methods and techniques that will help her students remember, particularly “hands-on” activities and by “sharing out their thinking.” Jo feels comfortable manipulating the educational environment to maximize student understanding. Pre PSI Professional Development Course interview data shows that she manipulates the learning environment according to student learning styles and strengths. Interview data also revealed limitations to Jo’s science planning because of the curriculum standards related to the Virginia SOL, Milton County School System’s curriculum map, Milton County’s benchmark testing, and time to fit all of the material into the school day. Jo’s belief that curriculum guidelines imposed limitations to her science planning might explain why Jo’s implementation of I-B methods into her classroom followed a slow and gradual path.
Research Question 5 Analysis

How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Interview analysis (see Appendix B for instrument) for Research Question 5 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, 8 and 9 listed in Table 1, (b) post PSI Professional Development Course interview question 6, (c) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), and (d) the Partner Portfolio for Professional Development. This information was utilized to examine Teacher Choice (TC) in an attempt to disclose methods that encourage teachers like Jo to overcome resistance to implementing I-B science teaching practices. When a teacher, like Jo, makes a choice she critically assesses the value of available options and decides upon a course of action made up of her own conceptual framework. Data analysis for Research Question 5 consisted of a study of Jo’s conceptual framework composed of: her Individual Identity (II), the portion of the Jo’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or personal constructs (Scribner et al., 2002); Jo’s science Subject Matter Knowledge (SMK), her knowledge of science content matter and pedagogy (the art and science of being a teacher) and curriculum knowledge (Shulman, 1986); and Jo’s Shared Identity (SI), the portion of the her conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her role as part of the professional community.
Jo’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 4 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 5, 7, 8 and 9 as well as post PSI Professional Development Course interview question 6. Mental models, “the images, assumptions, and stories, which we carry in our minds of our selves, other people, institutions, and every aspect of the world,” influence Teacher Choice (TC) (Senge, 1990). First, An investigation into Jo’s Individual Identity (II) was achieved through interview analysis. The researcher learned that Jo learns when she was actively engaged or participated in hands-on activities throughout the learning process. Jo describes her teaching style, noting that she likes structure and boundaries in her science classroom so that children feel safe. She often allows her students to have fun and will stray from the schedule if the students are still asking questions or investigating science concepts. In the following interview excerpt Jo details the methods uses in her science classroom. Jo explains, “I try to use all of them, everything from textbook or old school, to hands-on and experimentation. We use the computer, the computer lab, and technology.”

Next, a glimpse into Jo’s early Subject Matter Knowledge (SMK) was achieved through interview analysis. Jo’s science SMK was created from an interesting mixture of experiences. Her childhood experiences were positive. For example, she feels that learning about science in her father’s photography lab were “really neat.” However, Jo describes her college training in the area of science as poor. Jo notes that she was basically given a textbook and does not remember anything hands-on. She was told to read and then she was tested. Undergraduate science courses typically convey science as
a group of specifics and sets of laws to be memorized, instead of as a way of knowing about the natural world (NRC, 1998). Jo’s early college experiences support this statement. Fortunately, Jo notes some of her more recent training experiences were “really neat” and “awesome.” Jo reported that she recently took an integrated mathematics and science class at a local community college. She recalls making light shadows and learning a lot about the difference between experimentation and a scientific observation.

A glimpse of Jo’s Shared Identity (SI) was also obtained through interview analysis. Jo acknowledged that her teammates, her administration, her students, Milton County School System’s curriculum map, Milton County School System’s curriculum framework, Milton County School System’s benchmark tests, and past Virginia SOL data have influenced her choice of science teaching methods. Jo believes support from her administration and grade level team is positive. Jo’s pre PSI Professional Development Course interview data showed that she is influenced by her teammates, including her CF, Ariel. Jo indicates that she feels that within her team, “We share ideas. Ariel and I share a lot. We plan activities together.” Jo states that her administrators, “Pretty much let us do and trust that we do what we feel will best help the children learn.”

Jo’s students also have an influence on her choice of science teaching methods. In her pre PSI Professional Development Course interview analysis, Jo explains that she uses methods in her teaching that assisted in her learning as a student, for example, participating in visual and hands-on activities and making connections to her life. In her goal statement Jo believes getting the students activity engaged will increase retention. She explains, “I want to learn how to implement inquiry in my science teaching to get all
the kids engaged and enjoying the activities to increase retention of the lessons objectives.” Pre PSI Professional Development Course interview data showed that Jo is motivated to choose teaching methods because she “believes the kids will like them.” She feels that, “Usually, if I like something then I’m motivated and I’m up and raring’ to go and that gets them up, and sometimes too much up, which I found out. Sometimes I’ve got to tame myself down. I’m serious.” Pre PSI Professional Development Course interview data showed that Jo’s choice of teaching methods is motivated by her students. Post PSI Professional Development Course interview data supports these ideas. In her post PSI Professional Development Course interview, Jo stated that she is motivated to choose I-B methods or activities because, “Students usually seem to become totally involved with their own learning.” Jo repeated the idea when answering a question about what motivates her to keep going in the face of possible barriers. She thinks of “the students” when deciding which science teaching methods to use in her classroom. Jo exclaims, “They are so in to it!”

Following the staff development, Jo reported that “the curriculum framework” influences what she teachers. She believes that the most important science concepts for students to understand by the end of the school year are the concepts listed in the “framework.” She further discloses that she is influenced by Milton County School System’s “curriculum map, curriculum framework, benchmark tests and past [Virginia] SOL data.” These ideas are reinforced as Jo relates the reason she signed up for the professional development class in her pre PSI Professional Development Course interview in the following excerpt.
To improve the way I teach science, to learn about the Inquiry Method. That’s one of those ways to know. I’m sure there are other ways. I went online and tried to find out what is this going to be about, so I’m excited about that. I was very unhappy with the Benchmark scores so I knew that my methods were failing, so I need to do something to improve that.

In summary, interview data revealed that Jo makes choices about which methods to use to teach science based on the influences of: teammates, administration, her students, the county curriculum map, the curriculum framework, benchmark tests, and past SOL data. She gets excited when her students become involved with their own learning.

*Jo’s Partner Portfolio for Professional Development*

Pieces from Jo’s Partner Portfolio for Professional Development were studied to provide triangulation of multiple data sources (Yin, 2003). This included Jo’s (a) post PSI Professional Development Course lesson plan, (b) Invitation to Practice: Science Learning Personal History, (c) the post PSI Professional Development Course lesson plan, and (d) the journal entry titled “What is Inquiry?” This investigation leads to a more meaningful understanding of Jo’s perceptions as they relate to Teacher Choice (TC) as framed by her mental models, conceptions of science subject matter, and barriers related to teaching and learning. Throughout the duration of this study Jo reflected on her own education and teaching experiences, analyzed what she learned during the staff development training and made decisions whether or not to implement those ideas based on her own system of values. Following the pattern for data analysis used for the pre PSI Professional Development Course interview analysis, data analysis consisted of a study of Jo’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI).
Interview analysis gave the researcher a view of Jo’s Individual Identity (II). In summary, Jo learns when she is actively engaged or participating in hands-on activities. Jo describes her teaching style by explaining she “likes structure and boundaries in her science classroom so that children feel safe.” She often allows her students to have fun and will stray from the schedule if the students are still asking questions or investigating. Jo feels comfortable using all methods in her science classroom. Partner Portfolio data from Jo’s Science Learning Personal History supports Jo’s belief that she learns when she is actively engaged or participated in hands-on activities. The following excerpt about Jo’s experiences while learning about colors shows how Jo views herself as a learner. She feels she “learned because it was visual and hands-on.” Jo uses many of the methods that helped her learn in her own teaching. As noted in Research Question 4 analysis, this excerpt from post PSI Professional Development Course interview data illustrates Jo’s beliefs about science teaching methods and how children learn science.

In science they’ll remember the hands-on things we did. They’ll remember the edible cells, the ocean floor, things like that, projects. Things that I did back when I was little, those are the kinds of things I remember, the activities that we did.

Pre PSI Professional Development Course interview data showed that Jo chooses the methods that helped her learn and applies them in her own classroom. She prefers methods where students are actively engaged or participated in hands-on activities throughout the learning process.

Partner Portfolio analysis supported and extended previous findings related to Jo’s Subject Matter Knowledge (SMK). Excerpts from Jo’s pre PSI Professional Development Course interview analysis revealed that Jo experienced a wide mixture of science experiences. Her childhood experiences were positive; however, Jo describes her college
training in the area of science as poor. More recent training included activities that were “really neat” and “awesome.” Jo is interested in improving as a teacher through “implementation of inquiry” into her “science teaching to get all the kids engaged and enjoying the activities to increase retention of the lessons objectives.” In an Exit Slip, Jo notes that she found information about helping “students choose investigable questions” helpful. She was also hopeful that she could “pull the 5E’s together.”

As noted in pre PSI Professional Development Course interview data from Research Question 3 analysis, Jo worried that a lack of subject knowledge might present itself as a barrier to the implementation of I-B methods. Jo stated, “my own lack of knowledge. That would be a major one, just not prepared as well as I’d like to be.” Would this lack of knowledge of science subject matter have an influence on Jo’s implementation of I-B methods? Jo noted that her knowledge of subject matter was not an influence on her decision to use I-B methods in her science classroom. In a journal entry excerpt that follows Jo reveals that her knowledge of subject matter was not an influence on her decision to use I-B methods in her science classroom.

My memory of knowledge gained in the past often fails me. Therefore, I often have to go back and relearn the material before I teach certain academic areas. When planning the mini unit I had the opportunity to “refresh” my memory so it was not a barrier. Plus, I am really into fossils so it was minimal refreshing!

In summary, Jo did not feel that her knowledge of science subject matter served as a barrier to the implementation of I-B methods into her science classroom.

Data from interview analysis related to Jo’s Shared Identity (SI) revealed that Jo believed her administrators and grade level team had an influence on her choice of science teaching methods. Jo writes during her Invitation to Practice: Collaboration
activity that she feels she can help her CF in the area of science instruction by “sharing ideas and materials” and “possibly team teach on certain lessons.” In turn, she noted in an Exit Slip, “My critical friend was very helpful.”

A large motivator or influence on Jo’s choice of teaching methods is her students. Pre PSI Professional Development Course interview data showed that Jo is motivated to choose science teaching methods because she “believes the kids will like them.” In her post PSI Professional Development Course interview Jo stated that she is motivated to choose I-B methods or activities because, “students usually seem to become totally involved with their own learning.” These ideas are further enforced by Jo’s statement in the post PSI Professional Development Course interview that she is motivated to overcome barriers “because the students really seem to become totally involved with their own learning.” Partner Portfolio data supports Jo’s beliefs it is important for students to investigate and discover on their own. In her Invitation to Practice: Mapping My Classroom activity, Jo writes that she feels others might see her “as a facilitator leading them across bridges making discoveries along the way.”

*Summary of Jo’s Results for Research Question 5*

Information was used to study Jo’s choices in an attempt to disclose methods that encourage teachers like her to overcome resistance to implementing I-B teaching practices. Jo made choices about her preferences of teaching methods by assessing the value of the options available to her and deciding upon a course of action based on her own conceptual framework. Data analysis for Research Question 5, “How do teachers choose to use I-B methods as opposed to teacher-centered activities?” consisted of an examination of Jo’s conceptual framework made up of her Individual Identity (II),
Subject Matter Knowledge (SMK), and Shared Identity (SI). Partner Portfolio analysis supported previous findings related to Jo’s Individual Identity (II). Excerpts from Jo’s pre PSI Professional Development Course interview analysis, supported by secondary data, showed that Jo describes her teaching style by saying that “she likes structure and boundaries in her science classroom so that children feel safe.” She repeatedly allows her students to have fun and will stray from the schedule if the students are still asking questions or investigating. Jo feels comfortable using all methods in her science classroom. She learns when she is actively engaged or when she is participating in hands-on activities. Analysis of data uncovered information related to Jo’s Subject Matter Knowledge (SMK). Jo had a wide mixture of science experiences. Her childhood experiences were positive; however, Jo describes her college training in the area of science as poor. More recent training included activities that were “really neat” and “awesome.” Data from interview analysis related to Jo’s Shared Identity (SI) revealed that Jo believed support from her administration and grade level team was positive and that they had a large influence on her choice of science teaching methods. In conclusion, Jo acknowledged that her CF and her teammates, her students, the curriculum map, the curriculum framework, benchmark tests and past SOL data influenced her choice of science teaching methods.
Teacher Portrait T1 - Liz

I next present the data to answer the query, “Who is Liz?” This teacher portrait is described as it aligns with each research question. Data that yields information related to each question was analyzed. A discussion of the findings for each question is presented.

Research Question 1 Analysis

What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?

Liz’s Interview Analysis: Pre and Post Professional Development Course

The following data proved useful in providing insights about Research Question 1: (a) Liz’s pre PSI Professional Development Course interview, (b) STEBI survey, (c) CLES survey, (d) Liz’s Partner Portfolio for Professional Development, and (e) Liz’s post PSI Professional Development Course interview. This information was utilized to examine Liz’s beliefs in an effort to uncover patterns that influence her teaching behavior as it relates to her Individual Identity (II). Individual Identity (II) is defined as the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfield, 1998) that represents autonomy or personal constructs (Scribner et al., 2002). Liz’s Interview Codes and Transcript Statements for Research Question 1 are located in Table 10.
### Table 10

*Interview Codes and Transcript Statements for Liz (T3) Pre and Post – Research Question 1.*

<table>
<thead>
<tr>
<th>Beliefs about learning and teaching science</th>
<th>Beliefs About How Children Learn Science</th>
<th>Beliefs About Science Teaching Methods</th>
</tr>
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<tbody>
<tr>
<td><strong>Pre:</strong> I really cannot remember any particular science lesson I had in school. I mean, obviously I was taught science, I don’t remember that as being a subject that teachers really focused on. I’ve always been fascinated with science. I mean I did learn things from school, but I can’t tell you particular science that I learned at different grade levels. Probably most of my science knowledge came from a love of science. I was always outside. I was always investigating something in nature, bringing things home, growing this, or raising that. The science background that I remember is all of the investigating that I did. … (Memory) (See &amp; Do)</td>
<td><strong>Pre:</strong> As far as getting outside and learning, we do go outside a lot. I bring things from the outside into the classroom a lot. Sometimes we just can’t go out and do. I think just having a lot of science and hands-on things lying around is important. I like kids discovering things. I feel like I bring a lot of that in to the kids. I don’t think you can teach science out of a book. There is just too much going on that they really need to discover. That’s what I’ve always enjoyed doing. (Extend Learning) (Hands-on) (Investigating)</td>
<td><strong>Pre:</strong> Well I think sometimes I am unorganized. But I have my own type of organization…I think I’m very active. I think I’m encouraging. I like to think that I’m helping the kids learn in ways that maybe they haven’t before. I like to extend their learning…I like doing the higher level thinking activities with the kids and I think science gives you a real good way to use that. I think the other kids benefit too. I have, especially this year, some really smart kids, and they came up with all sorts of connections with things… (Organization) (Actively Involved) (Extend Learning)</td>
</tr>
<tr>
<td><strong>Pre:</strong> I think most teachers probably teach the way they like to learn.”</td>
<td><strong>Post:</strong> I have always used inquiry skills in teaching science because I think that is most often the best way to teach and learn science.” (Investigating) (Variety of Methods)</td>
<td><strong>Post:</strong> Students should know how to set up and perform an experiment and be able to make conclusions about the results. They should also be able to use tools such as: balance, thermometer, meter and centimeter in measuring tools, and hand lenses. (Process Skills)</td>
</tr>
<tr>
<td><strong>Pre:</strong> love of science</td>
<td><strong>Post:</strong> We did fun things in science. I learned to love science. Science is more exciting than I realized. (Emotions)</td>
<td></td>
</tr>
</tbody>
</table>
Data were utilized to examine Liz’s beliefs about teaching science, how children learn science, and science teaching methods to uncover patterns that influence her teaching behavior as it relates to autonomy or her Individual Identity (II). Data analysis started with an examination of Liz’s memories of her early schooling. Growing up, Liz doesn’t remember science as being a subject that her teachers really focused on. She attributes most of her science learning as coming from her fascination with science. She remembers always being outside investigation something in nature, bringing things home, growing this or raising that.

Liz doesn’t recall science as being a subject that her teachers really focused on when she was in school. She feels most of her science learning comes from her fascination with or love of science. This excerpt from the pre PSI Professional Development Course interview shows what Liz remembers about science learning while growing up.

I really cannot remember any particular science lesson I had in school. I mean, obviously I was taught science, I don’t remember that as being a subject that teachers really focused on. I’ve always been fascinated with science. I mean I did learn things from school, but I can’t tell you particular science that I learned at different grade levels. Probably most of my science knowledge came from a love of science. I was always outside. I was always investigating something in nature, bringing things home, growing this, or raising that. The science background that I remember is all of the investigating that I did. Now maybe it was spurred by some teachers who were really into science and led me into that direction, but I can’t remember any particular class, lessons or anything. That’s because I’m old too.

Liz remembered learning when she was actively engaged or investigating throughout the learning process. She remembers being outside, growing, and investigating things. Liz’s learning style follows the constructivist approach to how people learn. She learned best when provided with the opportunity to participate in relevant experiences and
opportunities that allowed her to construct knowledge (Piaget, 1929; Vygotsky, 1978). During her teacher preparation in college, Liz spent a lot of time simply going to classes and reading the book. Ten years before this study, Liz participated in a PSI Professional Development Course where teachers were able to go outside, play games, and look at ways of investigating things. This really showed her ways to teach science and make connections with math. She has also gotten good ideas from county staff development courses.

A teacher’s principles or attitude, her tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do (Souza Barros & Elia, 1998). Liz’s statements support this assertion. Liz explains, “I think most teachers probably teach the way they like to learn.” Liz feels a “love of science.” This excerpt from the pre PSI Professional Development Course interview shows how Liz models methods from her own past learning experiences in her classroom.

As far as getting outside and learning, we do go outside a lot. I bring things from the outside into the classroom a lot. Sometimes we just can’t go out and do. I think just having a lot of science and hands-on things lying around is important. I like kids discovering things. I feel like I bring a lot of that in to the kids. I don’t think you can teach science out of a book. There is just too much going on that they really need to discover. That’s what I’ve always enjoyed doing.

Liz brings things from the outside into her classroom. She allows her students to explore and discover. The excerpt that follows from the pre PSI Professional Development Course interview reveals how Liz describes herself as a classroom teacher.

Well I think sometimes I am unorganized. But I have my own type of organization. People can ask me for something and I can go right to it. I can find it for somebody. I think I’m very active. I think I’m encouraging. I like to think that I’m helping the kids learn in ways that maybe they haven’t before. I like to
extend their learning. I really like having higher thinking kids, the gifted kids. I've got an endorsement in gifted education too. That's an area that I am pursuing. I may get out and do that at one point. I like doing the higher level thinking activities with the kids and I think science gives you a real good way to use that. I think the other kids benefit too. I have, especially this year, some really smart kids, and they came up with all sorts of connections with things. I mean I learned through them. Certainly, I am very open to kids teaching me.

In summary, pre PSI Professional Development Course interview data showed that Liz learned best while actively investigating, especially things outside in nature. She teaches the way she likes to learn. Liz has her own way of organizing things. She is active and encouraging. She likes to extend learning and encourage higher levels of thinking for her students. Liz feels that she often learns from her students.

In the post PSI Professional Development Course interview data more of Liz’s beliefs are revealed. Liz shares and example that illustrates her beliefs about science teaching methods and how children learn science. Liz explains, “I have always used inquiry skills in teaching science because I think that is most often the best way to teach and learn science.” In her post PSI Professional Development Course interview excerpts Liz shares an example that she believes shows us the importance of allowing students to set up and perform experiments, make conclusions, and use scientific tools.

Students should know how to set up and perform an experiment and be able to make conclusions about the results. They should also be able to use tools such as: balance, thermometer, meter and centimeter in measuring tools, and hand lenses. Liz likes to see her students enjoying science. The following excerpt shows her feelings related to what she believes her students value. She believes her students would say they really liked her class because, “We did fun things in science. I learned to love science. Science is more exciting than I realized.”
In summary, data from the pre PSI Professional Development Course interview revealed information about Liz’s conceptual framework related to science teaching. The researcher analyzed data in an attempt to discover what Liz believes about how children learn science and science teaching methods, including her conceptions of how children learn and her own view of effective science teaching. Liz learned best while actively investigating, especially objects outside in nature. She teaches the way she likes to learn. Her teaching approach is active and encouraging. She enjoys extending learning and promoting higher levels of thinking for her students. Liz feels that she often learns from her students. Data from the post PSI Professional Development Course interview showed that Liz uses inquiry skills, and believes it is important for students to set up and perform experiments, make conclusions, and use scientific tools. Liz takes pleasure in seeing her students enjoying science.

Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post

Liz’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the high efficacy category, with 62 points and 59 points respectively (max=65 points) (see Figure 5). Therefore, she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased notably, with 47 (high OE) points to 41 (average OE) points (max=60 points); indicating she had a decrease in her confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).
Figure 5. Liz’s STEBI Scores

Constructivist Learning Environment Survey – CLES Analysis Pre and Post

The CLES Personal Relevance scale relates to students’ experience of the personal relevance of school science as perceived by teachers (Suters, 2004; Taylor et al., 1997). Liz’s pre (32) and post (29) CLES Personal Relevance scores were in the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences (see Figure 6). There was a decrease in score indicating that after participation in the PSI Professional Development Course Liz placed slightly less emphasis on linking school science with students’ everyday experiences.

The CLES Scientific Uncertainty scale relates to students’ perceptions of science as a fallible human activity as perceived by teachers (Suters, 2004; Taylor et al., 1997). Liz’s pre (19) and post (22) CLES Scientific Uncertainty scores increased slightly from a low intermediate agreement score to a high intermediate agreement score, which
indicated that after participating in the PSI Professional Development Course she placed more emphasis on engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values.

The CLES Critical Voice scale relates to students development as autonomous learners, through creation of a social climate in which students feel that their learning is legitimate and beneficial (Suters, 2004; Taylor et al., 1997). Liz’s pre (23) and post (22) CLES Critical Voice scores were both in the high intermediate agreement range. This indicated that students sometimes but not always were encouraged to question Liz’s plans and methods and express concerns about impediments to their learning. Pre PSI Professional Development Course interview data showed Liz brings things from the outside into her classroom. She allows her students to explore and discover.

The CLES Shared Control scale also relates to student autonomy. This scale is concerned with students sharing control of the classroom-learning environment with their teacher (Suters, 2004; Taylor et al., 1997). Liz’s pre (20) and post (17) CLES Shared Control scores dropped, both were in the low intermediate agreement range. This is an indication that her students are sometimes invited to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom.

The CLES Student Negotiation scores relate to teacher beliefs as they relate to student interaction with other students (Suters, 2004; Taylor et al., 1997). Liz’s pre (26) and post (25) CLES Student Negotiation scores were both in the high intermediate
agreement range. This is an indication that she often but not always provided opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas.

Last, the Attitude Scale scores provide a measure of the concurrent validity of the CLES. It is used to measure teachers’ interpretations of students’ attitudes towards the classroom environment (Suters, 2004; Taylor et al., 1997). Liz’s pre (30) and post (29) CLES Attitude Scale scores were in the high agreement range which indicated that she felt students: anticipated the activities within her classroom; found activities worthwhile; and understood and analyzed the activities. Pre PSI Professional Development Course data supports the idea that Liz likes to see her students enjoying science. She believes her students would say they really liked her class because “we did fun things in science. I learned to love science. Science is more exciting than I realized.”

![Figure 6. Liz’s CLES Scores](image)

*Figure 6. Liz’s CLES Scores*
**Liz’s Partner Portfolio for Professional Development Analysis**

Teachers were given the opportunity to reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006) throughout the PSI Professional Development Course. The researcher examined five products produced by Liz: (a) Invitation to Practice: Science Learning Personal History, (b) Invitation to Practice: Collaboration, (c) pre PSI Professional Development Course lesson observation, (d) personal goal for the PSI Professional Development Course, and (e) journal entries to confirm the previously mentioned data findings from the interview sessions. *Liz’s Partner Portfolio for Professional Development Analysis* findings, along with the STEBI and CLES data, serves as triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).

A framework for organization formed through reflection upon Liz’s interview excerpts related to her beliefs about teaching science. Liz’s interview excerpts showed that she learns best while actively investigating, especially things outside in nature. An excerpt from her Invitation to Practice: Science Learning Personal History (see Appendix G) activity supported the idea that Liz believes she has a difficult time with both learning and teaching when she or her students are not observing or being actively involved.

One of the more difficult concepts I’ve had to learn and try to teach is photosynthesis in plants. It is a difficult concept to understand and a challenge to teach because it is abstract and involves a type of chemical process which you cannot really see [observe] happening. I am not sure that I do understand it well enough to be able to teach it and answer some questions that students ask me about it. I don’t like to answer questions by saying “it just does…that’s why.”
Reflecting upon her own science teaching and learning, Liz notes that she thinks, “Most teachers probably teach the way they like to learn.” In one of her Partner Portfolio for Professional Development journal entries she explains that she learns when “sharing ideas with others and being open-minded.”

Data analysis was conducted to investigate Liz’s beliefs about how children learn science. In post PSI Professional Development Course interview excerpts Liz explains, “I have always used inquiry skills in teaching science because I think that is most often the best way to teach and learn science. I hope to incorporate more inquiry in my science lessons.” Thoughts in her Invitation to Practice: Mapping My Classroom support the statement made by Liz. In her reflections Liz writes that she wishes to “implement more Inquiry-Based instruction” into her classroom. Data from Liz’s goal statement concurs. In her goal for the PSI Professional Development Course Liz states, “I want to leave here with some great ideas to use and improve my science instruction this year.” Her post PSI Professional Development Course interview excerpts show that after the PSI Professional Development Course Liz indicated that she believes she knows that her students understand a concept when “he or she demonstrates the ability to take what he or she has learned and make connections with the world.” Data from the CLES also supports this idea. Liz’s CLES Personal Relevance scores, pre (32) and post (29), were in the high agreement range, which indicated that she placed a high emphasis on linking school science with students’ everyday experiences (see Figure 6) Interestingly, there was a decrease in Liz’s post CLES Personal Relevance score indicating that after participation in the PSI Professional Development Course Liz placed slightly less emphasis on linking school science with students’ everyday experiences (Suters, 2004; Taylor et al., 1997).
Liz’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (62) and post (59) assessments also decreased. In post PSI Professional Development Course interview excerpt Liz discusses curriculum guidelines at the local and state level that influence the way she teaches. She states that she is “required to follow the county curriculum map and [Virginia] SOL.” After the professional development course she discusses how she decides to move from one concept to another. Liz feels, “Unfortunately, I can only take so much time to teach a concept. I must follow the curriculum map and have students ready to take benchmark tests.” Liz is feeling increased pressure from time constraints imposed by curriculum guidelines, such as local and state standards. This might explain the decrease in her STEBI and CLES scores.

Data analysis was conducted to investigate Liz’s beliefs about science teaching methods. In the pre PSI Professional Development Course interview Liz reveals details about her science teaching methods. One excerpt lists examples of the methods Liz generally uses to teach science.

I use inquiry and investigation, hands-on, I do a lot of that. I use questioning, with me questioning them, and with them questioning me. My lessons are activity based. We play games in science. I even bring PE into it. We’ll take something we’re learning in science and it becomes a relay race or something outside. That’s really fun for the kids and you can kind-of do PE and science at the same time. That’s your PE for the day but you were also doing another 20 minutes of science! That’s fun to do to.

Liz uses a variety of methods in her science teaching. Liz uses inquiry, investigation, questioning, hands-on, and activity-based methods her lessons. Her CLES Attitude Scale scores, pre (30) and post (29), were in the high agreement range, which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997).
Tying it all together, Liz’s interview excerpts revealed that she uses inquiry, investigation, questioning, hands-on, and activity-based methods her science lessons. Data from her Invitation to Practice: Collaboration supported this idea as an excerpt showed that both Liz and her CF, Lucy, used hands-on methods in their science teaching. In an Exit Slip journal entry Liz notes that she would like to learn ideas for “time management so that I can balance inquiry and directed teaching to get everything done in the time allotted.” Her CLES Shared Control scores, pre (20) and post (17), supported this statement as it indicated that her students are sometimes invited to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom (Suters, 2004; Taylor et al., 1997). Available science instructional time may limit the amount of freedom students in Liz’s class are given to design their own activities and negotiate what goes on in the classroom. As noted in a previous paragraph, Liz feels, “Unfortunately, I can only take so much time to teach a concept. I must follow the curriculum map and have students ready to take benchmark tests.”

**Summary of Liz’s Results for Research Question 1**

Research Question 1 solicits an answer to the following: “What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?” Liz’s interview excerpts disclosed knowledge about her conceptual framework for science teaching. Liz discovered that she learns when she is actively engaged or investigating throughout the learning process. As a student, she remembers being outside, growing, and investigating things. She teaches science the way she likes to
learn. Her teaching approach is active and encouraging. Liz makes use of inquiry skills and promotes higher levels of thinking for her students in her science classroom. She believes it is important for students to set up and perform experiments, draw conclusions, and use scientific tools. Liz feels that she often learns from her students and takes pleasure in seeing her students enjoying science. Liz’s CLES Personal Relevance scores, pre (32) and post (29), for the pre PSI Professional Development Course and post PSI Professional Development Course assessments both fell in the high agreement range, which indicated that she placed a high emphasis on linking school science with students’ everyday experiences. The scores also indicated that Liz placed slightly less emphasis on linking school science with students’ everyday experiences after the PSI Professional Development Course. This decrease in scores might be attributed to constraints imposed on science instruction time due to increased pressure from curriculum guidelines, such as local and state standards.

In summary, Liz learns best while actively investigating, especially things outside in nature. Reflecting upon her own teaching and learning experiences, Liz believes that “most teachers probably teach the way they like to learn.” When teaching science in her classroom, Liz uses inquiry, investigation, questioning, hands-on, and activity-based methods her science lessons. She explains that she wishes to “implement more Inquiry-Based instruction” into her science classroom; however, Liz is feeling increased pressure from curriculum guidelines, including local and state standards. She feels increasing pressure and believes she “must follow the curriculum map and have students ready to take benchmark tests.”
Research Question 2 Analysis

How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

Interview analysis (see Appendix B for instrument) for Research Question 2 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, and 8 listed in Table 1, (b) post PSI Professional Development Course interview questions 3 and 4, (c) classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (d) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), (e) CLES analysis (see Appendix D1 for instrument and D2 for scoring instructions), as well as the teacher’s individual (f) Partner Portfolio for Professional Development. The researcher utilized this data in order to examine the way in which Liz perceives herself or describes her own abilities to produce desired or intended results in her science classroom. This information was also drawn upon to describe Liz’s Subject Matter Knowledge (SMK). Subject Matter Knowledge (SMK) is defined as the teacher’s knowledge of content matter and pedagogy (the art of being a teacher), along with her curriculum knowledge (Shulman, 1986). Last, the researcher analyzed the data to reveal information related to Liz’s understanding of I-B methods. In other words, the researcher has assembled all of the pieces to answer the teacher’s query, “How does Liz describe her abilities to produce desired or intended results in her science classrooms? What does Liz believe about her science content knowledge and her pedagogical science knowledge? What does Liz understand about I-B methods?”
Liz’s Interview Analysis: Pre and Post Professional Development Course

Pre PSI Professional Development Course interview data provided information to create a picture to describe Liz’s framework for understanding science and her ability to produce desired results according to her beliefs and self-efficacy. In her pre PSI Professional Development Course interview, Liz defines science as “investigation, questioning everything I have to teach, SOL tests, applying science concepts to their lives.” Information about Liz’s knowledge of content information was revealed previously in Research Question 1 analysis. The researcher learned that Liz doesn’t remember science being a subject that her teachers targeted as a focus of their instructional attention. Liz reported that she remembers spending a large amount of time in college reading out of a book. Although her schooling experiences were not memorable, Liz remembers learning through investigation outside of school by experimenting with the natural world. Liz spoke about a number of learning explorations where she grew plants. Liz explained that the majority of her content knowledge was acquired through her curiosity with the natural world and self-led explorations.

To create a picture to describe Liz’s framework for understanding science and her ability to produce desired results according to her beliefs and self-efficacy, data analysis includes: an examination of Liz’s description of her own efficacy, an examination of Liz’s description of her own framework for understanding science content and teaching methods, and a description of her own framework for understanding I-B methods. Interview codes and transcript statements for Liz’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions for Research Question 2 are listed in Table 11.
Table 11

Interview Codes and Transcript Statements for Liz (T3) Pre and Post – Research Question 2.

**Self-Efficacy Related to:**

<table>
<thead>
<tr>
<th>Understanding of Science Content</th>
<th>Teaching Methods</th>
<th>Definition of science and Inquiry science</th>
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<tr>
<td>Pre: “I really cannot remember any particular science lesson I had in school. I mean, obviously I was taught science, I don’t remember that as being a subject that teachers really focused on. I’ve always been fascinated with science. So, probably most of my science learning, I mean I did learn things from school, I can’t tell you particular science that I learned at different grade levels. But, probably most of mine came from a love of science. I was always outside. I was always investigating something in nature, bringing things home, growing this, or raising that…I can’t remember any particular class, lessons or anything. That’s because I’m old too.” (Sit n’ Git) (Love) (Positive Influences)</td>
<td>Pre: “I use inquiry and investigation, hands-on, I do a lot of that. I use questioning, with me questioning them and with them questioning me. My lessons are activity based. We play games in science. I even bring PE into it. We’ll take something we’re learning in science and it becomes a relay race or something outside. That’s really fun for the kids and you can kind-of do PE and science at the same time. That’s your PE for the day but you were also doing another 20 minutes of science! That’s fun to do to.” (Methods)</td>
<td>Pre: Liz defines Science as “investigation, questioning everything I have to teach, SOL tests, applying science concepts to their lives.” (Components-Science)</td>
</tr>
<tr>
<td>Pre: “Again that’s the way I’d like to learn. If it’s boring to me it’s probably boring to them. I take any chance to get out and do something, not just to sit there. I like to be active too; it’s just more fun.” (Motivation)</td>
<td>Pre: “I know if they understand a science concept if they make a connection to something else and bring that back in and share it. You can tell they understand it because they made that connection. If they can explain it to someone else. If they can take what they’ve learned and go beyond that then you know that they’ve grasped that concept and they’ve made a connection to something being a little bit further.” (Methods) (Apply or Connect)</td>
<td>Pre: “I take that [I-B methods] to mean you’re exploring, you’re investigating things. You are taking the unknown and learning a little more about what you don’t know. Or making connections to things that were not there before.” (Components-Inquiry)</td>
</tr>
<tr>
<td>Post: In her post PSI Professional Development Course interview Liz added, “Using investigative methods to learn science concepts,” to her definition of inquiry science. (Method)</td>
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Data analysis began with an examination of Liz’s description of her own efficacy, her ability to produce a desired or intended result. During this analysis, we learned that Liz remembers always being outside investigation something in nature, bringing things home, growing this or raising that. During her teacher preparation in college, Liz spent a lot of time simply going to classes and reading the book. Liz also participated in a staff development session where teachers were able to go outside, play games, and look at ways of investigating things. The factors of fear, knowledge, and affect as determined by the teachers’ cognitive framework help shape the teachers’ actions (Senge, 1990). In this excerpt from Liz’s pre PSI Professional Development Course interview, she talked about fears related to getting things done in time and how she would like to improve as a teacher.

I’d like to improve, probably, organization and time management. That’s probably another one because sometimes I don’t feel I have enough time to get things done or I’m running behind on things I wanted to finish before. So, I say probably those are things that I would like to improve.

In summary, Liz attributes most of her science learning as coming from her fascination with science. She feels a “love of science.” Liz is interested in improving her organization and time management skills because she fears not having enough time to get things done. Liz is not fearful of science; however, she is fearful of time constraints.

Data analysis continued with an examination of Liz’s description of her own framework for understanding science content and teaching methods. As detailed in Research Question 1 analysis, in the pre PSI Professional Development Course interview Liz reveals details about her teaching methods. One excerpt lists examples of the methods Liz generally uses to teach science.
I use inquiry and investigation, hands-on, I do a lot of that. I use questioning, with me questioning them and with them questioning me. My lessons are activity based. We play games in science. I even bring PE into it. We’ll take something we’re learning in science and it becomes a relay race or something outside. That’s really fun for the kids and you can kind-of do PE and science at the same time. That’s your PE for the day but you were also doing another 20 minutes of science! That’s fun to do to.

Liz further discloses the reason she uses inquiry, investigation, questioning, hands-on, and activity-based methods her lessons. An excerpt from her pre PSI Professional Development Course interview outlines her motivation.

Again that’s the way I’d like to learn. If it’s boring to me it’s probably boring to them. I take any chance to get out and do something, not just to sit there. I like to be active too; it’s just more fun.

The excerpt that follows describes how Liz knows when her students understand a concept.

I know if they understand a science concept if they make a connection to something else and bring that back in and share it. You can tell they understand it because they made that connection. If they can explain it to someone else. If they can take what they’ve learned and go beyond that then you know that they’ve grasped that concept and they’ve made a connection to something being a little bit further.

In summary, Liz uses inquiry, investigation, questioning, hands-on, and activity-based methods her lessons because that’s the way she would like to learn. She would like her students to have fun while they are learning and making connections to show understanding.

Last, data analysis focused on Liz’s description of her own framework for understanding I-B science methods. In her pre PSI Professional Development Course interview, Liz defines inquiry science as exploring, investigating, and making connections. Liz explains her definition further when she says, “I take that to mean
you’re exploring, you’re investigating things. You are taking the unknown and learning a little more about what you don’t know. Or making connections to things that were not there before.” Liz believes I-B methods involve exploring, investigating, and learning about the unknown.

In summary, Liz learned about science while being outside investigation something in nature, bringing things home, growing this or raising that. During her teacher preparation in college, Liz spent a lot of time simply going to classes and reading the book. Liz also participated in a staff development session where teachers were able to go outside, play games, and look at ways of investigating things. Liz learned best from the experiences that included investigation and active participation. Liz teaches science the way she likes to learn. Liz uses the techniques of inquiry, investigation, questioning, hands-on methods, and activity-based methods when teaching science lessons in her classroom. 

Classroom Observation Analysis: Pre and Post Professional Development Course

Researcher observations were completed in Liz’s science classroom on May 16, 2007 and August 31, 2007. Liz had a total of 24 students in each of her science classes during the pre PSI Professional Development Course and post PSI Professional Development Course observations. The demographics of the two classes observed for the pre and post PSI Professional Development Course observations are described in Table 12.
Table 12

_Liz’s Class Demographics Pre and Post Observations (T3)_

<table>
<thead>
<tr>
<th>Race</th>
<th>Pre (24)</th>
<th></th>
<th>Post (24)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>African American</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Caucasian American</td>
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<td>9</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Asian</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>14</strong></td>
<td><strong>10</strong></td>
<td><strong>13</strong></td>
<td><strong>11</strong></td>
</tr>
</tbody>
</table>

Data analysis includes a review of Liz’s interview and observation data followed by presentation of evidence related to the implementation of the forms inquiry as described by Martin-Hansen (2002). A review of the pre PSI Professional Development Course observation supports the pre PSI Professional Development Course interview data and suggests that Liz uses multiple methods while teaching one lesson. She uses inquiry, investigation, questioning, hands-on, and activity-based methods her lessons. A brief synopsis of the pre PSI Professional Development Course lesson is illustrated in this paragraph. In her lesson plan for the pre PSI Professional Development Course observation Liz started the lesson by calling on students to explain vocabulary terms. The next section of the lesson consisted of a discussion of safety rules and directions. Students next journeyed outside to the “Red Fox Trail.” Once outside students (a) checked on marigolds that they planted by the road sign, (b) looked for evidence of transpiration in baggies previously left on a tree, (c) measured and collected water in a graduated cylinder, and (d) collected leaves in a scavenger hunt fashion. Upon returning
to the classroom students used their science books to help identify the leaf traits. Liz took time to help students make connections between the vocabulary and the “real” world. Liz used a meter stick for a visual demonstration, allowed students to share samples and ask questions, and then glued the leaves to paper and labeled them.

Liz’s pre PSI Professional Development Course observation lesson was hands-on and activity based. The students followed directions to make observations and collected data to learn about transpiration using real trees outside in the schoolyard. Liz directed students to investigate ways to classify leaves using the textbook. Students also followed directions to gather leaves and classify them according to traits and characteristics. Liz allowed students to share leaf samples and encouraged them to ask questions. During the pre PSI Professional Development Course observation Liz asked students to follow specific directions exhibiting evidence of the use of Structured Inquiry, inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). Data from the pre PSI Professional Development Course observation verifies data from the pre PSI Professional Development Course interview that showed that Liz uses Structured Inquiry, investigation, questioning, hands-on, and activity-based methods her lessons.

Post PSI Professional Development Course observation Liz continued to use an assortment of teaching methods in each lesson, methods included: inquiry, investigation, questioning, hands-on, and activity based methods. As demonstrated in Liz’s lesson plans and pre PSI Professional Development Course observation data, she had already successfully implemented one form of inquiry as described by Martin-Hansen (2002), including Structured Inquiry. Structured Inquiry is inquiry based on teacher directed
methods and usually is not considered to be an authentic inquiry experience. Throughout the mini unit plan Liz gradually moved from Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design, to Coupled Inquiry, inquiry that starts as Structured Inquiry or Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002). The following excerpts from Liz’s mini-unit plan shows examples of Guided Inquiry and Coupled Inquiry.

We’ll go outside several times during the day. Students observe the sun and record their observations on a large poster of the sun. Students should wear the sunglasses they brought to school or the Sun Viewer to safely observe the sun. They should record observations about the physical description of the sun, the light and heat energy it provides, its change in position in the sky throughout the day, shadows.

Have students take off their shoes and observe temperature differences while walking across different surfaces (grass, sidewalk, blacktop, etc.) Observe differences in temperature felt by students wearing light and dark colored clothing. Students describe their observations in their science Journals.

As the lesson continued Liz lessoned teacher control by allowing students to design and build their own solar cooker.

Students work in groups to determine the speed [time] in which ice cubes will melt on different surfaces [grass, sidewalk, blacktop]. Ask students to predict the order in which they think the ice cubes will melt when placed on the different surfaces. Give each group several ice cubes to use to test each surface.

Liz allowed the students to choose their own surfaces and encouraged them to ask “what happens if?” questions related to their choice. Next, Liz lessoned teacher control by allowing students to design and build their own solar cooker.

Using materials provided, shoe boxes brought in by students, black paper, plastic wrap, and foil, students design and build a solar cooker to melt chocolate to design and build a solar cooker to melt chocolate to make a S’More. Students will work in pairs or small groups to design and make their solar cooker.
In summary, the researcher observed evidence of Full or Open inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). In the post PSI Professional Development Course observation as students created “what happens if?” questions throughout the design process while creating their solar cookers.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

As noted in Research Question 1 analysis, Liz’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the high efficacy category, with 62 points and 59 points respectively (max=65 points). Therefore, she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased notably, with 47 (high OE) points to 41 (average OE) points (max=60 points); indicating she had a notable decrease in her confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Liz’s Partner Portfolio for Professional Development Analysis.*

*Constructivist Learning Environment Survey – CLES Analysis Pre and Post*

As noted in Research Question 1 analysis, Liz’s pre (32) and post (29) CLES Personal Relevance scores were in the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences. There was a decrease in score indicating that after participation in the PSI Professional Development Course Liz placed slightly less emphasis on linking school science with
students’ everyday experiences. Her pre (19) and post (22) CLES Scientific Uncertainty scores increased slightly from a low intermediate agreement score to a high intermediate agreement score, which indicated that after participating in the PSI Professional Development Course she placed more emphasis on engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. Her pre (23) and post (22) CLES Critical Voice scores were both in the high intermediate agreement range and indicated that students sometimes but not always were encouraged to question Liz’s plans and methods and express concerns about impediments to their learning. Her pre (20) and post (17) CLES Shared Control scores dropped, both were in the low intermediate agreement range, which indicated that her students are sometimes invited to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom. Liz’s pre (26) and post (25) CLES Student Negotiation scores were both in the high intermediate agreement range which indicated that she often but not always provided opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas. Her pre (30) and post (29) CLES Attitude Scale scores were in the high agreement range which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (Suters; 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Liz’s Partner Portfolio for Professional Development Analysis.
**Liz’s Partner Portfolio for Professional Development Analysis**

The Partner Portfolio for Professional Development was utilized to hold Liz’s reflections and permitted the opportunity for her to manage her thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Liz’s (a) Goal Statement, (b) Exit Slips, and (c) journal entries were analyzed to confirm the earlier mentioned data findings. This examination offers a triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).

Data analysis for points of triangulation started with an examination of Liz’s description of her own efficacy and ability to produce a desired or intended result. During pre PSI Professional Development Course interview data analysis we learned that Liz learned about science concepts from being outside investigation something in nature, bringing things home, growing this or raising that. Liz spent a lot of time simply going to science classes and reading the science book during her teacher preparation in college. Liz attended a science staff development course where teachers were able to go outside, play games, and look at ways of investigating things. Liz’s STEBI Personal Science Teaching Efficacy Belief subscale scores, pre (62) and post (59), indicated she was comfortable with her ability to teach science (Riggs, 1988; Riggs & Enochs, 1990). Liz’s science lesson for the pre PSI Professional Development Course observation contained activities that involved the students traveling outside to collect leaves, observe evidence of transpiration, and check on the progress of flowers that they planted in an earlier lesson. The students also used the science textbook during the lesson learn about scientific vocabulary terms. Liz’s lesson plans in her science mini unit contained
activities that involved the students traveling outside to conduct investigations, such as: observing light and heat energy of the sun, recording the change in position of the sun several times during the day, noticing shadows, observing temperature changes while walking across different surfaces [grass, sidewalk, blacktop], and melting ice cubes on different surfaces. In her Invitation to Practice: Science Learning Personal History Liz wrote that she has a difficult time teaching science concepts that are “abstract” or those that students “cannot really see [observe] happening” like photosynthesis. Liz wasn’t really sure that she understands “it [photosynthesis] well enough to be able to teach it and answer some questions that students ask” her “about it.” In summary, Liz teaches science the way she learns, she encourages and guides her students to venture outside and engage in exploration and observation of events and items in nature. She emphasizes vocabulary using the science textbook. She feels comfortable teaching science to the students in her classroom.

Pre PSI Professional Development Course interview data showed that Liz would like to enhance her science teaching abilities. The following excerpt from Liz’s Goal Statement in her Partner Portfolio for Professional Development supported the idea that Liz would like to improve as a science teacher. Liz explains, “I want to leave here with some great ideas to use and improve my science instruction this year.” She continued to explain that she wanted to learn how she could use “inquiry more often and successfully” in her science classroom. In her pre PSI Professional Development Course interview Liz explained that she would like to learn ideas for organization and time management. An excerpt from an Exit Slip in Liz’s Partner Portfolio for Professional Development further supported the idea that Liz would like to improve time management skills. Liz wrote that
she would still like to learn “time management so that I can balance inquiry and directed teaching to get everything done in the allotted time.” In summary, Liz is interested in improving as a science teacher by learning more about organization and time management as those concepts relate to I-B science.

Data analysis for points of triangulation was conducted to examine Liz’s description of her own framework for understanding science content and science teaching methods. Interview and pre PSI Professional Development Course observation data shows that Liz is utilizing inquiry, investigation, questioning techniques, hands-on methods, and activity-based methods in her science lessons because that’s the way she would like to learn. Post PSI Professional Development Course observation data shows that Liz continued to use an assortment of teaching methods in each of her science lessons. In her Invitation to Practice: Collaboration, Liz and her CF, Lucy, both reveal that they use “hands-on” methods in their science classrooms. In a pre PSI Professional Development Course interview excerpt Liz explains the importance of using hands-on methods.

Well, I think the hands-on things are really important. The kids keep science notebooks. I think that helps them to understand and reflect on what we have done. Some of the homework that I give them to do is not the typical textbook homework. They do an experiment at home or this tear they went out in the spring and they just observed the surroundings, what was going on in the trees.

This excerpt also shows that Liz encourages her students to use journals to reflect on the viability of their own ideas in science. Pre PSI Professional Development Course interview data showed that Liz would like her students to have fun while they are learning science and wants them to make connections to show understanding of science concepts. An Invitation to Practice: Mapping My Classroom excerpt shows that Liz
wishes to provide opportunities for students to make sense of others ideas. Liz writes that she would like to create a “box for questions that students want answered [students can pass out the questions for other students to find answers]”. Her CLES Student Negotiation scores, pre (26) and post (25), were both in the high intermediate agreement range which indicated that she often but not always provided opportunities for students to explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas (Suters, 2004; Taylor et al., 1997). In summary, Liz uses a variety of teaching methods in her science classroom because that’s the way she likes to learn. She would like her students to experience science, observe science concepts outside, and to have fun while they are learning and making connections to show understanding.

Last, data analysis was conducted to examine Liz’s description of her own framework for understanding I-B methods. In her pre PSI Professional Development Course interview Liz defines inquiry science as exploring, investigating, and making connections. In her post PSI Professional Development Course interview Liz added the following statement to her definition of science, “Using investigative methods to learn science concepts.” The researcher learned more about Liz’s beliefs related to the definition of the work inquiry from this excerpt in her portfolio journal entry titled “What is Inquiry?”

Inquiry is looking more closely [deeply] at a topic, asking questions, using methods and senses to investigate, working with others to research and learn about the topic, sharing what you’ve discovered and learned, making connections between what you’ve learned and other things in the outside world, going beyond by learning more about the topic than just what has been presented.
Pre PSI Professional Development Course interview data findings were supported by data from the pre PSI Professional Development Course observation lesson. Liz’s science lesson included methods that were hands-on and activity based. The students followed directions to make observations and collect data in order to learn about transpiration and classification of leaves utilizing real trees that were located outside in the schoolyard. This data suggests that Liz had already successfully implemented Structured Inquiry into her science classroom prior to her participation in the PSI Professional Development Course.

Data from the pre PSI Professional Development Course observation verifies data from the pre PSI Professional Development Course interview that showed that Liz utilizes inquiry, investigation, questioning, hands-on, and activity-based methods in her science lessons. This impression was supported by an example from Liz’s post PSI Professional Development Course observation data. The researcher observed evidence of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). In the post PSI Professional Development Course observation as students created “what happens if?” questions throughout the design process while creating their solar cookers. This observation and data from Liz’s mini unit serves as evidence of the use of inquiry in the classroom. Throughout the mini unit plan Liz gradually moved from Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design, to Coupled Inquiry, inquiry that starts as Structured Inquiry or Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002).
Liz was experiencing some success while working towards implementation of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), into her science lessons. Liz’s STEBI Outcome Expectancy subscale scores, pre (47) and post (41), decreased notably, supporting the idea that Liz is still learning and working towards implementation of Full Inquiry. Her Outcome Expectancy subscale scores indicated she had a decrease in her confidence in her teaching ability to create desirable outcomes Riggs, 1988; Riggs & Enochs, 1990). Post PSI Professional Development Course observation data showed that Liz has “always used inquiry skills in teaching science.” She hopes “to incorporate more inquiry” in her science lessons. Liz offers an explanation related to her teaching ability to create desired outcomes in her post PSI Professional Development Course interview in the excerpt that follows. Liz explained, “I am not sure that I have changed much yet. I would like to set up more investigative centers in my room for science.” An excerpt from a journal entry in Liz’s Partner Portfolio for Professional Development supports this idea. Liz writes, “I have not consciously planned any other SE lessons although I feel I use a lot of inquiry when I teach science.” In summary, Liz had already successfully implemented Structured Inquiry in her science classroom prior to the PSI Professional Development Course. Liz uses inquiry, investigation, questioning techniques, hands-on activities, and activity-based methods her science lessons. Liz was experiencing a high degree of success while working towards implementation of Full or Open Inquiry. Although she uses inquiry when teaching science, she has not planned any other I-B science mini units.
Summary of Liz’s Results for Research Question 2

Research Question 2 seeks information to explain the following: “How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?” Assembling the pieces to create an understanding of how Liz’s cognitive framework incorporates her knowledge of science content and science teaching methods will help us form and explanation. Her conceptions of science subject matter or science content knowledge include the ideas, facts, and the concepts of the discipline, as well as the relationships among those concepts, facts, and ideas. Information related to Liz’s cognitive framework for science teaching and learning was uncovered through data analysis. Liz explained that teaches science the way she learns, by venturing outside to explore and observe things in nature. She emphasizes science vocabulary using the science textbook. She feels comfortable teaching science. Liz is interested in improving as a teacher by learning more about inquiry science and creating science lessons. Liz employs an assortment of methods to teach science, including: inquiry, investigation strategies, questioning techniques, hands-on activities, and activity based methods. Prior to the PSI Professional Development Course Liz had already successfully implemented Structured Inquiry into her science classroom. Liz was experiencing a degree of success while moving towards implementation of Full or Open Inquiry. Liz uses inquiry when teaching science; however, she has not planned any other 5E lessons or mini units for science.
Research Question 3 Analysis

What barriers to implementing I-B methods exist?

Interview analysis (see Appendix B for instrument) for Research Question 3 includes a look at of Liz’s Goal Statement, and selected pre PSI Professional Development Course and post PSI Professional Development Course interview questions listed in Table 1. To build credibility, information was compiled from the (a) STEBI and (b) CLES instruments, (c) through direct observation of the participant’s teaching, and (d) the Partner Portfolio for Professional Development, which included Lesson Plans for the mini-unit and the Invitation to Practice: Mapping My Classroom activity, Exit Slips, Quick Writes, and journal entries. The researcher made use of this data to study the teacher’s mental models in an effort to uncover patterns that shape teaching behavior as it relates to their role as part of the professional community or Shared Identity (SI), the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents his or her role as part of the professional community. In other words, we have assembled the pieces to answer the teacher’s query, “How does Liz describe her abilities to produce desired or intended results in her science classroom as they relate to barriers to implementation of I-B science methods?”

Liz’s Goal Statement Analysis

Teacher’s attitudes and beliefs about science are key influences on how they teach the subject. The teachers’ principles or attitude, their tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do. The teachers’ styles, principles, are rooted in experience and
develop into individual constructs slowly over time (Souza Barros & Elia, 1998). Next, the researcher next examined Liz’s goals related to her attitude and beliefs. During the PSI Professional Development Course Liz set her own goal for I-B instruction (Hammerness et al., 2005). Liz’s goal for the PSI Professional Development Course read as follows: “I want to leave here with some great ideas to use and improve my science instruction this year.” She wants to learn how she can “use inquiry more often and successfully” in her classroom. She feels she can achieve her goal “by sharing ideas with others and being open-minded to do some things differently in my classroom.” Looking at Liz’s goal allowed the researcher to study her attitude towards implementation of I-B methods into her classroom. This goal reveals that Liz is interested in leaving “with some great ideas to use and improve” her science instruction and she is “open-minded” or willing to try some different things in her science classroom.

*Liz’s Interview Analysis: Pre and Post Professional Development Course*

Interview analysis for Research Question 3 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 7, 8, and 9. This allowed the researcher to gather information to provide a picture of what was happening Liz’s classroom and school, thus providing information related to Liz’s knowledge and practice at the beginning of the research (Davis, 2002). Pre PSI Professional Development Course interview analysis showed that Liz used the following strategies in her classroom prior to the PSI Professional Development Course: talk, some lecture, group activities, partner activities, and discussion. Interview codes and transcript statements for Liz’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions are listed in Table 13.
Table 13

Interview Codes and Transcript Statements for Liz (T3) Pre and Post – Research Question 3.

**Barriers to Implementation of I-B Methods**

<table>
<thead>
<tr>
<th>Time for Science Instruction and Time Related to Curriculum Guidelines</th>
<th>Support</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: “We are limited on the amount of time we can spend on something. Anyway we’ve got the stupid benchmark tests. It is not nearly as flexible as it used to be. Even when I was going through some stuff today, organizing, I found a wonderful unit on bats that I used to do in October. We learned all about these different kinds of bats, the location how they survived, all of these things that you could tie into science, adaptations, and habitats and all of that. But, we don’t have time to spend two weeks or whatever on bats. It’s really say, it’s because of the curriculum map.” (Pacing) (Standards)</td>
<td>Post: In post PSI Professional Development Course interview excerpts Liz also notes that “time and materials” might inhibit her from using more inquiry based learning in her science curriculum. (Time to teach) (Materials)</td>
<td>Pre: If I had a class that just had a lot of trouble getting along. Katrina’s class this year fought…Most of the things that I did, because I taught her class science too, with my class, I did with hers. Because I just felt that is a better way to learn than just sitting in the classroom. But, every time I did it I had to talk to them. We’d come back in and we’d have to talk about it again. Like that activity where I took the kids through the Red Fox Trail, I could not have done that with her class. There would have been fights. (Teacher relationship with students)</td>
</tr>
<tr>
<td>Pre: “…Fortunately in our school, which is not the same in other schools, we really value science. I know some schools don’t. We’ve heard of some schools that have only 45 minutes a day for social studies and science. You can’t do that. We switch and we have an hour. She has my kids for an hour for social studies. I have her kids for an hour for science. You can’t do things like that [hands-on activities] if you’ve got twenty minutes, there’s no point. That’s where you just say. ‘Well, let’s just crack open the book.’ The reason is because to set up the experiment and discuss the conclusion, to make it worthwhile, you can’t do something like that in twenty minutes. Certainly time, the time factor would limit you. I don’t let it because I just take an hour for science because I think it’s important. (Share with other subjects)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post: “I will use them as I have time to plan so that I can implement them.” (Time to plan)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post: “Unfortunately I can only take so much time to teach a concept. I must follow the curriculum map and have students ready to take benchmark tests.” (Time to teach) (Pacing) (Testing)</td>
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</table>
Liz’s teaching team at her school consisted of other fourth grade teachers. The excerpt below illustrates the level of support Liz indicates that she feels she has received from her team.

We work together so we share any new ideas that we have. Somebody comes up with a new idea. One of the games I was telling you about, the PE game, another teacher came up with. That’s one thing we are really strong on sharing. We are not competitive at all. We share, if I’ve got a good idea, I’ll share with someone else.

Liz states that she has had three administrators and “they were all, I think, wonderful administrators.” She spends her own time sponsoring a science club. She further indicates, “I think just being happy in the school, you’re willing put out a little more” Liz continues by assuring that “if I was unhappy and I felt like I wasn’t being supported in other ways I wouldn’t do that.” Research supports that it is important that administrators and teammates are supportive of teachers while they are implementing the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). In summary, data from the pre PSI Professional Development Course interview analysis showed that Liz is receiving the support she needs from teammates and administrators in order to successfully implement I-B science methods into her classroom.

Although Liz possesses the desire to implement I-B methods, feels confidence in her teaching ability, and believes her colleagues and her administrators support her; there is a possibility that she might not be able to completely carry out her science teaching vision. Appropriately, the researcher next looked at likely threats to fidelity or barriers to use of I-B instruction besides lack of administrative and peer support. This was accomplished through interviews and classroom observation. This process permitted the
researcher to identify connections or relationships between Liz’s perceptions and use of I-B instruction (Davis, 2002).

Analysis of the pre PSI Professional Development Course interview questions revealed that Liz did face a number of barriers as she went about the process of teaching science in her classroom, including: time, curriculum maps, and benchmark testing. Liz finds that the factors of time and benchmark testing are concerns she feels when planning to teach science in her classroom. This excerpt from the pre PSI Professional Development Course interview illustrates Liz’s beliefs.

We are limited on the amount of time we can spend on something. Anyway we’ve got the stupid benchmark tests. It is not nearly as flexible as it used to be. Even when I was going through some stuff today, organizing, I found a wonderful unit on bats that I used to do in October. We learned all about these different kinds of bats, the location how they survived, all of these things that you could tie into science, adaptations, and habitats and all of that. But, we don’t have time to spend two weeks or whatever on bats. It’s really say, it’s because of the curriculum map.

Analysis of pre PSI Professional Development Course interview data revealed that Liz believed that her students might also prove to be a possible barrier to implementation of I-B methods. The following excerpt explains that student behavior plays a role in inhibiting her from using inquiry, investigation or hands-on activities.

If I had a class that just had a lot of trouble getting along. Katrina’s class this year fought constantly, she was so glad to get rid of the kids. Most of the things that I did, because I taught her class science too, with my class, I did with hers. Because I just felt that is a better way to learn than just sitting in the classroom. But, every time I did it I had to talk to them. We’d come back in and we’d have to talk about it again. Like that activity where I took the kids through the Red Fox Trail, I could not have done that with her class. There would have been fights.

Liz notes that time would be a factor that would limit teachers from using inquiry, investigation, and hands-on methods.
And even time. Fortunately in our school, which is not the same in other schools, we really value science. I know some schools don’t. We’ve heard of some schools that have only 45 minutes a day for social studies and science. You can’t do that. We switch and we have an hour. She has my kids for an hour for social studies. I have her kids for an hour for science. You can’t do things like that [hands-on activities] if you’ve got twenty minutes, there’s no point. That’s where you just say. “Well, let’s just crack open the book.” The reason is because to set up the experiment and discuss the conclusion, to make it worthwhile, you can’t do something like that in twenty minutes. Certainly time, the time factor would limit you. I don’t let it because I just take an hour for science because I think it’s important.

In summary, Liz feels that time, curriculum maps, and benchmark testing are factors that might limit teachers when thinking about implementing inquiry, investigation, and hands-on methods.

Interview analysis for Research Question 3 also included the analysis of the post PSI Professional Development Course interview questions numbered 3, 4, 6, and 7. Data analysis continued with the assumption that Liz might have encountered possible threats to fidelity or barriers to use of I-B instruction. This process permitted additional detection of connections or relationships between Liz’s perceptions and use of inquiry instruction (Davis, 2002). Analysis of the post PSI Professional Development Course interview questions disclosed that Liz faced a number of barriers as she went about the process of implementing I-B science in her classroom, including: time, which includes time to plan and time for instruction; curriculum maps; benchmark testing; and materials. Liz explains that finding time to plan might inhibit her from using I-B methods. She gives this account, “I will use them as I have time to plan so that I can implement them.” Liz further outlines some of her struggles with time, specifically, finding enough instructional time to spend on teaching one concept. Liz explains in the following excerpt from the post PSI Professional Development Course interview when she discusses pacing or moving on to a
new concept as it relates to student learning. She shares, “Unfortunately I can only take so much time to teach a concept. I must follow the curriculum map and have students ready to take benchmark tests.” In post PSI Professional Development Course interview excerpts Liz also notes that “time and materials” might inhibit her from using more inquiry based learning in her science curriculum. In summary, data from the post PSI Professional Development Course interview supports pre PSI Professional Development Course interview data in showing that Liz feels that time for planning and time for instruction, curriculum maps, benchmark testing, and materials might prove serve as barriers to her implementation of I-B science.

In summary, analysis of the pre PSI Professional Development Course interview questions revealed that Liz faced a number of barriers as she went about the process of implementing I-B science in her classroom, including: time for planning and time for instruction, curriculum maps, and benchmark testing. In post PSI Professional Development Course interview questions Liz revealed barriers she faced included: time for planning and time for instruction, curriculum maps, benchmark testing, and materials.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

Liz’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre PSI Professional Development Course and post PSI Professional Development Course assessments were in the high efficacy category indicating she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores for the pre PSI Professional Development Course and post PSI Professional Development Course assessments decreased notably, pre (47) and post (41), an indication that she had a decrease in her confidence in her teaching ability to create desirable outcomes (see
Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Details of the STEBI results were noted in Research Question 1 analysis, Science Teaching Efficacy Belief Instrument – STEBI analysis. This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Liz’s Partner Portfolio for Professional Development Analysis.

Constructivist Learning Environment Survey – CLES Analysis Pre and Post

Details of Liz’s CLES scores were noted in Research Question 1 analysis. Liz’s CLES Personal Relevance scores, pre (32) and post (29), were in the high agreement range, which indicated that she placed a high emphasis on linking school science with students’ everyday experiences (see Figure 6). There was a decrease in score indicating that after participation in the PSI Professional Development Course Liz placed slightly less emphasis on linking school science with students’ everyday experiences. Her CLES Scientific Uncertainty scores, pre (19) and post (22), increased slightly from a low intermediate agreement score to a high intermediate agreement score, which indicated that after participating in the PSI Professional Development Course she placed more emphasis on engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. Her CLES Critical Voice scores, pre (23) and post (22), were both in the high intermediate agreement range and indicated that students sometimes but not always were encouraged to question Liz’s plans and methods and express concerns about impediments to their learning. Her CLES Shared Control scores, pre (20) and post
(17), dropped, both were in the low intermediate agreement range, which indicated that her students are sometimes invited to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom. Liz’s CLES Student Negotiation scores, pre (26) and post (25), were both in the high intermediate agreement range which indicated that she often but not always provided opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas. Her CLES Attitude Scale scores, pre (30) and post (29), were in the high agreement range, which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and analyzed the activities (See Appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Liz’s Partner Portfolio for Professional Development Analysis.

**Liz’s Partner Portfolio for Professional Development Analysis**

Throughout the PSI Professional Development Course teachers were allowed the opportunity to reflect and take charge of their thoughts and behaviors through reflection, planned processing, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). To confirm the previously mentioned data findings as triangulation of multiple data sources provides for multiple measures of the same phenomenon (Yin, 2003) the following data from the Partner Portfolio for Professional Development were analyzed: (a) the Invitation to Practice: Mapping My Classroom activity, (b) the Invitation to Practice: Collaboration activity, (c) Exit Slips, (d) Quick Writes, and (e)
journal entries. A framework for organization formed through reflection upon Liz’s interview data and goals, beginning with her feelings of support from her team and her administration, followed by her desire to implement I-B methods, and finished with an examination of possible barriers that Liz faced while attempting to implement I-B methods into her classroom.

Data analysis for points of triangulation started with a look at Liz’s beliefs related to support of her teammates and administration. Analysis of pre and post PSI Professional Development Course interview data and Liz’s goal statement showed that she feels supported by her team and her administration. Data from her Partner Portfolio for Professional Development supports these findings. In her Invitation to Practice: Collaboration activity, Liz notes that she and her CF, Lucy, both “share ideas with other teachers.” In her goal statement she explained that she would like to accomplish her goals “by sharing ideas with others and being open-minded to so some things differently in her classroom.” Liz feels supported by and comfortable when working with others.

Data analysis for points of triangulation continued with a look at Liz’s beliefs related to her attitude towards implementation of I-B methods. Pre PSI Professional Development Course and post PSI Professional Development Course interview data showed that Liz had a desire to implement I-B methods into her classroom. An excerpt from Liz’s Invitation to Practice: Mapping My Classroom activity supports this idea. Liz wishes “to implement more Inquiry-Based instruction.” She notes in a journal entry, “I used my 5E lesson plan that I planned this summer.” Liz is willing and was able to implement her mini unit into her science classroom.
As noted in Research Question 1 analysis, Liz’s lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Structured Inquiry. Utilizing data from Liz’s post PSI Professional Development Course lesson, as noted in Research Question 2 analysis, it was evident that she was experiencing a degree of success while moving towards implementation of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). Liz’s lesson addressed Virginia SOL related to the characteristics of the sun. The researcher observed evidence of Full or Open Inquiry as students created, “What happens if?” questions throughout the design process while creating their solar cookers.

Last, data analysis for points of triangulation was completed with a look at barriers that Liz faced as she went about the course of implementing I-B methods into her science classroom. Analysis of the pre PSI Professional Development Course and post PSI Professional Development Course interview questions disclosed that Liz confronted a number of barriers, including: time for planning and time for instruction, curriculum maps, benchmark testing, and materials. Data from Liz’s Partner Portfolio for Professional Development supports findings that time for planning and time for instruction served as barriers as she began implementing I-B instruction.

Excerpts from Liz’s Partner Portfolio for Professional Development showed that time for planning was a barrier for Liz. The Invitation to Practice: Mapping My Classroom activity Liz planned changes that would have to take place in her classroom in order for her to implement I-B science. The excerpt that follows Liz outlines her plans, writing that she would like to set up a “box for questions students want answered.” Liz
notes in the follow-up Invitation to Practice: Mapping My Classroom activity that she had not accomplished this task yet. Liz describes her idea, “I would still like to set up a box where students can submit questions about our current unit of study. [The teacher can answer questions or pass out questions for other students to research and answer.]” In one of her journal entries Liz confirms that time for planning is indeed a barrier to implementation of I-B methods. She writes, “I have not consciously planned any other 5E lessons.” Data gathered from STEBI Outcome Expectancy scores indicated that Liz had a decrease in her confidence in her teaching ability to create desirable outcomes (Riggs, 1988; Riggs & Enochs, 1990). This supports Liz’s intent to plan and implement I-B methods, while facing the barrier of time, which prevents her from fully carrying out her plan. Excerpts from Liz’s Partner Portfolio for Professional Development also showed that time for instruction was a barrier for Liz. In an excerpt from one of Liz’s Exit Slips, she notes that she would still like to learn more about “time management so that I can balance inquiry and directed teaching to get everything done in the time allotted.”

Summary of Liz’s Results for Research Question 3

Liz’s professional development goal revealed that she was interested in leaving “with some great ideas to use and improve my science instruction this year.” During the PSI Professional Development Course Liz worked to create and implement an I-B lesson plan, Our Awesome Sun, into her classrooms. Classroom observation data showed that Liz had already made use of Structured Inquiry (Martin-Hansen, 2002). Analysis of the data revealed that Liz confronted a number of barriers as she went about the process of implementing I-B science in her classroom, including: time for planning and time for instruction, curriculum maps, county benchmark testing, and science materials.
Research Question 4 Analysis

What relationships exist between teachers’ perceptions and use of I-B methods?

Data were analyzed to address the query, “What relationships exist between Liz’s perceptions and use of I-B methods?” Interview analysis (see Appendix B for instrument) for Research Question 4 includes the examination of (a) post PSI Professional Development Course interview questions 2, 3, 6, and 7 listed in Table 1, (b) post PSI Professional Development Course classroom observation analysis (See Appendix E for the Classroom Observation Protocol), (c) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (d) Partner Portfolio for Professional Development. Influences such as Liz’s culture, educated-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual and style help mold the her beliefs about I-B methods. The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI).

John Dewey (1938, 1997) proposed that experience transpires as a result of the interrelationship of two principles, continuity and interaction. Continuity refers to how each experience a person has influences one’s future, for better or for worse. Interaction refers to the situational influence on one’s experience. The individual’s present experience is a function of the interaction between their past experiences and the present situation. No experience has a pre-destined value. Therefore, what might be a beneficial experience for one individual could be an unfavorable experience for another. In other words, "positive experiences" motivate, encourage, and enable students to go on to have
more valuable learning experiences, whereas, "negative experiences" tend to lead towards a student closing off from potential positive experiences in the future. Dewey believed that learning experiences should be meaningful to each student and that teachers should step back and act as facilitators (Dewey, 1938, 1997).

Returning to the bucket metaphor illustrated in the researcher’s conceptual framework, Liz examined the shells and treasures introduced at the PSI Professional Development Course and made a choice to either keep each one and place it in her bucket, or place it back on the beach based on her own system of values. The discovery of treasures of substantial value created a positive influence on Liz’s motivation, attitude, caring, determination and effort. The uncovering of treasures with moderate value had a negative influence on Liz’s motivation, attitude, caring, determination and effort. To illustrate Liz’s cognitive framework related to inquiry, data findings were drawn upon to uncover her beliefs about inquiry science teaching. An examination revealed how this ties into her daily science teaching experiences. This information is vital to understanding teacher change related to inquiry (Keys & Bryan, 2000; Spillane et al., 2002).

*Liz’s Interview Analysis: Pre and Post Professional Development Course*

Interview analysis for Research Question 4 includes the analysis of the post PSI Professional Development Course interview questions numbered 2, 3, 6, and 7. A qualitative research design serves as an appropriate methodology to utilize to examine any relationships the might exist between Liz’s perceptions and use of I-B methods, seeing as qualitative research is concerned with the perceptions of the participants and with process rather than outcomes or products (Bogdan & Biklen, 1992, Marshall &
Rossman, 2006). This design serves as an appropriate methodology to utilize to define inquiry as it is perceived and used by Liz.

First, information was drawn on to illustrate Liz’s cognitive framework related to inquiry prior to the PSI Professional Development Course Liz defined inquiry as written in the excerpt that follows.

I take that to mean you’re exploring; you’re investigating things. You are taking the unknown and learning a little more about what you don’t know; or making connections to things that were not there before.

In the post PSI Professional Development Course interview Liz added to her definition of inquiry. She adds the phrase “using investigative methods to learn scientific concepts.” She notes that prior to the PSI Professional Development Course she “had less understanding of how I-B instruction is used in a classroom.”

Next, interview data were drawn on to reveal her beliefs about inquiry teaching. Liz explains that she is motivated to use inquiry in the excerpt that follows, “I love to see students’ eyes open in awe and amazement when they discover something new.” She explains her beliefs related to student learning in the following excerpt.

I think a good learner is someone who is open to new ideas. Someone who is always enthusiastic and wants to take what they’ve learned in class and go beyond that with some type of investigation or inquiry. Someone who brings back things to share with others who has kind of extended what they have learned. A good learned helps other people learn.

In summary, Liz enjoys watching her students discover new science concepts. She believes a good learner is open to new ideas, is willing to investigate, and shares with others.

As a final point, the pre PSI Professional Development Course interview data findings were examined to determine how Liz’s cognitive framework related to inquiry
and her beliefs about inquiry teaching tie into her daily experiences. Liz generally uses inquiry, investigation and hands-on methods to teach science. The following excerpt shows her choice of science teaching methods.

I use inquiry and investigation, hands-on, I do a lot of that. I use questioning, with me questioning them, and with them questioning me. My lessons are activity based. We play games in science. I even bring PE into it. We’ll take something we’re learning in science and it becomes a relay race or something outside. That’s really fun for the kids and you can kind-of do PE and science at the same time. That’s your PE for the day but you were also doing another 20 minutes of science! That’s fun to do to.

Liz does not just use one style or method in her science classroom. This excerpt from her pre PSI Professional Development Course interview explains.

I think most teachers probably teach the way they like to learn. That’s why when you go into different teachers classrooms. Some are very effective in one way and that’s the way they learn toward. I think you have to be flexible. You can’t just have one style. You have to realize that not everybody in your classroom is going to learn your way. But that’s probably the way that you kind of gravitate towards.

Liz reveals more about her daily experiences in her post PSI Professional Development Course interview. She shares, “I continue to incorporate more inquiry based learning in my science curriculum.”

*Liz’s Goal Statement Analysis*

Liz’s goal for the PSI Professional Development Course read as follows: “I want to leave here with some great ideas to use and improve my science instruction this year.” She wants to learn how she can “use inquiry more often and successfully” in her science classroom. She feels she can achieve her goal “by sharing ideas with others and being open-minded to do some things differently in my classroom.” Liz’s goal statement shows that she is eager to participate in the PSI Professional Development Course so that she
can learn “some great ideas” that would enable her to improve her “science instruction this year."

*Science Teaching Efficacy Belief Instrument - STEBI Analysis Pre and Post*

Details of Liz’s STEBI results were noted in Research Question 1 analysis, *Science Teaching Efficacy Belief Instrument – STEBI analysis* (see Appendix C1 for instrument and C2 for scoring instructions). Liz’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (62) and post (59) assessments were in the high efficacy category indicating she was comfortable with her ability to teach science. This data supports Liz’s goal statement, which shows that she is eager to leave “with some great ideas to use and improve my science instruction this year.” Her STEBI Outcome Expectancy subscale scores for the pre (47) and post (41) assessments decreased notably, indicating she had a decrease in her confidence in her teaching ability to create desirable outcomes (Riggs, 1988; Riggs & Enochs, 1990). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Liz’s Partner Portfolio for Professional Development Analysis.*

*Liz’s Partner Portfolio for Professional Development Analysis*

Liz took part in activities that allowed her to reflect upon and manage her thoughts and behaviors through strategic processing, reflection and collaboration throughout the PSI Professional Development Course (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Liz’s portfolio data provided additional pieces that were used to solve the query, “*What relationships exist between Liz’s perceptions and use of I-B methods?*” Analysis focused on relationships connecting Liz’s perceptions as they
connected to her practice. Emic accounts, descriptions of behaviors in terms meaningful to the teacher, were used because these accounts are culture specific or are found in the context of the teacher’s classroom (Stake, 2006). The researcher completed three steps in analyzing the partner portfolio. First, Liz’s definition of inquiry, Liz’s methods of instruction, and the definition of inquiry used during the PSI Professional Development Course were reviewed for comparison with Liz’s definition of inquiry and choice of teaching methods. Second, a review of the findings from Liz’s Interview analysis, Goal Statement analysis, and STEBI analysis was conducted. Third, emic accounts were compared to excerpts from Liz’s mini-unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in an effort to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). Each of these steps is discussed more fully next.

First, the researcher examined Liz’s definition of inquiry. During the PSI Professional Development Course Liz defined inquiry as “exploring” and “investigating things,” “taking the unknown and learning a little more about what you don’t know” or “making connections to things that were not there before.” Through the course of the PSI instruction Liz had the opportunity to develop an understanding of the following topics: What is inquiry, learning through inquiry, developing a mind for constructivism, constructivism, how children learn, designing I-B classrooms, integrating I-B activities, the scientific method, learning cycles, skills and knowledge of I-B teachers, and questioning. Liz also participated in sample I-B science lessons that were modeled during the PSI Professional Development Course (a complete detailed description of the twenty-hour professional development course is located at Appendix K). As noted in Research
Question 2 analysis, the following excerpt from a journal entry describes what Liz believes inquiry includes.

Inquiry is looking more closely [deeply] at a topic, asking questions, using methods and senses to investigate, working with others to research and learn about the topic, sharing what you’ve discovered and learned, making connections between what you’ve learned and other things in the outside world, going beyond by learning more about the topic than just what has been presented.

In Liz’s post PSI Professional Development Course interview she added “using investigative methods to learn science concepts” to her definition of inquiry.

Next, the researcher looked at Liz’s methods of science instruction. Pre PSI Professional Development Course interview data showed that Liz enjoys watching her students discover new concepts. She believes a good learner is open to new ideas, is willing to investigate, and shares with others. As noted in Research Question 1 analysis, Liz’s lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Structured Inquiry. Utilizing data from Liz’s post PSI Professional Development Course science lesson, as noted in Research Question 2 analysis, it was evident that she was experiencing a degree of success while moving towards implementation of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). The researcher observed evidence of Full or Open inquiry in the post PSI Professional Development Course observation as students created “What happens if?” questions throughout the design process while planning and creating their own solar cookers.

Next, the definition of inquiry used during the PSI Professional Development Course was reviewed for comparison with Liz’s definition of inquiry and choice of
science teaching methods. During the PSI Professional Development Course, inquiry instruction was defined as referring to any teaching method that focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations, and discover answers to their questions about the natural world. Students may plan systems to collect data and choose how to organize and represent the data (Carin et al., 2004). The National Research Council (1998) defines scientific inquiry as:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.” (p. 23)

Liz’s definition of inquiry is aligned with the definition used in the PSI Professional Development Course. Interview data showed that in her classroom, Liz is “flexible,” and uses a variety of methods, including: inquiry, investigation, questioning, hands-on, and activity-based methods her lessons. Liz’s choice of methods allow for integration or use of I-B methods.

The next step in placing the pieces of the puzzle to solve the query, “What relationships exist between Liz’s perceptions and use of I-B methods?” consisted of a review of the findings from Liz’s interview analysis, Goal Statement analysis, and STEBI analysis. Beginning with her pre PSI Professional Development Course interview, Liz believes she is learning science best when she is actively investigating, especially things
outside in nature. When teachers use a constructivist approach, they provided relevant experiences and opportunities that allowed students to construct knowledge (Piaget, 1929; Vygotsky, 1978). Liz describes her science teaching style as her “own type of organization.” She is “active,” “encouraging,” and likes to “extend their [her students] learning.” In her post PSI Professional Development Course interview, Liz further explains to us that she “uses a lot of hands-on activities and experiments.” She often takes her “students outside for science lessons.” Liz’s Goal Statement illustrates that she is excited leave “with some great ideas to use and improve my science instruction this year.” Liz’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (62) and post (59) assessments decreased slightly; however both were in the high efficacy category, an indication that she was comfortable with her ability to teach science (Riggs, 1988; Riggs & Enochs, 1990). In summary, Liz is eager to learn about and implement I-B methods in her science classroom, but the PSI Professional Development Course did not really help her to feel more at ease with her ability to teach science.

Last, data findings were utilized to position the pieces of the puzzle to answer the query, “What relationships exist between Liz’s perceptions and use of I-B methods?” Emic accounts from Liz’s (a) interview analysis, (b) Goal Statement analysis, and (c) STEBI analysis were compared with excerpts from Liz’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). A teacher’s attitudes and beliefs about science are key influences on how they teach the subject (Souza Barros & Elia, 1998). In her pre PSI Professional Development Course interview, Liz shares her positive attitude about trying
new things. She passes on her thoughts, “I am very open to kids teaching me.” In one of her Partner Portfolio for Professional Development journal entries she explains that she learns science best when “sharing ideas with others and being open-minded.” Liz’s portfolio data supports her goal statement, which illustrates that she wants to learn how she can “use inquiry more often and successfully” in her classroom. She feels she can achieve her goal “by sharing ideas with others and being open-minded to do some things differently in my classroom.” Liz wants to learn about and implementing I-B methods into her science classroom, and she is capable of choosing which methods she uses in her classroom. Liz’s attitude had a positive influence in her decision to choose to implement I-B methods into her science classroom.

Summary of Liz’s Results for Question 4

Research question 4 asked the question “What relationships exist between teachers’ perceptions and use of I-B methods?” The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI). Data analysis for Research Question 4 showed that Liz was willing and eager to try to implement I-B methods into her science classroom. The perception that I-B methods hold large or great value had a positive influence on Liz’s motivation, attitude, caring, determination and effort during implementation of the methods in her science classroom. Liz’s definition and vision of inquiry matches her choice of methods for science instruction. Liz describes her teaching style as entailing her “own type of organization.” When teaching science, she is “active,” “encouraging,” and likes to “extend their [her students] learning.” Liz teaches science the way she likes to learn science. Liz uses
inquiry, investigation, questioning, hands-on, and activity-based methods her science lessons. As noted in Research Question 2, in her Partner Portfolio for Professional Development Liz describes her framework for understanding I-B science instruction. Liz describes her own definition of I-B in the excerpt that follows.

Inquiry is looking more closely [deeply] at a topic, asking questions, using methods and senses to investigate, working with others to research and learn about the topic, sharing what you’ve discovered and learned, making connections between what you’ve learned and other thing in the outside world, and going beyond by learning more about the topic than just what has been presented.

In her post PSI Professional Development Course interview Liz adds this phrase to her definition of inquiry, “using investigative methods to learn science concepts.” In her Goal Statement, Liz explained that she wanted to learn about I-B science methods and implementing I-B methods into her science classroom. Data analysis also revealed that Liz is capable of choosing which methods she implements into her science classroom. Liz held an optimistic attitude related to science teaching and learning; this had a positive influence in her decision to choose to implement I-B methods into her science classroom.

As noted in Research Question 1 analysis, Liz’s science lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Structured Inquiry into her science classroom. Utilizing data from Liz’s post PSI Professional Development Course science lesson, as noted in Research Question 2 analysis, the researcher discovered evidence that she was experiencing a degree of success while moving towards implementation of Full or Open Inquiry, inquiry in which students ask their own questions, design their own investigations, and convey results about their investigations (Martin-Hansen, 2002), throughout her self-created science mini unit plan.
Research Question 5 Analysis

How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Integrating analysis (see Appendix B for instrument) for Research Question 5 includes the examination of (a) post PSI Professional Development Course interview questions 4, 5, 7, 8 and 9 listed in Table 1, (b) post PSI Professional Development Course interview question 6, (c) Post PSI Professional Development Course Classroom Observation analysis (see Appendix E for the Classroom Observation Protocol), and (d) Partner Portfolio for Professional Development. This data findings were used to study Teacher Choice (TC) in an attempt to uncover techniques that encourage teachers like Liz to overcome resistance to implementing I-B teaching practices. When a teacher, like Liz, formulates a choice she critically measures the value of existing alternatives and chooses a course of action built upon her own conceptual framework. Data analysis for Research Question 5 was made up of a study of Liz’s conceptual framework. Her framework includes: her Individual Identity (II), the portion of the Liz’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or personal constructs (Scribner et al., 2002); Liz’s Subject Matter Knowledge (SMK), Liz’s knowledge of content matter and pedagogy (the art and science of being a teacher) and curriculum knowledge (Shulman, 1986); and Liz’s Shared Identity (SI), the portion of the Liz’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community.
Liz’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 5 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 5, 7, 8 and 9 as well as post PSI Professional Development Course interview question 6. Teacher Choice (TC) is influenced by mental models, “the images, assumptions, and stories, which we carry in our minds of our selves, other people, institutions, and every aspect of the world,” (Senge, 1990). First, interview analysis gave the researcher a glimpse of Liz’s Individual Identity (II). Liz describes her teaching style as her “own type of organization.” She is “active,” “encouraging,” and likes to “extend their [her students] learning.” In the following interview excerpt Liz details the methods uses in her science classroom.

I use inquiry and investigation, hands-on, I do a lot of that. I use questioning, with me questioning them, and with them questioning me. My lessons are activity based. We play games in science. I even bring PE into it. We’ll take something we’re learning in science and it becomes a relay race or something outside. That’s really fun for the kids and you can kind-of do PE and science at the same time. That’s your PE for the day but you were also doing another 20 minutes of science! That’s fun to do to.

When Liz thinks about teaching science to children she thinks about her own experiences, the things she loves, and how her students will react to them. Liz shared examples of how her experiences and her students’ reactions influenced her teaching in this pre PSI Professional Development Course interview excerpt.

I would just have to say from my own experiences. We go camping a lot. Every time I go camping I’m collecting something and bringing it back into the classroom to show the kids. Obviously, that’s not the reason that we go camping, this couple that we go camping with, I’m always collecting something. One time it was pinecones, another time it was seashells, another time it was leaves, we collected flowers. You probably know this, you go somewhere and your mind just cannot rest. You just can’t take a walk because suddenly there’s something that you can bring back in and show the kids. Even if you’re not talking about it. In the Fall I brought back a horseshoe crab I found washed up on the beach. I had
this big thing, I had to keep it from breaking apart to get it into the classroom, but I just think if that is what your real love is, it’s constantly with you. It’s what I really like to see in the kids. That’s how you’re going to become a lifelong learner. You’re going to learn more. I think that’s, and not just in science, that’s your foundation. You really want to go beyond on that. I think as a teacher that’s what we’re giving the kids, just a foundation and if that’s all you learn then that’s not really learning. That’s kind of that little narrow bit of information that we’re providing you with but there’s more out there. Science is such a great way to do that because it’s just all around you, it’s always happening. Sometimes once you get the kids started you can’t get them to stop. That’s fun.

In summary, Liz uses the following methods in her classroom: inquiry, investigation hands-on, questioning, and activity based techniques like games. She brings items from the outdoors and nature for students to explore. She wants to show students that science is all around them and it is fun.

Interview analysis also gave the researcher uncover information related to Liz’s Subject Matter Knowledge (SMK). Although Liz revealed that she “can not remember any particular science lesson,” she says, “Obviously, I was taught science.” She notes that most of her science content knowledge “came from a love of science.” She was “always outside” “investigating something in nature,” and “bringing things home.” Liz combines her own experiences with nature and Milton County’s curriculum map as a basis for deciding what to teach, then she adds more. She feels limited by time, benchmark tests, and the curriculum map.

I start with the curriculum map. I use the curriculum map, the SOL, I usually try to go beyond the basic stuff just because I love science and I put more into it. Obviously that’s what guides us. We are limited on the amount of time we can spend on something. Anyway we’ve got the stupid benchmark tests. It is not nearly as flexible as it used to be. Even when I was going through some stuff today, organizing, I found a wonderful unit on bats that I used to do in October. We learned all about these different kinds of bats, the location, how they survived, all of these things that you could tie into science, adaptations and habitats and all of that. But, we don’t have time to spend two weeks or whatever on bats. It’s really sad; it’s because of the curriculum map.
Liz further although reported that she is told what to teach, she is not told how to teach it. She teaches in her own way. Excerpts from her pre PSI Professional Development Course interview show this.

Well, no, I don’t think we’re told how we have to teach something. I mean if we are I just kind of do my own thing. I don’t know. Obviously, we have to follow the curriculum map, the SOL, the benchmark tests and all of that. Some of the summer classes and classes I’ve taken have really shown me some ways I can teach science. New approaches.

As far as the county, is there any type of protocol with the county? Is there a way? I didn’t feel there was. But, I’ve been around for so long, you just kind of do your own thing. If I’m supposed to be doing something and I’m doing it wrong, nobody said anything yet.

In an excerpt from her post PSI Professional Development Course interview Liz describes her own framework for understanding science content by saying, “I teach science following the county’s curriculum map and the framework. Limited time is given to teaching some of the content.” In the following excerpt Liz continues to describe how she decides what to teach and what not to teach.

I need to follow the SOL and be sure to teach what will be tested [SOL and benchmarks]. I usually include other information that I feel gives students a more thorough understanding of the topic or extend the information.

Liz combines her own experiences with nature and Milton County’s curriculum map to describe her own framework for understanding science content. Liz feels the way she teaches is influenced by her own love of science and her experiences outside in nature; as well as the Milton County’s curriculum map, curriculum framework, benchmark tests, and the Virginia SOL. Liz feels obligated or required to follow them. She makes this clear as she states, “I am required to follow the county’s curriculum map and SOL.” Liz
notes that she usually goes “beyond the basic” content information when teaching science.

In summary, Liz feels that most of her knowledge of subject matter came from a love of science, which included exploration and investigation outside. Liz combines her own experiences with nature and Milton County’s curriculum map as a basis for deciding what to teach, then she adds more. She often feels limited by time, benchmark tests, and the curriculum map.

Interview analysis also gave the researcher a glimpse of Liz’s Shared Identity (SI). Liz acknowledged that support from administrators influenced her choice of science teaching methods as well as other things she does at school. Liz believed support from her administration and grade level team was positive. The excerpt below shows how Liz is willing to go above and beyond what is expected from her as a teacher because she feels happy and supported by her school.

Well, I’ve had three administrators, Warren Talbot, Addison Banagher, and Dakota Caldwell. They were all, I think, wonderful administrators. Warren Talbot, in fact I wrote a letter as far as naming the Red Fox Trail for him. He was really big into science. We started these garden plots out back. He started that. We got the Red Fox Trail. What were some other things? Well, the science club, which I do, that started under him. So he was a real big proponent for kids learning and being very active. I’ve had the support of Addison Banagher and overnight camping trip in the science museum once a year. They help come up with the funds for that. Even though technically, I don’t think there’s another elementary school that does an overnight field trip, we’ve gotten approval for that. We’ve gone year after year after year. So that really helps a lot. I think just being happy in the school; you’re willing to put out a little more. Obviously you don’t get paid for it and it’s a lot of time and money out of your own pocket. I mean you do get reimbursed, but you don’t, not for everything. If I was unhappy and I felt like I wasn’t being supported in other ways, I wouldn’t do that. So, that really is important.
Liz’s Pre PSI Professional Development Course interview data showed that she is influenced by her teammates. The following interview excerpt relates what Liz explains as the role her teammates play in influencing her choice of teaching methods.

We work together so we share any new ideas that we have. Somebody comes up with a new idea. One of the games I was telling you about, the PE game, another teacher came up with. That’s one thing we are really strong on sharing. We are not competitive at all. We share, if I’ve got a good idea, I’ll share with someone else. If they come to me I’ll say take it, here you go. Some schools, or even some grade levels are competitive and they want to keep everything to themselves. It’s all for the kids, so who cares. It’s really nice when you share and you don’t have to worry about somebody who doesn’t want to give you something. And it all balances out. So that’s really helpful.

Liz’s students also have an influence on her choice of teaching methods. Liz also feels influenced by her students’ reactions when learning about science. Pre PSI Professional Development Course interview data showed that Liz is motivated to choose teaching methods because, “That’s the way I’d like to learn.” She feels that if it’s boring to her then “it’s probably boring to them.” In the following interview excerpt Liz shared the influence her students have on her teaching.

Again, I think you learn from the kids. I think seeing them, just the love of science in their eyes or what they bring in influences you. You see them happy. You see them learning. You see them going beyond what’s in that book and it makes you want to teach that way because you like to see that. Just to see the enthusiasm of the students.

In summary, she feels supported by her administration and is influenced by her teammates and her students. Pre PSI Professional Development Course interview data Liz stated that they “work together so we share any new ideas that we have.”

Following the staff development Liz reported that the “SOL and benchmarks” influence both what she teaches and the way she teaches it. She feels she is “required to follow the county’s curriculum map and SOL.” She believes that the most important
concepts for students to understand or know by the end of the school year are “how to set up and perform an experiment and be able to make conclusions about the results.” Liz also believes students “should also be able to use tools such as: balance, thermometer, meter and centimeter in measuring tools, and hand lenses.” Liz says she is motivated to keep going because, “I love to teach.”

In summary, data from this study uncovered details regarding Liz’s conceptual framework. Liz’s framework includes her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI). Liz is “active,” “encouraging,” and likes to “extend their [her kids] learning.” She feels comfortable teaching science. Interview data revealed that Liz makes choices about which methods to use to teach science based on the influences of her students, her teammates, her administration, state standards and county benchmark testing. Liz feels supported by her administration and she is positively influenced by her teammates. She loves to teach.

_Liz’s Partner Portfolio for Professional Development_

To provide triangulation of multiple data sources (Yin, 2003) the researcher studied pieces from Liz’s _Partner Portfolio for Professional Development_ including Liz’s (a) post PSI Professional Development Course lesson plan, (b) Invitation to Practice: Science Learning Personal History, (c) post PSI Professional Development Course lesson plan, and (d) the journal entry titled “What is inquiry?” This examination leads to a more substantial appreciation of Liz’s perceptions as they speak about Teacher Choice (TC) as framed by her mental models, conceptions of science subject matter, and barriers related to teaching and learning. Throughout the course of this study, Liz reflected upon her own education and teaching experiences, analyzed what she learned during the staff
development training, and made decisions pertaining to keeping the ideas or tossing them based on her own system of values. Following the pattern for data analysis used for the pre PSI Professional Development Course interview analysis, data analysis consisted of a study of Liz’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI).

Data analysis for points of triangulation started with an examination of Liz’s Individual Identity (II). Interview analysis gave the researcher a view of Liz’s II. Liz describes her teaching style as her “own type of organization.” She is “active,” “encouraging,” and likes to “extend their [her kids] learning.” Liz noted in her interview that she Liz uses inquiry, investigation hands-on, questioning, and activity based techniques like games in her classroom. She often brings items from the outdoors into her classroom for students to explore. Liz shows her students that science is all around them and that it is fun. Partner Portfolio data from Liz’s mini unit supports Liz’s statements that she makes sure science is all around her students. Post PSI Professional Development Course observation data revealed that Liz does use inquiry, investigation hands-on, questioning, and activity-based techniques. The researcher observed science related items throughout the classroom, items included: live animals (reptiles, fish, and guinea pigs); natural items (pine cones, leaves, and nuts); a bee hive; numerous terrariums; various measuring tools (a barometer, rulers, balances); posters; mobiles; and more.

Data analysis for points of triangulation continued with an examination of Liz’s SMK. Partner Portfolio analysis clarified previous findings related to Liz’s SMK. Interview data showed that Liz feels most of her science content knowledge “came from a love of science.” She was “always outside” “investigating something in nature,” and
“bringing things home.” Liz explains in her pre PSI Professional Development Course interview that she usually goes “beyond the basic” content information when teaching science. Liz feels confident in her ability to teach science. This confidence is supported by Liz’s STEBI Personal Science Teaching Efficacy Belief score, which indicated that she was comfortable with her ability to teach science. Liz is interested in improving as a teacher through in the areas of organization and time.

Last, data analysis for points of triangulation included an examination of data related to Liz’s SI. Data from interview analysis related to Liz’s SI revealed that Liz feels supported by her administration and is influenced by her teammates and her students. Excerpts from her portfolio support these ideas. Liz writes in her professional development goal that she wants to learn by “sharing ideas with others.” In her Invitation to Practice: Collaboration activity Liz wrote that she and her CF, Lucy, both shared ideas with other teachers.

Liz also feels that her students are a sizeable motivator or influence on her choice of teaching methods. In her pre PSI Professional Development Course interview Liz stated that she felt motivated to choose an activity because “if you’re really trying to teach the kids and you want them to have the best chance to learn something that’s what motivates you.” Liz continues to explain that she loves to “see the kids learn and make connections and bring in things they have discovered because of something you have taught them. In her journal entries, Liz indicates that she has added “knowledge of how to plan and implement a 5E lesson” to her bucket of science treasures. She has set up a table with” books and other visuals” that “support and extend” her unit of study so that students “are able to investigate the unit taught using the books and other items on the
table.” These ideas are further enforced by Liz’s statement in the post PSI Professional Development Course interview that she is motivated to use hands-on activities, experiments and inquiry because she loves “to see students’ eyes open in awe and amazement when they discover something new.”

**Summary of Liz’s Results for Research Question 5**

Data findings were utilized to study Liz’s choices in an attempt to reveal methods that encourage teachers like her to conquer resistance to implementing I-B teaching practices. Liz made choices about her preferences of teaching methods by assessing the value of the options accessible to her. Based on these choices, Liz decided upon a course of action founded on her own conceptual framework. Data analysis for Research Question 5 examined the question, “How do teachers choose to use I-B methods as opposed to teacher-centered activities?” This study consisted of an examination of Liz’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK) Shared Identity (SI). Partner Portfolio analysis supported previous findings related to Liz’s II. Excerpts from Liz’s pre PSI Professional Development Course interview analysis, supported by secondary data, showed that Liz describes her teaching style as her “own type of organization.” She is “active,” “encouraging,” and likes to “extend their (her kids) learning.” Partner Portfolio analysis clarified previous findings related to Liz’s SMK. Liz feels most of her science content knowledge “came from a love of science.” Liz remembers that she was “always outside” “investigating something in nature,” and “bringing things home.” Liz usually goes “beyond the basic” content information when teaching science. Analysis related to Liz’s SI revealed that Liz feels supported by her administration and is influenced by her teammates and her students.
Teacher Portrait T4 – Hailey

I next present the data to answer the query, “Who is Hailey?” This teacher portrait is described as it aligns with each research question. Data that yields information related to each question was analyzed. A discussion of the findings for each question is presented.

Research Question 1 Analysis

What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?

Hailey’s Interview Analysis: Pre and Post Professional Development Course

The following data proved useful in providing insights about Research Question 1: (a) Hailey’s pre PSI Professional Development Course interview, (b) STEBI survey, (c) CLES survey, (d) Hailey’s Partner Portfolio for Professional Development, and (e) Hailey’s post PSI Professional Development Course interview. Data findings were utilized to examine Hailey’s beliefs in an effort to uncover patterns that influence her teaching behavior as it relates to her Individual Identity (II). Individual Identity (II) is defined as the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfield, 1998) that represents autonomy or personal constructs (Scribner et al., 2002). Hailey’s Interview Codes and Transcript Statements for Research Question 1 are located in Table 14.
Table 14

*Interview Codes and Transcript Statements for Hailey (T4) Pre and Post – Research Question 1.*

<table>
<thead>
<tr>
<th>Beliefs about learning and teaching science</th>
<th>Beliefs About How Children Learn Science</th>
<th>Beliefs About Science Teaching Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: The only one I remember is when we were hatching baby chicks and we had an incubator in the classroom. That was exciting. Most of my classes as a child, the rest of my memory is just opening a textbook and reading. (Memory) (See &amp; Do)</td>
<td>Post: see relationships, ask questions, and be willing to complete work (Investigating) (Actively Involved)</td>
<td>Pre: I think I try to find different ways to teach subjects, like using the MI…I feel like I am fairly strict but the children know they can kid around with me. I try to maintain a sense of humor. I think I really try to follow the objective,…I am not as organized as I want… (Variety of Methods) (Emotions) (Organization)</td>
</tr>
<tr>
<td>Pre: We had a wonderful professor, very outgoing and understood that a lot of people felt uncomfortable teaching science. Most of the class really did admit they felt uncomfortable teaching it and we, it was so long ago. I do remember putting together lessons and demonstrating them to the class and providing lessons for everybody so that they could all take them home. (See &amp; Do) (Struggles with Science)</td>
<td>Pre: Sometimes I use inquiry, but I think sometimes I forget to. I catch myself just explaining things. I definitely use hands-on as much as possible because I know that there’s so many concepts that a lot of students won’t get unless they are hands-on sometimes songs work well too. (Investigating) (Actively Involved)</td>
<td></td>
</tr>
<tr>
<td>Pre: …definitely very hands-on and was pertinent to the curriculum. I’ve taken some of it and used it in the classroom… Pre: definitely by seeing and doing (See &amp; Do)</td>
<td>Post: We performed experiments, move around in silly ways to remember concepts, did more than read out of a book and complete worksheets. They felt comfortable.” (Actively Involved) (Novelty) (CZ)</td>
<td>Post: We performed experiments, move around in silly ways to remember concepts, did more than read out of a book and complete worksheets. They felt comfortable. (Novelty) (Variety of Methods)</td>
</tr>
</tbody>
</table>
Data were utilized to examine Hailey’s beliefs about teaching science, how children learn science, and science teaching methods to uncover patterns that influence her teaching behavior as it relates to autonomy or Individual Identity (II). Data analysis started with an examination of Hailey’s memories of her early schooling. Hailey recalls her college science training as putting together lessons and demonstrating them to her classmates. She remembers most of the class admitting they felt uncomfortable teaching science. More recently, Hailey took a PSI Professional Development Course last summer that was very hands-on and was pertinent to the curriculum. She has taken some of the ideas that she learned and used them in her classroom. This excerpt from the pre PSI Professional Development Course interview reveals what Hailey explains as playing a role in shaping her beliefs related to students and learning.

The only one I remember is when we were hatching baby chicks and we had an incubator in the classroom. That was exciting. Most of my classes as a child, the rest of my memory is just opening a textbook and reading.

Hailey remembers that during her college training many of her fellow students felt uncomfortable teaching science. Hailey explained that her professor understood this and provided opportunities for students to participate in lessons and demonstrations.

We had a wonderful professor, very outgoing and understood that a lot of people felt uncomfortable teaching science. Most of the class really did admit they felt uncomfortable teaching it and we, it was so long ago. I do remember putting together lessons and demonstrating them to the class and providing lessons for everybody so that they could all take them home.

Another excerpt from the pre PSI Professional Development Course interview emphasizes the idea that Hailey remembers a content training session in which she participated in hands-on activities throughout the learning process.
That was last summer and definitely very hands-on and was pertinent to the curriculum. I’ve taken some of it and used it in the classroom. The first one I remember using was the globe, showing them how much of the Earth was ocean and how much was land.

Hailey explained that she feels she learns best, “definitely by seeing and doing.” Hailey learns best using a constructivist approach to learning, which focuses on providing relevant experiences and opportunities that allow students to construct knowledge (Piaget, 1929; Vygotsky, 1978).

A teacher’s principles or attitude, her tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do (Souza Barros & Elia, 1998). This excerpt from the pre PSI Professional Development Course interview reveals how Hailey describes herself as a classroom teacher.

I think I try to find different ways to teach subjects, like using the multiple intelligences, but again it’s not always possible. I am, I feel like I am fairly strict but the children know they can kid around with me. I try to maintain a sense of humor. I think I really try to follow the objective, whatever it is I need to teach. Probably I guess my downfall is that I am not as organized as I want to be.

In summary, Hailey remembers a lot of reading in her early childhood science classes. Hailey feels she learns best, “definitely by seeing and doing.” She learned from college classes and professional development courses that contained hands-on activities that were pertinent to the curriculum. Hailey is strict, but has sense of humor.

Interview data analysis next focused on Hailey’s beliefs about science teaching methods. The excerpt that follows from pre PSI Professional Development Course interview data outlines the methods Hailey feels she generally uses to teach science.

Sometimes I use inquiry, but I think sometimes I forget to. I catch myself just explaining things. I definitely use hands-on as much as possible because I know
that there’s so many concepts that a lot of students won’t get unless they are hands-on sometimes songs work well too.

Pre PSI Professional Development Course interview data shows that Hailey uses the following methods: inquiry, hands-on, and songs.

In her post PSI Professional Development Course interview Hailey explains that she feels shows us that she believes it is important for students to “see relationships, ask questions, and be willing to complete work.” This finding supports Hailey’s pre PSI Professional Development Course interview statement. She shares beliefs about science teaching methods and what children should learn in science in the excerpt that follows.

You know you have a lot of students that, no matter what I’ve done in the science, they’re not going to remember that, for example: What’s a compound? What’s a mixture? They’re not going to come away with that. The other day I was talking to them. We read a story about Jane Goodall and talked about the chimpanzees. So I guess my main goal is for them to walk away from the classroom understanding that this is the only Earth we’ve got and we’ve got to take care of it. It is important for them to learn some of the things that we can do to take care of the Earth, to understand what it means to be a scientist, what it means to investigate something, and to explore and ask questions and discover things.

Hailey believes that her students value their learning experiences in her classroom; they explore, ask questions, and make connections or discoveries. The following post PSI Professional Development Course interview excerpt shows what she feels they value most. “We performed experiments, move around in silly ways to remember concepts, did more than read out of a book and complete worksheets. They felt comfortable.”

In summary, data from the pre PSI Professional Development Course interview revealed information about Hailey’s conceptual framework for science teaching. The researcher analyzed data in an attempt to discover what Hailey believes about how children learn science and science teaching methods. This includes Hailey’s conceptions
of how children learn and her own view of effective science teaching. Hailey remembers a lot of reading in her early childhood science classes. Hailey feels she learns best, “definitely by seeing and doing.” She learned from college classes and professional development courses that contained hands-on activities that were pertinent to the curriculum. Hailey is strict, but has sense of humor. In her post PSI Professional Development Course interview Hailey explained that she felt it was important for her students to: see relationships, ask questions, understand science process skills, and care for the Earth. She feels her students are engaged in learning through hands-on activities, experimenting, songs, and movement. She only uses the textbook after students have participated in hands-on activities.

Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post

Hailey’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the high efficacy category, with 58 points and 57 points respectively (max=65 points) (see Figure 7). Therefore, she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores for the pre and post assessments increased notably, with 47 (high OE) points to 52 (high OE) points (max=60 points); indicating she had an increase in her confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).
Constructivist Learning Environment Survey – CLES Analysis Pre and Post

The CLES Personal Relevance scale relates to students’ experience of the personal relevance of school science as perceived by teachers (Suters, 2004; Taylor et al., 1997). Hailey’s pre (27) and post (24) CLES Personal Relevance scores were in the high intermediate agreement range, which indicated that she often but not always emphasized a linkage between school science and students’ everyday experiences (see Figure 8). Her scored decreased slightly indicating that in the 2007-2008 class she placed emphasis on a linkage between school science and students’ everyday experiences. This finding is supported by Hailey’s statement in her post PSI Professional Development Course interview session which reads, “I teach whatever needs to be given as background knowledge to understand a concept, and sometimes go further to make the content more
meaningful and interesting in their lives. Hailey “sometimes” emphasizes the link between school science and students’ everyday experiences.

The Scientific Uncertainty scale relates to students’ perceptions of science as a fallible human activity as perceived by teachers (Suters, 2004; Taylor et al., 1997). Hailey’s pre (20) and post (20) CLES Scientific Uncertainty scored were identical, both in the low intermediate range. This is an indication that Hailey did not feel comfortable engaging students in opportunities to learn to be skeptical and critical about the nature and value of science. In particular to learn that scientific knowledge is evolving and provisional, that scientific knowledge is shaped by social and cultural influences, and that scientific knowledge arises from human interests and values.

The Critical Voice scale relates to students development as autonomous learners, through creation of a social climate in which students feel that their learning is legitimate and beneficial (Suters, 2004; Taylor et al., 1997). Hailey’s pre (26) and post (26) CLES Critical Voice scores were identical, both in the high intermediate agreement range which indicated that she sometimes but not always placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediment to their learning. Hailey notes the emphasis she places on the Milton County curriculum map when planning for science instruction in this post PSI Professional Development Course interview statement.

I have to emphasize content on the curriculum map. I would sometimes like to delve further to allow students time to research or experiment more, but I am limited due to the amount of content on the curriculum map and the need to review all the fourth grade content as well as the fifth grade.
Hailey sometimes wished that she could allow students more freedom to question her teaching plans, but she felt that school and state level restrictions on curriculum limit her ability to do this.

The CLES Shared Control scale also relates to student autonomy. This scale is concerned with students sharing control of the classroom-learning environment with their teacher (Suters, 2004; Taylor et al., 1997). Hailey’s pre (14) and post (17) Shared Control scores increased slightly. Both scores were in the low intermediate agreement category. This indicates that during the 2007-2008 school year she placed slightly more emphasis on inviting students to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms for the classroom. Again, Hailey sometimes wished to allow students more freedom to question her teaching plans, but school and state level restrictions on curriculum limit her.

The CLES Student Negotiation scores relate to teacher beliefs as they relate to student interaction with other students (Suters, 2004; Taylor et al., 1997). Hailey’s Student Negotiation scores increased notably from a high intermediate agreement level for the pre PSI Professional Development Course assessment (23) to a high agreement level for the post PSI Professional Development Course assessment (29). This indicated that after participating in the PSI Professional Development Course she offered more opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas during science lessons in her classroom.

Last, the Attitude Scale scores provide a measure of the concurrent validity of the CLES. It is used to measure teachers’ interpretations of students’ attitudes towards the
classroom environment (Suters, 2004; Taylor et al., 1997). Hailey’s Attitude Scale scores increased slightly from a high intermediate pre PSI Professional Development Course assessment (26) to a high agreement level for the post PSI Professional Development Course assessment (28). This indicated that during the 2007-2008 school year she felt that students more often: anticipated the activities within her classroom, found the activities worthwhile, and understood and enjoyed the activities. This finding is supported by data from Hailey’s pre PSI Professional Development Course interview session. Hailey explains that she feels her students value their science educational experience in her classroom because, “They’ve told me that they love doing experiments. They love doing hands-on things instead of just reading the book. That is what they would tell me.”

![Figure 8. Hailey’s CLES Scores](image)

**Figure 8.** Hailey’s CLES Scores
Hailey’s Partner Portfolio for Professional Development Analysis

Hailey was offered the opportunity to reflect and manage her thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006) throughout the PSI Professional Development Course. The researcher examined five products produced by Hailey: (a) Invitation to Practice: Science Learning Personal History, (b) Invitation to Practice: Collaboration, (c) pre PSI Professional Development Course lesson observation, (d) Hailey’s personal goal for the PSI Professional Development Course, and (e) journal entries to confirm the previously mentioned data findings from the pre interview session.

Hailey’s Partner Portfolio for Professional Development Analysis findings, along with the STEBI and CLES data serves as triangulation of multiple data sources. This provides for multiple measures of the same phenomenon (Yin, 2003).

A framework for organization is based upon Hailey’s interview excerpts related to her beliefs about teaching science. Hailey’s interview excerpts showed that she science learns best “definitely by seeing and doing.” An excerpt from the Invitation to Practice: Science Learning Personal History (see Appendix G) activity supported the idea that Hailey believes that she is a visual learner and needs to learn through hands-on interactions.

While I grew up in a town that revered education, I only remember hatching baby ducks in elementary school. I remember working straight out of the book. Science really didn’t grab my attention until college when we had more labs. I know I am a visual learner and learn by hands-on. I would never remember Newton’s law of equal and opposite reaction if the professor hadn’t demonstrated it for me. Perhaps if he had actually thrown the ball, I would have better understood how to solve those acceleration problems. This inquiry helps me to understand how important the visual and actually doing the experiment is to understanding. I’m sure my students have gotten more out of lessons that are visual as opposed to
those dull lessons of reading, taking notes, and explain orally. The most vivid moments of a science lesson in my mind is when my physics professor taught us about Newton’s law of how for every reaction there is an equal and opposite reaction. It was a typical morning in Philip’s Hall. Students had meandered in, many reading the school newspaper, myself included. In walks the professor with a helmet on and a scooter in one hand and a fire extinguisher in the other. He said, “Good morning,” to capture our attention. Once we looked up, he definitely had our attention. Without saying anything else, he sat on the scooter, faced the wall, and sprayed the fire extinguisher against the wall. This sent him flying across the auditorium. He then stood up and said, “Newton discovered that for every action there is an equal and opposite reaction.” I really can’t come up with his other laws at the top of my head, but I never forgot that one.

From this excerpt we see that Hailey believes that her students learn more when they are actively engaged and experimenting with science concepts than reading from a book, taking notes or listening to oral explanations. Her experience learning about Newton’s law vividly stood out in Hailey’s mind.

Data analysis continued with an investigation to further explore Hailey’s beliefs about how children learn science. Pre PSI Professional Development Course interview data showed that Hailey remembers a lot of reading in her early childhood science classes. In her own science teaching Hailey notes that she doesn’t read from a book unless the students have tried something hands-on first. Hailey explains, “I generally don’t just open a book and open the workbook and say, ‘now this is what we’re doing, or reading, now do the workbook.’ If I do that it’s only after I’ve done something hands-on first.” In one of her Invitation to Practice: Collaboration entries, Hailey writes that she and her CF, Robin, are both “not afraid to try new things.” Hailey’s goal for the PSI Professional Development Course reads, “I would like to use inquiry in every science unit, particularly in those that currently seem like it would not lend itself to it.”
Last, data analysis focused on Hailey’s beliefs about science teaching methods. Pre PSI Professional Development Course interview data shows that Hailey uses the following methods to teach science: inquiry, hands-on activities, and songs. In one of her Partner Portfolio for Professional Development journal entries, Hailey explains that she chose a glove as an artifact to represent her science teaching “to represent how I try to provide hands-on lessons in science. So much is abstract for fifth graders that unless it is hands-on or equated with something you feel they know, they can’t grasp it.” In her post PSI Professional Development Course interview data, Hailey explained that she felt it was important for her students to: see relationships, ask questions, understand science process skills, and care for the Earth. She feels her students are engaged in learning science through hands-on activities, experimenting, songs, and movement. She only uses the science textbook after students have participated in hands-on activities. Hailey’s CLES Attitude Scale scores increased slightly from a high intermediate pre PSI Professional Development Course assessment (26) to a high agreement level for the post PSI Professional Development Course assessment (28). This indicated that following the PSI Professional Development Course she felt that her students more often: anticipated the activities within her classroom, found the activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997). As noted in Hailey’s CLES analysis, this finding is supported by data from Hailey’s pre PSI Professional Development Course interview session. Hailey explains that she feels her students value their educational experience in her classroom because, “They’ve told me that they love doing experiments. They love doing hands-on things instead of just reading the book. That is what they would tell me.”
Summary of Hailey’s Results for Research Question 1

Research Question 1 solicits an answer to the following questions: “What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?” Hailey’s pre and post PSI Professional Development Course interview excerpts disclosed knowledge about her conceptual framework for science teaching. Hailey explained that she discovered that she learns science best “definitely by seeing and doing.” Through a series of reflective activities during the PSI Professional Development Course, Hailey explained that she believes her students learn more when they are experimenting with science, rather than reading from a book, taking notes or listening to oral explanations. Hailey reported that she is not afraid to try new activities and lessons in her science classroom. Hailey explained that she would like to use inquiry in her classroom; in fact, she set this as her goal for the PSI Professional Development Course. In her post PSI Professional Development Course interview data, Hailey explained that during her science lessons she felt it was important for her students to: see relationships, ask questions about the concepts, understand science process skills, and care for the Earth. Hailey feels her students in her classroom are actively engaged in learning science through hands-on activities, experimenting, songs, and movement. She only uses the science textbook after her students have been presented with the opportunity to participate in hands-on science activities. Data analysis from Hailey’s Partner Portfolio for Professional Development, STEBI analysis, and CLES analysis support these finding.
Research Question 2 Analysis

How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

Interview analysis (see Appendix B for instrument) for Research Question 2 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, and 8 listed in Table 1, (b) post PSI Professional Development Course interview questions 3 and 4, (c) classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (d) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), (e) CLES analysis (see Appendix D1 for instrument and D2 for scoring instructions), and the (f) Partner Portfolio for Professional Development. The researcher utilized this data in order to examine the way in which Hailey perceives herself or describes her own abilities to produce desired or intended results in her science classroom. This data were also drawn on to describe the Hailey’s Subject Matter Knowledge (SMK). Subject Matter Knowledge (SMK) is defined as the teacher’s knowledge of content matter and pedagogy (the art of being a teacher), along with her curriculum knowledge (Shulman, 1986). Last, the researcher analyzed the data to reveal information related to Hailey’s understanding of I-B methods. In other words, we have assembled the pieces to answer the teacher’s query, “How does Hailey describe her abilities to produce desired or intended results in her science classrooms? What does Hailey believe about her science content knowledge and her pedagogical science knowledge? What does Hailey understand about I-B methods?”

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**Hailey’s Interview Analysis: Pre and Post Professional Development Course**

Data analysis started with an examination of Hailey’s description of her own efficacy and her ability to produce a desired or intended result. The researcher analyzed pre PSI Professional Development Course interview data, which was useful in describing Hailey’s framework for understanding science and her ability to produce desired results according to her beliefs and self-efficacy. In her pre PSI Professional Development Course interview, Hailey explains that when she thinks of science she thinks of “…discovery. I think of difficult concepts and questioning.” Information about Hailey’s knowledge of content information was revealed previously in Research Question 1 analysis. During the analysis, the researcher learned that Hailey remembered a lot of reading in her early childhood science classes. In college, Hailey remembered hands-on activities that pertained to the curriculum. Hailey believes that she learns best by “seeing and doing.” Hailey’s own elementary science classroom reflects the way in which she learns science best and was taught in college; rather than the way in which she was taught science in her early childhood classes.

To create a picture to describe Hailey’s framework for understanding science and her ability to produce desired results according to her beliefs and self-efficacy, data analysis includes: an examination of Hailey’s description of her own efficacy, an examination of Hailey’s description of her own framework for understanding science content and teaching methods, and a description of her own framework for understanding I-B methods. Interview codes and transcript statements for Hailey’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions for Research Question 2 are listed in Table 15.
Table 15

Interview Codes and Transcript Statements for Hailey (T4) Pre and Post – Research Question 2.

**Self-Efficacy Related to:**

<table>
<thead>
<tr>
<th>Understanding of Science Content</th>
<th>Teaching Methods</th>
<th>Definition of science and Inquiry science</th>
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<tr>
<td>Pre: “The only one I remember is when we were hatching baby chicks and we had an incubator in the classroom. That was exciting. Most of my classes as a child, the rest of my memory is just opening a textbook and reading.” (Sit n’ Git)</td>
<td>Pre: Hailey knows when her students understand a concept. “If they are able to, not just list, but explain their answer and maybe take another example to demonstrate the concept worked outside of what they’ve already learned.” (Methods) (Apply and Connect)</td>
<td>Pre: Hailey explains that when she thinks about science, “I think discovery. I think difficult concepts and questioning.” (Components-Science)</td>
</tr>
<tr>
<td>Pre: “I think that one of my strengths is my willingness to look for new ways of teaching something. Looking for new things and as a science teacher, the mess doesn’t seem to bother me. That disorganized side of my self does come into play in a positive way. I think I maintain a classroom where the students are engaged and it’s not, but they know their limitations in behavior and all of that.” (Make Better)</td>
<td>Hailey describes her own framework for understanding I-B methods before the PSI Professional Development Course as “limited to asking questions to gain understanding.” (Methods)</td>
<td>Pre: She feels inquiry science includes, “providing exploration so that students will ask the questions and solve the problems through discovery.” (Components-Inquiry)</td>
</tr>
<tr>
<td>Pre: “We had a wonderful professor, very outgoing and understood that a lot of people felt uncomfortable teaching science. Most of the class really did admit they felt uncomfortable teaching it… “(Negative Emotions)</td>
<td>Pre: “I wish I could do lots of things; it’s the time thing. I thought about making a whole big plant cell out of the classroom. I’ve got the idea in my head but I just haven’t been able to do it. So I wish I could just turn the classroom into whatever I am studying. That would be great. But, time is an issue.” (Methods)</td>
<td>Post: She believes it is important for students to “see relationships, ask questions, and be willing to complete work.” (World View) (POV)</td>
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<td></td>
<td></td>
<td>Post: “It [inquiry science] is a process. It can be achieved by writing a lesson using the 5E’s.” She further explains that she will use “engagement,” the “5E’s template to write lessons” and “try to pose a problem” in her lessons. (Components-Inquiry) (Method)</td>
</tr>
</tbody>
</table>
During this analysis we learned that Hailey feels comfortable engaging her students in learning science through hands-on activities, experimenting, songs, and movement. Hailey explains what she believes are her main strengths as a science teacher in the pre PSI Professional Development Course interview excerpt that follows.

I think that one of my strengths is my willingness to look for new ways of teaching something. Looking for new things and as a science teacher, the mess doesn’t seem to bother me. That disorganized side of my self does come into play in a positive way. I think I maintain a classroom where the students are engaged and it’s not, but they know their limitations in behavior and all of that.

Hailey feels she is open to learn and try new ways of science teaching. Her students are allowed to get messy, but understand limits as they are engaged in science learning activities.

Hailey is interested in improving as a science teacher but fears that time might keep her from attaining her goals. Hailey feels she would like to improve the following: “Organization and parents, I need to probably call home to parents more often than I do. The organization and constant looking in assignment books to make sure it’s done. Those are the things.” In this excerpt from Hailey’s pre PSI Professional Development Course interview she revealed more about her wishes for improvement.

I wish I could do lots of things; it’s the time thing. I thought about making a whole big plant cell out of the classroom. I’ve got the idea in my head but I just haven’t been able to do it. So I wish I could just turn the classroom into whatever I am studying. That would be great. But, time is an issue.

The factors of fear, knowledge, and affect as determined by the teachers’ cognitive framework help shape the teachers’ actions (Senge, 1990). Hailey wishes she could do a lot of things, but fears she will not be able to carry out her wishes because of the factor of time. In summary, Hailey wishes to improve her science teaching related to organization
and parent communication; however, she is fearful that she will not have enough time to implement her ideas.

Data analysis continued with an examination of Hailey’s description of her own framework for understanding science content and science teaching methods. The researcher analyzed pre PSI Professional Development Course interview data, which was useful in describing Hailey’s framework for understanding science. In the pre PSI Professional Development Course interview Hailey explains that when she thinks about science, “I think discovery. I think difficult concepts and questioning.” In her post PSI Professional Development Course interview excerpts Hailey reveals that she believes it is important for students to “see relationships, ask questions, and be willing to complete work.”

Information about Hailey’s knowledge of science teaching methods, her pedagogical science content knowledge was revealed in Research Question 1 analysis. In the pre PSI Professional Development Course interview, Hailey revealed that she felt it was important for her students to: see relationships, ask questions, understand science process skills, and care for the Earth. She feels her students are engaged in learning science through inquiry, hands-on activities, experimenting, songs, and movement. She only uses the science textbook after students have participated in hands-on activities. The excerpt that follows describes how Hailey knows when her students understand a science concept. “If they are able to, not just list, but explain their answer and maybe take another example to demonstrate the concept worked outside of what they’ve already learned.”

Last, data analysis focused on Hailey’s description of her own framework for understanding I-B methods, what she understands about I-B science methods. This
excerpt from Hailey’s pre PSI Professional Development Course interview illustrates how she defines inquiry science, she feels it includes, “providing exploration so that students will ask the questions and solve the problems through discovery.” In her post PSI Professional Development Course interview, Hailey describes her own framework for understanding I-B methods before the PSI Professional Development Course as “limited to asking questions to gain understanding.” Following the professional development course, she describes I-B methods by saying, “It is a process. It can be achieved by writing a lesson using the 5E’s.” She further explains that she will use “engagement,” the “5E’s template to write lessons” and “try to pose a problem” in her lessons.

In summary, Hailey feels comfortable engaging her students in learning science through inquiry, hands-on activities, experimenting, songs, and movement. Her students are allowed to get messy, but understand limits as they are engaged in learning activities. Hailey feels she is open to learn and try new ways of teaching and wishes to improve her teaching related to organization and parent communication; however, she is fearful that she will not have enough time to implement her ideas. In the pre PSI Professional Development Course interview Hailey explains that when she thinks about science, “I think discovery. I think difficult concepts and questioning.” Hailey also revealed that she felt it was important for her students to: see relationships, ask questions, understand science process skills, and care for the Earth. She feels she engages her students through inquiry, hands-on activities, experimenting, songs, and movement. Hailey is careful to use the science textbook only after students have already participated in hands-on activities.
Classroom Observation Analysis: Pre and Post Professional Development Course

Researcher observations in Hailey’s science classroom were completed May 17, 2007 and October 17, 2007. Hailey had a total of 24 students in the pre PSI Professional Development Course observation and 23 students in the post PSI Professional Development Course observation. The demographics of the two classes observed for the pre PSI Professional Development Course and post PSI Professional Development Course observations are described in Table 16.

Table 16.

<table>
<thead>
<tr>
<th>Race</th>
<th>Pre (24)</th>
<th>Post (23)</th>
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<tbody>
<tr>
<td></td>
<td>Males</td>
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<tr>
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</tr>
<tr>
<td>Other</td>
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<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

Data analysis includes a review of Hailey’s interview and observation data followed by presentation of evidence related to the implementation of the forms inquiry as described by Martin-Hansen (2002). A review of the pre PSI Professional Development Course observation supports the pre PSI Professional Development Course interview data and suggests that Hailey used multiple methods while teaching one science
lesson, including: review, homework, whole group discussion, questioning, visual clues (use of highlighters), hands-on activities, reading and answering questions, small group activities, exploration, structured inquiry using mystery boxes, and use of science process skills including classification activities. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). A brief synopsis of the pre PSI Professional Development Course lesson is illustrated in this paragraph. Prior to the science lesson, Hailey checked and reviewed homework, which consisted of SOL review questions. Each day Hailey helped the students access prior knowledge to discuss and answer four different review questions. Hailey’s lesson followed the topics of static electricity and current electricity, a review of fourth grade material. In her lesson plan Hailey engaged students by demonstrating the concept of static electricity using a balloon, foil, and sugar. Students read aloud and discussed answers from a review sheet about static and current electricity. Students made use of highlighters to color code important pieces of information. Hailey encouraged them to explain why the answer was correct or incorrect. Students were encouraged to use vocabulary terms. In the next section of the lesson Safety issues were discussed and students were instructed that they would be responsible for their own sheet, but were allowed to work in groups to assist each other and collaborate. Students were directed to first, predict which bulbs might light. Second, they retrieved a mystery box to use to carry out the test. Third, they experimented, noting a red star light indicated that the bulb lights. Last, students were asked to explain the reason they believe their bulb did or did not light. Students were encouraged to predict, try, and then explain what was happening inside of their mystery box. The lesson was interrupted by lunch. Hailey chose
to continue the lesson after lunch. When students returned they completed a classification activity using a cut-and-paste worksheet.

During the pre PSI Professional Development Course observation lesson the students followed directions investigate how the electric circuit might be set up inside the mystery box, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). Data from the pre PSI Professional Development Course observation verifies data from the Pre PSI Professional Development Course interview that showed that Hailey feels comfortable engaging her students in science learning through Structured Inquiry, hands-on activities, experimenting, and movement. Her students were allowed to get messy, but also understood their limits as they were engaged in science learning activities in her classroom.

During the post PSI Professional Development Course observation Hailey continued to employ a variety of science teaching methods into her lessons, methods included: review, homework, whole group discussion, reading and answering questions, use of science process skills, sequencing, classification, hands-on activities, small group instruction, Structured Inquiry, and questioning. As demonstrated in Hailey’s science lesson plans and pre PSI Professional Development Course observation data, she had already successfully implemented Structured Inquiry into her science classroom. A brief synopsis of the lesson from the post PSI Professional Development Course observation is illustrated in this paragraph. As students entered the classroom, they were excited about a new fish tank that they learned how to set up and care for the day before. Many students
were also visiting a table at the back of the room to observe a salt crystal experiment that they started a few days prior to this lesson. There was a paraprofessional in the classroom to assist students throughout the lesson. Prior to the science lesson Hailey conducted a review session and a homework check; students used sticky notes to add pictures to a sequence activity from a prior lesson. Hailey started the new lesson by introducing the students to the concept of rock classification. She passed out three rocks to each group of students and explained that they would use the rocks to answer questions later. Hailey then directed students to locate a page in their textbook and engaged them in a discussion about where they might find minerals. Hailey shared an example of how a classification system might work through use of a hands-on interactive matching activity in which insects were classified into groups. Next, students were encouraged to work as a team to design their own observation in order to determine how the rocks might be classified. They used scientific observation skills and were able to choose their own categories for classification, students choose the following: color, texture, and shape. In summary, the researcher observed evidence of Guided Inquiry, inquiry in which the teacher develops the question and allows the students to co-construct the experimental design (Martin-Hansen, 2002). Upon closure, Hailey explained that students would learn more about the way that scientists classify rocks in later lessons. Hailey also hinted that she would allow students the opportunity to discover the answers to many of their questions on their own as they moved through the unit.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

As noted in Research Question 1 analysis, Hailey’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the
high efficacy category, with 58 points and 57 points respectively (max=65 points). Therefore, Hailey was comfortable with her ability to teach science. This finding supports pre PSI Professional Development Course interview data, which indicated that Hailey feels comfortable engaging her students in science learning through inquiry, hands-on activities, experimenting, songs, and movement. Hailey’s STEBI Outcome Expectancy subscale scores for the pre and post assessments increased notably, with 47 (high OE) points to 52 (high OE) points (max=60 points); indicating she had an increase in her confidence in her science teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Hailey’s Partner Portfolio for Professional Development Analysis.

Constructivist Learning Environment Survey – CLES Analysis Pre and Post

As noted in Research Question 1 Analysis, Hailey’s pre (27) and post (24) CLES Personal Relevance scores fell into the high intermediate agreement range, which indicated that she often but not always emphasized a linkage between school science and students’ everyday experiences. Hailey’s CLES Personal Relevance scores decreased slightly indicating that in the 2007-2008 class she placed emphasis on a linkage between school science and students’ everyday experiences. Her pre (20) and post (20) CLES Scientific Uncertainty scores were identical, both in the low intermediate range. Hailey did not feel comfortable engaging students in opportunities to learn to be skeptical and critical about the nature and value of science. In particular, to learn that scientific knowledge is evolving and provisional, that scientific knowledge is shaped by social and
cultural influences, and that scientific knowledge arises from human interests and values. Her pre (26) and post (26) CLES Critical Voice scores were identical, both in the high intermediate agreement range which indicated that she sometimes but not always placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediment to their learning. Her pre (14) and post (17) CLES Shared Control scores increased slightly. Both scores were in the low intermediate agreement category. This indicates that during the 2007-2008 school year she placed slightly more emphasis on inviting students to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms for the classroom. Her CLES Student Negotiation scores increased notably from a high intermediate agreement level for the pre assessment (23) to a high agreement level for the post assessment (29). This indicated that she offered more opportunities after participating in the professional development course for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. Her CLES Attitude Scale scores increased slightly from a high intermediate pre assessment (26) to a high agreement level for the post assessment (28). This indicated that during the 2007-2008 school year Hailey felt that her students more often: anticipated the activities within her classroom, found the activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Hailey’s Partner Portfolio for Professional Development Analysis.
Hailey’s Partner Portfolio for Professional Development Analysis

The Partner Portfolio for Professional Development was used to hold teacher reflections and allowed the opportunity for Hailey to manage her thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Hailey’s (a) Goal Statement, (b) Exit Slips, and (c) journal entries were analyzed to confirm the earlier mentioned data findings. This examination offers a triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).

Data analysis for points of triangulation started with an examination of Hailey’s description of her own efficacy and her ability to produce a desired or intended result in her science classroom. Pre PSI Professional Development Course interview data shows that prior to the PSI Professional Development Course Hailey was comfortable with her ability to teach science. Hailey’s STEBI Personal Science Teaching Efficacy Belief subscale scores support this belief. Hailey’s assessments, pre (58) and post (57), were in the high efficacy category, indicating that she was comfortable with her ability to teach science. Hailey’s STEBI Outcome Expectancy subscale scores for the pre (47) and post (52) assessments increased notably. This is an indication that she had an increase in her confidence in her teaching ability to create desirable outcomes in her classroom (Riggs, 1988; Riggs & Enochs, 1990). This finding is supported by a journal entry in Hailey’s Partner Portfolio for Professional Development. When describing what’s in her bucket or what she learned from the PSI Professional Development Course, Hailey indicated that she gained a number of “ideas for engagement.” She explained that she felt “less pressure, with “baby steps,” to do it all at once.” She also felt that she learned to put more
“emphasis on engagement.” This added to Hailey’s confidence in her teaching ability to create desirable outcomes. This finding supports Hailey’s STEBI Outcome Expectancy subscale scores. This increase in scores is an indication that she had an increase in her confidence in her teaching ability to create desirable outcomes (Riggs, 1988; Riggs & Enochs, 1990).

Pre PSI Professional Development Course interview data showed that Hailey would like to improve as a science teacher, but is unsure that she will accomplish her goal. She writes that she would like to learn how to improve her science teaching. Pre PSI Professional Development Course interview data revealed that Hailey wishes to improve her science teaching related to organization and parent communication; however, she is fearful that she will not have enough time to implement her ideas. The following excerpt from Hailey’s Goal Statement in her Partner Portfolio for Professional Development supported this idea. Hailey explains, “I would like to use inquiry in every science unit, particularly in those that currently seem like it would not lend itself to it.” An excerpt from an Exit Slip from Hailey’s Partner Portfolio for Professional Development provides triangulation as it further backed the idea that prior to and during the professional development course, Hailey was willing to try to improve as a science teacher, but is unsure about carrying out the process. Hailey wrote, “I am still unsure about how I will manage centers, but want to try.”

Data analysis for points of triangulation continued with an examination of Hailey’s description of her own framework for understanding science content and teaching methods, what she believes about her science content knowledge and her pedagogical science content knowledge. In the pre PSI Professional Development Course
interview, Hailey explained that she felt it was important for her students to: see relationships, ask questions, understand science process skills, and care for the Earth. She engages her students in learning through inquiry, hands-on activities, experimenting, songs, and movement. She notes that she only uses the textbook after students have participated in hands-on activities. Hailey’s pre PSI Professional Development Course observation data supports the pre PSI Professional Development Course interview data and suggests that Hailey used multiple methods while teaching one lesson, including: review, homework, whole group discussion, questioning, visual clues, hands-on activities, reading and answering questions, small group activities, exploration, Structured Inquiry, and use of science process skills including observation, sorting, and classification activities.

Last, data analysis for points of triangulation focused on Hailey’s description of her own framework for understanding I-B methods, the things she understands about I-B science methods. Hailey’s pre PSI Professional Development Course interview data revealed how she defines inquiry science, she believes it includes, “providing exploration so that students will ask the questions and solve the problems through discovery.” This idea was supported by the pre PSI Professional Development Course observation data. During the pre PSI Professional Development Course observation lesson the students followed directions investigate how the circuit might be set up inside the mystery box, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002).
Hailey’s Goal Statement in her Partner Portfolio for Professional Development supports Hailey’s pre PSI Professional Development Course interview data findings. Hailey is interested in improving as a science teacher through implementation of inquiry into her classroom, but is unsure she will be able to accomplish her goal. The excerpt that follows from Hailey’s Exit Slip from Partner Portfolio for Professional Development outlines her thoughts related to her framework for understanding I-B science teaching methods.

I have the tools to create an inquiry lesson and inquiry center activities. I hope to create some lessons tomorrow and would like to create center activities this summer. I have ideas for interactive bulletin boards and my classroom map has changed. It will take a lot of time and thought into creating centers that have some method of accountability. While I have the tools, it will take time to review what I’ve learned and feel comfortable creating I-B lessons.

In her post PSI Professional Development Course interview Hailey defined inquiry science as “posing a problem about the world around us and asking questions, finding a way to answer the questions. The questions are answered by doing, not just reading and researching. Interview data from Hailey’s post PSI Professional Development Course observation reveal that students were encouraged to work as a team to design their own scientific investigation which included observation that would enable the students to answer questions and determine how the rocks might be classified. They used observation skills and were able to choose their own categories for classification, students choose the following: color, texture, and shape. The researcher observed evidence of Guided Inquiry, inquiry in which the teacher develops the question and allows the students to co-construct the experimental design (Martin-Hansen, 2002).
Following the PSI Professional Development Course Hailey indicated that she felt more comfortable with the implementation process related to I-B methods. Hailey’s STEBI analysis, CLES analysis, Portfolio findings all supported this idea. Hailey’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (58) and post (57) assessments were in the high efficacy category, this was an indication that she was comfortable with her ability to teach science (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This finding supports pre PSI Professional Development Course interview data, which indicated that Hailey feels comfortable engaging her students in science learning through inquiry, hands-on activities, experimenting, songs, and movement. Hailey’s pre (14) and post (17) CLES Shared Control scores related to student autonomy increased slightly. Both scores were in the low intermediate agreement category. This indicates that during the 2007-2008 school year, Hailey placed slightly more emphasis on inviting students to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms for the classroom. Hailey’s CLES Student Negotiation scores, pre (23) and post (29), increased notably from a high intermediate agreement level to a high agreement level. This indicated that she offered more opportunities after participating in the PSI Professional Development Course for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas (Suters, 2004; Taylor et al., 1997). An excerpt from Hailey’s portfolio supports the CLES survey findings. In her Invitation to Practice: Mapping My Classroom activity Hailey explains that she purposefully changed the seating arrangement in her classroom to facilitate learning. She explains that, “Students sit in groups because of the number of students and
classroom size. Students in the classroom for inclusion are seated in different groups.”

Data analysis findings from Hailey’s post PSI Professional Development Course interview support Hailey’s CLES and portfolio findings. Hailey explained in her post PSI Professional Development Course interview, “Students sit in groups and work in groups more often. Students are given more time for discussion.” During the post PSI Professional Development Course observation, the researcher observed students sitting in groups while participating in their science lesson. Hailey encouraged the students to work as a team to design their own investigation using observation and classification skills. The students used observation and classification skills in order to determine how the rocks given to them by the teacher might be classified. Hailey was experiencing some success while taking baby steps to accomplish implementation of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), into her lessons.

Summary of Hailey’s Results for Research Question 2

Research Question 2 seeks information to explain the answer to the following questions: “How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?” To offer an explanation, one must understand that Hailey’s cognitive framework incorporates her knowledge of science content and teaching methods and her conceptions of science subject matter or content knowledge, which includes the ideas, facts, and the concepts of the discipline, as well as the relationships among those concepts, facts, and ideas. Further information related to Hailey’s cognitive framework
for science teaching and learning was exposed through data analysis. The researcher learned that prior to the PSI Professional Development Course, Hailey was comfortable with her ability to teach science. Hailey’s STEBI subscale scores and Partner Portfolio for Professional Development excerpts support this belief. Pre PSI Professional Development Course interview findings, supported by Hailey’s Goal Statement in her Partner Portfolio for Professional Development, showed that Hailey is interested in improving as a teacher through implementation of inquiry into her classroom, but is unsure she will be able to accomplish her goal.

Hailey employs an assortment of methods in each lesson in order to teach science concepts, including: review, homework, whole group discussion, questioning techniques, visual clues, hands-on activities, reading and answering questions, small group activities, exploration, Structured Inquiry, use of science process skills including observation, sorting, and classification activities. The researcher observed evidence of Guided Inquiry, inquiry in which the teacher develops the question and allows the students to co-construct the experimental design (Martin-Hansen, 2002). Following the PSI Professional Development Course, Hailey indicated that she felt more comfortable with the implementation process related to using I-B methods in her science classroom. Hailey was experiencing some success while taking baby steps to accomplish implementation of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), into her science content lessons.
Research Question 3 Analysis

What barriers to implementing I-B methods exist?

Interview analysis (see Appendix B for instrument) for Research Question 3 includes a look at of Hailey’s Goal Statement, and selected pre PSI Professional Development Course and post PSI Professional Development Course interview questions listed in Table 1. To build credibility, data were compiled from the (a) STEBI and (b) CLES instruments, (c) through direct observation of the participant’s teaching, and the (d) Partner Portfolio for Professional Development, which included the following: Lesson Plans for the mini-unit and the Invitation to Practice: Mapping My Classroom activity, Exit Slips, Quick Writes, and journal entries. The researcher made use of this data to study the teacher’s mental models in an effort to uncover patterns that shape teaching behavior as it relates to their role as part of the professional community or Shared Identity (SI). In other words, we have assembled the pieces to answer the teacher’s query, “How does Hailey describe her abilities to produce desired or intended results in her science classroom as they relate to barriers to implementation of I-B science methods?”

Hailey’s Goal Statement Analysis: Pre and Post Professional Development Course

Teacher’s attitudes and beliefs about science are key influences on how they teach the subject. The reality of the school classroom consists of lessons in which teachers transmit science as a set of facts, laws, and data. The teachers’ principles or attitude, their tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do. The teachers’ styles, principles, are rooted in experience and develop into individual constructs slowly over time (Souza
Barros & Elia, 1998). Hailey’s tendency to respond favorably or unfavorably towards a science topic, her students or other objects, determines what her students will see, hear, think, and do. During the PSI Professional Development Course Hailey set her own goal for I-B instruction (Hammerness et al., 2005). These tendencies make up her principles or attitude. Hailey’s goal for the PSI Professional Development Course read as follows: “I would like to use inquiry in every science unit, particularly in those that currently seem like it would not lend itself to it.” Looking at Hailey’s goal allowed the researcher to study her attitude towards implementation of I-B methods into her classroom. This goal reveals that Hailey views inquiry favorably and is interested in learning how to implement I-B methods into all of her science units.

*Hailey’s Interview Analysis: Pre and Post Professional Development Course*

Interview analysis for Research Question 3 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 7, 8, and 9. This allowed the researcher to gather information to provide a picture of what was happening Hailey’s classroom and school, thus providing information related to Hailey’s knowledge and practice at the beginning of the research (Davis, 2002). Pre PSI Professional Development Course interview analysis showed that Hailey used the following strategies in her classroom prior to the professional development course: inquiry, hands-on activities, experimenting, songs, and movement. Hailey was comfortable with her ability to teach science. Interview codes and transcript statements for Hailey’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions are listed in Table 17.
Table 17

*Interview Codes and Transcript Statements for Hailey (T4) Pre and Post – Research Question 3.*

**Barriers to Implementation of I-B Methods**

<table>
<thead>
<tr>
<th>Time for Science Instruction and Time Related to Curriculum Guidelines</th>
<th>Support</th>
<th>Teacher</th>
</tr>
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<tbody>
<tr>
<td>Pre: “I wish I could do lots of things; it’s the time thing. I thought about making a whole big plant cell out of the classroom. I’ve got the idea in my head but I just haven’t been able to do it. So I wish I could just turn the classroom into whatever I am studying. That would be great. But, time is an issue.” (Time to teach)</td>
<td>Pre: “Time, like I said before, forgetting, and I guess sometimes a lack of materials.” (Teacher Knowledge) (Materials)</td>
<td>Pre: “I think I really try to follow the objective, whatever it is I need to teach. Probably, I guess my downfall is that I am not as organized as I want to be.” (Teacher knowledge) Pre: “Time, like I said before, forgetting, and I guess sometimes a lack of materials.” (Teacher Knowledge) (Materials)</td>
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Pre: “I have definitely gotten to the point where I follow the curriculum map. For a while when we taught vertebrates and invertebrates we went into some depth. But, we were really running out of time because we have to review fourth grade material. This year we just stuck with vertebrates and invertebrates and moved on. So, basically, I just have to focus on whatever is the objective. I try not to with some things, but there is just too much in it.” (Standards) (Pacing)

Post: Hailey explains in her post PSI Professional Development Course interview that “time constraints and the curriculum map” inhibit her from using I-B methods. (Standards) (Pacing)
Hailey’s teaching team at her school consisted of her CF, Robin, and four other fifth grade teachers. Robin and Hailey each teach science to two different groups of students. The excerpt below illustrates the level of support Hailey indicates that she feels she has received from Robin.

This other teacher I work with, she and I will both get excited about it. She will come up with ideas and I’ll come up with ideas. Sometimes we’ll work on it together. Definitely, having someone else who is just as excited and wants to come up with new ideas definitely can motivate you.

Hailey states that her administration has been supportive of Hailey’s teaching methods, especially hands-on activities.

When they come in and observe and give you kudos for it. They’re glad to see you doing hands-on. Sometimes when you get a student that you feel like just didn’t want to learn and it’s a student that’s been uncooperative. Then that student does well in a science lesson they get excited.

Research supports that it is important that administrators and teammates are supportive of teachers while they are implementing the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). In summary, data from the pre PSI Professional Development Course interview analysis showed that Hailey is receiving the support she needs from teammates and administrators in order to successfully implement I-B science methods into her science classroom.

Although Hailey views inquiry favorably, is interested in learning how to implement I-B methods into all of her science units, feels comfortable with her ability to teach science, and believes her CF, colleagues and administration support her; there may be other barriers that inhibit Hailey to fully carry out her science teaching vision. A teacher’s visions are dependent upon the teacher’s abilities to enact on their cognitive frameworks. In the real world, the teachers’ visions do not always mirror practice.
Stakeholders, students, parents, colleagues, administrators, and the community all impact the teachers’ decision-making processes. Tension often occurs between conflict and consensus building as school divisions proceed with the day-to-day business of curriculum implementation, which could include programs of change. Teachers’ strive to maintain a balance between autonomy (individual identity) and their role as part of the professional community (shared identity) (Scribner et al., 2002). Accordingly, the researcher next examined possible threats to fidelity or barriers to use of I-B instruction. This was accomplished through interviews and classroom observation. This process permitted the researcher to identify connections or relationships between Hailey’s perceptions and use of I-B instruction (Davis, 2002).

Analysis of the pre PSI Professional Development Course interview questions revealed that Hailey did face number of barriers as she went about the process of teaching science in her classroom, including: time, time related to the amount of material to cover in the curriculum map, organization, forgetting, and a lack of materials. Hailey finds that the factor time is a concern she feels when planning to teach science in her classroom. This excerpt from the pre PSI Professional Development Course interview illustrates Hailey’s beliefs.

I wish I could do lots of things; it’s the time thing. I thought about making a whole big plant cell out of the classroom. I’ve got the idea in my head but I just haven’t been able to do it. So I wish I could just turn the classroom into whatever I am studying. That would be great. But, time is an issue.

Hailey explains that time related to the amount of information to cover in the curriculum map also serves as a barrier when planning science instruction.

I have definitely gotten to the point where I follow the curriculum map. For a while when we taught vertebrates and invertebrates we went into some depth. But,
we were really running out of time because we have to review fourth grade material. This year we just stuck with vertebrates and invertebrates and moved on. So, basically, I just have to focus on whatever is the objective. I try not to with some things, but there is just too much in it.

Analysis of pre PSI Professional Development Course interview data revealed that Hailey believed that organization might also prove to be a possible barrier to implementation of IB methods. She explains, “I think I really try to follow the objective, whatever it is I need to teach. Probably, I guess my downfall is that I am not as organized as I want to be.” Hailey further explains that possible barriers to using or implementing I-B methods include: “Time, like I said before, forgetting, and I guess sometimes a lack of materials.”

In summary, analysis of the pre PSI Professional Development Course interview questions revealed that Hailey did face a number of barriers as she went about the process of teaching science in her classroom. Those barriers included: time, time related to the amount of material to cover in the curriculum map, organization, forgetting, and a lack of materials.

Interview analysis for Research Question 3 also included the analysis of the post PSI Professional Development Course interview questions numbered 3, 4, 6, and 7. Data analysis continued with the assumption that Hailey might have encountered possible threats to fidelity or barriers to use of I-B instruction. This process allowed for further identification of connections or relationships between Hailey’s perceptions and use of inquiry instruction (Davis, 2002). Analysis of the post PSI Professional Development Course interview questions revealed that Hailey did face a number of barriers as she went about the process of implementing I-B science in her classroom, including time constraints and the curriculum map. Hailey explains in her post PSI Professional
Development Course interview that “time constraints and the curriculum map” inhibit her from using I-B methods.

In summary, analysis of the pre PSI Professional Development Course interview questions revealed that Hailey did face a number of barriers as she went about the process of implementing I-B science in her classroom, including time, time related to the amount of material to cover in the curriculum map, organization, forgetting, and a lack of materials. In post PSI Professional Development Course interview questions Hailey revealed barriers she faced included time constraints and the curriculum map.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

As noted in Research Question 1 analysis, Hailey’s Personal Science Teaching Efficacy Belief subscale scores for the pre (58) and post (57) assessments were in the high efficacy category. This was an indication that she was comfortable with her ability to teach science. This finding supports pre PSI Professional Development Course interview data, which indicated that Hailey feels comfortable engaging her students in learning through inquiry, hands-on activities, experimenting, songs, and movement. Hailey’s Outcome Expectancy subscale scores for the pre (47) and post (52) assessments increased notably. This is an indication that she had an increase in her confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Hailey’s Partner Portfolio for Professional Development Analysis.*
Details of Hailey’s CLES scores were noted in Research Question 1 analysis. As noted in Research Question 1 analysis, Hailey’s CLES Personal Relevance scores, pre (27) and post (24), were both in the high intermediate agreement range, which indicated that she often but not always emphasized a linkage between school science and students’ everyday experiences. Her scores decreased slightly indicating that in the 2007-2008 class she placed emphasis on a linkage between school science and students’ everyday experiences. Her CLES Scientific Uncertainty scores, pre (20) and post (20), were identical, both in the low intermediate range, an indication that Hailey did not feel comfortable engaging students in opportunities to learn to be skeptical and critical about the nature and value of science. Her CLES Critical Voice scores, pre (26) and post (26), were identical, both in the high intermediate agreement range which indicated that she sometimes but not always placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediment to their learning. Her CLES Shared Control scores, pre (14) and post (17), increased slightly. Both scores were in the low intermediate agreement category. This indicates that during the 2007-2008 school year she placed slightly more emphasis on inviting students to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms for the classroom. Her CLES Student Negotiation scores, pre (23) and post (29), increased notably from a high intermediate agreement level to a high agreement level. This indicated that she offered more opportunities after participating in the PSI Professional Development Course for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. Her
CLES Attitude Scale scores, pre (26) and post (28), increased slightly from a high intermediate score to a high agreement level score. This indicated that during the 2007-2008 school year she felt that students more often: anticipated the activities within her classroom, found the activities worthwhile, and understood and enjoyed the activities (see Appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Hailey’s Partner Portfolio for Professional Development Analysis.

Hailey’s Partner Portfolio for Professional Development Analysis

Throughout the PSI Professional Development Course, Hailey was allowed the opportunity to reflect and take charge of her thoughts and behaviors through reflection, planned processing, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). To confirm the previously mentioned data findings as triangulation of multiple data sources provide for multiple measures of the same phenomenon (Yin, 2003) the following data were analyzed: (a) the Invitation to Practice: Mapping My Classroom activity, (b) the Invitation to Practice: Collaboration activity, (c) Exit Slips, (d) Quick Writes; and (e) journal entries. Analysis of the pre PSI Professional Development Course and post PSI Professional Development Course interview questions disclosed that Hailey confronted a number of barriers as she went about the course of implementing I-B science in her classroom. Analysis of the pre PSI Professional Development Course interview questions revealed that Hailey faced a number of barriers as she went about the process of implementing I-B science in her classroom, including: time, time related to the amount of material to cover in the curriculum map, organization, forgetting, and a lack of
materials. In post PSI Professional Development Course interview questions Hailey revealed barriers she faced included time constraints and the curriculum map.

Hailey has the tools and ability to plan, create, and implement I-B methods. Pre PSI Professional Development Course interview data indicated that Hailey feels comfortable engaging her students in learning through inquiry, hands-on activities, experimenting, songs, and movement. This finding supports Hailey’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre PSI Professional Development Course and post PSI Professional Development Course assessments. Her scores were in the high efficacy category. This is an indication that she was comfortable with her ability to teach science. This finding is also supported by Hailey’s pre PSI Professional Development Course interview data, which indicated that she feels comfortable engaging her students in learning through inquiry, hands-on activities, experimenting, songs, and movement.

Data analysis for points of triangulation started with an examination of Hailey’s description that time and organization might serve as a barrier to her implementation of I-B methods. Interview data revealed that Hailey believed that time, time related to the amount of material to cover in the curriculum map, and organization were barriers she faced as she implemented inquiry into her classroom. As noted in Research Question 2 analysis, the excerpt that follows from Hailey’s Exit Slip from Partner Portfolio for Professional Development outlining her thoughts related to her framework for understanding I-B methods supports the idea that the amount of time for planning and creating, along with the organization of activities, might serve as a barrier.
I have the tools to create an inquiry lesson and inquiry center activities. I hope to create some lessons tomorrow and would like to create center activities this summer. I have ideas for interactive bulletin boards and my classroom map has changed. It will take a lot of time and thought into creating centers that have some method of accountability. While I have the tools, it will take time to review what I’ve learned and feel comfortable creating I-B lessons.

This excerpt from a journal entry in her Partner Portfolio for Professional Development gives Hailey’s reflection on what served as a barrier towards implementing I-B methods. Hailey writes, “I am not writing every lesson plan by defining the 5E’s because of time limitations. I need to put the template on my computer.” Hailey has a limited amount of time available to plan, create, and organize I-B lessons.

In her Invitation to Practice: Mapping My Classroom activity Hailey planned changes that would have to take place in her classroom in order for her to implement I-B science. The excerpt that follows outlines her plans.

On my map, I start with a question. I don’t generally start with a question that leads them to inquiry. I start with a review of the day before and often tell them what we are doing. I just haven’t taken the time to think of a way that starts with a question.

Hailey hasn’t taken the time to think of questions that promote inquiry for all of her science lessons. This supports findings from Hailey’s CLES Shared Control scores. Both pre (14) and post (17) were in the low intermediate agreement category, indicating that students are sometimes invited to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms for the classroom (Suters, 2004; Taylor et al., 1997). Post PSI Professional Development Course interview data showed that Hailey sometimes wished to allow students more freedom to question her teaching plans, but school and state level restrictions on curriculum limit her.
In her pre PSI Professional Development Course interview Hailey mentioned that forgetting to carry out certain tasks served as a barrier to implementation of I-B methods. The excerpt that follows from pre PSI Professional Development Course interview data outlines the methods Hailey feels she generally uses to teach science.

Sometimes I use inquiry, but I think sometimes I forget to. I catch myself just explaining things. I definitely use hands-on as much as possible because I know that there’s so many concepts that a lot of students won’t get unless they are hands-on. Sometimes songs work well too.

Forgetting to implement techniques is also mentioned in Hailey’s Partner Portfolio for Professional Development. As noted in the journal reflection above, Hailey notes, “I need to put the template on my computer.”

Data analysis continued for points of triangulation with an examination of Hailey’s description that a lack of materials might serve as a barrier to implementation of I-B methods. In an Exit Slip from Partner Portfolio for Professional Development she explains that she will have a difficult time gaining “access to a photocopier.” She also reports she might have a difficult time accessing computers to use the “websites given.”

*Hailey’s Classroom Observation Analysis: Pre and Post Professional Development Course*

As noted in Research Question 1 analysis, Hailey’s lesson plans and pre PSI Professional Development Course observation data showed she had already successfully implemented Structured Inquiry. In Hailey’s post PSI Professional Development Course lesson it was evident that she was in the process of implementing further use of I-B methods into her classroom. Hailey’s post PSI Professional Development Course lesson addressed Virginia SOL related to the classification of rocks. The researcher observed
evidence of Guided Inquiry, inquiry in which the teacher develops the question and allows the students to co-construct the experimental design. Hailey was able to implement some elements of inquiry into her classroom lessons. In an Exit Slip in her Partner Portfolio for Professional Development, Hailey explains, “I need to review investigable questions.” She explains, “It will take time to review what I’ve learned and feel comfortable creating I-B lessons. She indicated in one of her journal entries that she feels “less pressure with baby steps to do it all at once.”

*Summary of Hailey’s Results for Research Question 3*

Hailey’s professional development goal revealed that she views inquiry favorably and is interested in learning how to implement I-B methods into all of her science units. Hailey has the tools and ability to plan, create, and implement I-B methods. Hailey feels comfortable engaging her students in learning through inquiry, hands-on activities, experimenting, songs, and movement. During the PSI Professional Development Course Hailey worked with her CF, Robin, to create and implement an I-B lesson plan, Tri Grouping Rocks, into each of their classrooms. Pre PSI Professional Development Course observation data showed that that Hailey had already made use of Structured Inquiry as defined by Martin-Hansen (2002). In her post PSI Professional Development Course observation lesson, Hailey used Guided Inquiry. Analysis of the data revealed that Hailey confronted a number of barriers as she went about the process of implementing I-B science in her classroom, including: time, time related to the amount of material to cover in the curriculum map, organization, forgetting, and a lack of materials. She is gradually working, or taking baby steps, towards implementing Full Inquiry.
Research Question 4 Analysis

What relationships exist between teachers’ perceptions and use of I-B methods?

Data were analyzed to address the query, “What relationships exist between Hailey’s perceptions and use of I-B methods?” Interview analysis (see Appendix B for instrument) for Research Question 4 includes the examination of (a) post PSI Professional Development Course interview questions 2, 3, 6, and 7 listed in Table 1, (b) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (c) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (d) Partner Portfolio for Professional Development. Influences such as Hailey’s culture, educated-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual and style have influenced her beliefs about I-B methods. The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI).

John Dewey (1938, 1997) proposed that experience transpires as a result of the interrelationship of two principles, continuity and interaction. Continuity refers to how each experience a person has influences one’s future, for better or for worse. Interaction refers to the situational influence on one’s experience. The individual’s present experience is a function of the interaction between their past experiences and the present situation. No experience has a predestined value. Therefore, what might be a beneficial experience for one individual could be an unfavorable experience for another. In other words, "positive experiences" motivate, encourage, and enable students to go on to have
more valuable learning experiences, whereas, "negative experiences" tend to lead towards a student closing off from potential positive experiences in the future. Dewey believed that learning experiences should be meaningful to each student and that teachers should step back and act as facilitators (Dewey, 1938, 1997).

Returning to the bucket metaphor described in the researcher’s conceptual framework, Hailey examined the shells and treasures, which included science teaching ideas, techniques, and methods, introduced at the PSI Professional Development Course and made a decision to either keep each one and place it in her bucket, or place it back on the beach based on her own system of values. The unearthing of treasures of considerable value produced a positive influence on Hailey’s motivation, attitude, caring, determination and effort. The discovery of treasure with modest value had a negative influence on Hailey’s motivation, attitude, caring, determination and effort. The data findings were drawn on to illustrate Hailey’s cognitive framework related to inquiry, her beliefs about inquiry teaching, and how this ties into the her daily experiences. This information is vital to understanding teacher change related to inquiry (Keys & Bryan, 2000; Spillane et al., 2002).

*Hailey’s Interview Analysis: Pre and Post Professional Development Course*

Interview analysis for Research Question 4 includes the analysis of the post PSI Professional Development Course interview questions numbered 2, 3, 6, and 7. A qualitative research design served as an appropriate methodology to utilize to examine any relationships the might exist between Hailey’s perceptions and use of I-B methods, seeing as qualitative research is concerned with the perceptions of the participants and with process rather than outcomes or products (Bogdan & Biklen, 1992, Marshall &
Rossman, 2006). This design served as an appropriate methodology to utilize to define inquiry as it is perceived and used by Hailey.

This data findings were drawn on to first illustrate Hailey’s cognitive framework related to inquiry. As noted in Research Question 2 analysis, this excerpt from Hailey’s pre PSI Professional Development Course interview illustrates how she defines inquiry science, she feels it includes, “providing exploration so that students will ask the questions and solve the problems through discovery.” In her post PSI Professional Development Course interview, Hailey describes her own framework for understanding 1-B methods before the PSI Professional Development Course as “limited to asking questions to gain understanding.” Following the PSI Professional Development Course, she describes 1-B methods by saying, “It is a process. It can be achieved by writing a lesson using the 5E’s.” She further explains that she will use “engagement,” the “5E’s template to write lessons” and “try to pose a problem” in her lessons. In her pre PSI Professional Development Course interview Hailey explained that she sees her “willingness to look for new ways of teaching something” as one of her strengths as a teacher. In summary, Hailey’s cognitive framework for understanding inquiry prior to the PSI Professional Development Course was “limited to asking questions to gain understanding.” She feels inquiry includes, “providing exploration so that students will ask the questions and solve the problems through discovery.”

The next step in data analysis for Research Question 4 would include drawing upon data to reveal Hailey’s beliefs about inquiry teaching. She shares her reasons for signing up to take the PSI Professional Development Course in the excerpt below.
I know I’ve tried inquiry. I’m still learning about it and I know it’s just the way to go. I catch myself too many times saying, “I didn’t do that right. I could have done this a different way.” So I feel like if I know more about it then I’ll be less apt to do that and more apt to teach that way.

Hailey feels that if she learns more about inquiry science she will be more likely to teach using that method.

As a final point, the data findings were examined to determine how Hailey’s cognitive framework related to inquiry and her beliefs about inquiry teaching tie into her daily experiences. Hailey tries to model teaching and learning situations in which students learn by “seeing and doing.” She gives an example in the pre PSI Professional Development Course interview excerpt below.

Sometimes it’s just harder than others. Like when I think about populations and communities. It is not as easy to model or do something hands-on. We did drawing, but it is not as easy as, say, something in a matter unit, like an experiment.

She believes her students value the experience in her classroom. She explains, “They’ve told me that they love doing experiments. They love doing hands-on things instead of just reading the book.” Hailey provides opportunities for her students to see and do. Her students do not just read out of a textbook.

In summary, Prior to the PSI Professional Development Course, Hailey’s understanding to inquiry science was “limited to asking questions to gain understanding.” She defined inquiry as “providing exploration so that students will ask the questions and solve the problems through discovery.” Hailey feels that if she learns more about inquiry science she will be more likely to teach science using that method. Hailey’s cognitive framework related to inquiry and her beliefs about inquiry teaching tie into her daily experiences as she provides opportunities for her students to see and do, and to

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participate in hands-on science activities. Hailey’s students do not just read out of a textbook.

*Hailey’s Goal Statement Analysis*

Hailey’s goal for the PSI Professional Development Course read as follows: “I would like to use inquiry in every science unit, particularly in those that currently seem like it would not lend itself to it.” Hailey’s goal was examined to address the query, “*What relationships exist between Hailey’s perceptions and use of I-B methods?*” Hailey’s goal statement reveals that her perceptions of inquiry science are favorable. It also shows that she is interested in learning how to implement I-B methods into all of her science units.

*Science Teaching Efficacy Belief Instrument - STEBI Analysis Pre and Post*

Details of Hailey’s STEBI results were noted in Research Question 1 analysis, *Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post* (see Appendix C1 for instrument and C2 for scoring instructions). Hailey’s STEBI data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003). Hailey’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (58) and post (57) assessments were in the high efficacy category. This was an indication that she was comfortable with her ability to teach science. This finding supports Hailey’s pre PSI Professional Development Course interview data, which indicates that she feels comfortable engaging her students in learning science through inquiry, hands-on activities, experimentating, songs, and movement. Hailey’s STEBI Outcome Expectancy subscale scores for the pre (47) and post (52) assessments increased notably. This is an indication that she had an increase in
her confidence in her teaching ability to create desirable outcomes (Riggs, 1988; Riggs & Enochs, 1990). This data supports Hailey’s goal statement that shows her perceptions of inquiry science are favorable and she is interested in learning how to implement I-B methods into all of her science units.

*Hailey’s Partner Portfolio for Professional Development*

Hailey took part in activities that allowed her to reflect upon and manage her thoughts and behaviors through strategic processing, reflection and collaboration throughout the PSI Professional Development Course (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Hailey’s Partner Portfolio for Professional Development data provides additional pieces that were used to solve the query, “*What relationships exist between Hailey’s perceptions and use of I-B methods?”* Analysis focused on relationships connecting Hailey’s perceptions as they relate to her science teaching practice. Emic accounts, descriptions of behaviors in terms meaningful to the teacher, were used because these accounts are culture specific or are found in the context of the teacher’s classroom (Stake, 2006). The researcher completed three steps in analyzing the partner portfolio. First, Hailey’s definition of inquiry, Hailey’s methods of instruction, and the definition of inquiry used during the PSI Professional Development Course were reviewed for comparison. Hailey’s definition of inquiry and choice of teaching methods was examined. Second, a review of the findings from Hailey’s Interview analysis, Goal Statement analysis, and STEBI analysis was conducted. Third, emic accounts were compared to excerpts from Hailey’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide
additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). Each of these steps is discussed next.

First, the researcher examined Hailey’s definition of inquiry. During the pre PSI Professional Development Course interview session Hailey defined inquiry science, she felt it included: “providing exploration so that students will ask the questions and solve the problems through discovery.” Throughout the duration of the PSI Professional Development Course instruction, Hailey was given the opportunity to develop an understanding of the following topics: What is inquiry, learning through inquiry, developing a mind for constructivism, constructivism, how children learn, designing I-B classrooms, integrating I-B activities, the scientific method, learning cycles, skills and knowledge of I-B teachers, and questioning. Hailey also participated in sample I-B science lessons that were modeled during the PSI Professional Development Course (a complete detailed description of the twenty-hour professional development course is located at Appendix K). During her post PSI Professional Development Course interview, Hailey described her own framework for understanding I-B methods before the PSI Professional Development Course as “limited to asking questions to gain understanding.” During the PSI Professional Development Course Hailey wrote about inquiry in her journal entry titled, “What is Inquiry?” She explained that she feels inquiry is “learning by observing, observations creating questions, sometimes the unpredicted leading to new questions, conclusions creating questions, and creating an experiment based on questions.” Following the PSI Professional Development Course she described I-B methods by saying, “It is a process. It can be achieved by writing a lesson using the
5E’s.” She continued to explain that she will use “engagement,” the “5E’s template to write lessons,” and “try to pose a problem” in her lessons.”

Next, the researcher looked at Hailey’s methods of science instruction. Pre PSI Professional Development Course interview data shows that Hailey used the following teaching methods prior to the PSI Professional Development Course: Structured Inquiry, hands-on activities, songs, and movement. In her post PSI Professional Development Course interview, Hailey explains that she believes it is important for students to “see relationships, ask questions, and be willing to complete work.” Hailey’s students often participate in hands-on activities or experiments. She explained that she only uses the textbook after students have participated in hands-on activities. This excerpt from post PSI Professional Development Course interview data illustrates Hailey’s beliefs about science teaching methods and how children learn science.

A good learner is a good listener. One that might take a concept and find a solution that’s correct, but maybe did not find it in the same way as everybody else. A good learner is someone who is willing to accept new ideas. Someone that has the patience enough that if they fail they try again.

In her post PSI Professional Development Course mini unit lessons, Hailey began implementing Guided Inquiry. During the course of the mini unit, the students were encouraged to work in teams to design their own observations in order to determine how the rocks might be classified. They used observation skills and were able to choose their own categories for classification. Students choose the following: color, texture, and shape.

Then, the definition of inquiry used during the PSI Professional Development Course was reviewed for comparison with Hailey’s definition of inquiry and choice of
science teaching methods. During the PSI Professional Development Course Inquiry instruction was defined as referring to any teaching method focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations and discover answers to their questions about the natural world. Students may plan systems to collect data and choose how to organize and represent the data (Carin et al., 2004). The National Research Council (1998) defines scientific inquiry as:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.” (p. 23)

During the PSI Professional Development Course Hailey wrote about inquiry in her journal entry titled “What is Inquiry?” Hailey explained that she feels inquiry involves “learning by observing, observations creating questions, sometimes the unpredicted leading to new questions, conclusions creating questions, and creating an experiment based on questions.” Hailey’s definition of inquiry is aligned with the definition used during the PSI Professional Development Course. In her science classroom, Hailey often uses a variety of teaching methods including: Structured Inquiry, hands-on science activities, experimentation, reading from the textbook, and the singing of silly or memorable science songs. Hailey’s choice of methods allow for integration or use of I-B methods.
The next step in placing the pieces of the puzzle to solve the query, “What relationships exist between Hailey’s perceptions and use of I-B methods?” consisted of a review of the findings from Hailey’s (a) interview analysis, (b) Goal Statement analysis, and (c) STEBI analysis. Beginning with her pre PSI Professional Development Course interview, the researcher learned that Hailey feels she learns best, “definitely by seeing and doing,” or when her teachers use a constructivist approach. The constructivist approach involves learning when the instructors provide relevant experiences and opportunities that allow the learners to participate and construct knowledge (Piaget, 1929; Vygotsky, 1978). Hailey describes herself as a classroom science teacher in the following excerpt.

I think I try to find different ways to teach subjects, like using the multiple intelligences, but again it’s not always possible. I am, I feel like I am fairly strict but the children know they can kid around with me. I try to maintain a sense of humor. I think I really try to follow the objective, whatever it is I need to teach. Probably I guess my downfall is that I am not as organized as I want to be.

In her post PSI Professional Development Course interview excerpts Hailey further explained, “I teach whatever needs to be given as background knowledge to understand a concept and sometimes go further in order to make the content more meaningful and interesting in their lives.” Analysis of Hailey’s goal statement revealed that her perceptions of inquiry science are favorable. It also showed that she is interested in learning how to implement I-B methods into all of her science units. Hailey’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (58) and post (57) assessments were in the high efficacy category. This was an indication that she was comfortable with her ability to teach science. This finding supports pre PSI Professional Development Course interview data, which indicates that Hailey feels comfortable
engaging her students in learning science through inquiry, hands-on activities, experimenting, songs, and movement. Hailey’s STEBI Outcome Expectancy subscale scores for the pre (47) and post (52) assessments increased notably (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This is an indication that she had an increase in her confidence in her teaching ability to create desirable outcomes. This data supports Hailey’s interview data and her pre PSI Professional Development Course goal statement, which indicates that her perceptions of inquiry science are favorable and she is interested in learning about ways to implement I-B methods into all of her science units.

Last, in assembling the pieces of the puzzle to solve the query, “What relationships exist between Hailey’s perceptions and use of I-B methods?” Emic accounts from Hailey’s (a) interview analysis, (b) Goal Statement analysis, and (c) STEBI analysis were compared with excerpts from Hailey’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). A teacher’s attitudes and beliefs about science are key influences on how they teach the subject (Souza Barros & Elia, 1998). In her pre PSI Professional Development Course interview, Hailey shares her positive attitude about her “…willingness to look for new ways of teaching something.” She passes on her thoughts about trying new things in her Invitation to Practice: Collaboration activity. Hailey writes that she and her CF, Robin, are “not afraid to try new things.” She also notes that they both share a “willingness to embarrass themselves in order for children to learn” and they both choose to “teach above and beyond the SOL.” In an Exit Slip journal entry, Hailey
shares her thoughts about implementing inquiry into her science classroom. She explains, “I have the tools to create an inquiry lesson and inquiry center activities. I hope to create some lessons tomorrow and would like to create center activities this summer.” Hailey’s portfolio data supports her interview data, goal statement, and STEBI scores, which illustrate that her perceptions of inquiry science are favorable, she is interested in learning how to implement I-B methods into all of her science units, and she is capable of choosing which methods she uses in her science classroom. Hailey’s positive attitude had an influence in her decision to choose to implement I-B methods into her classroom.

As noted in Research Question 2 analysis, during Hailey’s pre PSI Professional Development Course observation lesson, the students followed the directions to investigate how the circuit might be set up inside the mystery box, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). Data from the pre PSI Professional Development Course observation verifies data from the pre PSI Professional Development Course interview that shows that Hailey feels comfortable engaging her students in learning science through inquiry, hands-on activities, experimenting, and movement. Her students were allowed to get messy, but also understood limits as they were engaged in science learning activities. Throughout the post PSI Professional Development Course observation lesson Hailey’s students were encouraged to work as a team to design their own observation in order to determine how the rocks might be classified. Students used observation skills and were allowed to choose their own categories for classification. The researcher observed evidence of Guided Inquiry, inquiry in which the teacher develops the question and
allows the students to co-construct the experimental design (Martin-Hansen, 2002). Upon closure, Hailey explained to her students that they would learn more about the way that scientists classify rocks in later lessons. Hailey also hinted that she would allow her students the opportunity to discover the answers to many of their questions on their own as they moved through the science unit. In Hailey’s post PSI Professional Development Course lesson, it was evident that she was in the process of implementing further use of I-B methods into her classroom. Hailey notes the reasons she may not have implemented I-B methods into all of her lessons. She writes, “I am not writing every lesson plan by defining to 5E’s because of time limitations. I need to put the template on my computer.”

Summary of Hailey’s Results for Question 4

Research question 4 asked the question “What relationships exist between teachers’ perceptions and use of I-B methods?” The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI). Data analysis for Research Question 4 showed that Hailey’s perceptions of inquiry science are favorable and she is interested in learning how to implement I-B methods into all of her science units. The perception that I-B methods hold large or great value had a positive influence on Hailey’s motivation, attitude, caring, determination and effort during implementation of the methods in her classroom. Hailey’s definition and vision of inquiry matches her choice of methods for instruction. She feels comfortable when her students in learning science through inquiry, hands-on activities, experimenting, and movement. Hailey’s progress toward the implementation of I-B methods is following a slow and gradual and careful path because of time limitations.
Research Question 5 Analysis

How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Interview analysis (see Appendix B for instrument) for Research Question 5 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, 8 and 9 listed in Table 1, (b) post PSI Professional Development Course interview question 6, (c) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), and (d) the Partner Portfolio for Professional Development. This data were utilized to examine Teacher Choice (TC) in an attempt to disclose methods that encourage teachers like Hailey to overcome resistance to implementing I-B teaching practices. When a teacher, like Hailey, makes a choice she critically assesses the value of available options and chooses a course of action built on her own conceptual framework. Data analysis for Research Question 5 was completed through of a study of Hailey’s conceptual framework composed of: her Individual Identity (II), the portion of the Hailey’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or personal constructs (Scribner et al., 2002); Hailey’s Subject Matter Knowledge (SMK), Hailey’s knowledge of content matter and pedagogy (the art and science of being a teacher) and curriculum knowledge (Shulman, 1986); and Hailey’s Shared Identity (SI), the portion of the Hailey’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community.
Hailey’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 5 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 5, 7, 8 and 9 as well as post PSI Professional Development Course interview question 6. Teacher Choice (TC) is influenced by mental models, “the images, assumptions, and stories, which we carry in our minds of our selves, other people, institutions, and every aspect of the world” (Senge, 1990). Interview analysis allowed the researcher to gather important information related to Hailey’s Individual Identity (II). As noted in Research Question 1 analysis, Hailey revealed that she feels she is open to learn and try new ways of teaching and wishes to improve her science teaching related to organization and parent communication; however, she is fearful that she will not have enough time to implement her ideas. Hailey feels she has a strict classroom management style, but has sense of humor. Her students are allowed to explore and get messy, but understand limits as they are engaged in learning activities. In the pre PSI Professional Development Course interview Hailey explains that when she thinks about science, “I think discovery. I think difficult concepts and questioning.” Hailey also revealed that she felt it was important for her students to: see relationships, ask questions, understand science process skills, and care for the Earth. She feels she engages her students through inquiry, hands-on activities, experimenting, songs, and movement. Hailey is careful to use the textbook only after students have already participated in hands-on activities. In her post PSI Professional Development Course interview Hailey explained that she believes it is important for students to “see relationships, ask questions, and be willing to complete work.”
Interview analysis also revealed information related to Hailey’s early Subject Matter Knowledge (SMK). Undergraduate science courses usually convey science as a group of specifics and sets of laws to be memorized, instead of as a way of knowing about the natural world (NRC, 1998). Hailey’s experiences support this statement. Hailey remembers a lot of reading in her early childhood science classes; however, Hailey noted that she feels she learns best “definitely by seeing and doing.” Hailey reported that she learned best from college science classes and professional development courses that contained hands-on activities that were pertinent to the curriculum.

Interview analysis also gave the researcher a glimpse of Hailey’s Shared Identity (SI). Hailey acknowledged that her CF, her teammates, her students, the Chesapeake Bay, and curriculum guidelines such as the Milton County School System’s curriculum map and state curriculum standards (the Virginia SOL) influenced the way Hailey teaches and her choice of science teaching methods. Hailey believed support from her administration and grade level team was positive. Hailey’s Pre PSI Professional Development Course interview data showed that her CF and her grade level teammates influence her science teaching. The following interview excerpt relates what Hailey explains as the role her CF and her teammates play in influencing her choice of teaching methods.

This other teacher I work with, she and I will both get excited about it. She will come up with ideas and I’ll come up with ideas. Sometimes we’ll work on it together. Definitely, having someone else who is just as excited and wants to come up with new ideas. Definitely can motivate you.

Hailey’s students also have an influence on her choice of teaching methods. Hailey often feels influenced by her students’ reactions to her teaching. Pre PSI Professional Development Course interview data showed that Hailey believes, “Their
excitement makes it worthwhile.” “Hailey is motivated to teach because she feels, “It’s fun. It’s enjoyable to teach. When they demonstrate they understand it and they get excited about it, that’s what makes it fun. When they start asking other questions that they hadn’t thought of before.”

Hailey talked about things at the local and state level that influence the way she teaches. Hailey reported explained that at the state level, “definitely, the SOL influence everything that I teach.” At the local level, Hailey notes, “I have definitely gotten to the point where I follow the [Milton County School System’s] curriculum map.” Hailey continued to explain more about what influences her science teaching, “I guess on the local level. I bring in the Chesapeake Bay watershed and we talk about that. I guess that’s it.” The excerpt below explains Hailey’s thoughts.

You know you have a lot of students that, no matter what I’ve done in the science, they’re not going to remember that, for example: What’s a compound? What’s a mixture? They’re not going to come away with that. The other day I was talking to them. We read a story about Jane Goodall and talked about the chimpanzees. So I guess my main goal is for them to walk away from the classroom understanding that this is the only Earth we’ve got and we’ve got to take care of it. It is important for them to learn some of the things that we can do to take care of the Earth, to understand what it means to be a scientist, what it means to investigate something, and to explore and ask questions and discover things.

Hailey believes that the most important concept for students to understand by the end of the school year is to take care of the Earth through investigation, exploration, questioning, and discovery. She shares information about real scientists with her students in her science classroom.

In summary, Interview data revealed that Hailey makes choices about which methods to use to teach science based on the influences of her CF, her teammates, and her students. She is also influenced by county and state curriculum standards. Issues
related to the care of the Earth and our environment, especially the Chesapeake Bay watershed, had an influence on her science teaching. She believes teaching science is fun and enjoyable.

**Hailey’s Partner Portfolio for Professional Development**

To provide triangulation of multiple data sources (Yin, 2003) the researcher studied pieces from Hailey’s Partner Portfolio for Professional Development including her (a) post PSI Professional Development Course lesson plan, (b) Invitation to Practice: Science Learning Personal History, (c) the post PSI Professional Development Course lesson plan, and (d) the journal entry titled “What is Inquiry?” This study leads to a more meaningful understanding of Hailey’s perceptions as they connect to Teacher Choice (TC) framed by her mental models, conceptions of science subject matter, and barriers related to teaching and learning. Throughout the course of this study, Hailey made use of on her own science education and science teaching experiences, analyzed what she learned during the PSI Professional Development Course, and made a decision whether or not to hold on to, or implement, the ideas based on her own system of values.

Following the pattern for data analysis used for the pre PSI Professional Development Course interview analysis, this portion of the data analysis consisted of a study of Hailey’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI).

First, interview analysis gave the researcher a view of Hailey’s Individual Identity (II). Hailey describes her teaching style as strict, but notes that she has a sense of humor. In the pre PSI Professional Development Course interview Hailey explains that when she thinks about science, “I think discovery. I think difficult concepts and questioning.” She
feels she engages her students through inquiry, hands-on science activities, experimenting, singing songs, and movement. Hailey is careful to use the textbook only after students have already participated in hands-on activities. In her post PSI Professional Development Course interview, Hailey explained that she felt it was important for her students to: see relationships, ask questions, understand science process skills, and care for the Earth. Data from the pre PSI Professional Development Course observation verifies data from the pre PSI Professional Development Course interview that shows that Hailey feels comfortable engaging her students in learning through inquiry, hands-on science activities, experimenting, and movement. Her students were allowed to get messy, for example: they worked in groups cutting and pasting and experimented with growing salt crystals. During the post PSI Professional Development Course observation lesson, the researcher observed students correcting the behavior of their classmates within their groups and encouraging each other to remain on task, supporting the pre PSI Professional Development Course interview statement Hailey made explaining that her students also understood limits as they were engaged in science learning activities. Interview data also showed that Hailey feels she is open to learn and try new ways of teaching science and wishes to improve her teaching related to organization and parent communication; however, she is fearful that she will not have enough time to implement her ideas. Partner Portfolio data from one of Hailey’s Exit Slips supports Hailey’s belief that she is open to new ideas, but is fearful of implementation. Hailey writes she is “still unsure about how I will manage centers, but want to try.”
Next, Partner Portfolio analysis supported and extended previous findings related to Hailey’s Subject Matter Knowledge (SMK). Hailey remembers a lot of reading in her early childhood science classes; however, Hailey feels she learns best “definitely by seeing and doing.” She learned best from college classes and professional development courses that contained hands-on science activities that were pertinent to the science curriculum. When learning, Hailey uses multiple methods, including “seeing” and “doing.” Hailey uses many of the teaching methods that helped her learn in her own teaching. This excerpt from Hailey’s Invitation to Practice: Science Learning Personal History illustrates her beliefs about science teaching methods and how children learn science.

This inquiry helps me to understand how important the visual and actually doing the experiment is to understanding. I’m sure my students have gotten more out of lessons that were unusual as opposed to those dull lessons of reading, taking notes, and explaining orally.

Hailey feels actually seeing and doing an experiment in her classroom an important component to her students’ developing an understanding of a science concept. She believes the unusual and interesting activities help her students remember science concepts.

Last, the researcher examined artifacts from Hailey’s Partner Portfolio for Professional Development for data related to her Shared Identity (SI). In the pre PSI Professional Development Course interview session, Hailey acknowledged that the following have influenced the way she teaches science: Hailey’s CF, her teammates, her students, the Chesapeake Bay, and curriculum guidelines, including the Milton County School System’s curriculum map and state curriculum standards (the Virginia SOL). Data
from interview analysis related to Hailey’s Shared Identity (SI) revealed that Hailey believes her administration and grade level team has an influence on her choice of science teaching methods. Hailey writes during her Invitation to Practice: Collaboration activity that she feels she and her CF can help each other. Hailey explains, “Robin and I will both brainstorm and build on each other’s ideas.” These ideas are further enforced a statement that Hailey wrote in one of her Exit Slips. Hailey explained that she found both “her critical friend” and the instructor’s “guidance” to be helpful during her participation in the PSI Professional Development Course.

Data from interview analysis revealed that another influence on Hailey’s choice of science teaching methods is her students. In her post PSI Professional Development Course interview, Hailey stated that she felt motivated to choose an activity because it helps her students to grasp a science concept. In one of her Partner Portfolio for Professional Development journal entries she explains that she chose a glove as an artifact to stand for her science teaching. Hailey explains that she chose the glove “to represent how I try to provide hands-on lessons in science. So much is abstract for fifth graders that unless it is hands-on or equated with something you feel they know, they can’t grasp it.”

Data from interview analysis revealed that influences on Hailey’s choice of science teaching methods are issues related to the care of the Earth and our environment, especially the Chesapeake Bay watershed. During the post PSI Professional Development Course interview the researcher observed students entering the classroom, they were excited about a new fish tank that they learned how to set up and care for during science class the previous day. The students excitedly shared information about the guest speaker.
The students explained how the guest speaker talked to them about caring for the environment that their new fish will live in and shared a comparison with an outside aquatic environment.

Data from interview analysis revealed that another motivator or influence on Hailey’s choice of science teaching methods is influenced by curriculum guidelines, including the Milton County School System’s curriculum map and state curriculum standards (the Virginia SOL). The researcher noted that both the pre PSI Professional Development Course observation lesson objectives and the post PSI Professional Development Course observation lesson objectives were based upon science content required by the Virginia SOL. Both lessons were taught within the guidelines or timeframe of Milton County’s curriculum map. In her Invitation to Practice: Collaboration activity, Hailey writes that she and her CF, Robin, both choose to “teach above and beyond the SOL.”

*Summary of Hailey’s Results for Research Question 5*

Data findings were used to examine Hailey’s choices in an effort to reveal methods that encourage teachers like her to overcome resistance to implementing I-B science teaching practices. Hailey made decisions about her choice of science teaching methods by assessing the value of the options available to her and deciding upon a course of action based on her own conceptual framework. Data analysis for Research Question 5, “How do teachers choose to use I-B methods as opposed to teacher-centered activities?” consisted of an examination of Hailey’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI). Hailey’s Partner Portfolio analysis supported previous data findings related to her
Individual Identity (II). Hailey describes her teaching style as strict, but notes that she has a sense of humor. In the pre PSI Professional Development Course interview, Hailey explains that when she thinks about science, “I think discovery. I think difficult concepts and questioning.” She feels she engages her students in her science classroom through inquiry, hands-on activities, experimenting, songs, and movement. Partner Portfolio analysis clarified previous findings related to Hailey’s Subject Matter Knowledge (SMK) where it was revealed that Hailey remembers a lot of reading in her early childhood science classes. Hailey feels she learns best “definitely by seeing and doing.” She learned best from college classes and professional development courses that contained hands-on activities that were pertinent to the curriculum. Hailey uses many of the methods that helped her learn in her own teaching. Hailey feels motivated to choose an activity because it helps her students to grasp a concept. Data from interview analysis related to Hailey’s SI revealed that Hailey believed support from her administration and grade level team was positive and that they had a large influence on her choice of science teaching methods. In conclusion, Hailey acknowledged that her CF, her teammates, her students, the Chesapeake Bay, and curriculum guidelines such as the county curriculum map and state curriculum standards (Virginia SOL) influence the way she teaches science in her classroom.
Teacher Portrait T5 – Robin

I next present the data to answer the query, “Who is Robin?” This teacher portrait is described as it aligns with each research question. Data that yields information related to each question was analyzed. A discussion of the findings for each question is presented.

Research Question 1 Analysis

What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?

Robin’s Interview Analysis: Pre and Post Professional Development Course

The following data proved useful in providing insights about Research Question 1: (a) Robin’s pre PSI Professional Development Course interview, (b) STEBI survey, (c) CLES survey, (d) Robin’s Partner Portfolio for Professional Development, and (e) Robin’s post PSI Professional Development Course interview. Data findings were utilized to examine Robin’s beliefs in an effort to uncover patterns that influence her teaching behavior as it relates to her Individual Identity (II). Individual Identity (II) is defined as the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfield, 1998) that represents autonomy or personal constructs (Scribner et al., 2002). Robin’s Interview Codes and Transcript Statements for Research Question 1 are located in Table 18.
Table 18.

Interview Codes and Transcript Statements for Robin (T5) Pre and Post – Research Question 1.

<table>
<thead>
<tr>
<th>Beliefs about learning and teaching science</th>
<th>Beliefs About How Children Learn Science</th>
<th>Beliefs About Science Teaching Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre:</strong> I don’t remember a lot of the activities. I remember a biology professor. No, it wasn’t biology, it was physics. We used those cars with the ticker tape. I remember we were collecting all of the data to analyze the speed of the car down the ramp. I remember actually enjoying that. It was a long time ago. I can’t tell you exactly what the outcome was or any data or anything like that. I just remember doing it. It was experimental, hands-on. (Memory) (See &amp; Do)</td>
<td><strong>Pre:</strong> I’m kind of crazy, I guess, kind of silly. I take a real silly approach, a sense of humor approach. For the hard concepts to understand, I make them think about something crazy so it’s going to stick in their head. When they think about it, they’re going to say, “I remember when she did that.” It might be embarrassing for me, but the kids laugh and they get it. So, it makes more of a point to them if I can bring humor into it. (Novelty) (Emotions) (Organization)</td>
<td><strong>Post:</strong> I ask students to think about the concept and how it relates to the world around them. I try to get them interested in the concept by showing enthusiasm and interest in it myself.” (Relate to) (Emotions)</td>
</tr>
<tr>
<td><strong>Pre:</strong> not just with science, but with any subject. I am a very visual, hands-on learner. I like to see it and play with it myself (See &amp; Do)</td>
<td></td>
<td><strong>Post:</strong> I give them a variety of ways to explore a concept. I give them meaningful and engaging activities. We have fun and learn at the same time! (Variety of Methods)</td>
</tr>
</tbody>
</table>
Data were utilized to examine Robin’s beliefs about teaching science, how children learn science, and science teaching methods to uncover patterns that influence her teaching behavior as it relates to autonomy or Individual Identity (II). Data analysis started with an examination of Robin’s memories of her schooling. Robin can’t recall any specific directions that she learned for teaching science or mathematics. She remembers her college science training as more of a broad teaching. Throughout the years she has participated in a number of different summer in-service professional development sessions or courses that provided great activities to use in the classroom. She has also learned from watching other teachers. In the following pre PSI Professional Development Course interview excerpt Robin explains that she does not remember a lot of activities, but she remembers a college physics lesson that really stood out or played a role in shaping her beliefs related to science teaching and learning.

I don’t remember a lot of the activities. I remember a biology professor. No, it wasn’t biology, it was physics. We used those cars with the ticker tape. I remember we were collecting all of the data to analyze the speed of the car down the ramp. I remember actually enjoying that. It was a long time ago. I can’t tell you exactly what the outcome was or any data or anything like that. I just remember doing it. It was experimental, hands-on.

Robin remembers best when actively involved, experimenting, and participating in visual and hands-on activities, when her teachers apply a constructivist approach. The constructivist approach to how people learn focuses on providing relevant experiences and opportunities that allow students to construct knowledge (Piaget, 1929; Vygotsky, 1978). She feels, “not just with science, but with any subject. I am a very visual, hands-on learner. I like to see it and play with it myself.”
A teacher’s principles or attitude, her tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do (Souza Barros & Elia, 1998). This excerpt from Robin’s pre PSI Professional Development Course interview shows what she explains as a description of herself as a classroom teacher.

I’m kind of crazy, I guess, kind of silly. I take a real silly approach, a sense of humor approach. For the hard concepts to understand, I make them think about something crazy so it’s going to stick in their head. When they think about it, they’re going to say, “I remember when she did that.” It might be embarrassing for me, but the kids laugh and they get it. So, it makes more of a point to them if I can bring humor into it.

Robin uses humor and novelty in her teaching because she believes it will help students remember concepts. The human body reacts biochemically to laughing; these changes in the chemical balance of the blood may boost the body’s production of neurotransmitters needed for alertness and memory (Jensen, 1996).

Data analysis was conducted to investigate Robin’s beliefs about she believes students should learn about science. In her post PSI Professional Development Course interview excerpts Robin shares an example that shows us that she believes it is important for students to understand the “scientific method,” including “parts of experiments” like “variables and constants,” and the “tools used in science to gather data.” She also believes students should understand “how science is everywhere.” In post PSI Professional Development Course interview data more of Robin’s beliefs are revealed. Robin shares an example that illustrates her beliefs about science teaching methods and how children learn science in the excerpt that follows. She explains, “I ask students to think about the concept and how it relates to the world around them. I try to get them
interested in the concept by showing enthusiasm and interest in it myself.” Robin believes that her students value their learning experiences in her classroom. The excerpt that follows shows what she feels they value most. Robin explains, “I give them a variety of ways to explore a concept. I give them meaningful and engaging activities. We have fun and learn at the same time!”

Data analysis was conducted to investigate the science teaching methods that Robin uses in her classroom. The following excerpt outlines methods Robin uses in her classroom.

When I first introduce something, I try to have them relate it to something they have learned before. I kind of build it up, for example I say, “today we are going to be talking about matter.” We always try to investigate something with it first. I say, “What is this?” and then we talk about it. I will lead into it. I like that slow approach to get them thinking about it. I ask them, “What about this? Why are we looking at this? What do you think it could be about?” Then from there we springboard, and then we talk about their background knowledge, things like that. It’s a slow approach. Following that we get into the hands-on, getting things ready and then the journaling. Next, if they still need help, would be to see if there’s any technology. I try to pull that in. We have a lot with united streaming videos. I usually use that after words, after the concept has been introduced. We talk about it. It’s more of reinforcement to what they’ve already learned. I let them see it first, then, I ask, “OK, you got it now?” I use anything I can bring in to actually show them. You should have seen us trying to get ferns, for the SOL, with the spores on it. We were trying to find liverwort, but we cannot find liverwort anywhere. We need to show them an example; we can’t just show them a picture. They don’t know what it is. We were going to go hiking in the woods looking for liverwort. But, yes, I rarely, I shouldn’t say, read the book. We do that after we’ve had some introduction. So they do need to have that textbook with them. But, it’s more of a back up rather than the initial.

This excerpt shows that Robin utilizes a variety of methods in her science teaching, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on activities, journaling, technology, and reinforcement.
In summary, data from the pre PSI Professional Development Course interview revealed information about Robin’s conceptual framework for science teaching. The researcher analyzed data to discover what Robin believes about how children learn science and science teaching methods. This includes her conceptions of how children learn and her own view of effective science teaching. Robin learns science by being actively involved, experimenting, and participating in visual and hands-on activities. She offers her students a variety of ways to explore concepts. Robin sees herself as crazy and silly. She believes using enthusiasm, humor, and novelty in her lessons will help students remember concepts. She also tries to keep that same sense of humor when dealing with discipline. Robin values the use of structured science process skills in her lessons.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

Robin’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the high efficacy category, with 63 points and 60 points respectively (max=65 points) (see figure 9). Therefore, she was comfortable with her ability to teach science. Robin’s STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased notably, with 39 points (average OE) and 33 points (average OE) respectively (max=60 points); however, both scores were in the average expectancy category indicating that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Robin’s Partner Portfolio for Professional Development Analysis.*
Figure 9. Robin’s STEBI Scores

Constructivist Learning Environment Survey – CLES Analysis Pre and Post

The CLES Personal Relevance scale relates to students’ experience of the personal relevance of school science as perceived by teachers (Suters, 2004; Taylor et al., 1997). Robin’s pre (32) and post (33) CLES Personal Relevance scores were in the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences (see Figure 10). In a pre interview statement, Robin supported this idea when she said, “science is everywhere, that’s what I teach them.” An excerpt from post PSI Professional Development Course interview data also supports this survey result, Robin explained, “I ask students to think about the concept and how it relates to the world around them.”

The CLES Scientific Uncertainty scale relates to students’ perceptions of science as a fallible human activity as perceived by teachers (Suters, 2004; Taylor et al., 1997).
Robin’s pre (21) and post (23) CLES Scientific Uncertainty scores were both in the high intermediate agreement range, which is an indication that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is evolving and provisional, shaped by social and cultural influences, and arises from human interests and values.

The CLES Critical Voice scale relates to students development as autonomous learners, through creation of a social climate in which students feel that their learning is legitimate and beneficial (Suters, 2004; Taylor et al., 1997). Robin’s pre (30) and post (29) CLES Critical Voice scores were both in the high agreement range which indicated that she placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediment to their learning. Data from Robin’s pre PSI Professional Development Course interview supports this survey result. The excerpt from Robin’s pre PSI Professional Development Course interview that follows shows that students value and remember their learning in Robin’s classroom. Robin explains, “I tell the kids, ‘I embarrass myself, but you know you guys are really going to remember this.’ And they are like, ‘yes, we will remember that. We remember that song you taught us and that.’” Students in Robin’s science classroom are also asked to question their learning. Robin notes that she will ask the kids, “What does science mean to you?” and allow them to “come up with a variety of things and then they brainstorm.” They students are encouraged to look at things around them and ask questions like, “What does that make you think about?”
The CLES Shared Control scale also relates to student autonomy. This scale is concerned with students sharing control of the classroom-learning environment with their science teacher (Suters, 2004; Taylor et al., 1997). Robin’s pre (15) CLES Shared Control score and her and post (14) CLES Shared Control score both fell into the low intermediate agreement range, which is an indication that her students are sometimes invited to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the science classroom. Robin took the time to explain in her pre PSI Professional Development Course interview that she might choose to alter her science teaching methods related to student control based upon the needs of the students in her science classroom. She notes, “It varies from year to year, the students I have, some need a lot of structure and can’t handle the freedom to explore on their own.”

The CLES Student Negotiation scores relate to teacher beliefs as they connect to or have bearing upon student interaction with other students in the science classroom (Suters, 2004; Taylor et al., 1997). Robin’s CLES Student Negotiation scores increased notably from a low intermediate agreement level for the pre PSI Professional Development Course assessment (20) to a high intermediate agreement level for her post PSI Professional Development Course assessment (24). This increase in Robin’s CLES Student Negotiation scores indicated that she offered more opportunities after participating in the PSI Professional Development Course for her students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas in her science classroom.
Last, the Attitude Scale scores provide a measure of the concurrent validity of the CLES. It is used to measure teachers’ interpretations of students’ attitudes towards the classroom environment (Suters, 2004; Taylor et al., 1997). Robin’s pre (29) and post (31) Attitude Scale scores showed a slight increase, both were in the high agreement range which indicated that she felt her students: anticipated the activities within her science classroom, found activities worthwhile, and understood and enjoyed the science activities (see Appendix D1 for instrument and D2 for scoring instructions). This finding supports data from Robin’s pre PSI Professional Development Course interview excerpts where she explains, “I give them a variety of ways to explore a concept. I give them meaningful and engaging activities. We have fun and learn at the same time!”

![Figure 10. Robin’s CLES Scores](image)

### Figure 10. Robin’s CLES Scores

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<th>PR</th>
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<tr>
<td>Post</td>
<td>33</td>
<td>23</td>
<td>29</td>
<td>14</td>
<td>24</td>
<td>31</td>
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Robin’s Partner Portfolio for Professional Development Analysis

Robin reflected upon and managed her thoughts and behaviors through reflection, strategic processing, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). The researcher examined five products produced by Robin: (a) Invitation to Practice: Science Learning Personal History, (b) Invitation to Practice: Collaboration, (c) pre PSI Professional Development Course lesson observation, (d) Robin’s personal goal statement, and (e) journal entries to confirm the previously mentioned data findings from the interviews. Robin’s Partner Portfolio for Professional Development Analysis findings, along with the STEBI and CLES data serves as triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).

A framework for organization is based on Robin’s interview excerpts related to her beliefs about teaching science. Interview excerpts showed that Robin learns by being actively involved, experimenting, and participating in visual and hands-on activities. An excerpt from the Invitation to Practice: Science Learning Personal History (see Appendix G) activity supported the idea that Robin believes she needs to see and do when learning.

I think back to when I first moved to Milton County and I had to learn the new science curriculum. Most of the concepts I had taught before or had at least had some familiarity with. However, I was least comfortable with Matter, as I really had little exposure with it. I basically had to learn it before I could teach it. The first thing I did was to try to read about it. That helped somewhat but then some of the literature was way too complex and more than I wanted to know. My husband knew a lot, as he is an engineer, so I went to him to help explain it. He tried to bring it down to my level, but was not successful! I had the basic knowledge down [density and atomic structure] but needed to try the experiments to visualize the concepts. Reading about it was just not enough. It gave me a foundation but actually seeing it and doing it helped solidify my learning. I think most of my learning is done like that. I am a visual and kinesthetic learner. I need to read about it as well as do something. I feel my learning style is reflected in the way I teach.
When learning Robin needs “to read about it as well as do something” and she also notes that she feels, “My learning style is reflected in the way I teach.”

Data analysis was conducted to investigate Robin’s beliefs about science teaching methods. Pre PSI Professional Development Course interview data shows that Robin uses humor and novelty in her teaching. She does this because she believes it will “stick in their head.” In one of her Partner Portfolio for Professional Development Invitation to Practice entries, she explains that she brought a frog with wacky hair to class because it says something about her as a science teacher. Robin writes, “I love frogs and science and this one is a little wacky, which is how I approach most of my lessons.” In one of her Invitation to Practice: Collaboration entries, Robin writes that she and her CF, Hailey, are both “willing to embarrass themselves in order for students to learn.” Robin’s STEBI Personal Science Teaching Efficacy Belief subscale scores, pre (63) and post (60), indicate that she was comfortable with her ability to teach science (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

More information about Robin’s beliefs about science teaching methods was uncovered in her post PSI Professional Development Course interview data. Robin explains that she gives students “a variety of ways to explore a concept.” Robin utilizes a variety of methods in her science teaching, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on, journaling, technology, and reinforcement. Her CLES Attitude Scale scores, pre (29) and post (31), were in the high agreement range, which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997). In her Invitation
to Practice: Collaboration entries, Robin writes that she and her CF, Hailey, are both “not afraid to try new things.” Robin’s goal for the PSI Professional Development Course reads, “I would like to have several lessons to implement in the classroom. I want to be comfortable in my knowledge of inquiry to use it effectively.”

Robin’s post PSI Professional Development Course interview excerpts show that after the PSI Professional Development Course Robin indicated that she believes it is important for students to understand the “how science is everywhere.” Data from the CLES supports this idea. Robin’s Personal Relevance scores, pre (32) and post (33), were in the high agreement range, which indicated that she placed a high emphasis on linking school science with students’ everyday experiences (Suters, 2004; Taylor et al., 1997).

Summary of Robin’s Results for Research Question 1

Research Question 1 solicits an answer to the following: “What do teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?” Robin’s interview excerpts disclosed knowledge about her conceptual framework for science teaching. Robin feels that she learns by being actively involved, experimenting, and participating in visual and hands-on activities. Robin believes humor and novelty help her students remember. Robin uses a variety of methods when teaching, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on, journaling, technology, and reinforcement. Robin’s Personal Science Teaching Efficacy Belief subscale scores indicate that she was comfortable with her ability to teach science. She isn’t afraid to try new things.
Research Question 2 Analysis

How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

Interview analysis (see Appendix B for instrument) for Research Question 2 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, and 8 (listed in Table 1), (b) post PSI Professional Development Course interview questions 3 and 4, (c) classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (d) STEBI analysis (see Appendix C1 for the instrument and C2 for the scoring instructions), (e) CLES analysis (see Appendix D1 for the instrument and D2 for the scoring instructions), and the (f) Partner Portfolio for Professional Development. The researcher utilized this data in order to examine the way in which Robin perceives herself or describes her own abilities to produce desired or intended results in her science classroom. Data were also drawn upon to describe Robin’s Subject Matter Knowledge (SMK). Subject Matter Knowledge (SMK) is defined as the teacher’s knowledge of content matter and pedagogy (the art of being a teacher), along with her curriculum knowledge (Shulman, 1986). Last, the researcher analyzed the data to reveal information related to Robin’s understanding of I-B methods. In other words, the researcher has assembled the pieces to answer the teacher’s query, “How does Robin describe her abilities to produce desired or intended results in her science classrooms? What does Robin believe about her science content knowledge and her pedagogical science knowledge? What does Robin understand about I-B methods?”
Robin’s Interview Analysis: Pre and Post Professional Development Course

The researcher analyzed Robin’s pre PSI Professional Development Course interview data, which was useful in describing her framework for understanding science as well as her ability to produce desired results according to her own beliefs and self-efficacy. There is a close link between teacher content knowledge in mathematics and science and student performance in these disciplines (Darling-Hammond, 2000; Loucks-Horsley et al., 2003). Keeping this in mind, the researcher examined the information related to Robin’s knowledge of science content information that was revealed in Research Question 1 analysis. During this analysis, the researcher learned that Robin doesn’t recall any specific directions that she learned for teaching science. She explained that she remembers her college science training as more of a broad teaching. Robin explained that she learns science best by being actively involved, experimenting, and participating in visual and hands-on activities. She believes that novelty and humor are effective techniques that she uses to help her students remember science concepts. Robin’s learning style is reflected in the way that she teaches science in her classroom. She uses a variety of methods in her science classroom. Interview codes and transcript statements for Robin’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions for Research Question 2 are listed in Table 19.
Table 19.

Interview Codes and Transcript Statements for Robin (T5) Pre and Post – Research Question 2.

*Self-Efficacy Related to:*

<table>
<thead>
<tr>
<th>Understanding of Science Content</th>
<th>Teaching Methods</th>
<th>Definition of science and Inquiry science</th>
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<tr>
<td>Pre: Robin doesn’t recall any specific directions that she learned for teaching science. She remembers her college science training as more of a broad teaching. She learns by being actively involved, experimenting, and participating in visual and hands-on activities. Robin’s learning style is reflected in the way that she teaches. (Sit n’ Git)</td>
<td>Pre: “Because it’s fun and they enjoy it and I think they learn better from it.” (Motivation)</td>
<td>Pre: “Science is everywhere. We start the year with it. I start telling the kids, to start thinking about science...I’ll tell them, ‘Science is all around. It’s everywhere. It’s all around you. I think about in science, it’s not just a lab, a man in a white coat or a woman in a white coat. It’s all around you. You could be a scientist without having to be in a lab coat. You just explore your back yard and science is there.’...You’ll probably be exploring that now, middle school and beyond. It really is everywhere.” (Components-Science) (World View)</td>
</tr>
<tr>
<td>Pre: “...At first, to be truthful, I think I was a little leery about teaching science. When we first decided we were going to do team teaching we asked, ‘Well which subject are you going to teach?’ I feel I’m more of a math person than science. Then I thought about it and I said, ‘No it’s not that hard. I’m kind of a science person.’ So, I tried it. I am definitely loving it! I’m teaching all science now. I don’t think there was specifically a mentor that helped me, just seeing some of the other teachers and seeing that it [teaching science] was not that difficult for them and their interest in it. That made me see.”</td>
<td>Pre: “Well, there’s paper and pencil tests and things like that, but really what we’ve tried to do this year is some journal writing. I believe they show through their writing if they really understand the concept. We try to do that in science and math. To see, yes, you can answer a question on it, but if you’re writing to explain it then they are really able to show more of a deeper understanding. If they can explain in their own words what is happening and why.” (Reach All) (Methods)</td>
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<tr>
<td>Pre: “I think with science, if I’m going to go that route, I would say, I would like to improve my skills to plan so that when I do an experiment with students or show that they are going to have</td>
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The factors of fear, knowledge, and affect as determined by the teachers’ cognitive framework help shape the teachers’ actions (Senge, 1990). When Robin and her teammates first decided they were going to team-teach, she was a little fearful. The excerpt below outlines how Robin felt about science teaching when she first moved here to Milton County.

As far as training, I think when I moved here from Ohio, when I first started here, I was surprised by the variety of different teachers here in the school. There were some that were interested in science. I think just taking part in the different training sessions, seeing the other teachers helped me learn. At first, to be truthful, I think I was a little leery about teaching science. When we first decided we were going to do team teaching we asked, “Well which subject are you going to teach?” I feel I’m more of a math person than science. Then I thought about it and I said, “No it’s not that hard. I’m kind of a science person.” So, I tried it. I am definitely loving it! I’m teaching all science now. I don’t think there was specifically a mentor that helped me, just seeing some of the other teachers and seeing that it [teaching science] was not that difficult for them and their interest in it. That made me see.
Robin was able to overcome her fear of teaching science by observing others. In the excerpt that follows from Robin’s pre PSI Professional Development Course interview she explains that she is interested in improving her planning skills as a teacher so that she can use her knowledge to give the students the science tools that they need so that can apply them on their own.

I think with science, if I’m going to go that route, I would say, I would like to improve my skills to plan so that when I do an experiment with students or show that they are going to have to apply more of that self learning that they are used to doing. That they understand it, it’s not just me telling them what to do. To ask, “Why is this experiment working this way?” I want them to be able to do that. Maybe even looking for more of those lessons where that light bulb will go off in their head on their own.

Robin is interested in learning how to encourage her students to ask questions to think for themselves.

In summary, as Robin describes elements of her own efficacy, she reveals that she doesn’t recall any specific directions that she learned for teaching science. She remembers her college science training as more of a broad teaching. She feels that she learns best by being actively involved, experimenting, and participating in visual and hands-on activities. Her own learning style is reflected in the way that she teaches science. Robin would like to improve on her planning skills related to applying what she knows about science in order to teach the students how to utilize which science tools to use while working on their own.

Interview analysis continued, focusing on Robin’s own framework for understanding science content and teaching methods. The researcher analyzed pre PSI Professional Development Course interview data, which was useful in describing Robin’s framework for understanding science. The following excerpt illustrates how Robin
defines science when speaking about it in her pre PSI Professional Development Course interview.

Science is everywhere. We start the year with it. I start telling the kids, to start thinking about science. We map it out. I ask the kids, “What does science mean to you?” And then they come up with a variety of things and then they brainstorm. Then we talk about that. I say, “When you look at all of this, what does that make you think about?” They’ll name things in space, the rockets, and the rocks. I’ll ask, “What does that mean?” I’ll tell them, “Science is all around. It’s everywhere. It’s all around you. I think about in science, it’s not just a lab, a man in a white coat or a woman in a white coat. It’s all around you. You could be a scientist without having to be in a lab coat. You just explore your back yard and science is there.” We make a list of science things and keep it until the end of the year. At the end of the year, it’s funny because then we look back at the things that we learned throughout the year. We go back to that list because I save it and we say, “Hey look, look at all of these things that you mentioned that you talked about this year. Guess what? You’ll probably be exploring that now, middle school and beyond. It really is everywhere.”

Robin feels that science is everywhere. She encourages her students to explore and look for science all around them.

In the pre PSI Professional Development Course interview Robin reveals details about her science teaching methods, her pedagogical science content knowledge. Research Question 1 analysis showed that Robin uses a variety of methods in her science teaching, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on, journaling, technology, and reinforcement. Robin further discloses what motivates her to varies her teaching and uses the previously mentioned teaching methods, “Because it’s fun and they enjoy it and I think they learn better from it.” The excerpt that follows describes how Robin knows when her students understand a concept.

Well, there’s paper and pencil tests and things like that, but really what we’ve tried to do this year is some journal writing. I believe they show through their writing if they really understand the concept. We try to do that in science and
math. To see, yes, you can answer a question on it, but if you’re writing to explain it then they are really able to show more of a deeper understanding. If they can explain in their own words what is happening and why.

In summary, Robin uses a variety of methods in her science classes, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on, journaling, technology, and reinforcement because her students learn better and enjoy learning more. She uses journal writing to check to see if her students are truly learning.

Last, data analysis focused on Robin’s description of her own framework for understanding I-B methods, what she understands about I-B science methods. This excerpt from Robin’s pre PSI Professional Development Course interview illustrates how she defines inquiry science.

To define Inquiry science I would say questions. We need to ask questions. Why is it this way? What do you think? Why did we do it this way? So inquiry is having the students, or whomever it is, exploring for that lab trying to understand the question that was asked and trying to explain further. They might ask, “what if we were to make these changes?” and “why is it doing that?” So it’s more exploring for themselves and trying to understand on their own, with guidance, how they arrived at the answers.

Robin explained that she feels science inquiry includes: guided exploration, asking questions, explaining, and understanding how they arrived at the answers. In her post PSI Professional Development Course interview Robin defines inquiry science by saying, “Inquiry science is allowing students to take ownership and generate questions about ideas or concepts that are presented by the teacher.” Robin views learning through I-B methods from a student centered point of view.

In summary, data analysis from Research Question 2 shows that Robin reveals that she doesn’t recall any specific directions that she learned for teaching science, but
remembers her college science training as more of a broad teaching. She feels that she learns best when actively involved, experimenting, and participating in visual and hands-on activities. Her own learning style is reflected in her choice of teaching methods. Robin wishes to improve her planning skills related to applying what she knows about science while giving the student tools to use on their own. When describes her own framework for understanding science content and teaching methods she explains that she uses a variety of methods in her science classes, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on, journaling, technology, and reinforcement. She is motivated to use a variety of methods because her students learn better and enjoy learning more. She uses journal writing to check to see if her students are truly learning. Robin describes her own framework for understanding I-B methods by explaining that she feels science inquiry includes: asking questions, exploring, explaining, and understanding how they arrived at the answers.

*Classroom Observation Analysis: Pre and Post Professional Development Course*

Researcher observations were completed May 17, 2007 and September 7, 2007. Robin had a total of 25 students in the pre PSI Professional Development Course observation and 20 students in the post PSI Professional Development Course observation. Demographics of her two classes during the pre PSI Professional Development Course and post PSI Professional Development Course observations are presented in Table 20.
Data analysis includes a review of Robin’s interview and observation data followed by presentation of evidence related to the implementation of the forms inquiry as described by Martin-Hansen (2002). A review of the pre PSI Professional Development Course observation supports the pre PSI Professional Development Course interview data and suggests that Robin used a variety of methods while teaching one lesson. A brief synopsis of the pre PSI Professional Development Course lesson is illustrated in this paragraph. Robin implemented a review lesson on the topic of measurement. Robin started the lesson by surveying students in a whole group setting about the previous nights homework, review questions for the Virginia SOL test. Robin engaged the students in her measurement lesson by asking them to think of all of the things they had learned related to measurement. They worked as a class to create a list. Some of the students accessed objects on the science table at the back of the room to help as they shared answers. Robin led the children in a discussion and encouraged them to
make connections to their daily lives. She called on students to answer questions. They discussed tricks that they were taught to use to help them remember measurement terms; for example: to remember gram they crushed a gram cracker up into little pieces. Next, students played bingo with pictures of words and units of measurement. Finally, students cleaned-up, Robin summarized the learning, and assigned homework.

During the pre PSI Professional Development Course observation lesson Robin guided the students through the instruction. The researcher observed use of the following methods: discussion, questioning, accessing background knowledge, hands-on activities, and reinforcement. Data from the pre PSI Professional Development Course observation verifies data from the Pre PSI Professional Development Course interview that showed that Robin uses a variety of methods in her lessons. She used questioning techniques to encourage students to make inquiries about measurement tools, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002).

During the post PSI Professional Development Course observation Robin continued to employ a variety of teaching methods into her lessons, methods included: questioning; the reading of children’s literature; use of manipulatives; recording, representing and analyzing data; evaluation of the validity of claims or looking for evidence; writing or reflections in a journal. Prior to the lesson on the layers of the Earth, students worked in pairs to observe, measure, and plant a bean sprout that they started from a seed in a plastic baggie. Students recorded their findings in a journal. They will continue to monitor growth throughout the next few weeks. Moving on to the lesson
about the layers of the Earth, Robin engaged the students by having them guess, “What’s in the bag?” She told students that they were using scientific observation to develop a conceptual understanding. She led them to draw conclusions between the mystery object, a shovel, and concepts they would study about the Earth, for example: digging into the Earth, digging fossils, and searching for evidence related to Pangaea. Robin integrated literature into her science lesson, reading a book about digging a hole to the other side of the Earth. She made connections to information her students studied the previous day about temperature. The class worked together as a whole group to create a list of the layers inside the Earth. Students worked as individuals or pairs to piece together foam pieces of Pangaea. Next, students worked in small groups to explore the layers of the Earth using unifix cubes and clue cards. They investigated possible answers to the questions, “What does the interior of the Earth look like?” and “How do models help us understand things we cannot see directly?” They put the clues together to solve a mystery. Upon concluding the lesson, Robin tied the activity to the work that real scientists might complete, specifically using clues to solve problems.

As demonstrated in Robin’s lesson plans and pre PSI Professional Development Course observation data, she made use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). During the post PSI Professional Development Course observation, Robin allowed students the opportunity to use scientific process skills to discover the answers to the question, “What’s in the bag?” through a teacher guided activity. Robin also allowed students the opportunity to discover the answers to the teacher generated questions, “What does the interior of the Earth look
like?” and “How do models help us understand things we cannot see directly?” Robin reduced the amount of teacher control in this part of the lesson by allowing the students to use a collaborative approach to construct, draw and label the layers of the Earth through the use of clue cards. In summary, the researcher observed evidence of several forms of inquiry as described by Martin-Hansen (2002), including Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design. This form of inquiry was observed as students created questions and used their observation skills to guess what object was inside of a brown paper bag during an activity called “What’s in the bag?” The researcher also observed evidence of Coupled Inquiry, inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002) as Robin reduced teacher control and allowed students to work as individuals or pairs to piece together foam pieces of Pangaea.

Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post

As noted in Research Question 1 analysis, Robin’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the high efficacy category, with 63 points and 60 points respectively (max=65 points). Therefore, she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased notably, with 39 points and 33 points respectively (max=60 points); however, both scores were in the average expectancy category indicating that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data serves as a source for
triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Robin’s Partner Portfolio for Professional Development Analysis.

**Constructivist Learning Environment Survey – CLES analysis Pre and Post**

As noted in Research Question 1 analysis, Robin’s pre (32) and post (33) CLES Personal Relevance scores were in the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences. Her pre (21) and post (23) CLES Scientific Uncertainty scores were in the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. Her pre (30) and post (29) CLES Critical Voice scores were both in the high agreement range which indicated that she placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediment to their learning. Her pre (15) and post (14) CLES Shared Control scores were in the low intermediate agreement range, which indicated that her students are sometimes invited to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom. Her student CLES Negotiation scores increased notably from a low intermediate agreement level for the pre assessment (20) to a high intermediate agreement level for her post assessment (24). This indicated that she offered more opportunities after participating in the PSI Professional Development Course for students to: explain their ideas to other students, make sense of other students’
ideas, and reflect on the viability of their own ideas. Her pre (29) and post (31) CLES Attitude Scale scores showed a slight increase, both were in the high agreement range which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (see Appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Robin’s Partner Portfolio for Professional Development Analysis.

Robin’s Partner Portfolio for Professional Development Analysis

The Partner Portfolio for Professional Development was used to hold teacher reflections and permitted the opportunity for participants to manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Robin’s (a) Goal Statement, (b) Exit Slips, and (c) journal entries were analyzed to confirm the earlier mentioned data findings. This examination offers a triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).

Data analysis for points of triangulation started with an examination of Robin’s description of her own efficacy and her ability to produce a desired or intended result. Pre PSI Professional Development Course interview data shows that Robin feels her college science training consisted of a broad teaching. She doesn’t remember any specific directions that she learned for teaching science. She feels that she learns by being actively involved, experimenting, and participating in visual and hands-on activities. Robin’s learning style is reflected in the way that she teaches. Robin is interested in improving her
planning and instruction skills. Robin’s STEBI Personal Science Teaching Efficacy Belief subscale scores, pre (63) and post (60), were in the high efficacy category indicating that she was comfortable with her ability to teach science (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

Pre PSI Professional Development Course interview data showed that Robin would like to improve as a teacher. The following excerpt from Robin’s Goal Statement in her Partner Portfolio for Professional Development supported the idea that Robin would like to improve as a teacher. She writes that, “I would like to have several lessons to implement in the classroom. I want to be comfortable in my knowledge of inquiry to use it effectively.” An excerpt from her Invitation to Practice: Collaboration activity in Robin’s Partner Portfolio for Professional Development further supported the idea that Robin would like to work with her CF and improve as a teacher. Robin wrote, “I can be a sounding board for her [Hailey], give her ideas as I think of them and also tell her what works and what doesn’t as I try different lessons.” In summary, Robin is interested in improving as a teacher through working with her CF, Hailey, to learn more about inquiry, create lessons, and implement them effectively into her science classroom.

Data analysis for points of triangulation continued with an examination of Robin’s description of her own framework for understanding science content and teaching methods, what she believes about her science content knowledge and her pedagogical science content knowledge. In her pre PSI Professional Development Course observation lesson, Robin uses a variety of methods to teach science, including: discussion, questioning, accessing background knowledge, hands-on, and reinforcement. In her post PSI Professional Development Course observation lesson, Robin continued to
employ a variety of teaching methods into her lessons, methods included: questioning; the reading of children’s literature; use of manipulatives; recording, representing and analyzing data; evaluation of the validity of claims or looking for evidence; writing or reflections in a journal. Robin added new teaching techniques to her list of science teaching methods following the PSI Professional Development Course. For example, post PSI Professional Development Course interview data showed that following the PSI Professional Development Course, Robin placed more emphasis on “engaging and extension activities because she now knows they are “…also important parts of the picture,” teaching following the PSI Professional Development Course. Robin’s CLES Student Negotiation scores also reflected this change. Her student Negotiation scores increased notably from a low intermediate agreement level for the pre PSI Professional Development Course assessment (20) to a high intermediate agreement level for her post PSI Professional Development Course assessment (24). This indicated that she offered more opportunities after participating in the PSI Professional Development Course for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. Her CLES Attitude Scale scores, pre (29) and post (31). also showed a slight increase, both were in the high agreement range, which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (see Appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997).

Last, data analysis for points of triangulation focused on Robin’s description of her own framework for understanding I-B methods, on what she understands about I-B science methods. Pre PSI Professional Development Course interview data revealed that
Robin uses a variety of methods in her lessons. This idea was supported by Pre PSI Professional Development Course observation data, where she used questioning techniques to encourage students to make inquiries about measurement tools, exhibiting evidence of the use of Structured Inquiry as defined by Martin-Hansen (2002). Interview data from Robin’s post PSI Professional Development Course interview reveals why only evidence of use of Structured Inquiry was found in her classroom prior to the PSI Professional Development Course. Robin reported that before the in-service, “I knew about questioning and exploration and explanation.” She continues, “Now I know that engaging and extension are also important parts of the picture.”

Post PSI Professional Development Course observation data showed Robin was experiencing some success while implementing Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design (Martin-Hansen, 2002) through use of the “What’s in the bag?” activity. The researcher also observed evidence of Coupled Inquiry, inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002) as she reduced teacher control and allowed students to work as individuals or pairs to piece together foam pieces of Pangaea.

Robin’s Personal Science Teaching Efficacy Belief subscale scores, from the STEBI analysis, for the pre (63) and post (60) assessments were in the high efficacy category indicating that she was comfortable with her ability to teach science (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). As Robin went about the process of implementing I-B methods data confirmed that she felt comfortable with Guided Inquiry and Coupled Inquiry. Robin was
not as comfortable with the implementation of Full or Open Inquiry. Robin’s CLES Shared Control scores were in the low intermediate agreement range, which indicated that her students are sometimes invited to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom (Suters 2004; Taylor et al., 1997). Her STEBI Science Teaching Outcome Expectancy subscale scores for the pre (39) and post (33) assessments decreased notably; however, both scores were in the average expectancy category indicating that she had some confidence in her teaching ability to create desirable outcomes (Riggs, 1988; Riggs & Enochs, 1990). An indication as to the reason why Robin’s STEBI Outcome Expectancy subscale scores might have decreased can be found in an Exit Slip excerpt, Robin writes, “One thing I might have a hard time implementing is the ‘investigable questions’ [a process by which students create questions and design experiments from their own questions]. I like the idea, but just wonder about time constraints.”

Summary of Robin’s Results for Research Question 2

Research Question 2 seeks information to explain the following: “How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?” To offer an explanation, one must understand that Robin’s cognitive framework incorporates her knowledge of science content and teaching methods. Her conceptions of science subject matter or content knowledge includes the ideas, facts, and the concepts of the discipline, as well as the relationships among those concepts, facts, and ideas. Information related to Robin’s cognitive framework was exposed through interview data
analysis. Data analysis for points of triangulation focused on an examination of Robin’s description of her own efficacy and her ability to produce a desired or intended result. Robin doesn’t recall any specific directions that she learned for teaching science, instead she remembers more of a broad teaching. She feels that she learns by being actively involved, experimenting, and participating in visual and hands-on activities. Her own learning style is mirrored in the way that she teaches. The researcher learned that at first she was a “little leery on doing science.” She observed others teaching science. Robin excitedly explains, “So, I tried it. I am definitely loving it! I’m teaching all science now.” Robin is interested in improving her planning skills related to applying what she knows about science to giving the student tools to use on their own. Robin employs an assortment of methods to teach science. In her pre PSI Professional Development Course observation lesson, Robin used: discussion, questioning, accessing background knowledge, hands-on, and reinforcement. In her post PSI Professional Development Course observation lesson, Robin used: questioning, the reading of children’s literature, use of manipulatives, recording, representing and analyzing data, evaluation of the validity of claims or looking for evidence, writing or reflections in a journal. Prior to the PSI Professional Development Course Robin was using an element of inquiry in her classroom already, evidence of Structured Inquiry was observed. Post PSI Professional Development Course interview and post PSI Professional Development Course observation data showed that Robin felt comfortable with Guided Inquiry and Coupled Inquiry. She felt she had a hard time implementing the investigable questions, student created I-B investigation questions or because of time constraints.
Research Question 3 Analysis

What barriers to implementing I-B methods exist?

Interview analysis (see Appendix B for instrument) for Research Question 3 includes a look at of Robin’s Goal Statement, and selected pre and post PSI Professional Development Course interview questions listed in Table 1. To build credibility, data were compiled from the (a) STEBI and (b) CLES instruments, (c) through direct observation of the participant’s teaching, and the (d) Partner Portfolio for Professional Development, including: mini-unit lesson plans, the Invitation to Practice: Mapping My Classroom activity, Exit Slips, Quick Writes, and journal entries. The researcher utilized the data to study the teacher’s mental models to uncover patterns that shape teaching behavior as it relates to her Shared Identity (SI), the portion of her conceptual framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her role as part of the professional community. In other words, we have assembled the pieces to answer the teacher’s query, “How does Robin describe her abilities to produce desired or intended results in her science classroom as they relate to implementation of I-B science methods?”

Robin’s Goal Statement Analysis: Pre and Post Professional Development Course

A teacher’s attitudes and beliefs about science are key influences on how they teach the subject. In most classrooms, teachers transmit science as a set of facts, laws, and data. The teacher’s principles or attitude, their tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do. The teachers’ styles, principles, are rooted in experience and develop into individual constructs slowly over time (Souza Barros & Elia, 1998). Robin’s
tendency to respond favorably or unfavorably towards a science topic, her students or other objects, determines what her students will see, hear, think, and do. During the PSI Professional Development Course Robin set her own goal for I-B instruction (Hammerness et al., 2005). Robin’s goal for the PSI Professional Development Course read as follows: “I would like to have several lessons to implement in the classroom. I want to be comfortable in my knowledge of inquiry to use it effectively.” Robin describes that she wants to learn “how to use it effectively, ideas for using it, how it is not effective, and when and how often it would be used.” Robin further states that she would “use the tips and lessons that” the researcher “teaches [shares] with us, finding resources that will help, and collaborating with other teachers.” Analysis of Robin’s goal allowed the researcher to study her attitude towards implementation of I-B methods. This goal reveals that Robin is interested in learning about and implementing I-B methods effectively.

*Robin’s Interview Analysis: Pre and Post Professional Development Course*

Interview analysis for Research Question 3 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 7, 8, and 9. This allowed the researcher to gather information to provide a picture of what was happening Robin’s classroom and school, thus providing information related to Robin’s knowledge and practice at the beginning of the research (Davis, 2002). Pre PSI Professional Development Course interview analysis showed that Robin used the following strategies in her classroom: talk; some lecture; group activities; partner activities; and discussion. Interview codes and transcript statements for Robin’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions are listed in Table 21.
Table 21.

*Interview Codes and Transcript Statements for Robin (T5) Pre and Post – Research Question 3.*

**Barriers to Implementation of I-B Methods**

<table>
<thead>
<tr>
<th>Time for Science Instruction and Time Related to Curriculum Guidelines</th>
<th>Support</th>
<th>Teacher</th>
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<td>Pre: “Well, it’s all spelled out for me on the curriculum map. This year we did cut out a lot, actually in the vertebrates and the invertebrates. We knew what we had to focus on, but as far as time went, we kind of looked at the curriculum map. We asked, ‘What are we going to need for the SOL?’ …So, yes, we go with the map and try to keep up with their time schedule, but a lot of times it doesn’t work. Quick thinking.” (Standards) (Pacing) (Time to teach)</td>
<td>Pre: “If I was not comfortable with the lesson or what I was doing then that would be the only drawback. If I hadn’t done the experiment before or I didn’t try it out myself, then I would be reluctant to bring it to the classroom.” (Teacher knowledge)</td>
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<td>Pre: “I think the subject matter certainly lends itself to how I’m going to approach it. Some things are much more geared toward the hands-on experiments than others. So, I guess, subject matter will influence how I approach it.” (Teacher Knowledge) (Standards)</td>
<td>Pre: “I think the subject matter certainly lends itself to how I’m going to approach it. Some things are much more geared toward the hands-on experiments than others. So, I guess, subject matter will influence how I approach it.” (Teacher Knowledge) (Standards)</td>
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<td>Pre: “My teaching varies year to year, the students I have… The students have influenced me very much. The students themselves are going to determine, ‘Is this too much for them to handle?’ ‘Are they going to need more structure?’ ‘Do they need more time?’ ‘How would I vary the lesson?’ (Time related to student needs)</td>
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<td>Post: “Sometimes time is a factor in planning the activities.” (Time for planning)</td>
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<td>Post: This is illustrated in the following excerpt, in which Robin discusses how she decides what to teach and what not to teach. “I go first by the curriculum map and then pick and choose from the materials that I feel will best suit my students’ needs.” (Standards) (Teacher relationship with students)</td>
<td>Post: This is illustrated in the following excerpt, in which Robin discusses how she decides what to teach and what not to teach. “I go first by the curriculum map and then pick and choose from the materials that I feel will best suit my students’ needs.” (Standards) (Teacher relationship with students)</td>
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Her teaching team at her school consisted of her CF, Hailey, and four other fifth grade teachers. Robin and Hailey each teach science to two different groups of students. The excerpt below illustrates the level of support Robin indicates that she feels she has received from Hailey.

I’ve always known it myself, but seeing Hailey, I think she’s very similar to me. We use lots of the hands-on methods and we use a variety of different ways. We both say, “Well they still haven’t go it. What else can we do to help them?” I think she and I feed off of one another. We say, “Well this works” and “well, this didn’t work, but this will.” I don’t think we’re limited in our methods. We influence each other, like I said, in that we have the same interests, the same way of approaching science, and the same interest in science. We both love science, so it really helps having somebody like that here. It’s kind of crazy.

Robin and Hailey share similar teaching styles. They love science, share ideas, and influence each other’s approach to science.

When first asked about support from her administrators, Robin explained that she thought her administration has not influenced her choice of teaching methods. As she continued to speak she came to the realization that her administrators were very open to help when she needs them and supportive by allowing them to conduct experiments and try new things. She explains this in the excerpt that follows.

I don’t think they [her administrators] really have influenced me. I mean we’re kind of doing our own thing here. I think they’re very supportive with materials if we needed anything. I know that they are easy to approach. I know that they are able to get a lot of things. That is a drawback too, when you don’t have supplies or equipment, that’s frustrating. We say, ”Well, how can we do this?” Before we had these outdated microscopes. How can you look at a cell without a microscope? That’s crazy. You know, you can’t just talk about it. You have to see it. We went around and we made sure we got more of the science equipment we needed. That’s kind of away from you question, but, as far as how they help us, I think they are very open to help us. They ask us what we need to get help from them. I guess that is influencing. In a way it has influenced us because it allows us to use those methods where we are doing.
Research supports that it is important that administrators and teammates are supportive of teachers while they are implementing the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). In summary, data from the pre PSI Professional Development Course interview analysis showed that Robin does feel the support she needs from teammates and administrators in order to successfully implement I-B science methods into her classroom.

Although Robin has the desire to implement I-B methods, feels confident about her teaching ability, and believes that her CF, colleagues and administration support her; there is a possibility that Robin might not be able to fully carry out her science teaching vision. Accordingly, the researcher next examined possible threats to fidelity or barriers to use of I-B instruction. This was accomplished through interviews and classroom observation. This process permitted the researcher to identify connections or relationships between Robin’s perceptions and use of I-B instruction (Davis, 2002).

Analysis of the pre PSI Professional Development Course interview questions revealed that Robin did face a number of barriers as she went about the process of teaching science in her classroom, including: finding enough instructional time, keeping pace with Milton County’s curriculum map, the Virginia SOL, students, knowledge of subject matter, and a lack of experience with the lesson or experiment. Robin explains that the factors of time, the Virginia SOL, and keeping pace with the curriculum map are indeed concerns she feels when planning to teach science in her classroom. This excerpt from the pre PSI Professional Development Course interview illustrates Robin’s beliefs.

Well, it’s all spelled out for me on the curriculum map. This year we did cut out a lot, actually in the vertebrates and the invertebrates. We knew what we had to focus on, but as far as time went, we kind of looked at the curriculum map. We
asked, “What are we going to need for the SOL?” There was a lot in there that was not necessary, so to speak, for information they would need to know to answer the questions on the SOL. It is important to know those things, but when it comes down to the time crunch and we’ve got so much packed in there, then we need to look at where we have things chopped up so that we can fit it into our schedule. There is, if you want my opinion, a lot in that curriculum map that we have to include. Especially when it is the fourth grade material as well that is also covered on that fifth grade SOL test information that we have to cover and review at the end of the year. So, yes, we go with the map and try to keep up with their time schedule, but a lot of times it doesn’t work [and] quick thinking.

Analysis of pre PSI Professional Development Course interview data revealed that Robin believed that her lack of experience with the lesson or experiment might also prove to be a possible barrier to implementation of IB methods. Robin stated, “If I was not comfortable with the lesson or what I was doing then that would be the only drawback. If I hadn’t done the experiment before or I didn’t try it out myself, then I would be reluctant to bring it to the classroom.” This belief is further clarified when Robin explains in the excerpt that follows. Robin explains, “I think the subject matter certainly lends itself to how I’m going to approach it. Some things are much more geared toward the hands-on experiments than others. So, I guess, subject matter will influence how I approach it.” Robin feels that her students have influenced her choice of teaching methods. The following excerpt explains her thoughts.

My teaching varies year to year, the students I have. Some need a lot of structure and can’t handle the freedom to explore on their own. They wouldn’t know how to go from there. They really need a lot of direction. So, I just kind of see or gauge from them how it is going to work. I could have a routine here and I could have two classes. One could be fine and [for] the other class, I might have to tailor it more to what they need. The students have influenced me very much. The students themselves are going to determine, “Is this too much for them to handle?” “Are they going to need more structure?” “Do they need more time?” “How would I vary the lesson?”
In summary, Robin feels that possible barriers to implementing I-B instruction might include the following: finding enough instructional time, keeping pace with Milton County’s curriculum map, the Virginia SOL, students, knowledge of subject matter, or a lack of experience with the lesson or experiment.

Interview analysis for Research Question 3 also included the analysis of the post PSI Professional Development Course interview questions numbered 3, 4, 6, and 7. Data analysis continued with the assumption that Robin might have encountered possible threats to fidelity or barriers to use of I-B instruction. This process allowed for further identification of connections or relationships between Robin’s perceptions and use of inquiry instruction (Davis, 2002). Analysis of the post PSI Professional Development Course interview questions revealed that Robin did face a number of barriers as she went about the process of implementing I-B science in her classroom, including: time for planning, the curriculum map, and meeting the needs of her students. Robin explains that time for planning might inhibit her from using I-B methods. Robin outlines some of her struggles with finding enough time to plan lessons that implement I-B in the following excerpt from the post PSI Professional Development Course interview, she explains, “Sometimes time is a factor in planning the activities.” Robin notes that keeping pace with her county’s curriculum map and her students influence the way she teaches. This is illustrated in the following excerpt, in which Robin discusses how she decides what to teach and what not to teach. “I go first by the curriculum map and then pick and choose from the materials that I feel will best suit my students’ needs.”

In summary, analysis of the pre PSI Professional Development Course interview questions revealed that Robin faced a number of barriers as she went about the process of
implementing I-B science in her classroom, including: finding enough instructional time, keeping pace with the curriculum map, the Virginia SOL, knowledge of subject matter, or a lack of experience with the lesson or experiment. In post PSI Professional Development Course interview questions Robin revealed barriers she faced included time to implement I-B methods, including: time for planning, keeping pace with the curriculum map, and meeting the needs of her students.

*Robin’s Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

As noted in Research Question 1 analysis, Robin’s Personal Science Teaching Efficacy Belief subscale scores for the pre (63) and post (60) assessments were in the high efficacy category. Therefore, she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores for the pre (39) and post (33) assessments decreased notably; however, both scores were in the average expectancy category indicating that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Details of the STEBI results were noted in Research Question 1 analysis, *Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*. This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Robin’s Partner Portfolio for Professional Development Analysis*.

*Constructivist Learning Environment Survey – CLES Analysis Pre and Post*

Details of Robin’s CLES scores were noted in Research Question 1 analysis. Robin’s CLES Personal Relevance scores, pre (32) and post (33), were in the high agreement range, which indicated that she placed a high emphasis on linking school
science with students’ everyday experiences (see Figure 10). Her CLES Scientific Uncertainty scores, pre (21) and post (23), were in the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. Her CLES Critical Voice scores, pre (30) and post (29), were both in the high agreement range which indicated that she placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediment to their learning. Her CLES Shared Control scores, pre (15) and post (14), were in the low intermediate agreement range, which indicated that her students are sometimes invited to: participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom. Her CLES Student Negotiation scores, pre (20) and post (24), increased notably. This indicated that she offered more opportunities after participating in the PSI Professional Development Course for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. Her CLES Attitude Scale scores, pre (29) and post (31), showed a slight increase, both were in the high agreement range which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (see Appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Robin’s Partner Portfolio for Professional Development analysis.
Throughout the PSI Professional Development Course Robin was given the opportunity to reflect and take charge of their thoughts and behaviors through reflection, planned processing, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). To confirm the previously mentioned data findings as triangulation of multiple data sources and provide for multiple measures of the same phenomenon (Yin, 2003) the following data were analyzed: (a) the Invitation to Practice: Mapping My Classroom activity, (b) the Invitation to Practice: Collaboration activity, (c) Exit Slips, (d) Quick Writes; and (e) journal entries. Analysis of the pre PSI Professional Development Course and post PSI Professional Development Course interview questions disclosed that Robin confronted a number of barriers as she went about the course of implementing I-B science in her classroom. Robin’s pre PSI Professional Development Course interview questions revealed that Robin did face a number of barriers as she went about the process of implementing I-B science in her science classroom, including: finding enough instructional time, keeping pace with the curriculum map, the Virginia SOL, knowledge of subject matter, or a lack of experience with the lesson or experiment. In post PSI Professional Development Course interview questions Robin revealed barriers she faced included time to implement I-B methods into her science classroom, including: time for planning, the curriculum map, and meeting the needs of all of her students.

In pre PSI Professional Development Course and post PSI Professional Development Course interview analysis findings data indicated that time is a factor that might serve as a barrier to the implementation of I-B methods. In one of her Exit Slip
excerpts, Robin again noted that time is a factor in implementation of I-B methods. She writes, “One thing I might have a hard time implementing is the investigable questions. I like the idea, but just wonder about time constraints.” In the excerpt that follows from another Exit Slip entry, Robin again expresses her concerns related to time.

It seemed as we were working on the 5E [from the 5E Model of science teaching (Bybee, 1993, 2000; Carin et al., 2004)] lesson plans that we were doing a lot of activities. I am concerned about the time frame for each. I guess we will have to just see as we do each activity how much time we actually need.

Post PSI Professional Development Course interview questions revealed the barriers she faced related to time available to implement I-B methods were associated to curriculum guidelines, including keeping pace with the curriculum map and the Virginia SOL, and meeting the needs of her students.

In previous interview data analysis we learned that when planning, Robin will begin planning “first by the curriculum map and then pick and choose from the materials that I feel will best suit my students’ needs.” Portfolio data supported the idea that Robin considered her students’ needs when planning instruction. During the Invitation to Practice: Mapping My Classroom activity Robin planned changes that would have to take place in her classroom in order for her to implement I-B science. She writes that she would like to make “stations available,” include “student directed learning,” and assure that “process skills” are “incorporated into concepts.” Figure 11. Robin’s Graphic Organizer: Changes Towards Implementation of I-B outlines her plans related to moving towards implementation of I-B science into her science classroom.
Robin notes that following her participation in the PSI Professional Development Course, she has: offered more student directed opportunities, led group inquiry activities, and implemented the use of a science notebook. Robin has not implemented I-B science centers in her classroom. An excerpt from her follow-up Invitation to Practice: Mapping My Classroom activity illustrates her progress towards implementing I-B methods into her science classroom.

I have changed my classroom into more student directed opportunities to explore and share. I have utilized a science notebook to do more writing about science. I do not have centers yet that students can go to when they are done, but we have done group activities that students participate in during class time as part of the 5E lesson plans.

Data gathered from CLES scores showed that Robin’s Student Negotiation scores, pre (20) and post (24), increased notably. This indicated that she offered more opportunities after participating in the PSI Professional Development Course for students to: explain

FIGURE 11. Robin’s Graphic Organizer: Changes Towards Implementation of I-B
their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas (Suters, 2004; Taylor et al., 1997). This supports Robin’s statement that she offered more student directed opportunities in her science classroom following the PSI Professional Development Course.

Although Robin acted to arrange her science classroom to facilitate I-B instruction, she was not able to implement all of her ideas as planned. After the PSI Professional Development Course Robin reflected on her plans. Robin explained that she was able to add the following items to her bucket if science instruction methods: “new ideas on how to use inquiry, 5E models sample lessons, students can take on roles, knowing it is OK to do things in small steps, resources to use, AIMS activities.” She notes that she has used the following techniques or methods in her classroom: “what’s in the bag activity, engagement with short stories and books, and the 5E model to spice up cookbook labs.” This excerpt details barriers she encountered towards carrying out her plans.

I have not officially assigned roles to students. I keep forgetting to talk about the roles and when it comes time to do the investigation I don’t want to take the time to explain. Time is short!

This excerpt supports previous data indicating that time proved to be a barrier in the implementation of I-B methods, thus supporting the idea from pre PSI Professional Development Course interview data that indicates that time is a factor that might serve as a barrier to the implementation of I-B methods, specifically, time related to curriculum guidelines, including keeping pace with the curriculum map and the Virginia SOL, and meeting the needs of her students.
Analysis of pre PSI Professional Development Course interview data revealed that Robin believed that her knowledge of subject matter might also prove to be a possible barrier to implementation of I-B methods. Robin stated, “subject matter will influence how I approach it.” In her Invitation to Practice: Science Learning Personal History activity, Robin noted that when came across a topic that she “had little exposure with” she would “learn it before” she “could teach it.” She “needs to read about it as well as do something” to learn the content before she can teach it. There was no data in the post PSI Professional Development Course interview or the Partner Portfolio for Professional Development that would indicate that knowledge of subject matter came into play as a barrier to implementation of I-B methods. Robin explains in an Exit Slip reflection that she “found out that I am already doing a lot of inquiry!” She also noted, “this really motivated me to get things organized this summer.” Robin’s Personal Science Teaching Efficacy Belief subscale scores indicated that she was comfortable with her ability to teach science.

Robin’s Classroom Observations: Pre and Post Professional Development Course

As noted in Research Question 1 analysis, Robin’s lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Structured Inquiry. In Robin’s post PSI Professional Development Course lesson it was evident that she was in the process of implementing further use of I-B methods into her classroom. Robin’s post PSI Professional Development Course lesson addressed the Virginia SOL related to the layers of the Earth. During the lesson, the researcher observed evidence Guided Inquiry, through an activity titled “What’s in the bag?” Robin asked the students to guess, “What’s in the bag?” She
told students that they were using scientific observation to develop a conceptual understanding. She led them to draw conclusions between the mystery object, a shovel, and concepts they would study about the Earth, for example: digging into the Earth, digging fossils, and searching for evidence related to Pangaea. The researcher also observed evidence of Coupled Inquiry, inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002) as she reduced teacher control and allowed students to work as individuals or pairs to investigate clues and to position together foam pieces of Pangaea.

Analysis of pre PSI Professional Development Course interview data revealed that Robin believed that her lack of experience with the lesson or experiment might also prove to be a possible barrier to implementation of IB methods. Robin stated that she might be “reluctant” to try it in the classroom. Robin was able to overcome this fear and implement her I-B mini unit into her classroom. In the excerpt that follows Robin illustrates her thoughts about implementing her lesson on the layers of the Earth for the first time.

I liked the “What’s in the bag?” activity to engage and then the book [How to Dig a Hole to the Other Side of the World by Faith McNulty, Marc Simont, and Peter Fernandez] was a good follow-up before the cubes. First time I had done it so I was pretty pleased on how things went. One thing I would change for next time is the way the clues are given. I think they were a little too complicated for some to grasp.

The excerpt showed that Robin was able to overcome the barrier of a lack of experience with the science lesson or experiment. She was pleased with the implementation of her lesson.
Summary of Robin’s Results for Research Question 3

Robin’s professional development goal for the PSI Professional Development Course revealed that she “would like to have several lessons to implement in the classroom.” Robin further stated that she has the desire “to be comfortable” in her knowledge of inquiry to use it effectively.” During the PSI Professional Development Course, Robin worked with her CF, Hailey, to create and implement an I-B science lesson plan, Layers of the Earth, into each of their science classrooms. Classroom observation data revealed that Robin was able to successfully use the following I-B methods, as defined by Martin-Hansen (2002), into her science classroom, including: Guided Inquiry, Structured Inquiry, and Coupled Inquiry. Analysis of the data revealed that Robin confronted a number of barriers as she went about the process of implementing I-B science in her classroom. In Robin’s science classroom, time emerged as a factor that might serve as a barrier to the implementation of I-B science methods; specifically, time related to curriculum guidelines, including the Milton County School System’s curriculum map and the Virginia SOL, as well as meeting the needs of her students. Robin felt uncomfortable allowing her students to choose their own investigable questions fearing that they would not have enough time for implementation of their quests. Robin thought a lack of experience with a science lesson might become a barrier to implementation of I-B science methods but this proved not to be the case. Robin was able to overcome the barrier of a lack of experience with the science lesson or experiment.
Research Question 4 Analysis

What relationships exist between teachers’ perceptions and use of I-B methods?

Data were analyzed to address the query, “What relationships exist between Robin’s perceptions and use of I-B methods?” Interview analysis (see Appendix B for instrument) for Research Question 4 includes the examination of (a) post PSI Professional Development Course interview questions 2, 3, 6, and 7 listed in Table 1, (b) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (c) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (d) Partner Portfolio for Professional Development. Influences such as Robin’s culture, educated-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual and style help mold the her beliefs about I-B methods. The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI).

John Dewey (1938, 1997) proposed that experience transpires as a result of the interrelationship of two principles, continuity and interaction. Continuity refers to how each experience a person has influences one’s future, for better or for worse. Interaction refers to the situational influence on one’s experience. The individual’s present experience is a function of the interaction between their past experiences and the present situation. No experience has a pre-destined value. Therefore, what might be a beneficial experience for one individual could be an unfavorable experience for another. In other words, "positive experiences" motivate, encourage, and enable students to go on to have
more valuable learning experiences, whereas, "negative experiences" tend to lead towards a student closing off from potential positive experiences in the future. Dewey believed that learning experiences should be meaningful to each student and that teachers should step back and act as facilitators (Dewey, 1938, 1997).

Returning to the bucket metaphor described in the researcher’s conceptual framework, Robin examined the shells and treasures related to I-B teaching techniques introduced at the PSI Professional Development Course and made a decision to either keep each one and place it in her bucket, or place it back on the beach based on her own system of values. The discovery of treasures of considerable value produced a positive influence on Robin’s motivation, attitude, caring, determination and effort. The unearthing of treasure with moderate value had a negative influence on Robin’s motivation, attitude, caring, determination and effort. This data utilized to illustrate Robin’s cognitive framework related to inquiry, her beliefs about inquiry teaching, and how this ties into her daily experiences. This information is vital to understanding teacher change related to inquiry (Keys & Bryan, 2000; Spillane et al., 2002).

*Robin’s Interview Analysis: Pre and Post Professional Development Course*

Interview analysis for Research Question 4 includes the analysis of the post PSI Professional Development Course interview questions numbered 2, 3, 6, and 7. A qualitative research design served as an appropriate methodology to utilize to examine any relationships the might exist between Robin’s perceptions and use of I-B methods, seeing as qualitative research is concerned with the perceptions of the participants and with process rather than outcomes or products (Bogdan & Biklen, 1992, Marshall & Rossman, 2006). This design serves as an appropriate methodology to make use of in
order to define inquiry as it is perceived and used by Robin. Data findings were drawn on to first illustrate Robin’s cognitive framework related to inquiry. The excerpt below illustrates how Robin defined inquiry prior to the PSI Professional Development Course.

To define Inquiry science I would say questions. We need to ask questions. Why is it this way? What do you think? Why did we do it this way? So inquiry is having the students, or whomever it is, exploring for that lab trying to understand the question that was asked and trying to explain further. They might ask, “what if we were to make these changes?” and “why is it doing that?” So it’s more exploring for themselves and trying to understand on their own, with guidance, how they arrived at the answers.

Prior to the staff development, Robin believed that inquiry involves questioning and exploration, students are working “on their own” with some guidance.

Post PSI Professional Development Course interview data were drawn on to reveal Robin’s beliefs about inquiry. In her post PSI Professional Development Course interview Robin explained that she believes, “Inquiry science is allowing students to take ownership and generate questions about ideas or concepts that are presented by the teacher.” Data from her post PSI Professional Development Course interview showed that Robin felt that prior to the PSI Professional Development Course she “knew about questioning and exploration and explanation.” Following the PSI Professional Development Course she explains, “Now I know that engaging and extension are also important parts of the picture.”

Robin was willing to try to implement I-B methods into her classroom. In post PSI Professional Development Course interview excerpts she reflected on her teaching prior to the PSI Professional Development Course. She explains, “I feel I already do a lot of hands-on activities that help the students grasp different concepts.” In the excerpt that follows she outlines why she signed up for the PSI Professional Development Course.
I signed up because I wanted to do more, I know I’m not the best science teacher. But, I really am interested in it and I wanted something that was going to be worthwhile. Not just something let me think, to just let me get my 20 hours over with. I wanted to gain something from it. Like I said, we’re going to try to do the team teaching next year so I think this is great. I want to focus on science. I want to have time to devote to science and math. I’m going to need something that will really help me that I’m going to use. I love science and I’m really looking forward to your class.

Robin “wanted to do more.” She wanted to add to the “hands-on activities” she was already doing in her classroom. She wished to “gain something” that she is “going to use” when she tries team teaching during the 2007-2008 school year.

In summary, data findings were drawn on to first illustrate Robin’s cognitive framework related to inquiry. Prior to the PSI Professional Development Course Robin reported that she believes that inquiry involves questioning and exploration, students are working “on their own” with some guidance. Data from Robin’s post PSI Professional Development Course interview revealed she felt prior to the PSI Professional Development Course, she “knew about questioning and exploration and explanation.” Following the PSI Professional Development Course, she explains, “Now I know that engaging and extension are also important parts of the picture.” She also added that she felt students should “take ownership and generate their own questions.” Robin was willing to try to implement I-B methods into her classroom because she “wanted to do more,” she wished to “gain something” that she is “going to use.”

The next step in data analysis for Research Question 4 would include drawing upon data to reveal her beliefs about inquiry teaching. Given that pre PSI Professional Development Course interview data showed that Robin already “did a lot of hands-on activities that help the students grasp different concepts,” in other words, she was already
implementing some aspects of inquiry, supplementary sources will be used to enhance analysis for this portion of the question in the section labeled *Robin’s Partner Portfolio for Professional Development.*

As a final point, the data findings were examined to determine how Robin’s cognitive framework related to inquiry and her beliefs about inquiry teaching tie into her daily experiences. In the previous paragraph we learned that Robin was already implementing some aspects of inquiry into her lessons. An examination of Robin’s beliefs related to classroom learning gives us a glimpse into her thoughts related to teaching in general. Robin believes that students are learning when they are able to “show through their writing” that they really understand the concept. She continues, “…If you’re writing to explain it then they are really able to show more of a deeper understanding. If they can explain in their own words what is happening and why.” If students in Robin’s class have difficulty writing, she allows them to “do it orally.” Robin encourages the students to keep science journals. She also believes that students value the “fun approach” that she exhibits towards teaching. She believes that she enjoys what she is doing “so much, they catch on and get that fever too.” Although she encourages fun, she expects her students to “take things seriously.” Starting at the beginning of each school year, Robin encourages her students to “start thinking about science,” to look around, and realize that science “really is everywhere.”

In summary, pre PSI Professional Development Course interview data shows that Robin believes students can show “more of a deeper understanding if they can explain in their own words.” She believes that her students value her “fun approach.” She believes her positive attitude is contagious. She encourages her students to “take things seriously”
and encourages them to “start thinking about science” by looking around and coming to
the realization that science “really is everywhere.”

*Robin’s Goal Statement Analysis*

Robin’s goal for the PSI Professional Development Course read as follows: “I
would like to have several lessons to implement in the classroom. I want to be
comfortable in my knowledge of inquiry to use it effectively.” Robin describes what she
wants to learn about I-B methods by noting that she would like to learn: “How to use it
effectively, ideas for using it, how it is not effective, and when and how often it would be
used.” Robin further states that she would “use the tips and lessons that” the researcher
“teaches [shares] with us, finding resources that will help, and collaborating with other
teachers.” Robin’s goal statement shows that she is interested in learning about and
implementing I-B methods into her science classroom and is able to choose which
methods she employs in her classroom.

*Science Teaching Efficacy Belief Instrument - STEBI Analysis Pre and Post*

Details of Robin’s STEBI results were noted in Research Question 1 analysis,

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post* (see
Appendix C1 for instrument and C2 for scoring instructions). Robin’s STEBI data serves
as a source for triangulation of multiple data sources and provides for multiple measures
of the same phenomenon (Yin, 2003). Robin’s STEBI Personal Science Teaching
Efficacy Belief subscale scores for the pre (63) and post (60) assessments were in the
high efficacy category. Therefore, she was comfortable with her ability to teach science.
Her STEBI Outcome Expectancy subscale scores for the pre (39) and post (33)
assessments decreased notably; however, both scores were in the average expectancy
category indicating that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). In summary, Robin wrote in her goal statement, “I would like to have several lessons to implement in the classroom. I want to be comfortable in my knowledge of inquiry to use it effectively.” Robin is interested in feeling comfortable with her knowledge of inquiry and was interested in creating I-B lessons to implement into her science classroom and she is able to choose which methods she employs in her classroom.

Robin’s Partner Portfolio for Professional Development

Robin took part in activities that allowed her to reflect upon and manage her thoughts and behaviors through strategic processing, reflection and collaboration throughout the PSI Professional Development Course (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Robin’s portfolio data provides additional pieces that were used to solve the query, “What relationships exist between Robin’s perceptions and use of I-B methods?” Analysis focused on relationships connecting Robin’s perceptions as they connected to her practice. Emic accounts, descriptions of behaviors in terms meaningful to the teacher, were used because these accounts are culture specific or are found in the context of the teacher’s classroom (Stake, 2006). The researcher completed three steps in analyzing the partner portfolio. First, Robin’s definition of inquiry, Robin’s methods of instruction, and the definition of inquiry used during the PSI Professional Development Course were reviewed for comparison. Robin’s definition of inquiry and choice of teaching methods were also compared to her definition of inquiry used during the PSI Professional Development Course. Second, a review of the findings from Robin’s
Interview analysis, Goal Statement analysis, and STEBI analysis was conducted. Third, emic accounts were compared to excerpts from Robin’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). Each of these steps is discussed more fully in the paragraphs that follow.

First, the researcher examined Robin’s definition of inquiry. Prior to the staff development Robin believed that inquiry involves questioning and exploration. She believes students are working “on their own” with some guidance. In the excerpt below Robin shares her definition of inquiry during the PSI Professional Development Course.

Inquiry is getting kids to think about something before they explore, asking questions, finding answers to questions through hands-on exploration, looking at data and comparing, students wanting to find answers, not just being told information, and using background information [knowledge] to help formulate ideas and questions.

Robin noted that she felt that prior to the PSI Professional Development Course she “knew about questioning and exploration and explanation.” Throughout the course of the PSI Professional Development Course, Robin was offered the opportunity to develop an understanding of the following topics: What is inquiry, learning through inquiry, developing a mind for constructivism, constructivism, how children learn, designing I-B classrooms, integrating I-B activities, the scientific method, learning cycles, skills and knowledge of I-B teachers, and questioning. Robin also participated in sample I-B lessons that were modeled during the PSI Professional Development Course. (A complete detailed description of the twenty-hour professional development course is located at Appendix K.) Following the PSI Professional Development Course she explains, “Now I
know that engaging and extension are also important parts of the picture.” In her post PSI Professional Development Course interview, Robin explained that she felt “inquiry science is allowing students to take ownership and generate questions about ideas or concepts that are presented by the teacher.”

Next, the researcher looked at Robin’s methods of instruction. The excerpts that follow from Robin’s post PSI Professional Development Course interview data illustrate Robin’s beliefs about science teaching methods and how children learn science.

When I first introduce something, I try to have them relate it to something they have learned before. I kind of build it up, for example I say, “today we are going to be talking about matter.” We always try to investigate something with it first. I say, “What is this?” and then we talk about it. I will lead into it. I like that slow approach to get them thinking about it. I ask them, “What about this? Why are we looking at this? What do you think it could be about?” Then from there we springboard, and then we talk about their background knowledge, things like that. It’s a slow approach. Following that we get into the hands-on, getting things ready and then the journaling. Next, if they still need help, would be to see if there’s any technology. I try to pull that in. We have a lot with united streaming videos. I usually use that after words, after the concept has been introduced. We talk about it. It’s more of reinforcement to what they’ve already learned. I let them see it first, then, I ask, “OK, you got it now?” I use anything I can bring in to actually show them. You should have seen us trying to get ferns, for the SOL, with the spores on it. We were trying to find liverwort, but we cannot find liverwort anywhere. We need to show them an example; we can’t just show them a picture. They don’t know what it is. We were going to go hiking in the woods looking for liverwort. But, yes, I rarely, I shouldn’t say, read the book. We do that after we’ve had some introduction. So they do need to have that textbook with them. But, it’s more of a back up rather than the initial.

Robin feels that it is important to build upon what the students have learned prior to the lesson being taught. She encourages questioning, hands-on activities, and journaling. In the excerpt below Robin explains her beliefs about the characteristics of a good learner.

A good learner is open to challenges, is willing to explore things that are unknown, and has an open mind. A good learner is somebody who takes things seriously. That’s probably my pet peeve, maybe at this age, getting them to take it seriously. They get in there and they want to play instead of really wanting to
explore the science behind it. So, I would say a good learned is someone who is willing to try and has an open mind to understand why this is working.

Robin feels that the characteristics of a good learner include a willingness to explore and keep an open mind. She believes her students should be serious about their learning.

As noted in Research Question 1 analysis, Robin’s lesson plans and pre-observation data showed that she had already successfully implemented Structured Inquiry. As noted in Research Question 3 analysis, Robin’s post PSI Professional Development Course lesson showed that she was in the process of implementing further use of I-B methods into her classroom. During the mini unit lesson, the researcher observed evidence Guided Inquiry, through an activity titled “What’s in the bag?” The researcher also observed evidence of Coupled Inquiry, inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002), as she reduced teacher control and allowed students to work as individuals or pairs to investigate clues and to position together foam pieces of Pangaea.

Last, as data analysis continued, the definition of inquiry used during the PSI Professional Development Course was reviewed for comparison with Robin’s definition of inquiry and choice of teaching methods. During the PSI Professional Development Course Inquiry instruction was defined as referring to any teaching method focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations and discover answers to their questions about the natural world. Students may plan systems to
collect data and choose how to organize and represent the data (Carin et al., 2004). The National Research Council (1998) defines scientific inquiry in this way:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.” (p. 23)

As noted in Research Question 2, this excerpt from Robin’s pre PSI Professional Development Course interview illustrates how she defines inquiry science.

To define Inquiry science I would say questions. We need to ask questions. Why is it this way? What do you think? Why did we do it this way? So inquiry is having the students, or whomever it is, exploring for that lab trying to understand the question that was asked and trying to explain further. They might ask, “what if we were to make these changes?” and “why is it doing that?” So it’s more exploring for themselves and trying to understand on their own, with guidance, how they arrived at the answers.

Robin explained that she feels science inquiry includes: asking questions, exploring, explaining, and understanding how they arrived at the answers. During the PSI Professional Development Course, Robin explained that she understood the elements included in the following excerpt to define inquiry.

Inquiry is getting kids to think about something before they explore, asking questions, finding answers to questions through hands-on exploration, looking at data and comparing, students wanting to find answers, not just being told information, and using background information [knowledge] to help formulate ideas and questions.

In her post PSI Professional Development Course interview Robin explained that she felt “inquiry science is allowing students to take ownership and generate questions about
ideas or concepts that are presented by the teacher.” Robin’s definition of inquiry is aligned with the definition used in the PSI Professional Development Course.

In her classroom, Robin uses a variety of methods, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on, journaling, technology, and reinforcement. Robin learns by being actively involved, experimenting, and participating in visual and hands-on activities. She offers her students a variety of ways to explore science concepts. Robin sees herself as both silly and crazy. Robin believes using enthusiasm, humor, and novelty in her lessons will help students remember concepts. Robin’s choice of methods allow for integration or use of I-B methods.

The next step in placing the pieces of the puzzle to solve the query, “What relationships exist between Robin’s perceptions and use of I-B methods?” consisted of a review of the findings from Robin’s (a) Interview analysis, (b) Goal Statement analysis, and (c) STEBI analysis. Beginning with her pre PSI Professional Development Course interview, Robin remembers best when actively involved, experimenting, and participating in visual and hands-on activities, or when her teachers use a constructivist approach, they provided relevant experiences and opportunities that allowed Robin to construct knowledge (Piaget, 1929; Vygotsky, 1978). Robin feels she needs “to read about it as well as do something” and she also notes that she feels “her learning style is reflected in the way I teach.” Pre PSI Professional Development Course interview data also shows that Robin uses humor and novelty in her teaching. She does this because she believes it will “stick in their head.” In her post PSI Professional Development Course interview excerpts Robin further explains that her post PSI Professional Development
Course interview excerpts show that she believes it is important for students to understand “how science is everywhere.” Data from the CLES supports this idea. Robin’s Personal Relevance scores, pre (32) and post (33), were in the high agreement range, which indicated that she placed a high emphasis on linking school science with students’ everyday experiences (Suters, 2004; Taylor et al., 1997). Robin’s goal statement shows that she is interested in learning more about I-B methods, she wrote, “I would like to have several lessons to implement in the classroom. I want to be comfortable in my knowledge of inquiry to use it effectively.” Robin’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (63) and post (60) assessments increased notably, an indication that she felt more at ease with her ability to teach science. Robin’s STEBI Outcome Expectancy subscale scores, pre (39) and post (33), decreased notably; however, both scores were in the average expectancy category demonstrating that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). In summary, Robin is interested in learning about I-B methods. Her teaching style lends itself to implementation of I-B methods. The professional development session helped her to feel more at ease with her ability to teach I-B science.

Last, in assembling the pieces of the puzzle to solve the query, “What relationships exist between Robin’s perceptions and use of I-B methods?” emic accounts from Robin’s Interview analysis, Goal Statement analysis, and Science Teaching Efficacy Belief Instrument - STEBI analysis were compared with excerpts from Robin’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple
measures of the same phenomenon (Yin, 2003). A teacher’s attitudes and beliefs about science are key influences on how they teach the subject (Souza Barros & Elia, 1998). In an Exit Slip journal entry Robin shares her positive attitude about trying new things. She shares her thoughts about her learning during the staff development session, saying, “This really motivated me to get things organized this summer.” Robin’s portfolio data supports both her goal statement and her STEBI scores, which illustrate that she is interested in creating several I-B lessons to implement into her science classroom, and wishes to learn enough to feel comfortable using inquiry in her classroom. Robin’s positive attitude had an influence in her decision to choose to implement I-B methods into her classroom.

In Robin’s post PSI Professional Development Course lesson it was evident that she was working towards implementing inquiry into her science classroom. Robin’s Personal Science Teaching Efficacy Belief subscale scores, from the STEBI analysis, for the pre (63) and post (60) assessments were in the high efficacy category indicating that she was comfortable with her ability to teach science (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). As noted in Research Question 2 analysis, data gathered throughout her mini unit plan showed that she felt comfortable with Guided Inquiry and Coupled Inquiry. Robin was not as comfortable with the implementation of Full or Open Inquiry into her science classroom. In an Exit Slip excerpt, Robin explained her feelings by saying, “One thing I might have a hard time implementing is the investigable questions. I like the idea, but just wonder about time constraints.”
Summary of Robin’s Results for Question 4

Data analysis for Research Question 4 included an examination that was designed to investigate possible answers to the question, “What relationships exist between teachers’ perceptions and use of I-B methods?” The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI). Data analysis for Research Question 4 showed that Robin is interested in creating several I-B science lessons to implement into her science classroom. Robin also wishes to learn enough information and gain enough experience to feel comfortable using inquiry in her science classroom. The perception that I-B methods hold large or great value had a positive influence on Robin’s motivation, attitude, caring, determination and effort during implementation of the methods in her science classroom. Robin’s definition and vision of inquiry matches her choice of methods for science instruction. Robin revealed that she learns science best by being actively involved, experimenting, and participating in visual and hands-on science activities. Robin offers her students a variety of ways to explore science concepts. In her science classroom, she uses a variety of methods, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on, journaling, technology, and reinforcement. Robin sees herself as both crazy and silly. Robin believes using enthusiasm, humor, and novelty in her lessons will help students remember science concepts. As Robin went about the process of implementing I-B science methods data confirmed that she felt comfortable with Guided Inquiry and Coupled Inquiry. Robin did not feel as comfortable with the implementation of Full or Open Inquiry into her science classroom.
Research Question 5 Analysis

How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Interview analysis (see Appendix B for instrument) for Research Question 5 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, 8 and 9 listed in Table 1, (b) post PSI Professional Development Course interview question 6, (c) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), and (d) Partner Portfolio for Professional Development. Data findings were utilized to examine Teacher Choice (TC) in an attempt to disclose methods that encourage teachers like Robin to overcome resistance to implementing I-B teaching practices. When a teacher, like Robin, makes a choice she critically assesses the value of available options and chooses a course of action built on her own conceptual framework. Data analysis for Research Question 5 was made up of a study of a teacher’s conceptual framework composed of: her Individual Identity (II), the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or personal constructs (Scribner et al., 2002); Robin’s Subject Matter Knowledge (SMK), the teacher’s knowledge of content matter and pedagogy (the art and science of being a teacher) and curriculum knowledge (Shulman, 1986); and Robin’s Shared Identity (SI), the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community.
Robin’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 4 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 5, 7, 8 and 9 as well as post PSI Professional Development Course interview question 6. Teacher Choice (TC) is influenced by mental models, “the images, assumptions, and stories, which we carry in our minds of our selves, other people, institutions, and every aspect of the world,” (Senge, 1990). Interview analysis gave the researcher a glimpse of Robin’s Individual Identity (II). When learning, Robin needs “to read about it as well as do something” and she also notes that she feels her “…learning style is reflected in the way I teach.” Pre PSI Professional Development Course interview data shows that Robin uses humor and novelty in her teaching. She does this because she believes it will “stick in their head.” She gives students “a variety of ways to explore a concept.” Robin utilizes a variety of methods in her science teaching, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on, journaling, technology, and reinforcement. When Robin thinks about teaching science to children she thinks about a fun approach. She believes, “I enjoy what I am doing so much, they catch on and get that fever too.”

In summary, Interview analysis gave the researcher a view of Robin’s Individual Identity (II). In her pre PSI Professional Development Course interview, Robin describes her teaching style by explaining that she uses humor and novelty in her teaching, as well as “a variety of ways to explore a concept,” because she believes it will “stick in their head.” She wants her students to have fun while learning.
Interview analysis also gave the researcher a glimpse into Robin’s early Subject Matter Knowledge (SMK). Undergraduate science courses usually convey science as a group of specifics and sets of laws to be memorized, instead of as a way of knowing about the natural world (NRC, 1998). Robin’s experiences support this statement. In her pre PSI Professional Development Course interview during Research Question 1 analysis, Robin revealed that she doesn’t recall any specific directions that she learned for teaching science, but remembers her college science training as more of a broad teaching. In another pre PSI Professional Development Course interview excerpt, Robin explained that she did not remember a lot of activities; in fact, only one college physics lesson really stood out in her mind. Information about Robin’s beliefs about science teaching methods was uncovered in her post PSI Professional Development Course interview data. Robin teaches the way she learns best, her own learning style is reflected in the way that she teaches. Robin believes using enthusiasm, humor, and novelty in her lessons will help students remember concepts. Robin explained that she gives students “a variety of ways to explore a concept.” Pre PSI Professional Development Course interview data analysis revealed that Robin utilizes a variety of methods in her science teaching, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on, journaling, technology, and reinforcement.

In summary, Interview analysis also gave the researcher a glimpse into Robin’s early Subject Matter Knowledge (SMK). Robin doesn’t recall any specific directions that she learned for teaching science. She teaches the way she learns best. Robin uses a variety of methods to teach science.
Interview analysis also gave the researcher a glimpse of Robin’s Shared Identity (SI). Robin acknowledged that her administrators, teammates, students, and keeping pace with the curriculum map have influenced her choice of science teaching methods. Referring back to data from Research Question 2 analysis, we learned that Robin believed support from her administration and grade level team was positive. Her administrators were very open to help when she needs them and supportive by allowing them to conduct experiments and try new things. Robin’s Pre PSI Professional Development Course interview data also showed that she is influenced by her teammates. Robin’s students also have an influence on her choice of teaching methods. The following excerpt explains her thoughts.

My teaching varies year to year, the students I have. Some need a lot of structure and can’t handle the freedom to explore on their own. They wouldn’t know how to go from there. They really need a lot of direction. So, I just kind of see or gauge from them how it is going to work. I could have a routine here and I could have two classes. One could be fine and [for] the other class, I might have to tailor it more to what they need. The students have influenced me very much. The students themselves are going to determine, “Is this too much for them to handle?” “Are they going to need more structure?” “Do they need more time?” “How would I vary the lesson?”

This excerpt showed that Robin is motivated to choose teaching methods because the methods meet the needs of her students. She also feels curriculum guidelines, which includes keeping pace with the curriculum map, influence the way she teaches. This is illustrated in the following excerpt, in which Robin discusses how she decides what to teach and what not to teach. “I go first by the curriculum map and then pick and choose from the materials that I feel will best suit my students’ needs.”

Following the staff development Robin reported that her own learning style is reflected in the way that she teaches. Robin believes using enthusiasm, humor, and
novelty in her lessons will help students remember concepts. In her post PSI Professional Development Course interview excerpts Robin shares an example that shows us that she believes it is important for students to understand the “scientific method, including “parts of experiments” like “variables and constants,” and the “tools used in science to gather data.” She also believes they should understand the “how science is everywhere.” These ideas are reinforced as Robin relates the reason she signed up for the professional development class in her pre PSI Professional Development Course interview session. Robin explained that she “wanted to do more,” to add to the “hands-on activities” she was already doing in her classroom. She also wished to “gain something” that she is “going to use” when team teaching. Robin is motivated to keep going because her students learn better and enjoy learning more.

In summary, Interview data revealed that Robin makes choices about which methods to use to teach science based on the influences of administrators, teammates, students, and the curriculum map. She feels supported by her administration and teammates. She is also influenced by her students and feels it is important to meet their individual needs. When planning, Robin begins with the curriculum map and alters activities to meet the needs of her students. She wants her students to learn more and enjoy learning.

Robin’s Partner Portfolio for Professional Development

To provide triangulation of multiple data sources (Yin, 2003) the researcher studied pieces from Robin’s Partner Portfolio for Professional Development including Robin’s post PSI Professional Development Course lesson plan, Invitation to Practice: Science Learning Personal History, the post PSI Professional Development Course lesson
plan, and the journal entry titled “What is inquiry?” This study leads to a more meaningful understanding of Robin’s perceptions as they connect to Teacher Choice (TC) framed by her mental models, conceptions of science subject matter, and barriers related to teaching and learning. Throughout the course of this study Robin made use of on her own education and teaching experiences, analyzed what she learned during the staff development training and made a decision whether or not to hang on to the ideas based on her own system of values. Following the pattern for data analysis used for the pre PSI Professional Development Course interview analysis, data analysis consisted of a study of Robin’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI).

First, interview analysis gave the researcher a view of Robin’s Individual Identity (II). When describing her own framework for understanding science content and teaching methods in her pre PSI Professional Development Course interview, she explains that she uses a variety of methods in her science classes, including: relating the concept to prior learning, investigation, discussion, questioning, accessing background knowledge, hands-on, journaling, technology, and reinforcement. She is motivated to use a variety of methods because her students learn better and enjoy learning more. She uses journal writing to check to see if her students are truly learning. In her pre PSI Professional Development Course interview, Robin describes her teaching style by explaining that she uses humor and novelty in her teaching. She does this because she believes it will “stick in their head.” She gives students “a variety of ways to explore a concept.” During the post PSI Professional Development Course observation Robin continued to employ a variety of teaching methods into her lessons, methods included: questioning, the reading
of children’s literature, use of manipulatives, recording, representing and analyzing data, evaluation of the validity of claims or looking for evidence, writing or reflections in a journal.

Robin explained her learning style in a pre PSI Professional Development Course interview session, saying, “Not just with science, but with any subject. I am a very visual, hands-on learner. I like to see it and play with it myself.” Partner Portfolio data from Robin’s Invitation to Practice: Science Learning Personal History supports Robin’s belief that she learns by being actively involved, experimenting, and participating in visual and hands-on activities. When learning Robin needs “to read about it as well as do something” and she also notes that she feels her “…learning style is reflected in the way I teach.”

Next, Partner Portfolio analysis supported and extended previous findings related to Robin’s Subject Matter Knowledge (SMK). Robin offers her students a variety of ways to explore science concepts. Robin sees herself as both crazy and silly. Robin believes using enthusiasm, humor, and novelty in her lessons will help students remember concepts. Robin describes her own framework for understanding I-B methods by explaining that she feels science inquiry includes: asking questions, exploring, explaining, and understanding how they arrived at the answers. Partner Portfolio analysis clarified previous findings related to Robin’s Subject Matter Knowledge (SMK). In one of her Partner Portfolio for Professional Development Invitation to Practice entries she explains that she brought a frog with wacky hair to class because it says something about her as a science teacher. Robin writes, “I love frogs and science and this one is a little wacky which is how I approach most of my lessons.” In her Invitation to Practice:
Collaboration entries, Robin writes that she and her CF, Hailey, are both “not afraid to try new things.” Robin’s goal for the PSI Professional Development Course reads, “I would like to have several lessons to implement in the classroom. I want to be comfortable in my knowledge of inquiry to use it effectively.” Reflecting back upon previous research question analysis, Robin’s CLES Attitude Scale scores were in the high agreement range, which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities.

Last, data from interview analysis related to Robin’s Shared Identity (SI) revealed that Robin believed that her administrators, her grade level teammates, her students and the curriculum map had an influence on her choice of science teaching methods. In her Invitation to Practice: Collaboration entries, Robin writes that she and her CF, Hailey, are both “willing to embarrass themselves in order for students to learn.” Another large motivator or influence on Robin’s choice of teaching methods is her students. Pre PSI Professional Development Course interview data showed that Robin uses humor and novelty in her teaching because she believes it will help students remember concepts. She offers her students a variety of ways to explore science concepts. Robin sees herself as both crazy and silly.

Data from Robin’s portfolio supports the idea that Robin’s students have an influence on her choice of teaching methods. In her initial Invitation to Practice: Mapping My Classroom activity Robin writes that she is interested in making sure she incorporates “student directed learning.” In her Invitation to Practice: Mapping My Classroom follow-up activity, Robin writes, “I have changed my classroom into more student directed. I have given them more opportunities to explore and share.” As noted in Research
Question 2 analysis, the researcher observed evidence of this during the post PSI Professional Development Course observation as she led students in activities where they were able to make connections to information they studied the previous day about temperature. They worked together as a whole group to create a list of the layers inside the Earth. Students worked as individuals or pairs to piece together foam pieces of Pangaea. Next, students worked in small groups to explore the layers of the Earth using unifix cubes and clue cards. Robin created and implemented a student-centered science lesson.

Summary of Robin’s Results for Research Question 5

Data findings were used to examine Robin’s choices in an effort to reveal methods that encourage teachers like her to overcome resistance to implementing I-B teaching practices. Robin made decisions about her choice of teaching methods by assessing the value of the options available to her and deciding upon a course of action based on her own conceptual framework. Data analysis for Research Question 5, “How do teachers choose to use I-B methods as opposed to teacher-centered activities?” consisted of an examination of Robin’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI).

Partner Portfolio analysis supported previous findings related to Robin’s Individual Identity (II). Excerpts from Robin’s pre PSI Professional Development Course interview analysis, supported by secondary data, showed that Robin feels that her learning style is reflected in the way she teaches. Robin learns by being actively involved, experimenting, and participating in visual and hands-on activities. She offers her students a variety of ways to explore science concepts. Robin sees her teaching style as both crazy
and silly. She values the use of structured science process skills in her classroom. Robin also believes using enthusiasm, humor, and novelty in her lessons will help students remember concepts. When dealing with discipline issues, she also tries to keep that same sense of humor.

Using data from Subject Matter Knowledge (SMK), the researcher learned that Robin offers her students a variety of ways to explore science concepts. Robin sees herself as both crazy and silly. Robin believes using enthusiasm, humor, and novelty in her lessons will help students remember concepts. Robin describes her own framework for understanding I-B methods by explaining that she feels science inquiry includes: asking questions, exploring, explaining, and understanding how they arrived at the answers. Partner Portfolio analysis clarified previous findings related to Robin’s Subject Matter Knowledge (SMK). Robin’s goal showed she was interested in creating several “lessons to implement in the classroom” so that she is comfortable in her “knowledge of inquiry to use it effectively.”

Data from interview analysis related to Robin’s Shared Identity (SI) revealed that Robin believed support from her administration and grade level team was positive and that they had a large influence on her choice of science teaching methods. In conclusion, Robin acknowledged that her CF and her teammates, her students, and the curriculum framework influenced her choice of science teaching methods. She explained that she is “not afraid to try new things.”
Teacher Portrait T6 – Lucy

I next present the data to answer the query, “Who is Lucy?” This teacher portrait is described as it aligns with each research question. Data that yields information related to each question was analyzed. A discussion of the findings for each question is presented.

Research Question 1 Analysis

What do teachers believe about teaching science? What are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?”

Lucy’s Interview Analysis: Pre and Post Professional Development Course

The following data proved useful in providing insights related to Research Question 1: (a) Lucy’s pre PSI Professional Development Course interview, (b) STEBI survey, (c) CLES survey, (d) Lucy’s Partner Portfolio for Professional Development, and (e) Lucy’s post PSI Professional Development Course interview. Data findings were utilized to examine Lucy’s beliefs in an effort to uncover patterns that influence her teaching behavior as it relates to her Individual Identity (II). Individual Identity (II) is defined as the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfield, 1998) that represents autonomy or personal constructs (Scribner et al., 2002). Lucy’s Interview Codes and Transcript Statements for Research Question 1 are located in Table 22.
Table 22.

*Interview Codes and Transcript Statements for Lucy (T6) Pre and Post – Research Question 1.*

<table>
<thead>
<tr>
<th>Beliefs about learning and teaching science</th>
<th>Beliefs About How Children Learn Science</th>
<th>Beliefs About Science Teaching Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: I do remember as a kid being curious about things and I remember one time I conducted my own little experiment in secret…I didn’t think my Mom would let me do it…I thought I’d get in trouble. I do remember investigating things, being younger. (Memory) (Struggles with Science) (Investigating)</td>
<td>Pre: I guess it would be the stuff that they’re going to take and use daily to understand the world. They should learn things like measurement and the process skills, observing, creating graphs and charts, and communicating. I think those are the most important. Some other things, like the cycles and the seasons, are also important for them to learn about. Some of the concepts are a little bit harder for them and I think they’ll eventually get because the science seems to wrap up or spiral every year. (Process Skills)</td>
<td>Pre: I’m always busy… if you want to get to do the fun thing. We’ve got to do this, you know.” I’m very busy and always on the go. I’m not as organized as other teachers you might see because I always feel like we’re doing activities, piling up the stuff, and moving on to the next thing. I’m very busy. (Actively Involved) (Emotions) (Organization)</td>
</tr>
<tr>
<td>Pre: Lucy did not like science in school as a child…because they “read out of a book and memorized stuff” and she didn’t understand it. When she reached high school and took chemistry she still “didn’t get it.” Lucy’s early college science training was mostly reading, “doing a lot of reading out of the book.” (See &amp; Do)</td>
<td></td>
<td>Pre: I think I’m creative. I think I’m good at coming up with fun activities that get the point across. I think I’m hard working. I am usually the first one here and I’m usually one of the last ones to leave…I think I try to make things fun. It’s not so easy to learn some of the things, but if you make it fun somehow they are like tricked into learning. (Novelty) (Emotions) (Variety of Methods)</td>
</tr>
<tr>
<td>Pre: Lucy began to like science when she took a teaching science class in college that was “all hands on.” The professor first talked about each topic. Then students performed experiments. Last, the professor showed the students the connection between the topic and the experiment. She also remembers sitting “in the outdoors and just writing stuff down,” as well as competitive game-like activities… (Actively Involved) (Extend Learning) (Investigating) (Novelty)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A teacher’s styles and principles are rooted in experience and develop into individual constructs slowly over time (Souza Barros & Elia, 1998). The interview excerpt that follows relates an early childhood experience that she explains as playing a role in shaping Lucy’s beliefs.

I do remember as a kid being curious about things and I remember one time I conducted my own little experiment in secret. The reason I remember this, this is kind of funny. I don’t know where I saw this. I got a wire, and a battery, and a light bulb. I knew I could put them together and make the light bulb light up, and I just thought that was the neatest thing, but I didn’t think my Mom would let me do it. So I snuck the battery and the wire and I got this funny looking light bulb that had all these lines through it. Little did I know it was a flashbulb! So when I put it all together, it worked. I rigged it all up, made it go off. It went off in my hand and I remember I burned myself and everything! I still didn’t tell because I thought I’d get in trouble. I do remember investigating things, being younger.

Although she remembers investigating things when she was younger, Lucy did not like science in school as a child. Interview data revealed she did not like science because they “read out of a book and memorized stuff” and she didn’t understand it. When she reached high school and took chemistry she still “didn’t get it.” Lucy’s early college science training was mostly reading, “doing a lot of reading out of the book.” Although she took courses in chemistry and physical science she doesn’t remember much about them. In Physical Science Level I, she was able to have lab days where she participated in simple experiments.

Lucy began to like science when she took a teaching science class in college that was “all hands on.” The professor first talked about each topic. Then students performed experiments. Last, the professor showed the students the connection between the topic and the experiment. She also remembers sitting “in the outdoors and just writing stuff down,” as well as competitive game-like activities. “I got the second highest grade in the
class and I was like a straight C student. I just got it then. I was able to do stuff and learn about it that way. I got it!” "Positive experiences" motivate, encourage, and enable students to go on to have more valuable learning experiences, whereas, "negative experiences" tend to lead towards a student closing off from potential positive experiences in the future (Dewey, 1938, 1997). Lucy’s "positive experience" with science in college motivated, encouraged, and enabled Lucy to carry these valuable learning practices on to her students. Dewey (1916) asserts that the hands-on method and inquiry lead to meaningful learning.

If he [i.e., the student] cannot devise his own solution (not of course in isolation, but in correspondence with the teacher and other pupils) and find his own way out he will not learn, not even if he can recite some correct answer with 100 per cent accuracy. We can and do supply ready-made "ideas" by the thousand; we do not usually take much pain to see that the one learning engages in significant situations where his own activities generate, support, and clinch ideas—that is, perceived meanings or connections. (p. 160)

Dewey believed that learning experiences should be meaningful to each student and that teachers should step back and act as facilitators (Dewey, 1938, 1997). Pre PSI Professional Development Course interview data showed that in her teaching, Lucy allows students to develop their own solutions. She uses hands-on methods where she and her children are very busy doing activities that are creative and fun. Lucy uses the techniques of repetition, review, vocabulary words, and stations or centers to teach science in her classroom.
A teacher’s principles or attitude, her tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do (Souza Barros & Elia, 1998). This excerpt from Lucy’s pre PSI Professional Development Course interview shows what she explains as a description of herself as a classroom teacher.

I’m always busy. I’m always saying, “Come on, let’s go. Get your paper ready. Come on, we’ve got to move on the next thing if you want to get to do the fun thing. We’ve got to do this, you know.” I’m very busy and always on the go. I’m not as organized as other teachers you might see because I always feel like we’re doing activities, piling up the stuff, and moving on to the next thing. I’m very busy.

Lucy believes her strengths as a teacher are her creativity and dedication to working hard. She explains in the excerpt that follows.

I think I’m creative. I think I’m good at coming up with fun activities that get the point across. I think I’m hard working. I am usually the first one here and I’m usually one of the last ones to leave. It’s hard to think about yourself. I think I try to make things fun. It’s not so easy to learn some of the things, but if you make it fun somehow they are like tricked into learning.

Lucy works hard and tries to make learning fun for her students. Lucy believes it is important for her students to understand science process skills, to understand the world, and apply science to their daily lives. The excerpt that follows outlines Lucy’s thoughts about which science concepts she feels are important for her students to learn by the end of the school year.

I guess it would be the stuff that they’re going to take and use daily to understand the world. They should learn things like measurement and the process skills, observing, creating graphs and charts, and communicating. I think those are the most important. Some other things, like the cycles and the seasons, are also important for them to learn about. Some of the concepts are a little bit harder for them and I think they’ll eventually get because the science seems to wrap up or spiral every year.
In summary, Lucy allows students to develop their own solutions. She uses hands-on methods where she and her children are very busy doing activities that are creative and fun. She uses repetition, review, vocabulary words, and stations or centers to teach science. Lucy believes her strengths as a teacher are her creativity and dedication to working hard. Lucy believes it is important for her students to understand science process skills, to understand the world, and apply science to their daily lives. Although Lucy and her students work hard, Lucy takes time out to make sure her students have fun in her science classroom.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

Lucy’s STEBI Personal Science Teaching Efficacy Belief (PSTEB) subscale scores for the pre and post assessments were in the high efficacy category, with 55 points and 64 points respectively (max=65 points) (see Figure 12). Therefore, she was comfortable with her ability to teach science. Her level of comfort with her ability to teach science increased after participation in the PSI Professional Development Course. Lucy’s STEBI Outcome Expectancy (OE) subscale scores for the pre and post assessments also increased notably, with 44 (high OE) points to 54 (high OE) points (max=60 points); indicating she also had an increase in her confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).
Constructivist Learning Environment Survey – CLES Analysis Pre and Post

The CLES Personal Relevance scale relates to students’ experience of the personal relevance of school science as perceived by teachers (Suters, 2004; Taylor et al., 1997). Lucy’s pre (29) and post (35) CLES Personal Relevance scores showed an increase, both were in the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences (see Figure 13). This indicates that after the PSI Professional Development Course she felt more comfortable inviting students to engage in opportunities to experience the relevance of school science to their everyday interests and activities and to use their everyday experiences as a meaningful context for the development of their formal scientific knowledge.
The CLES Scientific Uncertainty scale relates to students’ perceptions of science as a fallible human activity as perceived by teachers (Suters, 2004; Taylor et al., 1997). Her pre (22) and post (24) CLES Scientific Uncertainty scores were in the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values.

The CLES Critical Voice scale relates to students development as autonomous learners, through creation of a social climate in which students feel that their learning is legitimate and beneficial (Suters, 2004; Taylor et al., 1997). Lucy’s pre (28) and post (27) CLES Critical Voice scores decreased slightly from a high to a high intermediate agreement range. This indicated that after Lucy’s participation in the PSI Professional Development Course she might have provided slightly fewer opportunities for students to question her plans and methods and express concerns about impediments to their learning.

The CLES Shared Control scale also relates to student autonomy. This scale is concerned with students sharing control of the classroom-learning environment with their teacher (Suters, 2004; Taylor et al., 1997). Her pre (16) and post (23) CLES Shared Control scores increased notably from a low intermediate to a high intermediate agreement range. This indicates that after the PSI Professional Development Course Lucy placed more emphasis on inviting students to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms of the classroom. This
finding supports data from Lucy’s pre PSI Professional Development Course interview excerpts where she explains that in her teaching, Lucy allows students to develop their own solutions.

The CLES Student Negotiation scores relate to teacher beliefs as they relate to student interaction with other students (Suters, 2004; Taylor et al., 1997). Lucy’s CLES Student Negotiation scores increased notably from the pre assessment (29) to the post assessment (35). Both scores were in the high agreement category, which indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas.

Last, the Attitude Scale scores provide a measure of the concurrent validity of the CLES. It is used to measure teachers’ interpretations of students’ attitudes towards the classroom environment (Suters, 2004; Taylor et al., 1997). Her pre (31) and post (33) Attitude Scale scores showed a slight increase, both were in the high agreement range which indicated that she felt students: anticipated the activities within her classroom; found activities worthwhile; and understood and enjoyed the activities (see Appendix D1 for instrument and D2 for scoring instructions). This finding supports data from Lucy’s pre PSI Professional Development Course interview excerpts where she explains that she uses hands-on methods where she and her children are very busy doing science activities that are creative and fun.
Figure 13. Lucy’s CLES Scores

Lucy’s Partner Portfolio for Professional Development Analysis

Lucy was offered the opportunity to reflect and manage her thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006) throughout the PSI Professional Development Course. The researcher examined five products produced by Lucy: (a) Invitation to Practice: Science Learning Personal History, (b) Invitation to Practice: Collaboration, (c) pre PSI Professional Development Course lesson observation, (d) Lucy’s personal goal for the PSI Professional Development Course, and (e) journal entries to confirm previously mentioned data findings from the pre PSI Professional Development Course interview. Lucy’s Partner Portfolio for Professional Development analysis findings, along with STEBI and CLES data serves as triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).
A framework for organization formed through reflection upon Lucy’s interview excerpts related to her beliefs about teaching science. Through the Invitation to Practice: Science Learning Personal History (see Appendix G) activity Lucy revealed that she believes that “you draw on your own experiences.” She further explained how she related this idea to her own beliefs as to how children learn science. Lucy writes, “When you look back at yourself you realize that when you teach you use examples from your own background and things you know about. I think kids do the same thing.”

Data analysis was conducted to investigate Lucy’s beliefs about how children learn science. This excerpt from the Invitation to Practice: Science Learning Personal History illustrates Lucy’s beliefs.

What I realize now is that in order to develop students who will do well in understanding the world around them you have to teach them how to become thinkers. In school I learned how to read out of a textbook and memorize facts. I had no idea how to think. I didn’t have much experience to draw from either. When I am planning my science lessons now I keep this in mind. I do my best to come up with thoughtful active lessons that will provide the kids with experience on topics that they can fall back on.

In her post PSI Professional Development Course interview answers Lucy reveals, “I believe in a hands-on method. When kids are active in their learning they remember and understand better.” Lucy notes that her students “look forward to the activities” that they do in her classroom. They are “always busy.” Lucy likes to “be very animated and goofy sometimes to keep them interested.” She also likes to “do something shocking or intriguing to help them remember the concept.” For example, when describing liquids she “dumped the water out on the table to show them it changed shape.” Her students had no idea she was going to do that and she exclaims, “They never forgot it!”
Last, data analysis was conducted to investigate Lucy’s beliefs about science teaching methods. Pre PSI Professional Development Course interview data showed that Lucy believes hands-on activities, combined with repetition, review, vocabulary word practice, and stations or centers are effective methods to use when teaching students science. An entry in Lucy’s Partner Portfolio for Professional Development offers insight into her decrease in CLES Critical Voice scores. Lucy’s pre (28) and post (27) CLES Critical Voice scores decreased slightly from a high to a high intermediate agreement range, indicating that after participation in the PSI Professional Development Course, she might have provided slightly fewer opportunities for students to question her plans and methods and express concerns about impediments to learning (Suters, 2004; Taylor et al., 1997). One of Lucy’s journal entries explains her struggle with letting go of control. Lucy wrote, “Changing the activities to match the inquiry method was not hard at all. It just took some different kind of thinking and deciding how to let go of some control.”

Summary of Lucy’s Results for Research Question 1

Lucy’s interview excerpts about her childhood science experiences revealed that although she was curious and interested in investigating, she was afraid to explore. In school she read out of a book and memorized information. She did not enjoy science. Lucy finally learned that science could be fun while participating in a hands-on science teaching class during college. She believes hands-on activities, combined with repetition, review, vocabulary word practice, and stations or centers are effective methods to use when teaching students science. According to the results of the STEBI, Lucy’s Personal Science Teaching Efficacy Belief subscale scores, pre (55) and post (64), were in the high efficacy category, indicating that Lucy feels comfortable teaching science.
PSI Professional Development Course Lucy had an increase in her confidence in her ability to create desirable outcomes (Riggs, 1988; Riggs & Enochs, 1990). Lucy’s CLES Personal Relevance scores, pre (29) and post (35), showed a notable increase. This was an indication that Lucy placed a high emphasis on linking school science with students’ everyday experiences. This finding was supported by data from the Pre PSI Professional Development Course interview that revealed Lucy’s belief that “you draw on your own experiences.” The CLES Shared Control scale scores, pre (16) and post (23), increased notably indicating that Lucy placed an emphasis on inviting students to participate in their own learning activities and provided opportunities for students to explain their ideas to other students (Suters 2004; Taylor et al., 1997).

Data from Lucy’s interview, STEBI analysis, and CLES analysis supports Bandura’s (1997) statement that knowledge of self-efficacy beliefs can have the ability to predict behavior. Based upon Bandura’s (1977) theory of social learning, the researcher asserts that, a teacher who possesses a high sense of self-efficacy, like Lucy, is more likely to use student-centered, constructivist teaching practices than teachers who have a low sense of self-efficacy. Lucy explained, “Changing the activities to match the inquiry method was not hard at a. It just took some different kind of thinking and deciding to let go of some control.” Lucy follows the constructivist view of learning in which people construct new understandings and knowledge based on what they already know and believe (National Research Council, 2000). This finding was supported by Lucy’s comment, “I believe in a hands-on method. When kids are active in their learning they remember and understand better.”
Research Question 2 Analysis

How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

Interview analysis (see Appendix B for instrument) for Research Question 2 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, and 8 listed in Table 1, (b) post PSI Professional Development Course interview questions 3 and 4, (c) Classroom Observation analysis (see Appendix E for the Classroom Observation Protocol), (d) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), (e) CLES analysis (see Appendix D1 for instrument and D2 for scoring instructions), and the (f) Partner Portfolio for Professional Development. The researcher utilized this data in order to examine the way in which Lucy perceives herself or describes her own abilities to produce desired or intended results in her science classroom. This data were also drawn upon to describe Lucy’s Subject Matter Knowledge (SMK). Subject Matter Knowledge (SMK) is defined as the teacher’s knowledge of content matter and pedagogy (the art of being a teacher), along with her curriculum knowledge (Shulman, 1986). Last, the researcher analyzed the data to reveal information related to Lucy’s understanding of I-B methods. In other words, the researcher has assembled the pieces to answer the teacher’s query, “How does Lucy describe her abilities to produce desired or intended results in her science classrooms? What does Lucy believe about her science content knowledge and her pedagogical science knowledge? What does Lucy understand about I-B methods?”
Lucy’s Interview Analysis: Pre and Post Professional Development Course

The researcher compiled interview data to create a picture to describe Lucy’s framework for understanding science and her ability to produce desired results in her science classroom according to her beliefs and self-efficacy. Information about Lucy’s knowledge of science content information was revealed in Research Question 1 analysis. Further data analysis began with an examination of Lucy’s description of her own efficacy and her ability to produce a desired or intended result in her science classroom. During this analysis we learned that Lucy did not like science in school because they merely “read out of a book and memorized stuff.” Lucy didn’t understand the science concepts. When she reached high school and took a chemistry class, she felt that she still “didn’t get it.” Lucy’s early college science training was mostly reading, “doing a lot of reading out of the book.” She doesn’t remember much about these science topics or lessons; however, Lucy believes that she found out that she could learn to understand science while participating in a hands-on science teaching class during college. Lucy discovered that she learned science best when she was actively engaged in her science learning. Lucy applied this idea of engagement and participation to her own learning and teaching.

A teacher’s conceptions might also include knowledge of science curriculum and standards. Therefore, interview analysis continued, focusing on Lucy’s own framework for understanding science content and teaching methods. Interview codes and transcript statements for Lucy’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions for Research Question 2 are listed in Table 23.
Table 23.

*Interview Codes and Transcript Statements for Lucy (T6) Pre and Post – Research Question 2.*

**Self-Efficacy Related to:**

<table>
<thead>
<tr>
<th>Understanding of Science Content</th>
<th>Teaching Methods</th>
<th>Definition of science and Inquiry science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: Lucy did not like science in school because they “read out of a book and memorized stuff.” Lucy didn’t understand it. When she reached high school and took chemistry she still “didn’t get it.” Lucy’s early college science training was mostly reading, “doing a lot of reading out of the book.” (Negative Emotions) (Sit n’ Git)</td>
<td>Pre: “I always want the kids to have the memory of the activity to fall back on. So if they were going to try to answer the question about why we have seasons. I want them to remember how we revolved around the room, or sang a song. And I want them to look back and say I remember it that way. I want them to make a connection.” (Methods) (Motivation)</td>
<td>Pre: “Experiments and fun. Kids love it. That’s it.” (Emotions) (Components-Science)</td>
</tr>
<tr>
<td>Pre: Lucy began to like science when she took a teaching science class in college that was “all hands on.” The professor first talked about each topic. Then students performed experiments. Last, the professor showed the students the connection between the topic and the experiment. She also remembers sitting “in the outdoors and just writing stuff down,” as well as competitive game-like activities… (Transition) (Love)</td>
<td>Pre: “I think because of the bad experience I had, I just always want to make the kids have a better experience.” (Reach All) Pre: “I guess it would be the stuff that they’re going to take and use daily to understand the world. They should learn things like measurement and the process skills, observing, creating graphs and charts, and communicating. I think those are the most important. Some other things, like the cycles and the seasons, are also important for them to learn about. Some of the concepts are a little bit harder for them and I think they’ll eventually get because the science seems to wrap up or spiral every year.” (Methods) (Reach All)</td>
<td>Post: (Science Definition) “Science is a way of helping us understand and explain the world around us.” (World View)</td>
</tr>
<tr>
<td>Post: (Inquiry Definition) “A method of teaching that enables students to explore, manipulate, and experiment in order to truly build and lay the foundation of scientific understanding.” (Components-Inquiry) (Method) (POV)</td>
<td></td>
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</tbody>
</table>
The researcher analyzed pre PSI Professional Development Course interview data, which was useful in describing Lucy’s framework for understanding science. The preliminary interview with Lucy revealed that she teaches from the state standards and adds more than students actually are required to learn. The teacher’s conceptions of science subject matter or content knowledge includes the ideas, facts, and the concepts of a discipline as well as the relationships among those concepts, facts, and ideas. An example of her concept of this relationship is found in an excerpt from Lucy’s energy unit.

They don’t have to know forms of energy, but if you’re teaching that the sun is directly the source of light and heat, I think they need to know about energy. You need to build a background before you can get up to that point. So I look at the standards and see the things they actually have to know and then I go a little beyond.

She further described her framework for understanding science content when she related the science concepts that she believed were the most important for her students to understand by the end of the school year. This is illustrated in the following excerpt.

I guess it would be the stuff that they’re going to take and use daily to understand the world. They should learn things like measurement and the process skills, observing, creating graphs and charts, and communicating. I think those are the most important. Some other things, like the cycles and the seasons, are also important for them to learn about. Some of the concepts are a little bit harder for them and I think they’ll eventually get because the science seems to wrap up or spiral every year.

Lucy’s framework for science teaching methods includes hands-on activities, backed by practice, games, songs, and technology. Lucy takes time to model activities for the students. She uses reading as a follow-up to most activities. She explains why she uses these methods in the following excerpt.
I always want the kids to have the memory of the activity to fall back on. So if they were going to try to answer the question about why we have seasons, I want them to remember how we revolved around the room, or sang a song. And I want them to look back and say I remember it that way. I want them to make a connection.

Lucy does not teach by just reading out of the book all year. She notes that this is because, “I think because of the bad experience I had, I just always want to make the kids have a better experience.”

Last, data analysis focused on Lucy’s description of her own framework for understanding I-B methods. Prior to the PSI Professional Development Course Lucy reported that she “hadn’t even heard of it [I-B] before. It sounded like another buzz word for hands-on.” In her post PSI Professional Development Course interview Lucy defined inquiry science as, “A method of teaching that enables students to explore, manipulate, and experiment in order to truly build and lay the foundation of scientific understanding.” She defined science as, “Science is a way of helping us understand and explain the world around us.” This data from the interview analysis is utilized in the section titled Lucy’s Partner Portfolio for Professional Development Analysis and serves as a source for triangulation of multiple data sources (Yin, 2003).

Classroom Observation Analysis: Pre and Post Professional Development Course

Researcher observations were completed May 16, 2007 and September 24, 2007. Demographics of her two classes during the pre PSI Professional Development Course and post PSI Professional Development Course observations are presented in Table 24. Lucy had a total of 24 students in the pre PSI Professional Development Course and 21 students in the post PSI Professional Development Course observations.
Table 24.

*Lucy’s Class Demographics Pre and Post Observations (T6)*

<table>
<thead>
<tr>
<th>Race</th>
<th>Pre (24)</th>
<th>Post (21)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>African American</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Caucasian American</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Asian</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>11</strong></td>
<td><strong>13</strong></td>
</tr>
</tbody>
</table>

Data analysis includes a review of Lucy’s interview and observation data followed by presentation of evidence related to the implementation of the forms inquiry as described by Martin-Hansen (2002). A review of the pre PSI Professional Development Course observation supports the pre PSI Professional Development Course interview data and suggests that Lucy uses multiple methods while teaching one lesson. She uses repetition, review, vocabulary words, and stations or centers to teach science. Lucy also emphasizes process skills such as observing, creating graphs and charts, and communicating. A brief synopsis of the pre PSI Professional Development Course lesson is illustrated in this paragraph. In her lesson plan Lucy and her students followed a structured sequence of activities. The lesson centered around the concept of soil layers on the Earth. First, Lucy provided an opportunity for students to access background knowledge through a discussion about soil. Next, Lucy introduced vocabulary. Lucy led an interactive note taking session where students raised their hands and put their thumbs
up or down to answer questions about soil, layers of soil, and the Earth. Lucy used the overhead projector to help students follow along with the note taking. Pictures and visual images were used to help students remember vocabulary terms. Following the note taking session, students worked in teams to create a “plan” as to how they will arrange the items, which represented the various layers of soil. Then students carried out their experiment. The lesson concluded with a closure activity. This plan shows evidence of the use of Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design (Martin-Hansen, 2002). Lucy selected a question, “What is the order of the layers of the Earth?” The students used their answer to the question as a framework. Lucy allowed the students to assist in the decision as to how they might answer the question through investigation.

A brief synopsis of the lesson from the post PSI Professional Development Course observation is illustrated in this paragraph. This lesson was lesson three in a series of seven lessons on the topic of Matter. Lucy engaged her students and reviewed the term physical properties by playing a game she called “Guess my Object.” To play the game, the teacher picks an object in the room and begins listing physical properties of the object. Students take turns guessing the object. Next, students explored four different stations. The stations did not have names because Lucy’s students were going to use the information they learned in the lesson to label the stations later. Station one contained liquids, examples of objects included water, colored water, and oil. Station two contained solid objects, examples of objects included ordinary classroom objects like pencils and erasers, beads, sand, salt, and sugar. Station three contained examples of gases, examples of objects included blown up balloons, zip-lock bags filled with air, and a helium balloon.
The “bonus” station contained shiny objects; examples included shiny yarn, shiny coins, plastic spoons, and plastic erasers. Lucy encouraged students to figure out how this station fits in to their unit of study. During their exploration, students asked questions, designed their own mini experiments to discover the answers to their questions, and discussed the results with their classmates and teacher. They created their own “plan” for examining the physical properties of the objects and recorded results on a worksheet. For example, students asked a question like, “What will happen if I pour this green liquid into this container of clear liquid?” Then they poured, discussed, and recorded what happened. There was a frequent hum of activity and ideas being exchanged. Students felt comfortable retrieving science equipment from other areas of the classroom, for example, during an investigation of the properties of solids students retrieved a balance to measure the mass of the objects and used it in their investigation. Before leaving the station, students chose one property to list on a sticky-note and place on a chart at the station. The lesson was interrupted for lunch. Lucy continued after lunch. Next, during the explanation portion of the lesson, Lucy led a discussion that allowed students to share information they discovered or recorded on their charts. They created a definition or statement of the commonalities of the physical properties describing the objects at each station. Lucy led the students to an understanding of the properties of matter. She read the book titled, *What is the World Made of? Solids, Liquids, and Gases* written by Kathleen Weidner Zoehfeld and Paul Meisel. Students created a “flip book” made with folded paper, where students wrote down the physical properties of each type of matter. Later students would participate in an Internet search for examples of each type of matter and make a poster to share and display their ideas.
As demonstrated in Lucy’s lesson plans, pre PSI Professional Development Course observation, and post PSI Professional Development Course observation data, she has successfully implemented several forms of inquiry as described by Martin-Hansen (2002). During the lesson Lucy and her students played “Guess my Object.” Lucy picked objects in the room and listed physical properties of the object. Students take turns guessing the object, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). Throughout her mini unit plan Lucy gradually moved from Structured Inquiry to Guided Inquiry, inquiry in which the teacher develops a question and allows the students to co-construct the experimental design. She then moved towards Coupled Inquiry, inquiry that starts as Structured Inquiry or teacher Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control. Lucy gradually lessened teacher control as she allowed students to ask questions about physical properties and the states of matter, design their own mini experiments, and discuss the results with their classmates and teacher. During their exploration portion of the lesson, students asked questions, designed their own mini experiments to discover the answers to their questions, and discussed the results with their classmates and teacher. They created their own “plan” for examining the physical properties of the objects and recorded results on a worksheet. For example, students asked a question like, “What will happen if I pour this green liquid into this container of clear liquid?” Then they poured, discussed, and recorded what happened. Lucy has successfully implemented the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002).
**Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post**

As noted in Research Question 1 analysis, Lucy’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the high efficacy category, with 55 points and 64 points respectively (max=65 points). Therefore, she was comfortable with her ability to teach science. Her level of comfort with her ability to teach science increased. STEBI Outcome Expectancy subscale scores for the pre and post assessments also increased notably, with 44 (high OE) points to 54 (high OE) points (max=60 points); indicating she had an increase in her confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Lucy’s Partner Portfolio for Professional Development*.

**Constructivist Learning Environment Survey – CLES Analysis Pre and Post**

Lucy’s pre (29) and post (35) CLES Personal Relevance scores showed an increase, both were in the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences. This indicates that after the PSI Professional Development Course she felt more comfortable inviting students to engage in opportunities to experience the relevance of school science to their everyday interests and activities and to use their everyday experiences as a meaningful context for the development of their formal scientific knowledge. Her pre (22) and post (24) CLES Scientific Uncertainty scores were in the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in
opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. Her pre (28) and post (27) CLES Critical Voice scores decreased slightly from a high to a high intermediate agreement range. This indicated that after Lucy’s participation in the PSI Professional Development Course she provided slightly fewer opportunities for students to question her plans and methods and express concerns about impediments to their learning. Her pre (16) and post (23) CLES Shared Control scores increased notably from a low intermediate to a high intermediate agreement range. This indicates that after the PSI Professional Development Course Lucy placed more emphasis on inviting students to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms of the classroom. Her CLES Student Negotiation scores increases notably from the pre assessment (29) to the post assessment (35). Both scores were in the high agreement category, which indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. Her pre (31) and post (33) CLES Attitude Scale scores showed a slight increase, both were in the high agreement range which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (see Appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Lucy’s Partner Portfolio for Professional Development.
Lucy’s Partner Portfolio for Professional Development

The Partner Portfolio for Professional Development was used to hold teacher reflections and permitted the opportunity for participants to manage their thoughts and behaviors through strategic processing, reflection, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Lucy’s (a) Goal Statement, (b) Exit Slips, and (c) journal entries were analyzed to confirm the earlier mentioned data findings. This examination offers a triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).

Data analysis for points of triangulation started with an examination of Lucy’s description of her own efficacy and ability to produce a desired or intended result. In her goal statement for the PSI Professional Development Course, Lucy writes, “I would like to learn some new ways to enhance my science teaching. I would especially like to improve on two units that I feel I could teach in a better way.” Lucy’s goal supports the idea that she would like to improve as a teacher.

Data analysis for points of triangulation was conducted to examine Lucy’s description of her own framework for understanding science content. As noted in Research Question 1 analysis, although she remembers investigating things when she was younger, Lucy did not like science in school as a child. Interview data revealed she did not like science because they “read out of a book and memorized stuff” and she didn’t understand it. When she reached high school and took chemistry she still “didn’t get it.” Lucy’s early college science training was mostly reading, “doing a lot of reading out of the book.” Although she took courses in chemistry and physical science she doesn’t remember much about them. Data from Lucy’s Portfolio for Professional Development
supports the idea that Lucy had a difficult time learning science in high school. She
shares her experience in an excerpt from her Invitation to Practice: Science Learning
Personal History.

My junior year of high school I took a chemistry class. I was just what you took if
you were in the college prep classes. I was completely lost in that class. I felt like
we were already supposed to know certain things in order to understand what was
going on. I have no experience what-so-ever with the topic. What I realize now is
that in order to create students who will do well in understanding the world
around them you have to teach them how to become thinkers. In school I learned
how to read out of a textbook and memorize facts. I had no idea how to think. I
didn’t have much experience to draw from either. When I am planning my science
lessons now I keep this in mind. I do my best to come up with thoughtful active
lessons that will provide the kids with experience on topics that they can fall back
on.

Lucy did not learn by reading out of a textbook and memorizing facts. She had no prior
knowledge to build upon when learning about science concepts. Lucy remembers her
own difficult experience and this influences the way she teaches her students, she is
careful to provide them with active lessons and experiences that will help facilitate
learning. Lucy began to like science when she took a teaching science class in college
that was “all hands on.” The PSI Professional Development Course provided Lucy with
ideas and suggestions to help with her science planning. Lucy explains in an exit slip, “I
think that I am getting the hang of writing the lessons. I’m working on rewriting some of
my experiments to make them more inquiry based and less “cookbook.” Lucy’s STEBI
scores support the idea that her comfort level related to content knowledge has increased.
Lucy’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (55)
and post (64) assessments increased notably, indicating that her level of comfort with her
ability to teach science increased. Her STEBI Outcome Expectancy subscale scores for
the pre (44) and post (54) assessments also increased notably, indicating she had an
increase in her confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

Data analysis for points of triangulation was conducted to examine Lucy’s description of her own framework for understanding teaching methods. Lucy’s framework for science teaching methods includes hands-on activities, backed by practice, games, songs, and technology. Lucy takes time to model activities for the students. She uses reading as a follow-up to most activities. A review of the pre PSI Professional Development Course observation supports the pre PSI Professional Development Course interview data and suggests that Lucy uses multiple methods while teaching one lesson. She uses repetition, review, vocabulary words, and stations or centers to teach science. Lucy also emphasizes process skills such as observing, creating graphs and charts, and communicating. Data from Lucy’s Invitation to Practice: Collaboration activity in her Portfolio for Professional Development supports the idea that Lucy uses hands-on activities in her classroom. Data from classroom observations provides evidence that Lucy used a variety of methods in her lessons, including: games, vocabulary review, incorporation of children’s literature, hands-on activities, and use of stations and centers. Lucy writes that she and Liz, her CF, both use “hands-on” in their science teaching. Lucy’s CLES Student Negotiation scores, pre (29) and post (35), increases notably, which indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. Her pre (31) and post (33) CLES Attitude Scale scores showed a slight increase, both were in the high agreement range which indicated that she
felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997).

Last, data analysis for points of triangulation was conducted to examine Lucy’s framework for understanding I-B methods. Prior to the PSI Professional Development Course Lucy reported that she “hadn’t even heard of it [I-B] before. It sounded like another buzz word for hands-on.” In her Partner Portfolio Lucy describes her framework for understanding I-B. She describes I-B as “letting go of some control and putting the reins into the children’s hands.” She further writes that I-B includes “tapping into the child’s natural curiosity.” Lucy feels I-B science “makes science exciting and meaningful” and “creates thinkers and problem solvers.” This supports Lucy’s definition of science in her post PSI Professional Development Course interview. She defines inquiry science as, “A method of teaching that enables students to explore, manipulate, and experiment in order to truly build and lay the foundation of scientific understanding.” She defined science saying, “Science is a way of helping us understand and explain the world around us.”

Summary of Lucy’s Results for Research Question 2

Research Question 2 seeks information to explain the following: “How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?”

To answer this question, one must understand that Lucy’s cognitive framework including her knowledge of science content and teaching methods, which includes the ideas, facts, and the concepts of the discipline, as well as the relationships among those concepts,
facts, and ideas. Interview data revealed that as a child, Lucy did not like science because they “read out of a book and memorized stuff” and she didn’t understand it. In college, Lucy learned that she could understand science while participating in a hands-on science teaching class. Lucy’s framework for science teaching methods includes hands-on activities, backed by practice, games, songs, and technology. Her CLES Attitude Scale scores support this idea showing that she felt students: anticipated the activities within her classroom; found activities worthwhile; and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997). Lucy’s conceptions also include knowledge of science curriculum and standards, and what she knows about inquiry instruction. Lucy revealed in the pre PSI Professional Development Course interview that she teaches from the state standards and adds more than students actually have to know. Lucy’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post PSI Professional Development Course assessments were in the high efficacy category, indicating that she was comfortable with her ability to teach science. Science reform efforts have painted a vision of science education in which all children have the opportunity to engage in science as inquiry—to explore and construct ideas and explanations of the natural world within a supportive community of learners (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Observations revealed that Lucy used Guided Inquiry in her classroom. Lucy’s CLES Personal Relevance scores indicated that she placed a high emphasis on linking school science with students’ everyday experiences. This idea is supported by data from Lucy’s pre PSI Professional Development Course interview session. Lucy described I-B learning as “tapping into the child’s natural curiosity.” She feels it “makes science exciting and meaningful” and “creates thinkers and problem solvers.”
Research Question 3 Analysis

What barriers to implementing I-B methods exist?

Interview analysis (see Appendix B for instrument) for Research Question 3 includes the examination of Lucy’s Goal Statement, and selected pre PSI Professional Development Course and post PSI Professional Development Course interview questions listed in Table 1. To build credibility, information was compiled through (a) the STEBI survey, (b) the CLES survey, (c) direct observation of the participant’s teaching, and the (d) Partner Portfolio for Professional Development, including: lesson plans for the mini-unit; Invitation to Practice: Mapping My Classroom activity; Exit Slips; Quick Writes; and journal entries. This data serves to examine the teacher’s mental models in an effort to uncover patterns that influence teaching behavior as it relates to her Shared Identity (SI), the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her role as part of the professional community. In other words, we have assembled the pieces to answer the teacher’s query, “How does Lucy describe her abilities to produce desired or intended results in her science classroom as they relate to barriers to implementation of I-B science methods?”

Lucy’s Goal Statement Analysis

A teacher’s attitudes and beliefs about science are key influences on how they teach the subject. The teachers’ principles or attitude, their tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do. The teachers’ styles, principles, are rooted in experience and develop into individual constructs slowly over time (Souza Barros & Elia, 1998). In
summary, Lucy’s principles or attitude, her tendency to respond favorably or unfavorably toward the science topic, her students, or other objects determines what her students will see, hear, think, and do. During the PSI Professional Development Course Lucy set her own goal for I-B instruction (Hammerness et al., 2005). Lucy’s goal for the PSI Professional Development Course read as follows: “I would like to learn some new ways to enhance my science teaching. I would especially like to improve on two units that I feel I could teach in a better way.” Examining Lucy’s goal allowed the researcher to examine her attitude towards implementation of I-B methods into her classroom. This goal reveals that Lucy is interested in learning new ideas and improving her current instruction related to I-B methods, specifically related to two of her science units.

*Lucy’s Interview Analysis: Pre and Post Professional Development Course*

Interview analysis for Research Question 3 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 7, 8, and 9. This allowed the researcher to gather information to provide a picture of what was happening Lucy’s classroom and school, thus providing knowledge and practice at the start of the research (Davis, 2002). Pre PSI Professional Development Course interview analysis revealed that Lucy used the following strategies in her classroom prior to the PSI Professional Development Course: hand-on activities backed by practice, games, modeling strategies, technology, songs and fun. She used reading as a follow-up activity to enhance instruction. Interview codes and transcript statements for Lucy’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions are listed in Table 25.
Table 25.

Interview Codes and Transcript Statements for Lucy (T6) Pre and Post – Research Question 3.

<table>
<thead>
<tr>
<th>Barriers to Implementation of I-B Methods</th>
<th>Time for Science Instruction and Time Related to Curriculum Guidelines</th>
<th>Support</th>
<th>Teacher</th>
</tr>
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<tbody>
<tr>
<td>Pre: “Sometimes I think the standards hinder us a little bit. They tell us what we have to teach and what has to get done, but at the same I think they put too much into it. You can go so much more in depth with some of the topics that we have to teach but I think we have to rush, rush, rush and get it done for the test. I think it also hurts us.” (Standards) (Pacing)</td>
<td>Pre: ”Probably the space, cause our rooms are teeny. So actually having enough space to put more projects out and things.” (Space)</td>
<td>Pre: The behavior of the students in her class might serve as a barrier if Lucy has “a very rowdy class that can’t control themselves. Obviously you can’t be doing experiments.” However, Lucy has “never had to ever just not do” an activity because her students always “got serious” when she had to discuss or correct their behavior. (Student behavior-relationship to teacher)</td>
<td></td>
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<tr>
<td>Post: “I feel pressured to teach fast so as to get all of the information taught before the benchmarks. This causes me to throw out some worthwhile activities in order to comply with county requirements. I feel like the students miss out.” (Pacing) (Testing)</td>
<td>Post: “In post PSI Professional Development Course interview analysis Lucy noted that she “really couldn’t change much due to limited space, but I did put more scientific tools out in the open so students can get them when they feel they need them.” (Space)</td>
<td></td>
<td></td>
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</tbody>
</table>
Lucy’s teaching team at her school consisted of young or new teachers who have given her ideas and helped her with activities. Lucy has been at her school “the longest of any of them, this is the first year for two of them.” They do not have a large influence on Lucy’s choice of science teaching methods but they have given her “a new perspective” on the things she does. Her administration has been “supportive of anything” she has done. When they heard that third grade was team teaching the administrators were “really excited.” One administrator commented that Lucy “does a really good job with that [science instruction].” Research supports that it is important that administrators and teammates are supportive of teachers while they implement the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). Data from the pre PSI Professional Development Course interview analysis showed that Lucy is receiving the support she needs from teammates and administrators related to her science teaching.

Although Lucy has the desire to implement I-B science methods, holds confidence in her teaching ability, and feels support from colleagues and administration, there is a possibility that Lucy might not be able to fully carry out her science teaching vision. Appropriately, the researcher examined possible threats to fidelity or barriers to use of I-B science instruction. This was accomplished through interviews and classroom observations. This process enabled the researcher to identify connections or relationships between Lucy’s perceptions and use of I-B science instruction in her classroom (Davis, 2002).

Analysis of the pre PSI Professional Development Course interview questions revealed that Lucy did face a number of barriers as she went about the process of
implementing I-B science in her classroom. Lucy lists curriculum guidelines, including the Virginia SOL, as a barrier to her I-B science teaching. This is illustrated in the following quote.

Sometimes I think the standards hinder us a little bit. They tell us what we have to teach and what has to get done, but at the same time I think they put too much into it. You can go so much more in depth with some of the topics that we have to teach but I think we have to rush, rush, rush and get it done for the test. I think it also hurts us.

Lucy also lists space as a possible barrier to I-B science teaching. Lucy elaborates, "Probably the space, cause our rooms are teeny. So actually having enough space to put more projects out and things.” The behavior of the students in her class might serve as a barrier if Lucy has “a very rowdy class that can’t control themselves. Obviously you can’t be doing experiments.” However, Lucy has “never had to ever just not do” an activity because her students always “got serious” when she had to discuss or correct their behavior.

Interview analysis for Research Question 3 also includes the analysis of the post PSI Professional Development Course interview questions numbered 3, 4, 6, and 7. This analysis was conducted again with the assumption that Lucy might have encountered possible threats to fidelity or barriers to use of I-B instruction. This process enabled the researcher to further identify connections or relationships between Lucy’s perceptions and use of inquiry instruction (Davis, 2002). Interview analysis revealed that classroom space and time imposed by division and state curriculum guidelines were barriers that Lucy did face while attempting to implement I-B science methods into her science classroom.
In pre PSI Professional Development Course interview analysis Lucy listed space as a possible barrier to I-B science teaching. In post PSI Professional Development Course interview analysis Lucy noted that she “really couldn’t change much due to limited space, but I did put more scientific tools out in the open so students can get them when they feel they need them.” This information shows that, for Lucy, a lack of classroom space was and continues to serve as a barrier to implementation of I-B science methods.

Post PSI Professional Development Course interview analysis also revealed that Lucy did face time constraints as a barrier to implementation of I-B methods. Lucy felt that curriculum pacing measured by curriculum guidelines including Milton County’s benchmark assessment tests caused her to feel pressure. The following excerpt illustrates the pressure that Lucy felt.

I feel pressured to teach fast so as to get all of the information taught before the benchmarks. This causes me to throw out some worthwhile activities in order to comply with county requirements. I feel like the students miss out.

In summary, Lucy saw the following as possible barriers to science teaching: curriculum guidelines, including the amount of content in the Virginia SOL, county requirements, and curriculum pacing; classroom space; the behavior of students; and time. Lucy was able to make only minor adjustments to the barrier of classroom space through organization and planning. Lucy found that she was also able to control for student behavior.

_Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post_

As noted in Research Question 1 analysis, Lucy’s STEBI Personal Science Teaching Efficacy Belief subscale scores, pre (55) and post (64), indicate that she is
comfortable with her ability to teach science. Lucy’s level of comfort with her ability to teach science increased after participation in the PSI Professional Development Course. Her STEBI Outcome Expectancy subscale scores, pre (44) and post (54), also increased notably, indicating she also had an increase in her confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). These results support data from Lucy’s pre PSI Professional Development Course interview session showed that Lucy feels confident about her ability to teach science and is receiving the support she needs from teammates and administrators, indicating that Lucy’s mental models as she relates her role as part of the professional community or shared identity did not act as a barrier to the implementation of I-B science in her classroom.

*Constructivist Learning Environment Survey – CLES Analysis Pre and Post*

As noted in Research Question 1 analysis, Lucy’s CLES Personal Relevance scores, pre (29) and post (35), indicated that she placed a high emphasis on linking school science with students’ everyday experiences. Her CLES Scientific Uncertainty scores, pre (22) and post (24), indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science. Her CLES Critical Voice scores, pre (28) and post (27), indicated that after Lucy’s participation in the PSI Professional Development Course she might have provided slightly fewer opportunities for students to question her plans and methods and express concerns about impediments to their learning. Her CLES Shared Control scores, pre (16) and post (23), increased notably indicating that after the PSI Professional Development Course Lucy placed more emphasis on inviting students to: participate in designing their
own learning activities, determine assessment criteria, and negotiate the norms of the classroom. Her CLES Student Negotiation scores, pre (29) and post (35), indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas. Her CLES Attitude Scale scores, pre (31) and post (33), indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (see Appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). None of these findings point toward a barrier to implementation of I-B methods.

*Lucy’s Partner Portfolio for Professional Development Analysis*

Throughout the course teachers were given the opportunity to reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). To confirm the previously mentioned data findings as triangulation of multiple data sources provides for multiple measures of the same phenomenon (Yin, 2003) the following data were analyzed: (a) the Invitation to Practice: Mapping My Classroom activity, (b) the Invitation to Practice: Collaboration activity, (c) Exit Slips, (d) Quick Writes, and (e) journal entries. Analysis of the pre PSI Professional Development Course interview questions revealed that Lucy believed that she did face barriers to the implementation of I-B instruction. Lucy saw the following as possible barriers to science teaching: curriculum guidelines, including the amount of content in the Virginia SOL, county requirements, and curriculum pacing; classroom space; the behavior of students; and time.
Data from the pre PSI Professional Development Course interview revealed that classroom space and accessibility of science tools served as a barrier to Lucy’s implementation of I-B methods. During the PSI Professional Development Course, Lucy wrote in one of her Exit Slip entries, “I would love to have my kids planning their own experiments on a more regular basis.” The Invitation to Practice: Mapping My Classroom activity conveyed that Lucy attempted to removed some of the barriers she did face to implementing I-B into her classroom on her own and provided more opportunities for students to participate in I-B activities. She “made spots for supplies” so she and her students “could find them” when they needed them. She put a “table in the middle of the classroom” so she can “perform demonstrations” so that all of her “students can see without having to move.” She was not able to carry out an idea she had to switch from desks to tables because tables were not available at her school. Although Lucy was able to make some adjustments related to providing space and opportunities for her students to participate in I-B science, she found that some factors like the furniture and the size of the room were beyond her control.

Lucy’s lack of complete understanding of the teaching method may have served as a barrier as Lucy worked towards implementation of Full or Open Inquiry, one of the models of inquiry as defined by Martin-Hansen (2002). The PSI Professional Development Course also allowed an opportunity for Lucy to participate in authentic inquiry based learning experiences, which allowed the opportunity to build pedagogical and content knowledge and skills. Lucy’s cognitive framework includes her knowledge of science content and teaching methods. Different individuals achieve understanding in a variety of ways, and different individuals attain different degrees of depth and breadth of
understanding depending on interest, ability and context (NRC, 1998). In one of her journal entries, Lucy mentioned that she had not yet implemented methods for allowing students to create their own “investigable questions.” Creating “investigable questions” is a process by which students create questions and design experiments from their own questions. Lucy has not implemented this strategy because she “didn’t quite get it.” Lucy has not yet mastered the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). As demonstrated in Lucy’s lesson plans and post PSI Professional Development Course observation data, she has successfully implemented Structured Inquiry, Coupled Inquiry, and Guided Inquiry. Lucy had some success with Full or Open Inquiry during their exploration, students asked questions, designed their own mini experiments to discover the answers to their questions, and discussed the results with their classmates and teacher.

Lucy’s Classroom Observation Analysis: Pre and Post Professional Development Course

Designing her own unit offered Lucy a sense of ownership and increased the potential fidelity of implementation of the I-B reform initiatives. Fidelity can be defined as the extent to which the delivery of an intervention follows or sticks to the procedure or program model developed originally (Mowbray et al., 2003). This also allowed Lucy to meet her goals for the PSI Professional Development Course, “to learn some new ways to enhance my science teaching.” Pre PSI Professional Development Course interview analysis revealed that Lucy used the following strategies in her classroom prior to the PSI Professional Development Course: hand-on activities backed by practice, games, modeling strategies, technology, songs, and fun. She uses reading as a follow-up activity to enhance instruction. As mentioned in Research Question 1 interview analysis, Lucy
displayed evidence of the use of Guided Inquiry as defined by Martin-Hansen (2002). Lucy was provided the opportunity to design her own I-B unit through the PSI Professional Development Course. This allowed Lucy to make conscious or unconscious decisions as to what methods she will use to teach science based on her concepts of science and science teaching, knowledge of science content and teaching methods, and school factors. Reflecting upon her science lesson, Lucy revealed:

It was really hard for me to plan at first because I wanted every single lesson and thing that I was going to do with the students to be inquiry. It took me a while to decide on which activities I wanted to focus. I found that I was trying to put too much into the unit and had to really decide which activities would be the most effective and would get the most across in the shortest amount of time. Changing the activities to attach the inquiry method was not hard at all. It just took some different kind of thinking and deciding how to let go of some control.

The pre PSI Professional Development Course observation data supported Lucy’s statement in the Invitation to Practice: Mapping My Classroom activity that her classroom space was limited. During classroom observations, the researcher observed that the classroom space was small. Students, activities, and supply shelves were all sandwiched into a very limited space. Lucy stated that following the PSI Professional Development Course, she “made spots for supplies” so she and her students “could find them” when they needed them. She put a “table in the middle of the classroom” so she can “perform demonstrations” so that all of her “students can see without having to move.” The post PSI Professional Development Course observation data supports her statements. During the post PSI Professional Development Course observation students felt comfortable retrieving science equipment from other areas of the classroom, for example, during an investigation of the properties of solids students retrieved a balance to measure the mass of the objects and used it in their investigation.
Summary of Lucy’s Results for Research Question 3

Research Question 3 examines the question, “What barriers to implementing I-B methods exist?” Lucy made conscious or unconscious decisions as to what instructional methods or techniques she used to teach science based on her concepts of science and science teaching, knowledge of science content and science teaching methods, and school factors. Lucy’s goal for the PSI Professional Development Course was to learn “some new ways to improve her science teaching” related to I-B science methods. Teacher’s form a self-concept or self-image of their own abilities based on feedback from stakeholders and their own impression of their visions of science teaching. Data revealed that Lucy’s mental models as she relates her role as part of the professional community did not act as a barrier to the implementation of I-B science in her classroom. Data analysis for Research Question 3 also revealed that Lucy saw curriculum guidelines, including the amount of content in the Virginia SOL, county requirements, and curriculum pacing; classroom space; the behavior of students; and time as possible barriers to implementing I-B science methods. Lucy was able to manage student behavior. Although Lucy was able to make some adjustments related to providing space and opportunities for her students to participate in I-B science, she found that some factors like the furniture and the size of the room were beyond her ability to control. Lucy’s lack of complete understanding of the I-B science teaching methods also proved to be a barrier towards her implementation of Full or Open Inquiry into her science classroom.
Research Question 4 Analysis

What relationships exist between teachers’ perceptions and use of I-B methods?

Data were analyzed to address the query, “What relationships exist between Lucy’s perceptions and use of I-B methods?” Interview analysis (see Appendix B for instrument) for Research Question 4 includes the examination of (a) post PSI Professional Development Course interview questions 2, 3, 6, and 7 listed in Table 1, (b) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (c) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (d) Partner Portfolio for Professional Development. Influences such as Lucy’s culture, educated-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual and style help mold the her beliefs about I-B science methods. The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between Lucy’s Individual Identity (II), her Subject Matter Knowledge (SMK) and her Shared Identity (SI).

John Dewey (1938, 1997) proposed that experience transpires as a result of the interrelationship of two principles, continuity and interaction. Continuity refers to how each experience a person has influences one’s future, for better or for worse. Interaction refers to the situational influence on one’s experience. The individual’s present experience is a function of the interaction between their past experiences and the present situation. No experience has a pre-destined value. Therefore, what might be a beneficial experience for one individual could be an unfavorable experience for another. In other
words, "positive experiences" motivate, encourage, and enable students to go on to have more valuable learning experiences, whereas, "negative experiences" tend to lead towards a student closing off from potential positive experiences in the future. Dewey believed that learning experiences should be meaningful to each student and that teachers should step back and act as facilitators (Dewey, 1938, 1997).

Returning to the bucket metaphor as described in the researcher’s conceptual framework, Lucy examined the shells and treasures, made up of I-B science strategies and techniques presented at the PSI Professional Development Course, and decided to either keep each one and place it in her bucket, or place it back on the beach based on her own system of values. The discovery of treasures of large or great value had a positive influence on Lucy’s motivation, attitude, caring, determination and effort toward science teaching. The discovery of treasure with little or low value had a negative influence on Lucy’s motivation, attitude, caring, determination and effort. Keeping this framework in mind, this data were drawn on to describe the Lucy’s cognitive frameworks related to inquiry, her beliefs about inquiry teaching, and how this ties into the her daily experiences. This information is crucial to understanding teacher change with regard to inquiry (Keys & Bryan, 2000; Spillane et al., 2002). In other words, data were analyzed to address the query, “What relationships exist between Lucy’s perceptions and use of I-B methods?”

Lucy’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 4 includes the analysis of the post PSI Professional Development Course interview questions numbered 2, 3, 6, and 7. Since qualitative research is concerned with the perceptions of the participants and with process
rather than outcomes or products (Bogdan & Biklen, 1992, Marshall & Rossman, 2006), this design serves as an appropriate methodology to utilize to define inquiry as it is perceived and used by Lucy. Data findings were drawn on to first illustrate Lucy’s cognitive framework related to inquiry. Prior to the PSI Professional Development Course Lucy reported that she “hadn’t even heard of it [I-B] before. It sounded like another buzz word for hands-on.” Lucy was willing to try to implement I-B methods into her science classroom because she is “always looking for new and innovative ways to teach my students.”

Through the course of the PSI Professional Development Course, Lucy had the opportunity to develop an understanding of the following topics: What is inquiry, learning through inquiry, developing a mind for constructivism, constructivism, how children learn, designing I-B classrooms, integrating I-B activities, the scientific method, learning cycles, skills and knowledge of I-B teachers, questioning, and she also participated in examples of I-B lessons. In her Partner Portfolio for Professional Development, Lucy describes her framework for understanding inquiry science as, “Letting go of some control and putting the reins into the children’s hands.” She perceives that the use of I-B science methods includes the following: “Tapping into the child’s natural curiosity.” Lucy believes that I-B science “makes science exciting and meaningful” and “creates thinkers and problem solvers.” Post PSI Professional Development Course interview data were drawn on to reveal Lucy’s beliefs about inquiry teaching. In her post PSI Professional Development Course interview, Lucy defines inquiry science as: “A method of teaching that enables students to explore, manipulate, and experiment in order to truly build and lay the foundation of scientific understanding.”
The perception that I-B science methods hold large or great value had a positive influence on Lucy’s motivation, attitude, caring, determination and effort during implementation of the methods in her classroom. This statement was confirmed when Lucy addressed the issue of motivation related to the implementation of I-B science into her classroom. She said, “Even though it [I-B science] does take more time, in the long run students come out ahead.”

As a final point, the interview data were examined to determine how Lucy’s cognitive framework related to inquiry and her beliefs about inquiry teaching tie into her daily experiences in her science classroom. As noted in Research Question 2 analysis, Lucy’s framework for teaching science includes hands-on activities, practice, games, songs, and use of technology. Lucy takes time to model activities for her students in her science classroom. Lucy’s students do not just read out of the textbook all year. Lucy uses reading as a follow-up to most science activities. She uses hands-on science methods where she and her students are busy doing activities that are creative and fun. She explains why she uses these methods in the following excerpt.

I always want the kids to have the memory of the activity to fall back on. So if they were going to try to answer the question about why we have seasons. I want them to remember how we revolved around the room, or sang a song. And I want them to look back and say I remember it that way. I want them to make a connection.

Lucy is willing to implement I-B methods into her science classroom because she believes it “makes science exciting and meaningful” and “creates thinkers and problem solvers.”

In summary, prior to the PSI Professional Development Course, Lucy’s understanding of inquiry science was limited, she “hadn’t even heard of it [I-B] before. It
sounded like another buzz word for hands-on.” Following the PSI Professional Development Course, Lucy explained that she perceives the use of I-B science methods to include “tapping into the child’s natural curiosity.” Lucy believes it “makes science exciting and meaningful” and “creates thinkers and problem solvers.” Lucy’s cognitive framework related to inquiry and her beliefs about inquiry science teaching tie into her daily experiences as she provides opportunities for her students to see and do, to participate in hands-on activities. Her students do not just read out of the textbook all year.

*Lucy’s Goal Statement Analysis*

Lucy created the following goal for her PSI Professional Development Course: “I would like to learn some new ways to enhance my science teaching. I would especially like to improve on two units that I feel I could teach in a better way.” Studying Lucy’s goal allowed the researcher to investigate and scrutinize her approach towards implementation of I-B methods into her science classroom. This goal illustrates that Lucy is interested in learning new ideas and improving her current science instruction related to I-B methods. Lucy felt positive about her own motivation, attitude, caring, determination and effort as it related to implementation of I-B methods in her science classroom.

*Science Teaching Efficacy Belief Instrument - STEBI Analysis Pre and Post*

As noted in Research Question 1 analysis, Lucy’s STEBI Personal Science Teaching Efficacy Belief subscale scores, pre (55) and post (64), indicate that she is comfortable with her ability to teach science. Lucy’s level of comfort with her ability to teach science increased after participation in the PSI Professional Development Course.
Her STEBI Outcome Expectancy subscale scores, pre (44) and post (54), also increased notably, indicating she also had an increase in her confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). These results support data from Lucy’s pre PSI Professional Development Course interview session showed that Lucy perceived that what she learned in the PSI Professional Development Course about I-B science methods had a positive influence on Lucy’s motivation, attitude, caring, determination and effort during implementation of the methods in her science classroom. This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Lucy’s Partner Portfolio for Professional Development.

Lucy’s Partner Portfolio for Professional Development

Lucy was given the opportunity to reflect and manage her thoughts and behaviors through strategic processing, reflection and collaboration throughout the PSI Professional Development Course (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Lucy’s Partner Portfolio for Professional Development data provided additional pieces that were used to address the query, “What relationships exist between Lucy’s perceptions and use of I-B methods?” Analysis focused on relationships connecting Lucy’s perceptions to her practice. Emic accounts, descriptions of behaviors in terms meaningful to the teacher, were used because these accounts are culture specific or are found in the context of the teacher’s classroom (Stake, 2006). The researcher completed three steps in analyzing the Partner Portfolio for Professional Development. First, Lucy’s definition of inquiry, Lucy’s methods of instruction, and the definition of inquiry used
during the PSI Professional Development Course were reviewed for comparison. Lucy’s definition of inquiry and choice of teaching methods was examined. Second, a review of the findings from Lucy’s Interview analysis, Goal Statement analysis, and STEBI analysis was conducted. Third, emic accounts were compared to excerpts from Lucy’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). Each of these steps is discussed next.

First, the researcher examined Lucy’s definition of inquiry. In her post PSI Professional Development Course interview Lucy defines inquiry science as: “A method of teaching that enables students to explore, manipulate, and experiment in order to truly build and lay the foundation of scientific understanding.” Through the course of the PSI instruction Lucy had the opportunity to develop an understanding of the following topics: What is inquiry, learning through inquiry, developing a mind for constructivism, constructivism, how children learn, designing I-B classrooms, integrating I-B activities, the scientific method, learning cycles, skills and knowledge of I-B teachers, and questioning. Lucy also participated in sample I-B lessons that were modeled during the PSI Professional Development Course (a complete detailed description of the twenty-hour professional development course is located at Appendix K). Analysis of the mini unit and individual lesson plans showed that Lucy implemented teaching methods consistent with her definition of inquiry. The researcher observed children planning and experimenting with concepts related to the states of matter. Students felt comfortable retrieving science equipment from other areas of the classroom, for example, during an
investigation of the properties of solids students retrieved a balance to measure the mass of the objects and used it in their investigation.

Next, the researcher looked at Lucy’s methods of science instruction. Data revealed that Lucy followed the 5E Model of science teaching (Bybee, 1993, 2000) allowing for engagement, exploration, explanation, elaboration, and evaluation. Lucy systematically accessed background knowledge, reviewed vocabulary, engaged the students in interactive note taking, encouraged team work, facilitated the planning and carrying out of hands-on inquiry based experiments. Lucy learned “…changing the activities to match the inquiry method was not hard at all, it just took some different kind of thinking and deciding how to let go of some control.”

As noted in Research Question 2 analysis, Lucy’s lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Guided Inquiry. During the mini unit lesson that Lucy created during the PSI Professional Development Course, the researcher observed evidence Guided Inquiry as defined by Martin-Hansen (2002). To engage students in the lesson, Lucy selected a question, “What is the order of the layers of the Earth?” She used the question to guide student investigation by allowing the students to assist in the decision as to how they might answer the question through investigation. The researcher also observed evidence of Coupled Inquiry, inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002), as she reduced teacher control and allowed students to work as individuals or pairs in centers to explore how the layers of the Earth might be arranged. Lucy started using Full or Open Inquiry during the post PSI Professional
Development Course observation when she allowed students to conduct their own mini experiments based on questions they created as they rotated through engaging hands-on centers.

Last, as data analysis continued, the definition of inquiry used during the PSI Professional Development Course was reviewed for comparison with Lucy’s definition of inquiry and choice of science teaching methods. During the PSI Professional Development Course, inquiry instruction was defined as referring to any teaching method focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations and discover answers to their questions about the natural world. Students may plan systems to collect data and choose how to organize and represent the data (Carin et al., 2004). The National Research Council (1998) defines scientific inquiry in this way:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.” (p. 23)

As noted in Research Question 2, prior to the PSI Professional Development Course Lucy reported that she “hadn’t even heard of it [I-B] before. It sounded like another buzz word for hands-on.” In her Partner Portfolio Lucy describes her framework for understanding I-B science. She describes I-B as “letting go of some control and putting
the reins into the children’s hands.” She further writes that I-B includes “tapping into the child’s natural curiosity.” She feels it “makes science exciting and meaningful” and “creates thinkers and problem solvers.”

The next step in data analysis to address the query, “What relationships exist between Lucy’s perceptions and use of I-B methods?” consisted of a review of the findings from Lucy’s Interview analysis, Goal Statement analysis, and Science Teaching Efficacy Belief Instrument - STEBI analysis. Beginning with her pre PSI Professional Development Course interview, Lucy remembers learning from a science class in college that was “all hands-on.” Lucy feels that she remembers best when actively involved, experimenting, participating in hands-on activities, or writing things down. She remembers best when her teachers use a constructivist approach, they provided relevant experiences and opportunities that allowed Lucy to construct knowledge (Piaget, 1929; Vygotsky, 1978). Lucy does not like to just “read out of a book and memorize stuff.” She applies her science learning experiences to her own science teaching. In her Invitation to Practice: Science Learning Personal history activity, Lucy explained that she believes, “You draw on your own experiences.” She continued to explain, “When you look back at yourself you realize that when you teach you use examples from your own background and things you know about. I think kids do the same thing.” Pre PSI Professional Development Course interview data also shows that Lucy allows her students to develop their own solutions. She uses hands-on science methods where she and her students are busy completing activities that are creative and fun. Lucy chooses to the following methods in her science classroom: repetition, review, vocabulary words, and stations or centers to teach science.
In her post PSI Professional Development Course interview excerpts Lucy explains to us that she describes inquiry science as: “Letting go of some control and putting the reins into the children’s hands.” Data from the CLES supports this idea. Lucy’s Shared Control scores, pre (16) and post (23), increased notably from a low intermediate to a high intermediate range, which indicated that after the PSI Professional Development Course, Lucy placed more emphasis in inviting students to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms of the classroom (Suters, 2004; Taylor et al., 1997). Lucy’s goal statement shows that she is interested in learning more about I-B methods, she wrote, “I would like to learn some new ways to enhance my science teaching. I would especially like to improve on two units that I feel I could teach in a better way.” Lucy’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (55) and post (64) assessments increased notably, an indication that she felt more at ease with her ability to teach science. Lucy’s STEBI Outcome Expectancy subscale scores, pre (44) and post (54) also showed a notable increase; indicating that she experienced an increase in her confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). In summary, Lucy is interested in learning about I-B methods. Her teaching style lends itself to the implementation of I-B science methods. The PSI Professional Development Course helped Lucy to feel more at ease with her ability to teach I-B science.

Last, in assembling the pieces of the puzzle to solve the query, “What relationships exist between Lucy’s perceptions and use of I-B methods?” emic accounts from Lucy’s Interview analysis, Goal Statement analysis, and Science Teaching Efficacy
Belief Instrument - STEBI analysis were compared with excerpts from Lucy’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). A teacher’s attitudes and beliefs about science are key influences on how they teach the subject (Souza Barros & Elia, 1998). In an entry in her Invitation to Practice: Science Learning Personal History activity, Lucy shares her positive attitude about trying new things in her science classroom. She shares her thoughts about her learning during the PSI Professional Development Course, “I do my best to come up with thoughtful active lessons that will provide the kids with experience on topics they can fall back on.” Lucy’s Partner Portfolio for Professional Development data supports both her goal statement for the PSI Professional Development Course and her STEBI scores, which illustrate that she is interested in learning new things, she writes, “I would like to learn some new ways to enhance my science teaching.” Lucy’s positive attitude had an influence in her decision to choose to implement I-B methods into her science classroom.

In Lucy’s post PSI Professional Development Course lesson, it was evident that she was implementing inquiry into her science classroom. As noted in Research Question 2 analysis, data confirmed that Lucy felt comfortable with Guided Inquiry and Coupled Inquiry as she went about the process of implementing I-B science methods. As noted in Research Question 3 analysis, Lucy has not yet mastered Full or Open Inquiry because she “didn’t quite get it.” Lucy is interested in working towards the implementation of Full or Open Inquiry. In one of her Exit Slip entries from her Partner Portfolio for Professional Development, she writes, “I would love to have my kids planning their own
experiments on a more regular basis.” Lucy’s Personal Science Teaching Efficacy Belief subscale scores, from the STEBI analysis, for the pre (55) and post (64) assessments were in the high efficacy category indicating that she was comfortable with her ability to teach science (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

**Summary of Lucy’s Results for Question 4**

Through Research Question 4 data analysis, the researcher uncovered an answer to the question, “What relationships exist between teachers’ perceptions and use of I-B methods?” The researcher examined Lucy’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI). Data analysis showed that Lucy was willing to try to implement I-B methods into her science classroom. The perception that I-B methods hold large or great value had a positive influence on Lucy’s motivation, attitude, caring, determination and effort during implementation of the methods in her classroom. Lucy’s definition and vision of inquiry matches her choice of methods for science instruction. Lucy felt comfortable with Guided Inquiry and Coupled Inquiry; however, Lucy has not yet mastered Full or Open Inquiry because she did not quite understand how to lead her students through the process or method. Full or Open Inquiry is defined as inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002).
Research Question 5 Analysis

How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Interview analysis (see Appendix B for instrument) for Research Question 5 includes the examination of (a) post PSI Professional Development Course interview questions 4, 5, 7, 8 and 9 listed in Table 1, (b) post PSI Professional Development Course interview question 6, (c) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), and (d) the Partner Portfolio for Professional Development. Data findings were used to examine Teacher Choice (TC) in an effort to reveal methods that encourage teachers like Lucy to overcome resistance to implementing I-B teaching practices. When a teacher, like Lucy, makes a choice she critiques the value of multiple options and selects a course of action based on her own conceptual framework. Data analysis for Research Question 5 consisted of an examination of Lucy’s conceptual framework made up of: her Individual Identity (II), the portion of the Lucy’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or personal constructs (Scribner et al., 2002); Lucy’s Subject Matter Knowledge (SMK), Lucy’s knowledge of content matter and pedagogy (the art and science of being a teacher) and curriculum knowledge (Shulman, 1986); and Lucy’s Shared Identity (SI), the portion of the Lucy’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community.
Lucy’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 4 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 5, 7, 8 and 9 as well as post PSI Professional Development Course interview question 6. Teacher Choice (TC) is influenced by mental models, “the images, assumptions, and stories, which we carry in our minds of our selves, other people, institutions, and every aspect of the world,” (Senge, 1990). Interview analysis gave the researcher a glimpse into Lucy’s Individual Identity (II). As a child Lucy carried around the images, or assumption in her mind that she did not like science. You might recall the following excerpt from her pre PSI Professional Development Course interview.

Well, I just remember as a kid in school, in science, I did not like science because we read out of a book and we had to memorize stuff, and I didn’t get it. So, then when I got up into high school it hurt me, cause we did chemistry. I didn’t get it. I always wanted to know why and they couldn’t tell me. The just said, “Because it is.” So, it was all, like I said, out of the book, didn’t really enjoy it that much.

Interview analysis also gave the researcher a glimpse into Lucy’s early Subject Matter Knowledge (SMK), Lucy’s perceptions as they are framed by her conceptions of science subject matter. Reviewing an earlier excerpt from the pre PSI Professional Development Course interview analysis, Lucy “just didn’t get it.” Lucy was “curious about things” as a child but was afraid to express her interest; she kept her experimenting a “secret.”

Lucy began to like science when she took her “science class in college. She enjoyed the class because it was “hands-on.” She finally “got it!” This experience influenced Lucy’s choice of science teaching methods. Further insight into Lucy’s Individual Identity (II) were illustrated by an excerpt from the pre PSI Professional
Development Course interview where Lucy was asked what she thinks of when someone says “inquiry science.” In this excerpt she shared her image of surprise or disappointment in teachers in prior grades that learned science by just reading out of the book all year.

I think it’s a fancy word for something we already do. Well, I don’t think everybody does it. Because, I was teaching summer school this year and we had some concepts in our reading series and I said, “do you guys remember when you studies this, and you made this?” And they were like, “we read out of the book all year.” “What are you talking about?” and I thought, “People still do that? Surprising!” I can’t get over that. I think because of the bad experience I had, I just always want to make the kids have a better experience.

This excerpt revealed the reason that Lucy chose to use inquiry science in her classroom. It was because she had a bad experience that she always wants the kids to have a better experience.

Interview analysis also gave the researcher a glimpse of Lucy’s Shared Identity (SI). Lucy believed support from her administration and grade level team was positive. Lucy’s administrators have “always been supportive of anything” she’s put into practice. Her team has “given her ideas” and “helped her see and activity.” Her team does not influence her choice of science methods.

Post PSI Professional Development Course interview analysis revealed more about Lucy’s conceptual framework. The following excerpt showed that student learning plays an important role in Lucy’s choice of teaching methods. Lucy teaches more than the required material because she feels “it will increase students’ understanding of the whole picture.” Lucy chooses hands-on inquiry methods because “when kids are active in their learning they remember and understand better.”

In summary, Lucy carried around the images, or assumption in her mind that she did not like science when she was a child. Lucy had a difficult time understanding
science concepts. A hands-on science class in college allowed Lucy to enjoy and understand science. One reason Lucy chooses to use inquiry science in her classroom because she does not want her students to suffer bad experiences like those she had to endure.

*Lucy’s Partner Portfolio for Professional Development*

To provide triangulation of multiple data sources (Yin, 2003) the researcher examined items from Lucy’s Partner Portfolio for Professional Development including Lucy’s post PSI Professional Development Course lesson plan, Invitation to Practice: Science Learning Personal History, the post PSI Professional Development Course lesson plan, and the journal entry titled “What is inquiry?” This investigation lead to a deeper understanding of Lucy’s perceptions related to Teacher Choice (TC) as framed by her mental models, conceptions of science subject matter, and barriers related to teaching and learning. Throughout the course of this study Lucy drew on her own education and teaching experiences, examined what she learned during the professional development training and decided whether to keep the ideas or not based on her own system of values. Following the pattern for data analysis used for the pre PSI Professional Development Course interview analysis, data analysis consisted of an examination of Lucy’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI).

First, interview analysis gave the researcher a view of Lucy’s Individual Identity (II). Partner Portfolio analysis supported previous findings related to Lucy’s Individual Identity (II). Excerpts from Lucy’s pre PSI Professional Development Course interview analysis revealed that Lucy carried around the images, or assumption in her mind that she
did not like science when she was a child. Excerpts from Lucy’s pre PSI Professional
Development Course interview analysis also revealed that Lucy chooses to use inquiry
science in her classroom because she does not want her students to suffer bad experiences
like those she had to endure. An excerpt from Lucy’s Invitation to practice science
Learning Personal History supports this idea.

What I realize now is that in order to create students who will do well in
understanding the world around them you have to teach them how to become
thinkers. In school I learned how to read out of a book and memorize facts. I had
no idea how to think.

Next, Partner Portfolio analysis clarified previous findings related to Lucy’s
Subject Matter Knowledge (SMK). Partner Portfolio analysis supported previous findings
related to Lucy’s Subject Matter Knowledge (SMK). Excerpts from Lucy’s pre PSI
Professional Development Course interview analysis revealed that Lucy had a difficult
time understanding science concepts. This excerpt from Lucy’s Invitation to Practice:
Science Learning Personal History supports this finding.

I didn’t have much experience to draw from either. When I am planning my
science lessons now I keep this in mind. I do my best to come up with thoughtful
active lessons that will provide the kids with experience on a topic that they can
fall back on.

Excerpts from Lucy’s pre PSI Professional Development Course interview analysis
revealed that a hands-on science class in college allowed Lucy to enjoy and understand
science. Lucy uses hands-on techniques with her own students. This idea is supported by
Lucy’s Invitation to practice science Learning Personal History when she writes, “you
draw on your own experiences.” This idea is also supported by data from the Lesson Plan
analysis. Lucy followed the 5E model. She allowed for exploration and hands-on
activities. Lucy’s Exploration activity from the post PSI Professional Development Course interview is an example of a hands-on activity that Lucy used in her classroom. Lucy describes the activity, “Give each group a bag of buttons and challenge them to sort their button as many different ways as they can and have the keep a running list of how many different ways the buttons can be classified.” Lucy’s Exploration activity from the post PSI Professional Development Course observation is another example of a hands-on activity that Lucy used in her classroom.

Set up different stations [solid, liquids, gases]. Don’t name the stations. Students visit each station and explore with the various objects and items. Students keep track of what they observed and keep track of the physical properties at each station on a worksheet. Before leaving, students choose one property to list on a sticky-note and place the sticky-note on the chart. No property can be listed twice. So some students might have to get creative.

An excerpt from Lucy’s Invitation to practice science Learning Personal History ties the ideas related to Lucy’s Subject Matter Knowledge (SMK), together. Lucy defines inquiry as follows: “Inquiry is: letting go of some control and putting the reins into the child’s hands; tapping into the child’s natural curiosity; makes science exciting and meaningful; and creates thinkers and problem solvers.”

Lesson plan and post PSI Professional Development Course Interview

Observation analysis also supported previous findings related to Lucy’s Subject Matter Knowledge (SMK). A comparison of Lucy’s lesson plans from her mini unit and post PSI Professional Development Course interview analysis supported the idea that I-B instruction that is designed by teachers (not prepackaged by researchers) encourages a higher fidelity of implementation (Mowbray et al., 2003). Lucy was able to implement her unit as planned. The first time she implemented the post PSI Professional
Development Course observation lesion she miscalculated the time needed for the
investigation. She allowed students time to finish the lesson after they returned from their
special area classes, music or art. She did make a slight adjustment in the amount of time
spent working at centers for the second class of students. An excerpt from Lucy’s
reflection on her lessons revealed this information.

The kids certainly enjoyed it. With my class in the afternoon I ended up giving
them five minutes to explore at each station instead of seven. They seemed to get
done a lot faster and be ready to move on. Of course they all wanted extra time at
the liquid center.

Lucy led the students through and inquiry investigation with the concepts of solid,
liquid, and gas. The lesson started as structured inquiry or teacher guided inquiry that was
followed by coupled inquiry, an inquiry making use of a reduced amount of teacher
control (Martin-Hansen, 2002). The students were permitted to follow their own
questions that have come about as a result of guided instruction. Students were given
freedom to explore and to record observations about physical properties. They worked at
investigative stations to discover how the bonus station “fits in.” In one of her journal
entries, Lucy mentioned that she had not yet implemented methods for allowing students
to create their own investigable questions. Lucy has not adopted the inquiry model for
Full or Open Inquiry, inquiry in which students ask their own questions, design
investigations, and convey results (Martin-Hansen, 2002).

Last, data analysis clarified findings related to Lucy’s SI. Data from interview
analysis related to Lucy’s Shared Identity (SI) revealed that Lucy believed support from
her administration and grade level team was positive. She expressed that her team has
“given her ideas” and “helped her see and activity.” An excerpt from Lucy’s Invitation to
Practice: Collaboration supports this idea. Lucy indicated that she and her CF all “share ideas with other teachers.”

Summary of Lucy’s Results for Research Question 5

Data findings were used to examine Lucy’s choices in an effort to reveal methods that encourage teachers like her to overcome resistance to implementing I-B practices. Lucy was able to make teaching method choices by critiquing the value of the options available to her and deciding upon a course of action based on her own conceptual framework. Data analysis for Research Question 5, consisted of an examination of Lucy’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI). Partner Portfolio analysis supported previous interview findings related to Lucy’s Individual Identity (II), showing that Lucy carries the images, or assumption in her mind that she did not like science when she was a child; she chooses to use inquiry science in her classroom because she does not want her students to suffer bad experiences like those she had to endure. Partner Portfolio analysis supported previous findings related to Lucy’s Subject Matter Knowledge (SMK) reveal that Lucy had a difficult time understanding science concepts. Data from interview analysis related to Lucy’s Shared Identity (SI) reveal that she believed support from her administration and grade level team was positive; they did not have a large influence on Lucy’s choice of science teaching methods. In conclusion, Lucy chooses to teach in the manner in which she learned best; she believes students learn from hands-on and engagement, and avoids methods that had a negative impact on her learning, like reading out of the book and answering questions. Freedom and support from her administrators and teammates gives her the ability to choose the method she feels is most effective.
Teacher Portrait T7 – Anna

I next present the data to answer the query, “Who is Anna?” This teacher portrait is described as it aligns with each research question. Data that yields information related to each question was analyzed. A discussion of the findings for each question is presented.

Research Question 1 Analysis

What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?

Anna’s Interview Analysis: Pre and Post Professional Development Course

The following data proved useful in providing insights about Research Question 1: (a) Anna’s pre PSI Professional Development Course interview, (b) STEBI survey, (c) CLES survey, (d) Anna’s Partner Portfolio for Professional Development, and (e) Anna’s post PSI Professional Development Course interview. Data findings were utilized to examine Anna’s beliefs in an effort to uncover patterns that influence her teaching behavior as it relates to her Individual Identity (II). Individual Identity (II) is defined as the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfield, 1998) that represents autonomy or personal constructs (Scribner et al., 2002). Anna’s Interview Codes and Transcript Statements for Research Question 1 are located in Table 26.
Table 26.

*Interview Codes and Transcript Statements for Anna (T7) Pre and Post – Research Question 1.*

<table>
<thead>
<tr>
<th>Beliefs about learning and teaching science</th>
<th>Beliefs About How Children Learn Science</th>
<th>Beliefs About Science Teaching Methods</th>
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<tbody>
<tr>
<td>Pre: I don’t remember when I was young. I’ve been teaching for thirty years. Unfortunately my one recollection of high school science is chemistry and we had cheat cards because I could never remember all of those chemical equations. That’s what I remember, and plunging sinks, that’s what I remember. I do not have recollections of interactive science, so that tells you right now probably there wasn’t a whole lot of interaction going on. So other than that I don’t remember much. I remember a nasty smell in one science class. Oh, I remember too, trying to prick my finger to get my blood type. I was too chicken to do it so somebody else had to do it. (Memory)</td>
<td>Pre: Probably, Mrs. Caraway, because she was one that I knew in all of my years teaching and I knew kids that had had her. Everybody talked about how phenomenal she was for math and science. The kids talked about her, the parents talked about her. When I took this class, she taught this class in conjunction with somebody else from Bradley Landon University. She made an impression because she was vivacious, she was funny, and she was right down there on the floor with us. And we did everything hands-on. So probably she has best influenced me, I remember her so it’s got to be her. (Emotions) (Actively Involved)</td>
<td>Pre: I am strict, but I like to be funny because I feel like if you are funny or you do something that clicks they are going to remember it more. With any subject, not just science, if I can get it into a game then I can create that type of an atmosphere or a learning experience they’re going to remember it more. In my class I don’t believe in just sitting there. We have to get up and move because I can’t stand sitting and doing stuff. So I try to read stories that go along with whatever concept we’re talking about and not science type books or social studies type books, I’m talking a story like <em>Swimmy</em> for fish, those literature type books. I try to make as much of it as I can fun because there was a time in my life when I was teaching up in Slate City, planning was page this in math, and that page this in science. I got so bored I couldn’t stand it. I though, my god, if I am this bored, what are the kids thinking? That was probably right around the time that whole language came out. I really didn’t jump into whole language, but I liked the literature based learning where everything came from the literature because I always believed in reading. So, that’s basically how I do most of my teaching, including math. (Organization) (Emotions) (Variety of Methods) (Actively Involved) (Extend Learning)</td>
</tr>
</tbody>
</table>
not one that can read and comprehend. I need to have it shown, like show and tell. Next, I have to actively do it with somebody beside me. Then, maybe I can do it the third time. That’s my learning style for almost anything. (See and Do)

Pre: I remember taking a class and it was one of those weekend classes, a Friday Saturday certification. Mrs. Caraway taught it in 5th grade and everything was hands-on and we got to play with everything, we made light bulbs light up, we made our own batteries and made the light bulbs light up. I remember doing that kind of stuff. Everything there was hands-on whether we failed or whether we succeeded, but we did everything that we talked about. But I remember the battery lighting up the light bulb. (See and Do) (Actively Involved)

<table>
<thead>
<tr>
<th>Pre: I begin a concept by reading children’s literature or watching a video.” (Extend Learning)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: Unfortunately, I don’t really think I have specific methods, again I try to read stories and then we discuss. Then when we can we do things, hands-on. There aren’t a whole lot of hands-on activities in the first grade science curriculum...But, AIMS [Activities Integrating Mathematics and Science] was a great way of incorporating things. That’s one thing I enjoyed in Slate City, we were big into AIMS and we took AIMS courses all of the time. They were so cool. I remember this one we had to have critters, everything we learned was about animals, so we had to have critters. There I was, I had every kind of animal that we taught, I had a mammal, and I had an amphibian. Unfortunately, the classroom stunk and the rabbit peed all of the time. When teaching, I always start off with the talking and then, if I can, I go into different ways of dealing with things. Like I said, I incorporate animals and plants because they are the easiest I can think of. Actually touching, feeling and doing are important parts of my classroom instruction. (Extend Learning) (Variety of Methods) (Actively Involved)</td>
</tr>
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Anna remembers very little from her early science training. Anna explains the reason she doesn’t remember most of the sessions is because they were not very interactive. She used cards to remember chemical equations in high school. In the following interview excerpt Anna gives her only recollection of high school science.

I don’t remember when I was young. I’ve been teaching for thirty years. Unfortunately my one recollection of high school science is chemistry and we had cheat cards because I could never remember all of those chemical equations. That’s what I remember, and plunging sinks, that’s what I remember. I do not have recollections of interactive science, so that tells you right now probably there wasn’t a whole lot of interaction going on. So other than that I don’t remember much. I remember a nasty smell in one science class. Oh, I remember too, trying to prick my finger to get my blood type. I was too chicken to do it so somebody else had to do it.

Anna was not comfortable with science. Anna does not remember a lot about her science learning when she was young because she wasn’t interacting with the subject matter. This excerpt from Anna’s pre PSI Professional Development Course interview shows how she learns best.

I think that the best way I actually learn anything is I have to feel it, touch it, and do it. I am not one that has to remember this, I teach first grade reading, I am not one that can read and comprehend. I need to have it shown, like show and tell. Next, I have to actively do it with somebody beside me. Then, maybe I can do it the third time. That’s my learning style for almost anything.

Anna needs to feel, touch, and do things in order to learn. She learns from hands-on interaction.

More recently, Anna took a hands-on weekend class. The teacher made an impression on her because she was vivacious and funny. She remembers the teacher getting right down on the floor with the students. This excerpt from the pre PSI Professional Development Course interview outlines an experience in which Anna remembered the learning.
I remember taking a class and it was one of those weekend classes, a Friday Saturday certification. Mrs. Caraway taught it in 5th grade and everything was hands-on and we got to play with everything, we made light bulbs light up, we made our own batteries and made the light bulbs light up. I remember doing that kind of stuff. Everything there was hands-on whether we failed or whether we succeeded, but we did everything that we talked about. But I remember the battery lighting up the light bulb.

This excerpt supports the idea that Anna learns best through hands-on and interactive methods of instruction. In another excerpt from the pre PSI Professional Development Course interview, Anna tells about a teacher that had an influence on her training explains as playing her role in shaping her beliefs related to students and learning.

Probably, Mrs. Caraway, because she was one that I knew in all of my years teaching and I knew kids that had had her. Everybody talked about how phenomenal she was for math and science. The kids talked about her, the parents talked about her. When I took this class, she taught this class in conjunction with somebody else from Bradley Landon University. She made an impression because she was vivacious, she was funny, and she was right down there on the floor with us. And we did everything hands-on. So probably she has best influenced me, I remember her so it’s got to be her.

This excerpt provides additional support for the assertion that Anna learns best when engaged through hands-on activities. She appreciates humor and unexpected surprises while learning. This excerpt from the pre PSI Professional Development Course interview outlines how Anna describes herself as a classroom teacher.

I am strict, but I like to be funny because I feel like if you are funny or you do something that clicks they are going to remember it more. With any subject, not just science, if I can get it into a game then I can create that type of an atmosphere or a learning experience they’re going to remember it more. In my class I don’t believe in just sitting there. We have to get up and move because I can’t stand sitting and doing stuff. So I try to read stories that go along with whatever concept we’re talking about and not science type books or social studies type books, I’m talking a story like Swimmy for fish, those literature type books. I try to make as much of it as I can fun because there was a time in my life when I was teaching up in Slate City, planning was page this in math, and that page this in science. I got so bored I couldn’t stand it. Though, my God, if I am this bored, what are the kids thinking? That was probably right around the time that whole language came
out. I really didn’t jump into whole language, but I liked the literature based learning where everything came from the literature because I always believed in reading. So, that’s basically how I do most of my teaching, including math.

Anna feels being “funny” or doing “something that clicks” will help students remember more. The human body reacts biochemically to laughing; these changes in the chemical balance of the blood may boost the body’s production of neurotransmitters needed for alertness and memory (Jensen, 1996). She creates an atmosphere that encourages learning. Anna also plays educational games and incorporates movement into her lessons.

Anna incorporates children’s literature into most of her science lessons. Post PSI Professional Development Course interview data supports the pre PSI Professional Development Course interview data suggesting that Anna uses literature in science. Anna explains, “I begin a concept by reading children’s literature or watching a video.” In the following excerpt, Anna shares her feelings about her choice of teaching methods.

Unfortunately, I don’t really think I have specific methods, again I try to read stories and then we discuss. Then when we can we do things, hands-on. There aren’t a whole lot of hands-on activities in the first grade science curriculum. Well I guess there are, you can stir up things in a glass. Plants and animals are examples of things that we can rip things apart, we can see them or watch them grow, or feel them to see the different types of skin. But, AIMS [Activities Integrating Mathematics and Science] was a great way of incorporating things. That’s one thing I enjoyed in Slate City, we were big into AIMS and we took AIMS courses all of the time. They were so cool. I remember this one we had to have critters, everything we learned was about animals, so we had to have critters. There I was, I had every kind of animal that we taught, I had a mammal, and I had an amphibian. Unfortunately, the classroom stunk and the rabbit peed all of the time. When teaching, I always start off with the talking and then, if I can, I go into different ways of dealing with things. Like I said, I incorporate animals and plants because they are the easiest I can think of. Actually touching, feeling and doing are important parts of my classroom instruction.

Anna feels she doesn’t really have specific methods she uses, however she tends to utilize the following techniques in her lessons: reading and discussion, hands-on activities,
incorporation of animals and plants into the classroom setting, talking and discussion. Anna feels that “actually touching, feeling, and doing” are important in her classroom instruction.

In summary, data from the pre PSI Professional Development Course interview revealed information about Anna’s conceptual framework for science teaching. The researcher analyzed data in an attempt to discover what Anna believes about how children learn science and science teaching methods. This includes Anna’s conceptions of how children learn and her own view of effective science teaching. Anna learns best through hands-on and interactive methods of instruction. Anna does not remember a lot about her own science learning when she was young because she wasn’t interacting with the subject matter. She was not comfortable with science. Anna creates an atmosphere that encourages learning in her classroom. Anna feels by “being funny” or doing “something that clicks” will help students remember more. Anna incorporates games, movement, and children’s literature into most of her science lessons.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

Anna’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the average efficacy category, with 40 points and 44 points respectively (max=65 points) (see Figure 14). Therefore, she had a slight increase in her confidence with her ability to teach science. Her STEBI Outcome Expectancy for the pre and post assessments were in the average expectancy category, with 36 points and 37 points respectively (max=60 points); which indicated that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).
Figure 14. Anna’s STEBI Scores

Constructivist Learning Environment Survey – CLES Analysis Pre and Post

The CLES Personal Relevance scale relates to students’ experience of the personal relevance of school science as perceived by teachers (Suters, 2004; Taylor et al., 1997). Anna’s pre (25) and post (26) CLES Personal Relevance scores were in the high intermediate agreement range, which indicated that she often but not always emphasized a linkage between school science instruction and students’ everyday experiences (see Figure 15).

The CLES Scientific Uncertainty scale relates to students’ perceptions of science as a fallible human activity as perceived by teachers (Suters, 2004; Taylor et al., 1997). Her pre (21) and post (22) CLES Scientific Uncertainty scores were in the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature
and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values.

The CLES Critical Voice scale relates to students development as autonomous learners, through creation of a social climate in which students feel that their learning is legitimate and beneficial (Suters, 2004; Taylor et al., 1997). Her pre (26) and post (26) CLES Critical Voice scores were identical, both in the high intermediate agreement range as well and indicated that students sometimes but not always were encouraged to question Anna’s plans and methods and express concerns about impediments to their learning.

The CLES Shared Control scale also relates to student autonomy. This scale is concerned with students sharing control of the classroom-learning environment with their teacher (Suters, 2004; Taylor et al., 1997). Her pre (22) and post (21) CLES Shared Control scores were in the high intermediate agreement range, which indicated that students are often but not always invited to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms of the science classroom.

The CLES Student Negotiation scores relate to teacher beliefs as they relate to student interaction with other students (Suters, 2004; Taylor et al., 1997). Anna’s pre (24) and post (25) CLES Student Negotiation scores were both in the high intermediate agreement range which indicated that she often but not always provided opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas.
Last, the CLES Attitude Scale scores provide a measure of the concurrent validity of the CLES. It is used to measure teachers’ interpretations of students’ attitudes towards the classroom environment (Suters, 2004; Taylor et al., 1997). Her pre (25) and post (25) CLES Attitude Scale scores were in the high intermediate agreement range, which indicated that she felt students: often anticipated the activities within her science classroom, often found activities worthwhile, and often understood and enjoyed the activities. Interview data confirms this finding. Anna feels she creates an atmosphere that encourages science learning. Anna’s students are encouraged to play educational games. Anna frequently incorporates children’s literature and movement into most of her science lessons.

![Figure 15. Anna’s CLES Scores](image)

Figure 15. Anna’s CLES Scores
Partner Portfolio for Professional Development Analysis

Teachers were given the opportunity to reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006) throughout the PSI Professional Development Course. The researcher examined five products produced by Anna: (a) Invitation to Practice: Science Learning Personal History, (b) Invitation to Practice: Collaboration, (c) pre PSI Professional Development Course lesson observation, (d) personal goal for the PSI Professional Development Course, and (e) journal entries to confirm the previously mentioned data findings from the interview sessions. The Partner Portfolio for Professional Development Analysis findings, along with the STEBI and CLES data serves as triangulation of multiple data sources. This provides for multiple measures of the same phenomenon (Yin, 2003).

A framework for organization is based upon Anna’s interview excerpts related to her beliefs about teaching science. Anna’s interview excerpts showed that she learns best through hands-on and interactive methods of instruction. An excerpt from the Invitation to Practice: Science Learning Personal History (see Appendix G) activity supported the idea that Anna believes that she needs to actively engaged using hands-on interactive methods while learning.

Science…nothing really comes to mind from my early education. I do remember a college psychology lab I took. I was a psyc major and we were required to take a lab course. I knew I didn’t want a class that required cutting up animals. Through the process of elimination, I took on where I trained a rat using Pavlov’s theory. First we had to become friends with our rat. I named mine Corny. I’d walk around the lab with him on my shoulder. I was very skeptical about being able to teach him to press that bar for food. I don’t recall the entire process, but I do remember being frustrated when he didn’t learn quickly! But, I remember how
excited I was when he began pressing the bar and getting his reward of food pellets.

Anna remembers her college psychology experience when she was actively participating and engaged in the learning process.

Data collection revealed information about Anna’s beliefs about how children learn science. In her own teaching she creates an atmosphere that encourages learning. Anna feels being funny or doing things that click will help students remember more. The following excerpt shows Anna’s goal for the PSI Professional Development Course.

I want to become a more interesting and exciting teacher, in all areas, not just in science. I would like to bring in new ways of teaching the same ‘ole stuff so I want to teach it and they want to learn it!

Anna wants to improve her teaching so her students are more interested in their learning so that they will remember more. Data from the CLES supports this idea. Anna’s Attitude Scale scores were in the high intermediate range, which indicated that she felt students sometimes: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997). Anna STEBI Outcome Expectancy for the pre and post assessments were in the average expectancy category, with 36 points and 37 points respectively (max=60 points); which indicated that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

Last, data analysis was conducted to investigate Anna’s beliefs about science teaching methods. Anna’s interview excerpts revealed that she likes to plays educational games and incorporates movement into her lessons. Anna also incorporates children’s
literature into most of her science lessons. Anna feels she doesn’t really have specific methods she uses, however she tends to utilize the following techniques in her lessons: reading and discussion, hands-on activities, incorporation of animals and plants into the classroom setting, talking and discussion. Anna feels that “actually touching, feeling, and doing” are important in her classroom instruction.

*Summary of Anna’s Results for Research Question 1*

Research Question 1 solicits an answer to the following: “What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?” Anna’s interview excerpts disclosed knowledge about her conceptual framework for science teaching. Anna discovered that she learns by through hands-on and interactive methods of instruction. Anna does not remember a lot about her own science learning when she was young because she wasn’t interacting with the subject matter. She was not comfortable with science. In her own teaching she creates an atmosphere that encourages learning. Anna feels being “funny” or doing “something that clicks” will help students remember more. Last, data analysis was conducted to investigate Anna’s beliefs about science teaching methods. Anna’s interview excerpts revealed that she likes to plays educational games and incorporates movement into her lessons. Anna also incorporates children’s literature into most of her science lessons. Anna feels she doesn’t really have specific methods she uses, however she tends to utilize the following techniques in her lessons: reading and discussion, hands-on activities, incorporation of animals and plants into the classroom setting, talking and discussion.
Research Question 2 Analysis

How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

Interview analysis (see Appendix B for instrument) for Research Question 2 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, and 8 listed in Table 1, (b) post PSI Professional Development Course interview questions 3 and 4, (c) Classroom Observation analysis (see Appendix E for the Classroom Observation Protocol), (d) STEBI analysis (e) CLES analysis, and the (f) Partner Portfolio for Professional Development. The researcher utilized this data in order to examine the way in which Anna perceives herself or describes her own abilities to produce desired or intended results in her science classroom. Data findings were also drawn on to describe the Anna’s Subject Matter Knowledge (SMK). Subject Matter Knowledge (SMK) is defined as the teacher’s knowledge of content matter and pedagogy (the art of being a teacher), along with her curriculum knowledge (Shulman, 1986). Last, the researcher analyzed the data to reveal information related to Anna’s understanding of I-B methods In other words, the researcher assembled the pieces to answer the query, “How does Anna describe her abilities to produce desired or intended results in her science classrooms? What does Anna believe about her science content knowledge and her pedagogical science knowledge? What does Anna understand about I-B methods?”
Anna’s Interview Analysis: Pre and Post Professional Development Course

The researcher was able to piece together pre PSI Professional Development Course interview data to create a picture to describe Anna’s framework for understanding science and her ability to produce desired results according to her beliefs and self-efficacy. There is a close link between teacher content knowledge in mathematics and science and student performance in these disciplines (Darling-Hammond, 2000; Loucks-Horsley et al., 2003). Keeping this in mind, the researcher examined the information related to Anna’s knowledge of science content information that was revealed in Research Question 1 analysis. During this analysis, the researcher learned that Anna doesn’t remember a lot about her own science learning when she was young because she wasn’t interacting with the subject matter. She was not comfortable with science. Anna learns best through hands-on and interactive methods of instruction. She likes to play educational games and incorporate movement into her science lessons. Anna believes that students will remember more when she is “funny” or engaging the students in a activity that “clicks.” Anna’s learning style is reflected in the way that she teaches science in her classroom. She uses a variety of methods in her science classroom. Interview codes and transcript statements for Anna’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions for Research Question 2 are listed in Table 27.
Table 27.

*Interview Codes and Transcript Statements for Anna (T7) Pre and Post – Research Question 2.*

**Self-Efficacy Related to:**

<table>
<thead>
<tr>
<th>Understanding of Science Content</th>
<th>Teaching Methods</th>
<th>Definition of science and Inquiry science</th>
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<tr>
<td>Pre: “I cringe about science and math because I was never good at science or math in school and I always wanted to be. This is a sad story, if I was good at math and science, I wouldn’t be a teacher. I would have gone into a totally different field. I blame it on the teachers. I don’t think they taught their subject well.” (Negative Emotions) Pre: “I would like to improve my students’ critical thinking skills. I don’t think I question them the correct way well enough. I don’t ask enough questions like, “How do you know this?” “How did you think this?” I would like to pull out their ways of thinking and explanations instead of just know it…” (Make Better) Pre: “I don’t remember… my one recollection of high school science is chemistry and we had cheat cards because I could never remember all of those chemical equations.” (Sit n’ Git)</td>
<td>Pre: “That would probably be with different learning centers, or with different examples or activities. I think if they’re actually doing it rather than just hearing it they’re going to remember it more…they understood what dissolving meant because we actually stirred up the glass of water with the dirt in it or the rocks in it…I try to do things that they are going to remember.” (Methods) (Motivation) (Apply and Connect) Pre: “I also try to make sure if we do things with plants… I tell the students, “It’s OK. Do you think that all of those scientists knew that the first time?” I want to make sure they know that mistakes are good, you learn from them. If things fail, it’s OK, you learn from that too.” (Methods) Pre: “I tell them the same thing about writing a book. I ask students, “Do you thing Eric Carl sat down and wrote the book the very first time he tried? No, it took hundreds of times. He wrote and rewrote and rewrote.” They don’t get that very easily at this age. They want it done the first time. It’s done. Immediate action. They feel they don’t need to improve.” (Methods)</td>
<td>Pre: “I cringe about science and math because I was never good at science or math in school and I always wanted to be…” (Emotions) Pre: [I-B] “I think it’s basically a question, you ask, I tell. The kids ask what they want to know and the teacher spends time answering things that they want to know about a subject. It’s showing them the answers; again, it’s hands-on. It’s got to be able to get down to their level and explain things at their level. A lot of that is with show and tell type things.” (Components-Inquiry) (POV)</td>
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Data analysis started with and examination of Anna’s description of her own efficacy, her ability to produce a desired or intended result. Anna believes she is a “really good reading teacher.” Her best strength is “phonics.” Anna feels confident teaching all subjects through literature-based learning. “…I liked the literature-based learning where everything came from the literature because I always believed in reading so that’s basically how I do most of my teaching, including math.”

Data analysis continued with an examination of Anna’s description of her own framework for understanding science content and teaching methods. In this excerpt from the pre PSI staff development course interview Anna explains what happens when someone says the word science.

I cringe about science and math because I was never good at science or math in school and I always wanted to be. This is a sad story, if I was good at math and science, I wouldn’t be a teacher. I would have gone into a totally different field. I blame it on the teachers. I don’t think they taught their subject well.

Anna is not comfortable with science or mathematics. The factors of fear, knowledge, and affect as determined by the teachers’ cognitive framework help shape the teachers’ actions (Senge, 1990). In this excerpt from Anna’s pre PSI Professional Development Course interview, Anna explained one of her fears related to science teaching when she talked about how she would like to improve as a teacher.

I would like to improve my students’ critical thinking skills. I don’t think I question them the correct way well enough. I don’t ask enough questions like, “How do you know this?” “How did you think this?” I would like to pull out their ways of thinking and explanations instead of I just know it. That’s what I get. For example, I ask, “Well, how did you know that?” The student answers, “I just know it.” I ask, “Can you go into more detail?” The student responds by saying, “I thought about it and I knew it.” I can’t get them to open up.
Anna would like to improve her students’ critical thinking skills by learning more about effective questioning techniques.

These excerpts reveal details how Anna manipulates the educational environment to maximize student learning.

That would probably be with different learning centers, or with different examples or activities. I think if they’re actually doing it rather than just hearing it they’re going to remember it more. I remember for the past several years we’ve used on activity. I know it’s doing the same thing over and over again, but one of the first grade teachers and myself did this dissolving activity. We asked, “What dissolves in water?” We played Vanna. “Dooo dooo dooooo.” The kids would all get into it and they would dance. But, they understood what dissolving meant because we actually stirred up the glass of water with the dirt in it or the rocks in it. We asked the students, “Can you see it? Is it gone?” It disappeared. Again, that’s kind of a goofy thing but they remembered it. I try to do things that they are going to remember.

Oh, I remember when we did this. I also try to make sure if we do things with plants. I didn’t do it this year because we ran out of time. But, if you put the seed in the paper towel and it rots, that’s OK. I tell the students, “It’s OK. Do you think that all of those scientists knew that the first time?” I want to make sure they know that mistakes are good, you learn from them. If things fail, it’s OK, you learn from that too.

I tell them the same thing about writing a book. I ask students, “Do you thing Eric Carl sat down and wrote the book the very first time he tried? No, it took hundreds of times. He wrote and rewrote and rewrote.” They don’t get that very easily at this age. They want it done the first time. It’s done. Immediate action. They feel they don’t need to improve.

The excerpts support data revealed in Research Question 1 analysis. During the pre PSI Professional Development Course interview, Anna revealed that she believes acting “funny” or doing “something that clicks” will help students remember more. She creates an atmosphere that encourages learning. Anna also plays educational games and incorporates movement into her lessons. Anna incorporates children’s literature into most
of her science lessons. The excerpt that follows describes how Anna knows when her
students understand a concept.

I know students are learning a concept when they can repeat it back to me. But,
how do I know even better? When they can teach others, here’s an example, when
the little girl pulled the plant up and showed her sister all of the parts. Or when a
parent comes back and says, “I had no idea…” because their child told them
something that they learned in school. There’s always that “I can pass a test
thing.” But again, it’s a test, at the end of the year. A first grade teacher made up a
quote, unquote, SOL test for social studies and science. We review for a quick ten
minutes and then they take an eighteen-question test and they know it, or they
don’t. Again, I measure test-taking ability for the whole year and if they still
remember things than that means I’ve done “something.” That “something” got
into their heads. Like an “Ah ha.”

Anna knows that her students are learning when they can repeat a concept back to her,
when they can teach the concept to others, and when they can show her on a summative
test at the end of the school year.

Last, data analysis focused on Anna’s description of her own framework for
understanding I-B methods. The excerpt that follows outlines how Anna defined I-B
science in the pre PSI Professional Development Course interview.

I think it’s basically a question, you ask, I tell. The kids ask what they want to
know and the teacher spends time answering things that they want to know about
a subject. It’s showing them the answers; again, it’s hands-on. It’s got to be able
to get down to their level and explain things at their level. A lot of that is with
show and tell type things.

Prior to the PSI Professional Development Course, Anna saw inquiry science as a hands-
on, teacher directed method of helping students learn the answers to their questions.

In summary, Anna is not comfortable with science or mathematics. Anna believes
she is a “really good reading teacher.” Her best strength is “phonics.” Anna feels
confident teaching all subjects through literature-based learning. She believes acting
“funny” or doing “something that clicks” will help students remember more. She creates
an atmosphere that encourages learning. Anna also plays educational games and incorporates movement into her lessons. Anna knows that her students are learning when they can repeat a concept back to her, when they can teach the concept to others, and when they can show her on a summative test at the end of the school year.

Prior to the PSI Professional Development Course, Anna saw inquiry science as a hands-on, teacher directed method of helping students learn the answers to their questions.

*Classroom Observation Analysis: Pre and Post Professional Development Course*

Observations were completed May 17, 2007 and October 26, 2007. Anna spent 8 hours on preparation and planning time for the mini unit. She had a total of 24 students in the pre PSI Professional Development Course observation and 21 students in the post PSI Professional Development Course observation. The demographics of the 2 classes observed for the pre and post PSI Professional Development Course observations are described in Table 28.

Table 28.

*Anna’s Class Demographics Pre and Post Observations (T7)*

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<thead>
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<th>Race</th>
<th>Pre (24)</th>
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<th>Post (21)</th>
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<tbody>
<tr>
<td></td>
<td>Males</td>
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<td>Totals</td>
<td>11</td>
<td>13</td>
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<td>8</td>
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</table>
Data analysis includes a review of Anna’s interview and observation data followed by presentation of evidence related to the implementation of the forms inquiry as described by Martin-Hansen (2002). A review of the pre PSI Professional Development Course observation supports pre PSI Professional Development Course interview data that suggests that Anna teaches all subjects through literature-based learning. Anna also plays educational games and incorporates movement into her lessons. The first classroom observations was completed May 17, 2007. Anna’s classroom contained a number of displays, including real butterflies, student work, children’s literature, theme books, and educational materials. Anna had an assortment of books that related to the theme of plants accessible to her students. There were plants and flowers, carnations, displayed on a counter near the sink.

A brief synopsis of the pre PSI Professional Development Course lesson is illustrated in this paragraph. As the lesson began, students were seated in groups. Anna called the students to the carpet by their group names, trees, sun, and stars. Anna showed excitement as she prepared the students for the upcoming experiment. She took time to set rules and expectations for the lesson. In her lesson plan for the pre PSI Professional Development Course observation Anna engaged students by asking questions and referenced prior knowledge related to the concepts of seeds and plant parts. She asked the students what provides food inside of the seed. She created a scenario, if you were starving inside of your house, where would you get food? Next, Anna passed around lima bean seeds that had been soaked overnight. She asked the students, “Why do you think I soaked them?” When answering questions throughout the lesson, Anna had students put their hands on their head depending on their answers to certain questions. She told the
students to put on their scientific hats and describe how the bean that was soaked was similar or different to the one that was not soaked. Next, the students peeled the seed coat off of the seed. Students identified the parts of the plants and the jobs performed by each. She directed the students to associate each plant part with concepts in their everyday lives. For example the roots work like a straw or a vacuum, they suck things. Following this portion of the lesson, Anna directed the attention of the students to the following question: “Where does all of the collected water go now that it is in the roots?” The students offered possible answers. Anna then asked students to think about ways they could use objects in the classroom to prove that the water goes up the stem. Anna allowed the students to offer suggestions and led them to describe an experiment using carnations, water, and food coloring. Students predicted how long it would take for the water to reach the pedals of the flower. Anna set up the experiment so the students could observe the carnation over time.

During the pre PSI Professional Development Course observation lesson the students followed Anna’s directions to investigate the parts of the seed, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). Anna moved on to the next portion of the experiment and allowed the students the opportunity to offer suggestions that would lead to the design their own class experiment with the carnation, this time exhibiting evidence of the use of Guided Inquiry. Guided Inquiry is inquiry in which the teacher develops a question and allows the student to co-construct the experimental design (Martin-Hansen, 2002). Data from the pre PSI Professional Development Course observation verifies data from the Pre
PSI Professional Development Course interview that showed that Anna had already successfully implemented several forms of inquiry as described by Martin-Hansen (2002), Structured Inquiry and Guided Inquiry.

The Post PSI Professional Development Course observation was completed on October 26, 2007. Anna was moved to another classroom, this one was smaller than her classroom the previous year. A brief synopsis of the lesson from the post PSI Professional Development Course observation is illustrated in this paragraph. There were pumpkins displayed throughout the classroom, they were all different sizes and colors. Anna also displayed children’s literature with a pumpkin theme. The classroom was set up to accommodate centers or stations consisting of pumpkin related educational activities. A parent helper and Anna, critical friend, Megan, were present to assist the children as they rotated through the centers. Anna engaged students with a vocabulary review activity. Then she explained the center activities to the students. Students rotated through centers and completed a series of activities, such as: a pumpkin sink or float inquiry, vocabulary practice using the SMART board [an interactive whiteboard that connects to your computer and digital projector], measuring pumpkins using standard and non-standard units, pumpkin observation and exploration, pumpkin crafts using string and seeds, and a game activity in which students labeled the parts of a pumpkin. Throughout the rotation, students recorded information on worksheets. As demonstrated in Anna’s lesson plans and pre PSI Professional Development Course observation data, she had already implemented several forms of inquiry as described by Martin-Hansen (2002), Structured Inquiry and Guided Inquiry. Anna allowed students the opportunity to discover the answers to many of their questions during the sink or float activity and
during the pumpkin observation and exploration activity. Both activities can be described as Structured Inquiry. In summary, the researcher observed evidence of Structured Inquiry and Guided Inquiry in Anna’s classroom. Anna explained to the researcher during the lesson that she emphasized exploration, as many of her students had no background information related to the concept of pumpkin.

Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post

As noted in Research Question 1 analysis, Anna’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the average efficacy category, with 40 points and 44 points respectively (max=65 points) (see Figure 14). Therefore, she had a slight increase in her confidence with her ability to teach science. Her STEBI Outcome Expectancy for the pre and post assessments were in the average expectancy category, with 36 points and 37 points respectively (max=60 points); which indicated that she had some confidence in her teaching ability to create desirable outcomes in her science classroom (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Anna’s Partner Portfolio for Professional Development Analysis.

Constructivist Learning Environment Survey – CLES Analysis Pre and Post

As noted in Research Question 1 analysis, Anna’s pre (25) and post (26) CLES Personal Relevance scores were in the high intermediate agreement range, which indicated that she often but not always emphasized a linkage between school science and students’ everyday experiences. Her pre (21) and post (22) CLES Scientific Uncertainty
scores were in the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. Her pre (26) and post (26) CLES Critical Voice scores were identical, both in the high intermediate agreement range as well and indicated that students sometimes but not always were encouraged to question Anna’s plans and methods and express concerns about impediments to their learning. Her pre (22) and post (21) CLES Shared Control scores were in the high intermediate agreement range, which indicated that students are often but not always invited to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms of the classroom. Anna’s pre (24) and post (25) CLES Student Negotiation scores were both in the high intermediate agreement range which indicated that she often but not always provided opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas. Her pre (25) and post (25) CLES Attitude Scale scores were in the high intermediate agreement range, which indicated that she felt students: often anticipated the activities within her classroom, often found activities worthwhile, and often understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Anna’s Partner Portfolio for Professional Development Analysis*. 

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Anna’s Partner Portfolio for Professional Development Analysis

The Partner Portfolio for Professional Development was employed to hold teacher reflections and permitted the opportunity for participants to manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006) throughout the PSI Professional Development Course. Anna’s Goal Statement for the PSI Professional Development Course, Exit Slips, and various journal entries were analyzed by the researcher in order to confirm the earlier mentioned data findings. This examination offers a triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).

Data analysis for points of triangulation started with an examination of Anna’s description of her own efficacy and ability to produce a desired or intended result in her science classroom. Pre PSI Professional Development Course interview data shows that prior to the PSI Professional Development Course, Anna was not always comfortable with science or mathematics. Anna explained her discomfort stating, “I cringe about science and math because I was never good at science or math in school and I always wanted to be.” Pre PSI Professional Development Course interview data also showed that Anna would like to improve as a science teacher. Anna wants to improve her science teaching so that her students will be more interested in their learning and subsequently they will remember more. Anna would like to improve her students’ critical thinking skills by learning more about effective questioning techniques for science instruction. In summary, Anna is not always comfortable with science and mathematics. She is interested in improving as a science teacher by learning more about techniques to engage
students and improve their critical thinking skills through questioning. Data from Anna’s Partner Portfolio for Professional Development supports these findings. In an October journal entry, Anna writes that she has added to following techniques or methods to her bucket, “questioning techniques.” Anna understands it is important to “let them [her students] lead the lesson and learning by letting them ask the questions When they put more of themselves [invest themselves] into a lesson, they’ll be more excited about the lesson.” Anna’s Personal Science Teaching Efficacy Belief subscale scores, from the STEBI analysis, for the pre and post assessments were in the average efficacy category, with 40 points and 44 points respectively (max=65 points) (see Figure 14). Anna had an increase in her confidence with her ability to teach science following the PSI Professional Development Course (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

Data analysis for points of triangulation was conducted to examine Anna’s description of her own framework for understanding science content and teaching methods. Pre PSI Professional Development Course data showed that Anna feels confident teaching all subjects through literature-based learning. She believes acting “funny” or doing “something that clicks” will help students remember science concepts more. She creates an atmosphere that encourages learning in her science classroom. Anna also plays educational games and incorporates movement into her science lessons. In Anna’s Invitation to Practice: Collaboration activity she tells us more about her science teaching methods. She writes that she and her CF, both use the following in their science teaching: hands-on activities, show and tell, demonstration techniques, United Streaming video clips, Magic School Bus, and technology. During the classroom observations, the
researcher observed evidence of hands-on science activities, demonstration techniques, and use of technology. Anna emphasized exploration as students rotated through science centers because many of her students had no background information related to the concept of pumpkin. The researcher also observed use of Structured Inquiry and Guided Inquiry in Anna’s classroom. Anna’s students worked together in groups to explore, this supports survey results from Anna’s CLES. Her CLES Student Negotiation scores were both in the high intermediate agreement range which indicated that she often but not always provided opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas (Suters, 2004; Taylor et al., 1997). In summary, Anna uses the following strategies or methods in her science classroom: whole group instruction, small group activities, hands-on activities, children’s literature, Structured Inquiry, Guided Inquiry, centers, demonstrations, use of technology, show and tell, educational games, humor, and things that “click.”

Last, data analysis for points of triangulation was conducted to examine Anna’s description of her own framework for understanding I-B science methods. Pre PSI Professional Development Course interview data revealed that prior to the PSI Professional Development Course, Anna saw inquiry science as a hands-on, teacher directed method of helping students learn the answers to their questions. Anna reported that her framework for understanding I-B methods before the PSI Professional Development Course was, “Nada!” She reports that following the PSI Professional Development Course, “I am still sketchy about it, but the more I implement it the better I’ll understand it.” The post PSI Professional Development Course observation data
supported this idea. During the post lesson the students were guided by Anna to discover the answers to their questions during the sink or float activity and during the pumpkin observation and exploration activity. Both activities can be described as Structured Inquiry. Anna was comfortable implementing Structured Inquiry and Guided Inquiry as described by Martin-Hansen (2002).

Data from Anna’s post PSI Professional Development Course interview reveals more about her thoughts related to science inquiry instruction. She explains, “inquiry science gets the students involved from the beginning because of the questions used and because they become actively engaged because of the E’s [from the 5E Model of science teaching (Bybee, 1993, 2000; Carin et al., 2004)]. It helps the children have more of an ownership and excitement in what they’re learning.” In her Partner Portfolio for Professional Development journal entry titled “What is Inquiry?” Anna defines inquiry as: “Asking questions, seeking out answers in different ways, and attacking science through different senses.” Anna believes inquiry is “not just a read and answer approach.” It “brings understanding, not just memorizing data.” It brings science “to the students level.” Anna’s Outcome Expectancy subscale scores, from the STEBI analysis, support the idea that she provides an exciting and engaging learning atmosphere for her students in her science classroom. Both of her STEBI Outcome Expectancy results for the assessments, pre (36) and post (37), were in the average expectancy category, indicating that she had some confidence in her teaching ability to create desirable outcomes in her science classroom (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).
Summary of Anna’s Results for Research Question 2

Research Question 2 seeks information to explain the following: “What can teachers do? How do teachers describe their own framework for understanding science content and teaching methods? How do teachers describe their own framework for understanding I-B methods?” To offer an explanation, one must understand that Anna’s cognitive framework incorporates her knowledge of science content and teaching methods. Her conceptions of science subject matter or content knowledge includes the ideas, facts, and the concepts of the discipline, as well as the relationships among those concepts, facts, and ideas. Information related to Anna’s cognitive framework was exposed through data analysis. The researcher learned that Anna was not always comfortable with science or mathematics. Anna wants to improve her teaching so her students are more interested in their learning so that they will remember more. Anna would like to improve her students’ critical thinking skills by learning more about effective questioning techniques. Anna feels confident teaching all subjects through literature-based learning. She believes acting “funny” or doing “something that clicks” will help students remember more. She creates an atmosphere that encourages learning. Anna also plays educational games and incorporates movement into her lessons. Prior to the PSI Professional Development Course Anna knew very little about I-B methods of science teaching. Anna saw inquiry science as a hands-on, teacher directed method of helping students learn the answers to their questions. Anna was comfortable implementing Structured Inquiry and Guided Inquiry as described by Martin-Hansen (2002) into her science classroom.
Research Question 3 Analysis

What barriers to implementing I-B methods exist?

Interview analysis (see Appendix B for instrument) for Research Question 3 includes examination of Anna’s Goal Statement, and selected pre and post interview questions listed in Table 1. To build credibility, information was compiled through (a) STEBI surveys, (b) CLES surveys, (c) direct observation of the participant’s science teaching, and (d) Partner Portfolio for Professional Development, including lesson plans for the mini-unit, Invitation to Practice: Mapping My Classroom activity, Exit Slips, Quick Writes, and journal entries. The researcher made use of this data to study the teacher’s mental models to uncover patterns that shape teaching behavior as it relates to Shared Identity (SI), the portion of the teacher’s conceptual framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her role as part of the professional community. In other words, we have assembled the pieces to answer the teacher’s query, “How does Anna describe her abilities to produce desired or intended results in her science classroom as they related to barriers to implementation of I-B science methods?”

Anna’s Goal Statement Analysis

Teacher’s attitudes and beliefs about science are key influences on how they teach the subject. The teachers’ principles or attitude, their tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do. The teachers’ styles, principles, are rooted in experience and develop into individual constructs slowly over time (Souza Barros & Elia, 1998). Anna’s tendency to respond favorably or unfavorably towards a science topic, her students or
other objects, determines what her students will see, hear, think, and do. During the PSI Professional Development Course Anna set her own goal (Hammerness et al., 2005).

Keeping this framework in mind, Anna’s Goal Statement was analyzed. Anna’s goal for the PSI Professional Development Course is outlined in the excerpts that follow.

I want to become a more interesting and exciting teacher, in all areas, not just in science. I would like to bring in new ways of teaching the same ‘ole stuff so I want to teach it and they want to learn it!

I want to learn: hands-on ways to teach the science SOL, how to “hook” kids, how to teach the information in a more exciting way, how to incorporate science with other subjects, and how to manage time so all is covered!”

Examining Anna’s goal allowed the researcher to study her attitude towards I-B implementation into her classroom, revealing that Anna is interested in becoming a more interesting and exciting teacher. She wants to learn more about hands-on methods, gaining students interest, integration of other subjects into science, and time management.

Anna’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 3 includes analysis of interview questions 4, 7, 8, and 9, allowing the researcher to gather information to provide a picture of what was happening Anna’s classroom, thus providing information related to her knowledge and practice at the beginning of the research (Davis, 2002). Research Question 1 analysis showed that Anna used the following strategies in her classroom: whole group instruction, small group activities, hands-on activities, children’s literature, Structured Inquiry, Guided Inquiry, centers, demonstrations, use of technology, show and tell, educational games, humor, and things that “click.” Interview codes and transcript statements for Anna’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions are listed in Table 29.
Table 29.

Interview Codes and Transcript Statements for Anna (T7) Pre and Post – Research Question 3.

*Barriers to Implementation of I-B Methods*

<table>
<thead>
<tr>
<th>Time for Science Instruction and Time Related to Curriculum Guidelines</th>
<th>Support</th>
<th>Teacher</th>
</tr>
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<tbody>
<tr>
<td>Anna Pre: “We try to feel, touch, and actively do things in the classroom, but unfortunately, our time is so limited. Our science and social studies time is the last half hour of the day. So, we did do some hands-on type things, but not that many. Not that many, because we didn’t have a whole lot of time and we were rushing so much at the end of the year. I usually do an animal thing where we touch, it’s not even animals stuff, but it’s feeling like scaly skin, which is an onion bag. We didn’t even get to that because, oh my gosh, we have to hurry up and get to the next unit, and the next. So, this year has not been very good, conducive for teaching any hands-on type things, unfortunately.” (Time to teach)</td>
<td>Post: Anna explained that her administrators “…haven’t influenced my choice of teaching methods…” This finding from pre PSI Professional Development Course interview data is not supported by data from the post PSI Professional Development Course interview. It is evident from post PSI Professional Development Course excerpts that this factor did serve as a barrier to the implementation of I-B science. Anna explains that the emphasis</td>
<td>Anna (pre): Well first of all, you have to teach what the SOL dictate that you have to teach. We go off on tangents because, “a”, I think the kids can deal with it. Or, “b”, they tend to go that way or ask questions that way…they [the students] tee hee and giggle, so it really depends on how well they can take it. How far I go with things…. It really depends on what the class is made up of, what questions they ask, and where we can go. But, of course everything is based on the SOL. The content is there, you have to start with this and then you go from there. (Standards) (Student behavior- relationship with teacher)</td>
</tr>
<tr>
<td>Pre: “Unfortunately with the thrust of the SOL with us, is to teach them to read more than even math, science, social studies, any of those subjects. So we base most of our day on reading.” (Standards) (Sharing time with other subjects)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre: “Unfortunately curriculum maps, just time allotted in a day. I know things I have got to get done, so unfortunately I push on. It’s terrible.” (Pacing) (Time to teach)</td>
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<tr>
<td>Post: “I think I would enjoy teaching many of the science concepts using the I-B approach. Unfortunately, in first</td>
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</table>
grade more emphasis is placed on reading than on science or social studies.” (Time to teach) (Sharing with other subjects)

Post: “...nothing is said or done about social studies or science.” Anna notes in the post PSI Professional Development Course that local, county, and state levels do influence her teaching. She explains, “Of course! They tell us what to teach and county level tells us when to teach it.” (Support) (Sharing with other subjects) (Standards)

Post: Reading is a priority in Anna’s school and serves as a barrier to science instruction. Social studies also served as a barrier to science instruction. Anna notes on October 15, 2007, which is seven weeks into the new school year, that she has just started her first science unit. She explains, “This pumpkin unit is my first science unit this year!” (Sharing with other subjects)

Post: “I am trying to” implement the methods outlined in the professional development course because “I try to find new and better ways to teach. I get tired of teaching the same old way.” She feels that “time” inhibits her from using I-B methods because “I know I have to cover all topics!” She had not implemented many of the concepts introduced through the PSI Professional Development Course. Anna notes the reasons she may not have implemented many I-B, “I’m not really using a lot of it for science because of time or a lack there of.” (Time to teach) (Pacing)

placed on reading by school administration inhibits her from using I-B methods. (Support)

kind of Ah ha moments that you get. But I would say plants and animals are maybe not the most beneficial, but the most remembered things in first grade. So interesting, they know what a plant is. They know what an animal is. (Student level of comprehension)

Post: Data collection revealed information about Anna’s understanding of I-B methods. A lack of understanding of some portions of I-B methodology might have served as a barrier towards implementation. When asked to describe her own framework for understanding I-B methods after the PSI Professional Development Course, Anna explains, “I am still sketchy about it, but the more I implement it the better I’ll understand it.” (Teacher knowledge)
Her teaching team at her school consists of four other first grade teachers. The excerpt below illustrates the level of support Anna indicates that she feels she has received from her team.

They will influence me more than the county guidelines, state or whatever. Basically we’ve been very good about sounding things off of each other, just throwing ideas out, tweaking, implementing, and trying. This year I have two new first grade teachers that I am working with, so the team has changed. The ideas have changed, which is good, cause you get a little old and stagnant if you keep doing the same old same old all of the time. So basically, just watching someone else do something and liking that idea and taking it over. It’s been very good with Ashley because she’s a very mathematical person and I am not. We challenge our classes. Mrs. Delphi says, “You can’t do this.” And the kids love it. They rise up to the bait and the challenge. Basically, just having discussions on how to do things or going to different web sites or stealing, creative stealing. I take whatever; I am very serious about that. I creatively steal everything I can.

Anna’s team influences her more than any other factor. Anna is willing to try new ideas in her classroom and shares ideas with others, she “creatively steal[s] everything” she can.

Anna states that, in the past, her administration has not set science or social studies as a priority. Anna explains in the excerpt that follows.

They haven’t influenced my choice of teaching methods. Really, they haven’t. Their thrust is reading and if they come observe, they come during reading. At second best, they come during math. Nothing is said or done about social studies or science.

Research supports that it is important that administrators and teammates are supportive of teachers while they implement the I-B process and as they change to new or unfamiliar methods (Keller, 2004). In summary, data from the pre PSI Professional Development Course interview analysis showed that Anna is receiving the support she needs from her teammates in order to successfully implement I-B science methods into her classroom.
Anna might not be receiving the support she needs from administrators in order to successfully implement I-B science methods into her classroom.

Although Anna possesses the desire to implement I-B methods, feels confidence in her teaching ability, and believes her CF and colleagues support her; there may be other barriers that inhibit Anna to fully carry out her science teaching vision. For example, the thrust of her administration is reading. Accordingly, the researcher next examined possible threats to fidelity or barriers to use of I-B instruction besides lack of peer support. This was accomplished through interviews and classroom observation. This process permitted the researcher to identify connections or relationships between Anna’s perceptions and use of I-B instruction (Davis, 2002).

Analysis of the pre PSI Professional Development Course interview questions revealed that Anna faced a number of barriers as she went about the process of teaching science in her classroom, including time to teach, sharing time with other subjects, curriculum guidelines like the Virginia SOL and Milton County’s curriculum maps. Anna finds that the factor of time is a concern she feels when planning to teach science in her classroom. This excerpt from the pre PSI Professional Development Course interview illustrates Anna’s beliefs.

We try to feel, touch, and actively do things in the classroom, but unfortunately, our time is so limited. Our science and social studies time is the last half hour of the day. So, we did do some hands-on type things, but not that many. Not that many, because we didn’t have a whole lot of time and we were rushing so much at the end of the year. I usually do an animal thing where we touch, it’s not even animals stuff, but it’s feeling like scaly skin, which is an onion bag. We didn’t even get to that because, oh my gosh, we have to hurry up and get to the next unit, and the next. So, this year has not been very good, conducive for teaching any hands-on type things, unfortunately.
This excerpt revealed that the barrier of time in relation to science instruction included time to teach and sharing time with other subjects, like social studies. Anna explains why science and social studies are not a priority in her school, “Unfortunately with the thrust of the SOL with us, is to teach them to read more than even math, science, social studies, any of those subjects. So, we base most of our day on reading.” From this excerpt we also see curriculum guidelines, like the Virginia SOL, emerging as a barrier to all science instruction, especially hands-on, interactive, and I-B methods. Anna emphasizes the fact that time and curriculum guidelines, such as curriculum maps, influence her science teaching. Anna explains that she decides to move from one concept to another based upon, “unfortunately curriculum maps, just time allotted in a day. I know things I have got to get done, so unfortunately I push on. It’s terrible.”

Analysis of pre PSI Professional Development Course interview data revealed that Anna believed that her students, their behavior and level of comprehension, might also prove to be a possible barrier to how far she can take a science subject or her choice of teaching methods. The excerpt that follows outlines Anna’s feelings related to the science content and the curriculum.

Well first of all, you have to teach what the SOL dictate that you have to teach. We go off on tangents because, “a”, I think the kids can deal with it. Or, “b”, they tend to go that way or ask questions that way. Like when you were here and somebody talked about that baby plant inside the seed, I was totally shocked when somebody said, “oh yeh, we get the food by the umbilical cord.” But, this year too, we kind of went into mom’s nurse babies. They didn’t, a lit of times they tee hee and giggle, so it really depends on how well they can take it. How far I go with things. This year everybody knew that mammals made mild for their babies. We didn’t go into necessarily where that milk comes from, but they seemed to deal with it without getting embarrassed or tee heeing. It really depends on what the class is made up of, what questions they ask, and where we can go. But, of course everything is based on the SOL. The content is there, you have to start with this and then you go from there.
Anna further explains that her students’ levels of comprehension is a factor that might prove to be a barrier to science instruction.

The things that they get the most out of are things dealing with animals and plants because that is something that they understand. They can comprehend that. I mean like matter, it doesn’t matter. The whole concept of, well all we have to teach is dissolving. But, it used to be gas, liquid, and solid. They don’t understand that. Plants and animals are something that they can reach out and touch. So I think that’s probably the most they get out of the whole science curriculum right now. I’m kind of impressed that one of my kids said, “the other day, yesterday I went home,” and for her little sister, Casey, she pulled up a little plant, an onion type thing, and she sat there and explained the different parts of the plant and what they did. And I’m like, “you know, something clicked, it worked.” Those are the kind of Ah ha moments that you get. But I would say plants and animals are maybe not the most beneficial, but the most remembered things in first grade. So interesting, they know what a plant is. They know what an animal is.

Student behaviors related to their maturity level and student comprehension are factors that influence the way Anna handles science learning situations.

Interview analysis for Research Question 3 also included the analysis of the post PSI Professional Development Course interview questions numbered 3, 4, 6, and 7. Data analysis continued with the assumption that Anna might have encountered possible threats to fidelity or barriers to use of I-B instruction. This process allowed for further identification of connections or relationships between Anna’s perceptions and use of inquiry instruction (Davis, 2002). Analysis of the post PSI Professional Development Course interview questions revealed that Anna faced a number of barriers as she went about the process of implementing I-B science in her classroom, including; a lack of time, sharing time with other subjects, a lack of administrative support or concern for science instruction, and a lack of understanding of some portions of I-B methodology.
In pre PSI Professional Development Course interview excerpts Anna explained that her administrators “…haven’t influenced my choice of teaching methods…” This finding from pre PSI Professional Development Course interview data is not supported by data from the post PSI Professional Development Course interview. It is evident from post PSI Professional Development Course excerpts that this factor did serve as a barrier to the implementation of I-B science. Anna explains that the emphasis placed on reading by school administration inhibits her from using I-B methods. Anna outlines her struggle with finding enough time to implement I-B in the following excerpt from the post PSI Professional Development Course interview. Anna explains, “I think I would enjoy teaching many of the science concepts using the I-B approach. Unfortunately, in first grade more emphasis is placed on reading than on science or social studies.” Pre PSI Professional Development Course interview data suggests that because Anna’s administrators have set reading is a priority “…nothing is said or done about social studies or science.” This lack of concern or support for science was in fact a barrier in Anna’s attempt to implement I-B science into her classroom. Anna notes in the post PSI Professional Development Course that curriculum guidelines at local, county, and state levels do influence her teaching. She explains, “Of course! They tell us what to teach and county level tells us when to teach it.”

Data collection revealed that sharing time with other subjects served as a barrier to the implementation of I-B methods. Reading is a priority in Anna’s school and serves as a barrier to science instruction. Social studies also served as a barrier to science instruction. Anna notes on October 15, 2007, which is seven weeks into the new school
year, that she has just started her first science unit. She explains, “This pumpkin unit is my first science unit this year!”

Data collected revealed information about the barrier of time, time for planning and time for teaching science. Anna felt that time served as a barrier to implementation of I-B methods in her science classroom. Anna notes the following, “I am trying to” implement the methods outlined in the PSI Professional Development Course because “I try to find new and better ways to teach. I get tired of teaching the same old way.” She feels that “time” inhibits her from using I-B methods because “I know I have to cover all topics!” She had not implemented many of the concepts introduced through the PSI Professional Development Course. Anna notes the reasons she may not have implemented many I-B, “I’m not really using a lot of it for science because of time or a lack there of.”

Data collection revealed information about Anna’s understanding of I-B methods. A lack of understanding of some portions of I-B methodology might have served as a barrier towards implementation. When asked to describe her own framework for understanding I-B methods after the PSI Professional Development Course, Anna explains, “I am still sketchy about it, but the more I implement it the better I’ll understand it.”

In summary, analysis of the pre PSI Professional Development Course interview questions revealed that Anna faced a number of barriers as she went about the process of implementing I-B science in her classroom, including: time to teach, sharing time with other subjects, and curriculum guidelines like the Virginia SOL and Milton County’s curriculum maps. In post PSI Professional Development Course interview questions,
Anna revealed that the barriers she faced included: a lack of time for planning science instruction, a lack of time for teaching science, sharing time with other subjects, a lack of administrative support or concern for science instruction, and a lack of understanding of some portions of I-B methodology.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

As noted in Research Question 1 analysis, Anna’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the average efficacy category, with 40 points and 44 points respectively (max=65 points) (see Figure 14). Therefore, she had a slight increase in her confidence with her ability to teach science in her classroom. Her STEBI Outcome Expectancy for the pre and post assessments were in the average expectancy category, with 36 points and 37 points respectively (max=60 points); which indicated that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Anna’s Partner Portfolio for Professional Development Analysis.*

*Constructivist Learning Environment Survey – CLES Analysis Pre and Post*

Details of Anna’s CLES scores were noted previously in Research Question 1 analysis. As noted in Research Question 1 analysis, Anna’s pre (25) and post (26) CLES Personal Relevance scores were in the high intermediate agreement range, which indicated that she often but not always emphasized a linkage between school science and students’ everyday experiences in her science classroom. Her pre (21) and post (22)
CLES Scientific Uncertainty scores were in the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. Anna’s pre (26) and post (26) CLES Critical Voice scores were identical, both scores fell into the high intermediate agreement range as well and indicated that students sometimes but not always were encouraged to question Anna’s plans and methods and express concerns about impediments to their learning in her science classroom. Anna’s pre (22) and post (21) CLES Shared Control scores were in the high intermediate agreement range, which indicated that students are often but not always invited to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms of the classroom. Anna’s pre (24) and post (25) CLES Student Negotiation scores were both in the high intermediate agreement range which indicated that she often but not always provided opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas in her science classroom. Her pre (25) and post (25) CLES Attitude Scale scores were in the high intermediate agreement range, which indicated that she felt students: often anticipated the activities within her science classroom, often found activities worthwhile, and often understood and enjoyed the activities (see Appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same
phenomenon (Yin, 2003) in the section titled *Anna's Partner Portfolio for Professional Development Analysis*.

*Anna’s Partner Portfolio for Professional Development Analysis*

Throughout the PSI Professional Development Course teachers were allowed the opportunity to reflect and take charge of their thoughts and behaviors through reflection, planned processing, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). To confirm the previously mentioned data findings as triangulation of multiple data sources provided for multiple measures of the same phenomenon (Yin, 2003) the following data were analyzed: (a) the Invitation to Practice: Mapping My Classroom activity, (b) the Invitation to Practice: Collaboration activity, (c) Exit Slips, (d) Quick Writes, and (e) journal entries. Analysis of the pre PSI Professional Development Course and post PSI Professional Development Course interview questions disclosed that Anna confronted numerous barriers as she went about the course of implementing I-B science in her science classroom. Analysis of the pre PSI Professional Development Course interview questions revealed that Anna faced the following barriers: time to teach, sharing time with other subjects, and curriculum guidelines like the Virginia SOL and Milton County’s curriculum maps. In post PSI Professional Development Course interview questions Anna reinforced previous findings or revealed additional barriers she faced including a lack of time, sharing time with other subjects, a lack of administrative support or concern for science instruction, and a lack of understanding of some portions of I-B methodology. The Partner Portfolio for Professional Development findings, along with the STEBI survey, the CLES survey
serves as triangulation of multiple data sources. This provides for multiple measures of the same phenomenon (Yin, 2003).

Interview data revealed that time was a barrier Anna faced as she attempted to implement I-B methods into her science classroom. Data analysis for triangulation was conducted to examine the barriers of time, time for planning science instruction and time for teaching science. The factor of time to plan science instruction was confirmed as Anna reflected in one of her Partner Portfolio for Professional Development Exit Slip entries, “This unit took a long time to put together and I don’t always have a lot of time during the school year. I loved having so much time to search the web.” Anna continued, “I would love to be able to do this activity with more of our units.” The factor of time, including time for planning and time to teach was also confirmed during the Invitation to Practice: Mapping My Classroom activity. Anna notes, “Many of my plans are out the window because of my schedule this year. My classroom is smaller than it was last year, so it’s hard to find room to have ‘cozy’ spots for literacy centers. Plus my daily schedule is not very helpful to doing anything!” The factor of classroom space for science instruction also proved to be a barrier towards Anna’s implementation of I-B methods in science.

Interview data revealed that sharing science instruction time with other subjects was also a barrier Anna faced as she attempted to implement I-B methods into her science classroom. Data analysis for triangulation was conducted to examine the barrier of sharing time with other subjects. Anna notes in an October 15, 2007 journal entry, which is seven weeks into the new school year, that, “As of right now, I haven’t pulled anything out of my bucket because I haven’t taught a science unit yet.”
Interview data revealed that a lack of administrative support was a barrier Anna faced as she attempted to implement I-B methods into her science classroom. Data analysis for triangulation was conducted to examine the barrier of a lack of administrative support. Pre PSI Professional Development Course data revealed that Anna’s school administration placed a strong emphasis on reading instruction. Anna struggles to find enough time to implement I-B lessons into her science classroom. Anna explains, “I think I would enjoy teaching many of the science concepts using the I-B approach. Unfortunately, in first grade more emphasis is placed on reading than on science or social studies.” In her Invitation to Practice: Mapping My Classroom activity, Anna makes plans to change her “literacy corners, to expand to include some math, science and social studies.” She has attempted to integrate science and other subjects into her reading program.

Interview data revealed that curriculum guidelines, including the Virginia SOL and her county’s curriculum maps, were a barrier Anna faced as she attempted to implement I-B methods into her science classroom. Data analysis for triangulation was conducted to examine the barrier of curriculum guidelines. Anna’s goal statement shows that the Virginia SOL influences her teaching instruction. This influence is evident in Anna’s goals for the PSI Professional Development Course outlined in the excerpt that follows.

I want to learn: hands-on ways to teach science SOL, how to “hook” kids, how to teach the information in a more exciting way, how to incorporate science with other subjects, and how to manage time so all is covered!”

Anna wishes to learn techniques so she can teach science following the guidelines of the Virginia SOL.
A lack of understanding of I-B methods emerged as a possible barrier to the implementation of all forms of inquiry, as described by Martin-Hansen (2002), into Anna’s classroom. Post PSI Professional Development Course interview data revealed that Anna is “…still sketchy about…” I-B methods; however, she explains, “But, the more I implement it the better I’ll understand it.” She also noted, “I’m not really using a lot of it for science because of time and a lack there of.” This delay in the utilization of science instruction was confirmed and explained further as Anna reflected in one of her journal entries, “As of right now, I haven’t pulled anything out of my bucket because I haven’t taught a science unit yet.”

In summary, the researcher analyzed Anna’s attitude towards implementation of I-B methods into her science classroom. Analysis of the pre and post PSI Professional Development Course interview questions disclosed that Anna confronted numerous barriers as she went about the course of implementing I-B science in her classroom. The Partner Portfolio for Professional Development findings, along with the STEBI survey, and the CLES survey supported findings that Anna faced numerous barriers as she attempted to implement I-B methods into her science classroom. Anna faced the following barriers: time for planning science instruction and time for teaching science, classroom space, sharing time with other subjects, lack of administrative support, curriculum guidelines, including the Virginia SOL and Milton County School System’s curriculum maps, and a lack of understanding of I-B science methods.

*Classroom Observation*

As noted in Research Question 2 analysis, Anna’s lesson plans and pre PSI Professional Development Course observation data showed that she had already
successfully implemented Structured Inquiry and Guided Inquiry into her science classroom. During the pre PSI Professional Development Course observation lesson the students followed Anna’s directions to investigate the parts of the seed, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). Anna moved on to the next portion of the experiment and allowed the students the opportunity to offer suggestions that would lead to the design their own class experiment with a carnation, this time exhibiting evidence of the use of Guided Inquiry. Guided Inquiry is inquiry in which the teacher develops a question and allows the student to co-construct the experimental design (Martin-Hansen, 2002). Data from the pre PSI Professional Development Course observation verifies data from the Pre PSI Professional Development Course interview that showed that Anna had already successfully implemented several forms of inquiry as described by Martin-Hansen (2002), Structured Inquiry and Guided Inquiry. In her post PSI Professional Development Course observation, the researcher observed Anna allowing students the opportunity to discover the answers to many of their questions during the sink or float activity and during the pumpkin observation and exploration activity. Both activities can be described as Structured Inquiry.

In summary, classroom observations show that Anna was implementing Structured Inquiry and Guided Inquiry into her classroom prior to the PSI Professional Development Course. Following the PSI Professional Development Course, the researcher observed Anna implementing Structured Inquiry. She has not implemented
Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002).

Summary of Anna’s Results for Research Question 3

Anna’s professional development goal revealed that she is interested in becoming a more interesting and exciting teacher. She wants to learn more about hands-on methods, gaining students interest, integration of other subject areas into science, and time management. During the PSI Professional Development Course Anna worked with her CF, Sara, to create and implement an I-B lesson plan, Investigating Pumpkins, into each of their classrooms. Classroom observation data showed that showing that Anna had already made use of Structured Inquiry and Guided Inquiry (Martin-Hansen, 2002). Analysis of the data revealed that Anna confronted a number of barriers as she went about the process of implementing I-B science in her classroom, including the following barriers: time for planning science instruction and time for teaching science, classroom space, sharing time with other subjects, lack of administrative support, curriculum guidelines, including the Virginia SOL and county curriculum maps, and a lack of understanding of I-B methods. Post PSI Professional Development Course interview data revealed that Anna is “…still sketchy about…” I-B methods. She is confident that she will be able to implement inquiry in the future. She explains, “but the more I implement it the better I’ll understand it.” She admits she is not using I-B methods in her classroom, “I’m not really using a lot of it for science because of time and a lack there of.” This delay was confirmed and explained further as Anna reflected in her journal, “As of right now [October 15, 2007], I haven’t pulled anything out of my bucket because I haven’t taught a science unit yet.”
Research Question 4 Analysis

What relationships exist between teachers’ perceptions and use of I-B methods?

Data were analyzed to address the query, “What relationships exist between Anna’s perceptions and use of I-B methods?” Interview analysis (see Appendix B for instrument) for Research Question 4 includes the examination of (a) post PSI Professional Development Course interview questions 2, 3, 6, and 7 listed in Table 1, (b) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (c) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (d) Partner Portfolio for Professional Development. Influences such as Anna’s culture, educated-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual and style help mold the her beliefs about I-B methods. The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI).

John Dewey (1938, 1997) proposed that experience transpires as a result of the interrelationship of two principles, continuity and interaction. Continuity refers to how each experience a person has influences one’s future, for better or for worse. Interaction refers to the situational influence on one’s experience. The individual’s present experience is a function of the interaction between their past experiences and the present situation. No experience has a pre-destined value. Therefore, what might be a beneficial experience for one individual could be an unfavorable experience for another. In other words, "positive experiences" motivate, encourage, and enable students to go on to have
more valuable learning experiences, whereas, "negative experiences" tend to lead towards a student closing off from potential positive experiences in the future. Dewey believed that learning experiences should be meaningful to each student and that teachers should step back and act as facilitators (Dewey, 1938, 1997).

Returning to the bucket metaphor described in the researcher’s conceptual framework, Anna examined the shells and treasures related to I-B methods and techniques introduced at the PSI Professional Development Course and made a decision to either keep each one and place it in her bucket, or place it back on the beach based on her own system of values. The unearthing of treasures of considerable value produced a positive influence on Anna’s motivation, attitude, caring, determination and effort. The discovery of treasure with modest value had a negative influence on Anna’s motivation, attitude, caring, determination and effort. Data findings were drawn on to illustrate Anna’s cognitive framework related to inquiry, her beliefs about inquiry teaching, and how this ties into her daily experiences. This information is vital to understanding teacher change related to inquiry (Keys & Bryan, 2000; Spillane et al., 2002).

Anna’s Interview analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 4 includes the analysis of the post PSI Professional Development Course interview questions numbered 2, 3, 6, and 7. A qualitative research design served as an appropriate methodology to utilize to examine any relationships the might exist between Anna’s perceptions and use of I-B methods, seeing as qualitative research is concerned with the perceptions of the participants and with process rather than outcomes or products (Bogdan & Biklen, 1992, Marshall & Rossman, 2006). This design serves as an appropriate methodology to utilize to define
inquiry as it is perceived and used by Anna. This information was drawn on to first illustrate Anna’s cognitive framework related to inquiry. The excerpt that follows outlines how Anna defined I-B science in the pre PSI Professional Development Course interview.

I think it’s basically a question, you ask, I tell. The kids ask what they want to know and the teacher spends time answering things that they want to know about a subject. It’s showing them the answers; again, it’s hands-on. It’s got to be able to get down to their level and explain things at their level. A lot of that is with show and tell type things.

Anna believes inquiry is basically starts with a question the teacher or students asks, and then the teacher explains the answer using hands-on activities and show and tell. Anna is willing to try new ideas in her classroom and shares ideas with others, she “creatively steal[s] everything” she can.

Then pre PSI Professional Development Course interview data were drawn on to reveal her beliefs about inquiry teaching. Anna learns best when she has the opportunity “…to feel it, touch it, and do it.” In Anna’s definition of inquiry, she includes “hands-on” activities and “show and tell.” Anna explained on her post PSI Professional Development Course interview, “I think I would enjoy teaching many of the science concepts using the I-B approach. Unfortunately, in first grade more emphasis is placed on reading than on science or social studies.”

As a final point, the data were examined to determine how Anna ‘s cognitive framework related to inquiry and her beliefs about inquiry teaching tie into the her daily experiences. Anna tries to give her students the opportunity “…to feel it, touch it, and do it.” She includes “hands-on” activities and “show and tell” in her lessons; however, her
time is limited so students are often rushed through activities. Anna explains in the excerpt that follows.

We try to do some of that, yes, but unfortunately, our time is so limited. Our science and social studies time is the last half hour of the day. So, we did do some hands-on type things, but not that many. Not that many, because we didn’t have a whole lot of time and we were rushing so much at the end of the year. I usually do an animal thing where we touch, it’s not even animals stuff, but it’s feeling like scaly skin, which is an onion bag. We didn’t even get to that because, oh my gosh, we have to hurry up and get to the next unit, and the next. So, this year has not been very good, conducive for teaching any hands-on type things, unfortunately.

Anna would like to tie inquiry teaching into her students’ daily experiences. She is often successful, but is sometimes limited by the amount of instructional time available for science.

In summary, prior to the PSI Professional Development Course, Anna’s understanding of inquiry basically starts with a question the teacher or students asks, and then the teacher explains the answer using hands-on activities and show and tell. Anna believes she would enjoy teaching using the I-B method, but feels she should place more emphasis on reading in the first grade. Anna would like to tie inquiry teaching into her students’ daily experiences. She is often successful, but is sometimes limited by the amount of instructional time available for science.

Anna’s Goal Statement Analysis

The following excerpt shows Anna’s goal for the PSI Professional Development Course.

I want to become a more interesting and exciting teacher, in all areas, not just in science. I would like to bring in new ways of teaching the same ‘ole stuff so I want to teach it and they want to learn it!
Anna tells more about what she wants to learn from the PSI Professional Development Course in the excerpt that follows.

I want to learn: hands-on ways to teach science SOL, how to “hook” kids, how to teach the information in a more exciting way, how to incorporate science with other subjects, and how to manage time so all is covered!”

Anna’s goal statement shows that she is interested in learning ways to become a more interesting and exciting teacher. She is interested in learning about student engagement, time management and hands-on techniques. Anna’s goal was examined to address the query, “What relationships exist between Anna’s perceptions and use of I-B methods?” Anna’s goal statement reveals that her perceptions of learning about ways to make teaching more exciting and interesting are favorable. It does not specifically mention I-B methods, but does mention hands-on techniques, use of technology, and student engagement.

Science Teaching Efficacy Belief Instrument - STEBI Analysis

Details of Anna’s STEBI results were noted in Research Question 1 analysis, Science Teaching Efficacy Belief Instrument – STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Anna’s STEBI data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003). Anna’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments were in the average efficacy category, with 40 points and 44 points respectively (max=65 points) (see Figure 14). Therefore, she had a slight increase in her confidence with her ability to teach science. Her STEBI Outcome Expectancy for the pre and post assessments were in the average expectancy category, with 36 points and 37 points respectively (max=60 points);
which indicated that she had some confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). This data supports Anna’s goal statement indicating that she is interested in learning ways to become a more interesting and exciting teacher. She is interested in learning about student engagement, time management and hands-on techniques.

Anna’s Partner Portfolio for Professional Development Analysis

Anna took part in activities that allowed her to reflect upon and manage her thoughts and behaviors through strategic processing, reflection and collaboration throughout the PSI Professional Development Course (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Anna’s portfolio data provides additional pieces that were used to solve the query, “What relationships exist between Anna’s perceptions and use of I-B methods?” Analysis focused on relationships associating Anna’s perceptions as they connected to her practice. Emic accounts, descriptions of behaviors in terms meaningful to the teacher, were used because these accounts are culture specific or are found in the context of the teacher’s classroom (Stake, 2006). The researcher completed three steps in analyzing the partner portfolio. First, Anna’s definition of inquiry, Anna’s methods of instruction, and the definition of inquiry used during the PSI Professional Development Course were reviewed for comparison. Anna’s definition of inquiry and choice of teaching methods was examined. Second, a review of the findings from Anna’s Interview analysis, Goal Statement analysis, and STEBI analysis was conducted. Third, emic accounts were compared to excerpts from Anna’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in
order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). Each of these steps is discussed next.

First, the researcher examined Anna’s definition of inquiry. Prior to the PSI Professional Development Course, Anna defined inquiry science in the pre PSI Professional Development Course interview.

I think it’s basically a question, you ask, I tell. The kids ask what they want to know and the teacher spends time answering things that they want to know about a subject. It’s showing them the answers; again, it’s hands-on. It’s got to be able to get down to their level and explain things at their level. A lot of that is with show and tell type things.

Prior to the PSI Professional Development Course, Anna saw inquiry science as a hands-on, teacher directed method of helping students learn the answers to their questions. Through the course of the PSI instruction Anna had the opportunity to develop an understanding of the following topics: What is inquiry, learning through inquiry, developing a mind for constructivism, constructivism, how children learn, designing I-B classrooms, integrating I-B activities, the scientific method, learning cycles, skills and knowledge of I-B teachers, and questioning. Anna also participated in sample I-B lessons that were modeled during the PSI Professional Development Course (a complete detailed description of the twenty-hour professional development course is located at Appendix K). In her Partner Portfolio for Professional Development journal entry titled “What is Inquiry?” Anna defines inquiry as: “asking questions, seeking out answers in different ways, and attacking science through different senses.” Anna believes inquiry is “not just a read and answer approach.” It “brings understanding, not just memorizing data.” It brings science “to the students level.”
Next, the researcher looked at Anna’s methods of instruction. Anna creates an atmosphere that encourages learning in her classroom. Anna feels by “being funny” or doing “something that clicks” will help students remember more. Anna incorporates games, movement, and children’s literature into most of her science lessons. Data from the pre PSI Professional Development Course observation showed that Anna had already successfully implemented several forms of inquiry as described by Martin-Hansen (2002), Structured Inquiry and Guided Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience. Guided Inquiry is inquiry in which the teacher develops the question and allows the students to co-construct the experimental design (Martin-Hansen, 2002). In her post PSI Professional Development Course mini unit lessons Anna successfully implemented Structured Inquiry into her science classroom. During the mini unit, Anna allowed students the opportunity to discover the answers to many of their questions during the sink or float activity and during the pumpkin observation and exploration activity.

Then, the definition of inquiry used during the PSI Professional Development Course was reviewed for comparison with Anna’s definition of inquiry and choice of teaching methods. During the PSI Professional Development Course Inquiry instruction was defined as referring to any teaching method focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations and discover answers to their questions about the natural world. Students may plan systems to collect data and choose
how to organize and represent the data (Carin et al., 2004). The National Research Council (1998) defines scientific inquiry as:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. (p. 23)

Prior to the PSI Professional Development Course, Anna saw inquiry science as a hands-on, teacher directed method of helping students learn the answers to their questions. During the PSI Professional Development Course Anna defined inquiry as: “asking questions, seeking out answers in different ways, and attacking science through different senses.” Anna believes inquiry is “not just a read and answer approach.” It “brings understanding, not just memorizing data.” It brings science “to the students level.” Her definition of inquiry is aligned with the definition Inquiry used during the PSI Professional Development Course. Her definition of inquiry is aligned with the definition of Guided and Structured Inquiry as defined by Martin-Hansen (2002). Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience. Guided Inquiry is inquiry in which the teacher develops the question and allows the students to co-construct the experimental design (Martin-Hansen, 2002). Anna feels she doesn’t really have specific methods she uses, however she tends to utilize the following techniques in her lessons: reading and discussion, hands-on activities, incorporation of animals and plants into the classroom setting, talking and discussion. Anna feels that “actually touching, feeling, and doing” are important in her
classroom instruction. Anna’s choice of methods allow for integration or use of I-B methods.

The next step in placing the pieces of the puzzle to solve the query, “What relationships exist between Anna’s perceptions and use of I-B methods?” consisted of a review of the findings from Anna’s Interview analysis, Goal Statement analysis, and Science Teaching Efficacy Belief Instrument - STEBI analysis. Beginning with her pre PSI Professional Development Course interview, Anna believes she learns from hands-on interaction. Anna needs to feel, touch, and do things in order to learn. In other words, she learns best when her teachers use a constructivist approach, when they provide relevant experiences and opportunities that allowed Anna to construct knowledge (Piaget, 1929; Vygotsky, 1978). Anna creates an atmosphere that encourages learning in her classroom. Anna feels by “being funny” or doing “something that clicks” will help students remember more. Anna incorporates games, movement, and children’s literature into most of her science lessons. Anna’s goal statement shows that she is interested in becoming a more interesting and exciting teacher. She wants to learn more about hands-on methods, gaining students interest, integration of other subject areas into science, and time management. Anna is able to choose which methods she employs in her classroom.

Anna’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (40) and post (44) assessments increased notably, an indication that she felt more at ease with her ability to teach science (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Anna’s STEBI Outcome Expectancy subscale scores, pre (36) and post (37), increased slightly; both scores were in the average expectancy category demonstrating that she had some confidence in her teaching ability.
to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). In summary, Anna is interested in learning more about hands-on methods, gaining students interest, integration of other subject areas into science, and time management. The PSI Professional Development Course helped her to feel more at ease with her ability to teach science.

Last, in assembling the pieces of the puzzle to solve the query, “What relationships exist between Anna’s perceptions and use of I-B methods?” emic accounts from Anna’s Interview analysis, Goal Statement analysis, and Science Teaching Efficacy Belief Instrument - STEBI analysis were compared with excerpts from Anna’s Mini Unit Plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). A teacher’s attitudes and beliefs about science are key influences on how they teach the subject (Souza Barros & Elia, 1998). Anna’s goal statement shows that she is interested in becoming a more interesting and exciting science teacher. She wants to learn more about hands-on methods, gaining students interest, integration of other subject areas into science, and time management. In an Exit Slip journal Entry, Anna shares her positive attitude about trying new things. She passes on her thoughts stating, “I plan on using my lesson plan of course!” Anna adds, “I’d like to be able to do this activity [plan I-B lessons] with more of our units.” Anna’s portfolio data supports both her goal statement and her STEBI scores, which illustrate that she is interested in learning about and implementing exciting an interesting ideas, including hands-on science activities and I-B methods into her science classroom, and
she is capable of choosing which methods she uses in her classroom. Anna’s attitude had an influence in her decision to choose to implement I-B methods into her classroom.

As noted in Research Question 2 analysis, Anna utilized Structured Inquiry and Guided Inquiry in her lesson plans. During the pre PSI Professional Development Course observation lesson the students followed Anna’s directions to investigate the parts of the seed, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). Anna moved on to the next portion of the experiment and allowed the students the opportunity to offer suggestions that would lead to the design their own class experiment using a carnation, this time exhibiting evidence of the use of Guided Inquiry. Guided Inquiry is inquiry in which the teacher develops a question and allows the student to co-construct the experimental design (Martin-Hansen, 2002). Data from the pre PSI Professional Development Course observation verifies data from the Pre PSI Professional Development Course interview that showed that Anna had already successfully implemented several forms of inquiry as described by Martin-Hansen (2002), Structured Inquiry and Guided Inquiry, into her science classroom. In the post PSI Professional Development Course classroom observation the researcher observed evidence Structured Inquiry and Guided Inquiry in Anna’s classroom. Anna explained to the researcher during the lesson that she emphasized exploration, as many of her students had no background information related to the concept of pumpkin.

*Summary of Anna’s Results for Question 4*

Research Question 4 asked the question “What relationships exist between teachers’ perceptions and use of I-B methods?” The researcher examined the teacher’s
Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI). Data analysis for Research Question 4 showed that Anna is willing to try to implement I-B methods into her classroom. Anna explained on her post PSI Professional Development Course interview, “I think I would enjoy teaching many of the science concepts using the I-B approach. When choosing her method of science instruction the perception that I-B methods hold large or great value had a positive influence on Anna’s motivation, attitude, caring, determination, and effort during implementation of the methods in her science classroom. Anna was willing and able to use the I-B lesson plan she created. Anna’s definition and vision of inquiry matches her choice of methods for science instruction. Anna creates an atmosphere that encourages learning in her science classroom. Anna feels by “being funny” or doing “something that clicks” will help students remember more about science concepts. Anna incorporates games, movement, and children’s literature into most of her science lessons. Anna had already successfully implemented several forms of inquiry as described by Martin-Hansen (2002), Structured Inquiry and Guided Inquiry. Unfortunately, in first grade more emphasis is placed on reading than on science or social studies.” The perception that reading holds a greater value than science instruction has a negative influence on Anna’s motivation, caring, determination, and effort towards scheduling time for science instruction. This belief might explain why Anna’s implementation of I-B methods into her science classroom followed a gradual and careful path. As noted in Research Question 3 analysis, Anna notes on October 15, 2007, which is seven weeks into the new school year, that she has just started her first science unit. She explains, “This pumpkin unit is my first science unit this year!”
Research Question 5 Analysis

How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Interview analysis (see Appendix B for instrument) for Research Question 5 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, 8 and 9 listed in Table 1, (b) post PSI Professional Development Course interview question 6, (c) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), and (d) the Partner Portfolio for Professional Development. Data findings were utilized to examine Teacher Choice (TC) in an attempt to disclose methods that encourage teachers like Anna to overcome resistance to implementing I-B teaching practices. When a teacher, like Anna, makes a choice she critically assesses the value of available options and chooses a course of action built on her own conceptual framework. Data analysis for Research Question 5 was completed through of a study of Anna’s conceptual framework composed of: her Individual Identity (II), the portion of the Anna’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or personal constructs (Scribner et al., 2002); Anna’s Subject Matter Knowledge (SMK), Anna’s knowledge of content matter and pedagogy (the art and science of being a teacher) and curriculum knowledge (Shulman, 1986); and Anna’s Shared Identity (SI), the portion of the Anna’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community.
Anna’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 5 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 5, 7, 8 and 9 as well as post PSI Professional Development Course interview question 6. Teacher Choice (TC) is influenced by mental models, “the images, assumptions, and stories, which we carry in our minds of our selves, other people, institutions, and every aspect of the world” (Senge, 1990). Interview analysis gave the researcher a glimpse of Anna’s Individual Identity (II). As noted in Research Question 1 analysis, Anna does not remember a lot about her own science learning when she was young because she wasn’t interacting with the subject matter. She was not comfortable with science. As a result, Anna takes extra steps to create an atmosphere that encourages science learning in her science classroom. Anna feels by “being funny” or doing “something that clicks” will help students remember more. Anna incorporates games, movement, and children’s literature into most of her science lessons. Anna feels she doesn’t really have specific methods she uses, however she tends to utilize the following techniques in her lessons: reading and discussion, hands-on activities, incorporation of animals and plants into the classroom setting, talking and discussion. Anna feels that “actually touching, feeling, and doing” are important in her classroom instruction. Anna learns best when engaged through hands-on activities. She appreciates humor and unexpected surprises while learning.

Interview analysis also gave the researcher a glimpse into Anna’s early Subject Matter Knowledge (SMK). Data analysis continued with an examination of Anna’s description of her own framework for understanding science content and teaching
methods. In this excerpt from the pre PSI staff development course interview Anna explains what happens when someone says the word science.

I cringe about science and math because I was never good at science or math in school and I always wanted to be. This is a sad story, if I was good at math and science, I wouldn’t be a teacher. I would have gone into a totally different field. I blame it on the teachers. I don’t think they taught their subject well.

Anna is not comfortable with science or mathematics. In her own teaching Anna feels she is a “really good reading teacher.” Her best strength is “phonics.” Anna feels confident teaching all subjects through literature-based learning. “…I liked the literature-based learning where everything came from the literature because I always believed in reading so that’s basically how I do most of my teaching, including math.” Anna incorporates children’s literature into most of her science lessons.

Interview analysis also gave the researcher a glimpse of Anna’s Shared Identity (SI). Anna acknowledged that her teammates, her students, and curriculum guidelines, including county and state curriculum standards influenced her choice of science teaching methods. Interview data also showed that time allotted for teaching science, related to an emphasis by administrators on teaching the subject of reading, influenced Anna’s science teaching. Anna believed support from her grade level team was positive. Anna’s pre PSI Professional Development Course interview data showed that her teammates influence her. Anna’s team influences her more than any other factor. Anna is willing to try new ideas in her classroom and shares ideas with others, she “creatively steal[s] everything” she can. The following interview excerpt relates what Anna explains as the role her teammates play in influencing her choice of teaching methods.

They will influence me more than the county guidelines, state or whatever. Basically we’ve been very good about sounding things off of each other, just
throwing ideas out, tweaking, implementing, and trying. This year I have two new first grade teachers that I am working with, so the team has changed. The ideas have changed, which is good, cause you get a little old and stagnant if you keep doing the same old same old all of the time. So basically, just watching someone else do something and liking that idea and taking it over. It’s been very good with Ashley because she’s a very mathematical person and I am not. We challenge our classes. Mrs. Delphi says, “You can’t do this.” And the kids love it. They rise up to the bait and the challenge. Basically, just having discussions on how to do things or going to different web sites or stealing, creative stealing. I take whatever; I am very serious about that. I creatively steal everything I can.

Data from the pre PSI Professional Development Course interview analysis showed that Anna is receiving the support she needs from her teammates in order to successfully implement I-B science methods into her classroom. Anna might not be receiving the support she needs from administrators in order to successfully implement I-B science methods into her classroom. In her pre PSI Professional Development Course interview Anna states that her administration has not set science or social studies as a priority. Anna explains in the excerpt that follows.

They haven’t influenced my choice of teaching methods. Really, they haven’t. Their thrust is reading and if they come observe, they come during reading. At second best, they come during math. Nothing is said or done about social studies or science.

Anna explains that her administration has not influenced her choice of teaching methods, but class time allowed for science instruction has been limited by the perception that reading instruction is a priority. Anna finds that the factor of time combined with the idea that reading is a priority over science is an influence she feels when planning to teach science in her classroom. This excerpt from the pre PSI Professional Development Course interview illustrates Anna’s beliefs.

We try to feel, touch, and actively do things in the classroom, but unfortunately, our time is so limited. Our science and social studies time is the last half hour of the day. So, we did do some hands-on type things, but not that many. Not that
many, because we didn’t have a whole lot of time and we were rushing so much at the end of the year. I usually do an animal thing where we touch, it’s not even animals stuff, but it’s feeling like scaly skin, which is an onion bag. We didn’t even get to that because, oh my gosh, we have to hurry up and get to the next unit, and the next. So, this year has not been very good, conducive for teaching any hands-on type things, unfortunately.

This excerpt revealed that the barrier of time in relation to science instruction, especially hands-on activities, included time to teach and sharing time with other subjects, like reading and social studies.

Anna’s students also have an influence on her choice of teaching methods. Anna also feels influenced by her students’ reactions to her teaching. Interview data from Research Question 3 analysis revealed that student behaviors related to their maturity level and student comprehension are factors that influence the way Anna handles science learning situations. In her own teaching she creates an atmosphere that encourages learning. Anna feels being funny or doing things that click will help students remember more. The following excerpt shows Anna’s goal for the PSI Professional Development Course.

I want to become a more interesting and exciting teacher, in all areas, not just in science. I would like to bring in new ways of teaching the same ‘ole stuff so I want to teach it and they want to learn it!

Anna wants to improve her teaching so her students are more interested in their learning so that they will remember more

During the pre PSI Professional Development Course interview, Anna indicated that curriculum guidelines, specifically the Virginia SOL, influence how she decides what to teach and what not to teach. Anna explains, “Well first of all, you have to teach what the SOL dictate that you have to teach…” She believes that the most important
concepts for students to understand by the end of the school year are, “Well, of course everything we have to teach…” She continues, “…but, of course, everything is based on the SOL. The content is there, you have to start with this and then you go from there.” Anna’s choices related to science teaching are influenced by curriculum guidelines, specifically the Virginia SOL.

In summary, Anna takes extra steps to create an atmosphere that encourages science learning in her classroom. Anna feels by “being funny” or doing “something that clicks” will help students remember more. Anna incorporates games, movement, and children’s literature into most of her science lessons. Anna feels she doesn’t really have specific methods she uses, however she tends to utilize the following techniques in her lessons: reading and discussion, hands-on activities, incorporation of animals and plants into the classroom setting, talking and discussion. Anna feels that “actually touching, feeling, and doing” are important in her classroom instruction. Interview data revealed that Anna sometimes makes choices about which methods to use to teach science based on the influences of her CF and her teammates; her students; and curriculum guidelines, specifically the Virginia SOL; and time for science teaching. Anna explains that her administration has not influenced her choice of teaching methods, but class time allowed for science has been limited by the perception that reading instruction is a priority over science instruction.

Anna’s Partner Portfolio for Professional Development

To provide triangulation of multiple data sources (Yin, 2003) the researcher studied pieces from Anna’s Partner Portfolio for Professional Development including Anna’s (a) post PSI Professional Development Course lesson plan, (b) Invitation to
Practice: Science Learning Personal History, (c) the post PSI Professional Development Course lesson plan, and (d) the journal entry titled “What is Inquiry?” This study leads to a more meaningful understanding of Anna’s perceptions as they connect to Teacher Choice (TC) framed by her mental models, conceptions of science subject matter, and barriers related to teaching and learning. Throughout the course of this study Anna made use of on her own education and teaching experiences, analyzed what she learned during the staff development training and made a decision whether or not to hang on to the ideas based on her own system of values. Following the pattern for data analysis used for the pre PSI Professional Development Course interview analysis, this portion of the data analysis consisted of a study of Anna’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI).

First, interview analysis gave the researcher a view of Anna’s Individual Identity (II). Anna creates an atmosphere that encourages science learning in her classroom. Anna feels by “being funny” or doing “something that clicks” will help students remember more. Anna incorporates games, movement, and children’s literature into most of her science lessons. Data from Anna’s Partner Portfolio for Professional Practice supports the idea that Anna creates an atmosphere that encourages science learning in her classroom. In her Invitation to Practice: Collaboration activity Anna writes that she and her CF both use the following methods: “hands-on,” “show and tell,” “demonstration,” “United Streaming,” “the Magic School Bus,” and “technology.” The researcher observed Anna’s classroom and noted that it contained a number of displays, including real butterflies, student work, children’s literature, theme books, and educational materials. Anna had an
assortment of books that related to the theme of plants accessible to her students. There were plants and flowers, carnations, displayed on a counter near the sink.

Next, Partner Portfolio analysis clarified previous findings related to Anna’s Subject Matter Knowledge (SMK). Anna is not comfortable with science or mathematics. In her own teaching Anna feels she is a “really good reading teacher.” Her best strength is “phonics.” Anna feels confident teaching all subjects through literature-based learning. Anna writes in her Invitation to Practice: Mapping My Classroom activity that she would like to expand her literacy corners “to include some math, science, and social studies.” The researcher observed Anna’s classroom and noted that it contained a number of displays, including, children’s literature and theme books.

Interview analysis also gave the researcher a glimpse of Anna’s Shared Identity (SI). Anna acknowledged that her teammates, her students, and curriculum guidelines, including county and state curriculum standards influenced her choice of science teaching methods. A large motivator or influence on Anna’s choice of teaching methods is her students. Anna goal statement reflects her interest in making her students experience more exciting. Anna tells more about what she wants to learn from the PSI Professional Development Course in the excerpt that follows.

I want to learn: hands-on ways to teach the science SOL, how to “hook” kids, how to teach the information in a more exciting way, how to incorporate science with other subjects, and how to manage time so all is covered!”

Anna is interested in teaching using methods that will interest her students. This excerpt also supports pre PSI Professional Development Course interview data showing that curriculum guidelines, including county and state curriculum standards have influenced her choice of science teaching methods.
Summary of Anna’s Results for Research Question 5

Data were used to examine Anna’s choices in an effort to reveal methods that encourage teachers like her to overcome resistance to implementing I-B teaching practices. Anna made decisions about her choice of teaching methods by assessing the value of the options available to her and deciding upon a course of action based on her own conceptual framework. Data analysis for Research Question 5, “How do teachers choose to use I-B methods as opposed to teacher-centered activities?” consisted of an examination of Anna’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI). Partner Portfolio analysis supported previous findings related to Anna’s Individual Identity (II). Anna creates an atmosphere that encourages science learning in her classroom. Anna feels by “being funny” or doing “something that clicks” will help students remember more. Anna incorporates games, movement, and children’s literature into most of her science lessons. Partner Portfolio analysis clarified previous findings related to Anna’s Subject Matter Knowledge (SMK). Anna is not comfortable with science or mathematics. In her own teaching Anna feels she is a “really good reading teacher.” Her best strength is “phonics.” Anna feels confident teaching all subjects through literature-based learning. Interview analysis also gave the researcher a glimpse of Anna’s Shared Identity (SI). Anna acknowledged that her teammates, her students, and curriculum guidelines, including county and state curriculum standards influenced her choice of science teaching methods.
Teacher Portrait T8 – Julia

I next present the data to answer the query, “Who is Julia?” This teacher portrait is described as it aligns with each research question. Data that yields information related to each question was analyzed. A discussion of the findings for each question is presented.

Research Question 1 Analysis

What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?

Julia’s Interview Analysis: Pre and Post Professional Development Course

The following data proved useful in providing insights about Research Question 1: (a) Julia’s pre PSI Professional Development Course PSI Professional Development Course interview, (b) STEBI survey, (c) CLES survey, (d) Julia’s Partner Portfolio for Professional Development, and (e) Julia’s post PSI Professional Development Course interview. This information was utilized to examine Julia’s beliefs in an effort to uncover patterns that influence her teaching behavior as it relates to her Individual Identity (II). Individual Identity (II) is defined as the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfield, 1998) that represents autonomy or personal constructs (Scribner et al., 2002). Julia’s Interview Codes and Transcript Statements for Research Question 1 are located in Table 30.
Table 30.

*Interview Codes and Transcript Statements for Julia (T8) Pre and Post – Research Question 1.*

<table>
<thead>
<tr>
<th>Beliefs about learning and teaching science</th>
<th>Beliefs About How Children Learn Science</th>
<th>Beliefs About Science Teaching Methods</th>
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<tr>
<td><strong>Pre:</strong> For me, because I went to parochial school and we didn’t have the science like we do now in the elementary school, I’d have to go to high school. The thing that comes to mind to me immediately was high school biology and it was dissecting a frog. It was definitely hands-on experience. That’s what comes to mind. (See &amp; Do)</td>
<td><strong>Pre:</strong> I think I’d have to say being able to integrate everything is a strength, enthusiasm, again. A sense of humor, I think the kids really need that. Making as much as possible a lot of interaction with their learning environment. I use a lot of hands-on learning, a lot of manipulatives and so forth, taking the learning outside of these four walls as well. Be it the outdoors or the halls. Our halls will be alive with whatever it is we are learning. Just in stretching them, I think I try to do a lot of that. I do as much as possible meet the individual needs of the child. Come up with activities in which they can be stretched as well as those that need help to make it and atmosphere that there’s a lot of collaboration as well. (Extend Learning) (Emotions) (Variety) (CZ) (Actively Involved)</td>
<td><strong>Pre:</strong> I think I’m enthusiastic. I hope I am. I do feel like I have a good rapport with my students. They are always excited when they come in and the day flies by. I think because I love what I do they love learning. I think there’s always the down days, occasionally, but overall I feel I’m always happy to come to work. I am excited to teach and I think they’re excited to learn. It’s really mutually beneficial. I think we really feed off of each other. I love it. (Emotions)</td>
</tr>
<tr>
<td><strong>Pre:</strong> When I was training I thought we had a good program. We had to take a class in teaching science. This was in the state university of New York system and we had to do a methodology class in science but it was very much early childhood. I have a master’s degree in that. Everything in my masters program as well as that was very hands-on. It was not just theory. It was always emphasizing the importance of getting in there and having the kids participate in multi-sensory ways. So I feel very grateful because I</td>
<td><strong>Post:</strong> I know students understand a concept through a variety of ways: orally when they explain the concept, by observation as they manipulate and</td>
<td><strong>Pre:</strong> I think in terms of, certainly how you arrange your room and make it come alive to make sure you have all of these centers and hands-on learning for the kids, and make it exciting and make it interactive. Again, it’s how you want your dream classroom with a lot more storage and a lot more space to do that. I definitely try to manipulate the environment as much as I can and change it constantly as I can. As you know, in elementary school you are teaching so many things all of the time, that it is a constant change over. Fortunately parent volunteers</td>
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</table>
Data were utilized to examine Julia’s beliefs about teaching science, how children learn science, and science teaching methods to uncover patterns that influence her teaching behavior as it relates to autonomy or Individual Identity (II). Data analysis started with an examination of Julia’s memories of her early schooling. The researcher learned that Julia did not learn science in her elementary school. In the excerpt that follows Julia tells us what she remembers about a high school experience that stood out.

For me, because I went to parochial school and we didn’t have the science like we do now in the elementary school, I’d have to go to high school. The thing that comes to mind to me immediately was high school biology and it was dissecting a frog. It was definitely hands-on experience. That’s what comes to mind.
Julia felt learned about biology through a hands-on experience. In her pre PSI Professional Development Course interview session, Julia explains that she feels that she learns science best by “doing.” She clarifies her beliefs, “You best learn it through the instruction and through observation and participation. It’s a real combination, it has to all meld together.” Julia recalls a good training program while at a state university. Julia tells about college courses that played a role in the shaping of her beliefs related to science teaching and learning in the excerpt that follows.

When I was training I thought we had a good program. We had to take a class in teaching science. This was in the state university of New York system and we had to do a methodology class in science but it was very much early childhood. I have a master’s degree in that. Everything in my masters program as well as that was very hands-on. It was not just theory. It was always emphasizing the importance of getting in there and having the kids participate in multi-sensory ways. So I feel very grateful because I know some preparation is not that way or are not that way now and I’m just glad that I got to see how well that did work. So I’m really happy that I had the opportunity to do that. That was good.

Julia’s classes in teaching science utilized early childhood concepts and science teaching methodology. Classes in her masters program combined hands-on activities as well as theory. Julia remembers learning best when she was actively engaged or participated in hands-on activities throughout the learning process. The constructivist approach to how people learn focuses on providing relevant experiences and opportunities that allow students to construct knowledge (Piaget, 1929; Vygotsky, 1978).

Julia learned best through active engagement, observation and participation, by doing hands-on activities. Memories of her early schooling had an impact on her teaching style and her choice of science teaching methods. A teacher’s principles or attitude, her tendency to respond favorably or unfavorably toward the topic, students or other objects,
determines what students will see, hear, think, and do (Souza Barros & Elia, 1998). Pre PSI Professional Development Course interview excerpts show Julia is excited to teach. Her happiness is passed on to her students. This excerpt from the pre PSI Professional Development Course interview reveals how she describes herself as a classroom teacher.

I think I’m enthusiastic. I hope I am. I do feel like I have a good rapport with my students. They are always excited when they come in and the day flies by. I think because I love what I do they love learning. I think there’s always the down days, occasionally, but overall I feel I’m always happy to come to work. I am excited to teach and I think they’re excited to learn. It’s really mutually beneficial. I think we really feed off of each other. I love it.

This excerpt further supports the idea that Julia remembered learning when she was actively engaged or participated in hands-on activities throughout the learning process and draws from her own experiences when planning instruction in her classroom. She loves what she is doing and this positive attitude is contagious. The excerpt that follows outlines what Julia believes are her strengths as a teacher.

I think I’d have to say being able to integrate everything is a strength, enthusiasm, again. A sense of humor, I thing the kids really need that. Making as much as possible a lot of interaction with their learning environment. I use a lot of hands-on learning, a lot of manipulatives and so forth, taking the learning outside of these four walls as well. Be it the outdoors or the halls. Our halls will be alive with whatever it is we are learning. Just in stretching them, I think I try to do a lot of that. I do as much as possible meet the individual needs of the child. Come up with activities in which they can be stretched as well as those that need help to make it and atmosphere that there’s a lot of collaboration as well.

Julia noted that she is able to integrate her knowledge of teaching methods and content information. She feels confident and enthusiastic about teaching science.

Julia manipulates the educational environment in her classroom based on her beliefs about science teaching methods. She explains how she does this in the excerpt that follows.
I think in terms of, certainly how you arrange your room and make it come alive to make sure you have all of these centers and hands-on learning for the kids, and make it exciting and make it interactive. Again, it’s how you want your dream classroom with a lot more storage and a lot more space to do that. I definitely try to manipulate the environment as much as I can and change it constantly as I can. As you know, in elementary school you are teaching so many things all of the time, that it is a constant change over. Fortunately parent volunteers are a big part of my classroom. I have someone here all of the time that helps me to do that and make it interactive. That’s been a big asset, having people to assist you because you want to make it exciting for the kids. Again, time constraints, without the help it would be hard to do that as we are able to do that here. And manipulating it also in terms of taking them out of the classroom as much as possible, be it field trips, extension trips or not just in our school to maximize it, and other parts as well.

Julia sets up her room to facilitate hands-on learning and interactive activities. She encourages parents to assist in the classroom.

Julia strives to implement new ideas into her classroom. Julia varies her professional development training between science, social studies, language arts, and mathematics. She has participated in science staff development training sessions that mixed hands-on strategies with theory. The excerpt that follows outlines Julia’s professional development philosophy.

What I personally try to do is vary each year and take a science, a social studies, a language arts, and a math. But when the sciences come up I have taken Laura’s and yours and both were awesome and hands-on. We went out and did the garden at Cloudland Elementary. And with her we had bulletin board things that were interactive. So they were both wonderful. Lots of hands-on, again, not just theory, it was this is what you’re doing and why you’re doing it, now let’s do it. We came back with a lot of great things to implement, which is so important. You just don’t have the time as much once the school year gets rolling. So, when it’s an in-service like that, yeh, I definitely avail myself of it.

Julia learns best through hands-on, interactive instruction. She believes it is important to discover new ideas to implement into her classroom.
Pre PSI Professional Development Course interview data show that Julia believes she learns science best by “doing.” She feels, “You best learn it through the instruction and through observation and participation. It’s a real combination, it has to all meld together.” Post PSI Professional Development Course interview excerpts support and extend pre PSI Professional Development Course interview data related to Julia’s beliefs about teaching science, how children learn science, and science teaching methods to uncover patterns that influence her teaching behavior as it relates to autonomy or her Individual Identity (II). In her post PSI Professional Development Course interview excerpts, Julia explains that a good learner is “inquisitive, engaged, exploring and making connections.” Julia shares an example that illustrates her beliefs about science teaching methods and how she knows her students are learning science in the excerpt that follows.

I know students understand a concept through a variety of ways: orally when they explain the concept, by observation as they manipulate and conduct investigative studies, also observing then interacting with peers, projects, flip books, etc. that demonstrate comprehension.

Julia believes her students are learning when they observe, manipulate, investigate, interact with peers, and can explain concepts.

In summary, data from the pre PSI Professional Development Course interview revealed information about Julia’s conceptual framework for science teaching. The researcher analyzed data in an attempt to discover what Julia believes about how children learn science and science teaching methods. This includes Julia’s conceptions of how children learn and her own view of effective science teaching. Julia learns by seeing and doing. Julia feels that she learns science best by “doing.” She explains, “You best learn it through the instruction and through observation and participation. It’s a real combination,
it has to all meld together.” Julia recalls a good training program while at a state university. Her class in teaching science utilized early childhood concepts and science methodology. Classes in her masters program combined hands-on activities as well as theory. Julia varies her staff development training between science, social studies, language arts, and mathematics. She has participated in science staff development training sessions that mixed hands-on strategies with theory. She strives to implement new ideas into her classroom. Post PSI Professional Development Course interview data supports these findings.

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

Julia’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre PSI Professional Development Course and post PSI Professional Development Course assessments decreased notably, with 64 points and 56 points respectively (max=65 points) (see Figure 16); however, both scores were in the high efficacy category indicating that she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores for the pre PSI Professional Development Course and post PSI Professional Development Course assessments decreased slightly, with 54 points and 51 points respectively (max=60 points); however, both scores were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). In her pre PSI Professional Development Course interview session Julia noted that she is able to integrate her knowledge of teaching methods and content information. She feels confident and enthusiastic about teaching science.
Figure 16. Julia’s STEBI Scores

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<th>PSTEB</th>
<th>OE</th>
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<tbody>
<tr>
<td>Pre</td>
<td>64</td>
<td>High</td>
</tr>
<tr>
<td>Post</td>
<td>56</td>
<td>High</td>
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Constructivist Learning Environment Survey – CLES Analysis Pre and Post

The CLES Personal Relevance scale relates to students’ experience of the personal relevance of school science as perceived by teachers (Suters, 2004; Taylor et al., 1997). Julia’s pre (35) and post (34) CLES Personal Relevance scores were in the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences in her science classroom (see Figure 17). In her pre PSI Professional Development Course interview session Julia explained that she remembered learning when she was actively engaged or participated in hands-on activities throughout the learning process, when her learning was tied into her experiences.

The CLES Scientific Uncertainty scale relates to students’ perceptions of science as a fallible human activity as perceived by teachers (Suters, 2004; Taylor et al., 1997).
Her pre (25) and post (21) CLES Scientific Uncertainty scores were in the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional; shaped by social and cultural influences; and arises from human interests and values. The scores decreased slightly indicating that in the 2007-2008 class she provided fewer opportunities for students to engage in opportunities to learn to be skeptical and critical about the nature and value of science in her classroom.

The CLES Critical Voice scale relates to students development as autonomous learners, through creation of a social climate in which students feel that their learning is legitimate and beneficial (Suters, 2004; Taylor et al., 1997). Her pre (35) and post (35) CLES Critical Voice scores were both in the high agreement range which indicated that she placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediment to their learning.

The CLES Shared Control scale also relates to student autonomy. This scale is concerned with students sharing control of the classroom-learning environment with their teacher (Suters, 2004; Taylor et al., 1997). Her pre (22) and post (17) CLES Shared Control scores decreased notably from a high to low agreement range. This indicates that during the 2007-2008 school year she placed less emphasis on inviting students to: participate in designing their own learning activities; determine assessment criteria; and negotiate the norms for the classroom. Julia indicated that this decrease in score might have occurred because she was teaching a lower grade level of students. She indicated
that she might have answered questions 4, 33, and 40 differently if she were teaching at a higher grade level.

The CLES Student Negotiation scores relate to teacher beliefs as they relate to student interaction with other students (Suters, 2004; Taylor et al., 1997). Julia’s pre (34) and post (32) CLES Student Negotiation scores were both in the high agreement range which indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas in the science classroom.

Last, the Attitude Scale scores provide a measure of the concurrent validity of the CLES. It is used to measure teachers’ interpretations of students’ attitudes towards the science classroom environment (Suters, 2004; Taylor et al., 1997). Her pre (32) and post (30) CLES Attitude Scale scores were in the high agreement range which indicated that she felt students: anticipated the activities within her science classroom, found activities worthwhile, and understood and enjoyed the activities. This score supports pre PSI Professional Development Course interview findings that Julia remembered learning science when she was actively engaged or participated in hands-on activities throughout the learning process and draws from her own experiences when planning instruction in her science classroom. She loves what she is doing and this positive attitude is contagious.
Figure 17. Julia’s CLES Scores

Julia’s Partner Portfolio for Professional Development Analysis

Teachers were given the opportunity to reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006) throughout the PSI Professional Development Course. The researcher examined five products produced by Julia: (a) Invitation to Practice: Science Learning Personal History, (b) Invitation to Practice: Collaboration, (c) pre PSI Professional Development Course lesson observation, (d) personal goal for the PSI Professional Development Course, and (e) journal entries to confirm the previously mentioned data findings from the interview sessions. Julia’s Partner Portfolio for Professional Development Analysis findings, along with the STEBI and CLES data, serves as triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).
A framework for organization is based upon Julia’s interview excerpts related to her beliefs about teaching science. Julia’s interview excerpts showed that she feels that she learns science best by “doing.” In her pre PSI Professional Development Course interview session she explained, “You best learn it through the instruction and through observation and participation. It’s a real combination, it has to all meld together.” An excerpt from the Invitation to Practice: Science Learning Personal History (see Appendix G) activity supported the idea that Julia believes that she needs to participate, use hands-on and inquiry type methods, when learning. Her first reflection entry described a painful elementary experience. The excerpt below gives insight into Julia’s beliefs about her teaching methods.

In elementary school [parochial] we had a visiting science teacher. I remember “inquiring” as to why if air was invisible I could see a “wavy motion” of air above the radiator. Her response was “ask that question in two years” and moved on. I was so frustrated and learned never to do that to my students. If I don’t know the answer to a question, I respond eagerly “great question, I wonder why…let’s investigate!!”

This experience might explain Julia’s high CLES Critical Voice scale results. The Critical Voice relates to students development as autonomous learners, through creation of a social climate in which students feel that their learning is legitimate and beneficial (Suters, 2004; Taylor et al., 1997). Julia’s CLES Critical Voice scores, pre (35) and post (35), were both in the high agreement range which indicated that she placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediment to their learning. Julia encourages students to ask questions and express concerns when they are not getting answers to those questions.
Continuing with analysis of Julia’s early school experiences, she explains that, “in high school I fell in love with biology. I believe because it was hands-on, dissecting frogs. It was the inquiry method!” In her pre PSI Professional Development Course interview session, Julia recalls a good science teaching training program while at a state university. Her class in teaching science utilized early childhood concepts as well as science methodology. Classes in her masters program combined hands-on science activities as well as theory. In an excerpt from the Invitation to Practice: Science Learning Personal History, Julia continues explaining how her college science courses shaped her belief that students need to participate in their learning in the excerpt that follows.

In college I took a few biology classes and the contrast drove the point of interaction home clearly. One was on predator and prey and the professor was renowned for his study of raptors, which he brought to class. Another, organisms and evolution was strictly memorizing the Latin term and classifying. It was dry and boring to do.

Julia participated in some science classes, for example biology, that was interactive. She participated in other science classes that were dry and boring. In her pre PSI Professional Development Course interview session Julia noted that she is able to integrate her knowledge of science teaching methods and science content information. She feels confident and enthusiastic about teaching science. Julia’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (64) and post (56) PSI Professional Development Course assessments were both in the high efficacy category indicating that she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores also support this belief. Julia’s pre (54) and (51) scores were in the high expectancy category indicating that she had confidence in her teaching ability to create
desirable outcomes in her science classroom (see Appendix C1 for instrument and C2 for

In summary, portfolio excerpts supported pre PSI Professional Development
Course interview data, which, showed that Julia learns science best by doing, that she
believes she needs to participate, use hands-on, and inquiry type methods, when learning
about science. Julia’s early education and college courses in science content and science
teaching methodology helped to shape her belief that students need to participate to learn
science.

Data collected revealed information about Julia’s beliefs about how children learn
science. Julia believes her students are learning science when they observe, manipulate,
investigate, interact with peers, and can explain concepts. Pre PSI Professional
Development Course interview data showed that Julia strives to implement new ideas
into her science classroom. Julia’s goal for the PSI Professional Development Course was
to learn “to be equipped with materials and ideas to ideally set up my classroom to
implement the inquiry method in science.” In one of her Partner Portfolio for Professional
Development Invitation to Practice: Collaboration entry she explains that she and her CF,
Sara both “plan together” and “take our learning outside the classroom [bluebird houses,
Red Fox Trail, etc.].” Her CLES Attitude Scale scores, pre (32) and post (30), were in the
high agreement range, which indicated that she felt students: anticipated the activities
within her science classroom, found activities worthwhile, and understood and enjoyed
the activities (Suters, 2004; Taylor et al., 1997).
Summary of Julia’s Results for Research Question 1

Research Question 1 solicits an answer to the following question: “What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?” Data analysis of Julia’s interview excerpts discloses knowledge about her conceptual framework for science teaching. Julia that she learns science best by “doing.” She explains, “You best learn it through the instruction and through observation and participation. It’s a real combination, it has to all meld together.” Portfolio excerpts supported pre PSI Professional Development Course interview data suggesting that Julia learns science best when actively participating in the learning. Julia discovered through a series of reflective activities presented during the PSI Professional Development Course, that she learns best by doing, that she believes she needs to participate, use hands-on, and inquiry type methods, when learning. Julia’s own early education and college courses in science content and pedagogy helped to shape her belief that students need to participate to learn science. Julia carries her beliefs about her own learning into her teaching practices in her science classroom. She makes an effort to implement new ideas into her science classroom. Julia believes her students are learning science when they are able to observe, manipulate, investigate, interact with peers, and can explain science concepts to others.
Research Question 2 Analysis

How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

Interview analysis (see Appendix B for instrument) for Research Question 2 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, and 8 listed in Table 1, (b) post PSI Professional Development Course interview questions 3 and 4, (c) Classroom Observation analysis (See Appendix E for the Classroom Observation Protocol), (d) STEBI analysis (e) CLES analysis, and the (f) Partner Portfolio for Professional Development. The researcher utilized this data in order to examine the way in which Julia perceives herself or describes her own abilities to produce desired or intended results in her science classroom. Data findings were also drawn on to describe the Julia’s Subject Matter Knowledge (SMK). Subject Matter Knowledge (SMK) is defined as the teacher’s knowledge of content matter and pedagogy (the art of being a teacher), along with her curriculum knowledge (Shulman, 1986). Last, the researcher analyzed the data to reveal information related to Julia’s understanding of I-B methods. In other words, the researcher has assembled the pieces to answer the teacher’s query, “How does Julia describe her abilities to produce desired or intended results in her science classrooms? What does Julia believe about her science content knowledge and her pedagogical science knowledge? What does Julia understand about I-B methods?”
**Julia’s Interview Analysis: Pre and Post Professional Development Course**

The researcher analyzed pre PSI Professional Development Course interview data, which was useful in describing Julia’s framework for understanding science and her ability to produce desired results according to her beliefs and self-efficacy. There is a close link between teacher content knowledge in mathematics and science and student performance in these disciplines (Darling-Hammond, 2000; Loucks-Horsley et al., 2003). Keeping this in mind, the researcher examined the information related to Julia’s knowledge of science content information that was revealed in Research Question 1 analysis. During this data analysis, the researcher learned that Julia did not learn about science in her elementary school. Julia does remember learning science concepts through hands-on instruction, observation, and participation in her high school science classes. Julia felt her college training experiences in science were positive and helpful. Julia’s college training classes showed her early childhood concepts and science teaching methodology. Julia explained that she learns best through doing, participating, using hands-on, and inquiry type methods. Julia’s learning style is reflected in the way that she teaches science in her classroom. Julia uses a variety of methods in her science classroom. Interview codes and transcript statements for Julia’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions for Research Question 2 are listed in Table 31.
Table 31.

*Interview Codes and Transcript Statements for Julia (T8) Pre and Post – Research Question 2.*

**Self-Efficacy Related to:**

<table>
<thead>
<tr>
<th>Understanding of Science Content</th>
<th>Teaching Methods</th>
<th>Definition of science and Inquiry science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: “For me, because I went to parochial school and we didn’t have the science like we do now in the elementary school, I’d have to go to high school. The thing that comes to mind to me immediately was high school biology and it was dissecting a frog. It was definitely hands-on experience. That’s what comes to mind.” (Sit n’ Git-no science)</td>
<td>Pre: “I would say inquiry approach, in that you set up your room so that it’s like a lab. The kids know the rules and regulations related to it. They know the information. They know where they’re going and they get to explore. I would say all of the methods that relate to the inquiry method being put into place in a classroom and allowing that opportunity to the kids is what works best.” (Methods) (Reach All)</td>
<td>Pre: “Excitement! To me it’s alive, it’s just life. When I think of science I think exploration, discovery, challenge. To be honest, it’s the most exciting of all of the classes because, it is, it really is, I’m always excited and so are the kids when you’re doing science, because it’s life and the kids can bring in and observe and just do so much. It’s not abstract. It’s real. It’s just a pleasure to teach because it’s so exciting. It’s so interactive. Those are the words that come to my mind, exploration, and life. It’s just multisensory. It’s fun, fun, it’s fun!” (Emotions) (Components-Science)</td>
</tr>
<tr>
<td>Pre: “Information about Julia’s knowledge of content information was revealed in Research Question 1 analysis. During this analysis we learned that Julia recalls a good training program while at a state university. Julia’s classes in teaching science utilized early childhood concepts and science methodology. Classes in her masters program combined hands-on activities as well as theory.” (Transition) (Love)</td>
<td>Pre: It’s because I know that’s what works best for the kids. They can go over and pick up a magnifying glass and make observations and I’ve got words there to help them put their thoughts together and explain what they’re seeing.” (Methods) (Apply and Connect)</td>
<td></td>
</tr>
<tr>
<td>Pre: “Sometimes it’s easy to know because they say, “oh, I get it!” They let you know. I’ll have that with my inquisitive learners particularly. They will ask and inquire. Then</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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suddenly the light bulb goes off and you can see it in their face. You can see it through their work, through observation, of course, through the written work as well, when you’re checking them. It is a multitude. You can see it by the way they respond to your questions and your discussions. You can figure out where they are in the spectrum. Then there are verbal responses and the way they create. It could be through art, showing that this is my understanding of the life cycle and they create it. This was one of their assessments this last time. We used a pencil to paper test to just show a life cycle, being able to create it and explain it. There is a true multiple intelligences at work there. That’s how they can demonstrate their knowledge.” (Motivation) (Apply and Connect

come to an understanding to acquire that knowledge. So, to me it’s a hands-on way to learn the end product. That’s what inquiry science means to me. You are inquiring and you are doing it through a variety of methods until you can come to a conclusion. Basically taking yourself through the scientific method.” (Comments-Inquiry) (Method) (POV)

Post: “I knew what worked but did not have a systematic approach prior to the session.” She continues to explain, “I now have a systematic approach that organized my lessons and engages the students.” (Method)

Post: Julia gave the following to her definition of inquiry science, “the inquiry approach to science is a methodical plan which captivates the students. It incorporates the 5E’s [from the 5E Model of science teaching (Bybee, 1993, 2000; Carin et al., 2004)] and is very much hands on and exciting.” (Components-Inquiry) (Method)
Julia gets excited when she thinks about science. The excerpt that follows outlines how Julia defined science in the pre PSI Professional Development Course interview.

Excitement! To me it’s alive, it’s just life. When I think of science I think exploration, discovery, challenge. To be honest, it’s the most exciting of all of the classes because, it is, it really is, I’m always excited and so are the kids when you’re doing science, because it’s life and the kids can bring in and observe and just do so much. It’s not abstract. It’s real. It’s just a pleasure to teach because it’s so exciting. It’s so interactive. Those are the words that come to my mind, exploration, and life. It’s just multisensory. It’s fun, fun, it’s fun!

When she thinks about science she thinks about fun, excitement, exploration, discovery, challenge, and life.

Data analysis continued with an examination of Julia’s description of her own framework for understanding science content and teaching methods. There is a close link between teacher content knowledge in mathematics and science and student performance in these disciplines (Darling-Hammond, 2000; Loucks-Horsley et al., 2003). Information about Julia’s knowledge of content information was revealed in Research Question 1 analysis. During this analysis we learned that Julia recalls a good training program while at a state university. Julia’s classes in teaching science utilized early childhood concepts and science methodology. Classes in her masters program combined hands-on activities as well as theory.

In the pre PSI Professional Development Course interview Julia reveals details about her teaching methods. One excerpt lists examples of the methods Julia generally uses to teach science.

I would say inquiry approach, in that you set up your room so that it’s like a lab. The kids know the rules and regulations related to it. They know the information. They know where they’re going and they get to explore. I would say all of the methods that relate to the inquiry method being put into place in a classroom and allowing that opportunity to the kids is what works best.
Julia uses a number of methods that all relate to the inquiry approach. This excerpt reveals details why she uses the teaching methods above science teaching methods.

It’s because I know that’s what works best for the kids. They can go over and pick up a magnifying glass and make observations and I’ve got words there to help them put their thoughts together and explain what they’re seeing.

The excerpt that follows describes how Julia knows when her students understand a concept.

Sometimes it’s easy to know because they say, “oh, I get it!” They let you know. I’ll have that with my inquisitive learners particularly. They will ask and inquire. Then suddenly the light bulb goes off and you can see it in their face. You can see it through their work, through observation, of course, through the written work as well, when you’re checking them. It is a multitude. You can see it by the way they respond to your questions and your discussions. You can figure out where they are in the spectrum. Then there are verbal responses and the way they create. It could be through art, showing that this is my understanding of the life cycle and they create it. This was one of their assessments this last time. We used a pencil to paper test to just show a life cycle, being able to create it and explain it. There is a true multiple intelligences at work there. That’s how they can demonstrate their knowledge.

Julia uses a large array of assessments to determine if students understand a concept, including: observation, written work, questioning, discussion, art, and paper and pencil tests.

Last, data analysis focused on Julia’s description of her own framework for understanding I-B methods. This excerpt from Julia’s pre PSI Professional Development Course interview reveals how she defines inquiry science.

For me I have a real positive feel because then you’re delving into it. You’re inquiring. Inquiring minds want to know. So when I think inquiry, I think you have something that you want to understand deeper and you are going to have to come to an understanding to acquire that knowledge. So, to me it’s a hands-on way to learn the end product. That’s what inquiry science means to me. You are inquiring and you are doing it through a variety of methods until you can come to a conclusion. Basically taking yourself through the scientific method.
Julia defines inquiry science as taking yourself through the scientific method using a variety of hands-on methods to develop a deeper understanding as you arrive at a conclusion. Julia describes her own framework for understanding I-B before the PSI Professional Development Course in her post PSI Professional Development Course interview, saying, “I knew what worked but did not have a systematic approach prior to the session.” She continues to explain, “I now have a systematic approach that organized my lessons and engages the students.” In her post PSI Professional Development Course interview session, Julia the following to her definition of inquiry science, “the inquiry approach to science is a methodical plan which captivates the students. It incorporates the 5E’s [from the 5E Model of science teaching (Bybee, 1993, 2000; Carin et al., 2004)] and is very much hands on and exciting.”

In summary, the researcher examined Julia’s description of her own efficacy. Julia gets excited when she thinks about science. When she thinks about science she thinks about fun, excitement, exploration, discovery, challenge, and life. Data analysis continued with an examination of Julia’s description of the own framework for understanding science content and teaching methods. Julia recalls a good training program while at a state university. Julia’s classes in teaching science utilized early childhood concepts and science methodology. Classes in her masters program combined hands-on activities as well as theory. Julia uses a number of methods that all relate to the inquiry approach. Julia uses a large array of assessments to determine if students understand a concept, including: observation, written work, questioning, discussion, art, and paper and pencil tests. Last, data analysis focused on Julia’s description of her own
framework for understanding I-B methods. Julia defines inquiry science as taking
yourself through the scientific method using a variety of hands-on methods to develop a
deeper understanding as you arrive at a conclusion. She excitedly explains, “The inquiry
approach to science is a methodical plan which captivates the students. It incorporates the
5E’s and is very much hands on and exciting.”

*Julia’s Classroom Observation Analysis: Pre and Post Professional Development Course*

Researcher observations were completed May 17, 2007 and October 18, 2007. She had 22 students during the pre PSI Professional Development Course observation
and a total of 21 in the post PSI Professional Development Course observations. The
demographics of the two classes observed for the pre PSI Professional Development
Course and post PSI Professional Development Course observations are described in
Table 32.

Table 32.

*Julia’s Class Demographics Pre and Post Observations (T8)*

<table>
<thead>
<tr>
<th>Race</th>
<th>Pre (22)</th>
<th></th>
<th>Post (21)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>African American</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Caucasian American</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Asian</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>11</td>
<td>11</td>
<td>12</td>
<td>9</td>
</tr>
</tbody>
</table>
Data analysis includes a review of Julia’s interview and observation data followed by presentation of evidence related to the implementation of the forms inquiry as described by Martin-Hansen (2002). A review of the pre PSI Professional Development Course observation data supports pre PSI Professional Development Course interview data and suggests that Julia uses a variety of methods in each lesson that all relate to the inquiry approach. Julia uses a large array of assessments to determine if students understand a concept, including: observation, written work, questioning, discussion, art, and paper and pencil tests. A brief synopsis of the pre PSI Professional Development Course observation lesson is illustrated in this paragraph. Julia’s lesson, which she called “Frog Rotation Day,” was based on the theme animal life cycles; the life cycle of a frog was emphasized. In her lesson plan for the pre PSI Professional Development Course observation the students participated in activities set up in ten different stations. The activities at the stations integrated science concepts with mathematics, reading, art, oral language, writing, and technology. The frog themed centers consisted of the following activities: a reading contract in which students read a passage and answered questions, a pond diorama art project, a tadpole and frog observation station and corresponding entry in students science journal, a life cycle listening center, a rounding activity in mathematics with a frog theme, acting out of a reader’s theatre play called “Take Your Time Tadpole,” a mathematics measuring activity using centimeters to measure the length of a frog’s path, a writing activity about the frog life cycle, an origami frog, and a research based search on the computer. The students rotated in small groups through the centers exploring and learning about the life cycle of frogs and other concepts. Suddenly, in the midst of the rotation, Julia took advantage of a teachable moment. She called the
students over to a net hanging in one corner of the room as students excitedly watched a butterfly coming out of a cocoon. There was a parent volunteer helping with students with the frog art project. Outside of the science lesson, the researcher observed an “acid rain center” set up on a table in the hallway. Students had been collecting rain and measuring the acidity over a period of several weeks.

During the pre PSI Professional Development Course observation lesson the students followed directions as they rotated through center activities, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered an authentic inquiry experience (Martin-Hansen, 2002). Data from the pre PSI Professional Development Course observation verifies data from the pre PSI Professional Development Course interview that showed that Julia uses a variety of methods in each lesson that all relate to the inquiry approach. Julia uses a large array of assessments to determine if students understand a concept, including: observation, written work, questioning, discussion, art, and paper and pencil tests.

A brief synopsis of the post PSI Professional Development Course observation lesson is illustrated in this paragraph. Julia’s lesson about force and motion, push and pull, followed the 5E model. The lesson observed was the fourth lesson in the sequence of the mini unit lessons. There were visual displays of science concepts, science process skills, and materials throughout the classroom. Julia engaged the students by playing a game with “motion” vocabulary words. Next, students showed and discussed “motion” objects that they brought to school as a homework assignment. Students offered their own explanations for concepts as they discussed the characteristics of objects they brought to class. The students talked about how the objects fit into their study of force and motion,
pushes and pulls. Julia slowly reduced teacher control as she allowed students to sort the objects into categories that they created themselves based on their knowledge of force and motion, pushes and pulls. Exploration continued as students traveled around the classroom in small cooperative groups, scavenger hunt style, searching for examples of force and motion, pushes and pulls. Materials included “real” objects found throughout the classroom. During their exploration, students asked questions, designed their own mini experiments to discover the answers to their questions, and discussed the results with their classmates and teacher. They created their own “plan” and recorded results on a sheet of paper. For example, students asked a question like, “What will happen if we push on the door?” Then they pushed on the door, discussed, and recorded what happened. There was a frequent hum of activity and ideas being exchanged. Throughout the lesson Julia encouraged students to explore more objects and make connections to their own lives. Students were actively engaged throughout the lesson.

In her post PSI Professional Development Course observation lesson, Julia used a variety of methods in her lesson that all relate to the inquiry approach. Julia used the following methods in her lesson: whole class instruction, small group work, discussion, questioning, experimentation, and use of science process skills including sorting and classification. As demonstrated in Julia’s lesson plans, pre PSI Professional Development Course observation, and post PSI Professional Development Course observation data, she has successfully implemented several forms of inquiry as described by Martin-Hansen (2002). Structured Inquiry, in which the teacher directs the methods of inquiry, was observed during the pre PSI Professional Development Course observation as students rotated through the frog themed centers exploring the concept of life cycles. Structured
Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience. Throughout her mini unit plan Julia gradually moved from Structured Inquiry to Guided Inquiry, inquiry in which the teacher develops a question and allows the students to co-construct the experimental design. She then moved towards Coupled Inquiry, inquiry that starts as Structured Inquiry or teacher Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control. Julia gradually lessened teacher control as she allowed students to ask questions about pushes and pulls, design their own mini experiments, and discuss the results with their classmates and teacher. Julia has successfully implemented the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002).

*Science Teaching Efficacy Belief Instrument – STEBI Analysis Pre and Post*

Julia’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments decreased notably, with 64 points and 56 points respectively (max=65 points) (see Figure 16); however, both scores were in the high efficacy category indicating that she was comfortable with her ability to teach science. Her Outcome Expectancy subscale scores for the pre and post assessments decreased slightly, with 54 points and 51 points respectively (max=60 points); however, both scores were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). In her pre PSI Professional Development Course interview session Julia noted that she is able to integrate her knowledge of teaching methods and content information. She feels confident and enthusiastic about teaching
science. This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled

*Julia’s Partner Portfolio for Professional Development Analysis.*

*Constructivist Learning Environment Survey – CLES Analysis Pre and Post*

As noted in Research Question 1 analysis, Julia’s pre (35) and post (34) CLES Personal Relevance scores were in the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences. Her pre (25) and post (21) CLES Scientific Uncertainty scores were in the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. The scores decreased slightly indicating that in the 2007-2008 class she provided fewer opportunities for students to engage in opportunities to learn to be skeptical and critical about the nature and value of science. Her pre (35) and post (35) CLES Critical Voice scores were both in the high agreement range which indicated that she placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediment to their learning. Her pre (22) and post (17) CLES Shared Control scores decreased notably from a high to low agreement range. This indicates that during the 2007-2008 school year she placed less emphasis on inviting students to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms for the classroom. Julia indicated that this decrease in score might have occurred because she was teaching a lower grade level of students. Julia indicated
that she might have answered questions 4, 33, and 40 differently if she were teaching at a higher grade level. Julia’s pre (34) and post (32) CLES Student Negotiation scores were both in the high agreement range which indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas. Her pre (32) and post (30) CLES Attitude Scale scores were in the high agreement range which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997). This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Julia’s Partner Portfolio for Professional Development Analysis.

Julia’s Partner Portfolio for Professional Development Analysis

The Partner Portfolio for Professional Development was employed to hold teacher reflections and permitted the opportunity for participants to manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Julia’s (a) Goal Statement, (b) Exit Slips, and (c) journal entries were analyzed to confirm the earlier mentioned data findings. This examination offers a triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003).

Data analysis for points of triangulation started with an examination of Julia’s description of her own efficacy and ability to produce a desired or intended result. Pre PSI Professional Development Course interview data shows that Julia gets excited when she thinks about science. When she thinks about science she thinks about fun, excitement,
exploration, discovery, challenge, and life. Julia’s Personal Science Teaching Efficacy Belief subscale scores, from the STEBI analysis, for the pre and post assessments decreased notably, with 64 points and 56 points respectively (max=65 points) (see Figure 16); however, both scores were in the high efficacy category indicating that she was comfortable with her ability to teach science (see Appendix C1 for instrument and C2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). An excerpt from an Exit Slip in Julia’s Partner Portfolio for Professional Development further supports the idea that Julia is feels comfortable with and is excited about teaching I-B science. She notes the she is “anxious to create ready made usable centers and task cards” as she is “setting up the science center to better utilize the inquiry method.”

In her pre PSI Professional Development Course interview analysis, data showed that Julia is able to integrate her knowledge of teaching methods and content information. She feels confident and enthusiastic about teaching science. Julia’s STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased notably, with 54 points and 51 points respectively (max=60 points); however, both scores were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Julia’s pre (22) and post (17) CLES Shared Control scores decreased notably from a high to low agreement range. This indicates that during the 2007-2008 school year she placed less emphasis on inviting students to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms for the classroom (Suters, 2004; Taylor et al., 1997). Julia indicated that this decrease in her score might have occurred because she was teaching a lower
grade level of students at the beginning of the 2007-2008 school year. Julia’s students changed from a group of graduating second graders to a fresh new group of beginning first graders. The following excerpt from Julia’s Partner Portfolio for Professional Development, she further explains Julia’s thoughts as she uses a metaphor to describe the shift or change she encounters every two years.

I am a “looping teacher” so I am constantly changing [grade level, materials, curriculum] I often feel as though I am “flitting” about from flower to flower [or child to child]. My flower garden and the butterflies in it act as a metaphor for my life.

In summary, Julia is able to integrate her knowledge of teaching methods and content. She feels confident and enthusiastic about teaching science. In Julia’s classroom, students are invited to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms for the classroom. Julia alters the amount or degree of student choice based on the age, grade level, or abilities of the students she is teaching.

Data analysis for points of triangulation was conducted to examine Julia’s description of her own framework for understanding science content and teaching methods. Pre PSI Professional Development Course interview data showed Julia recalls a good training program while at a state university. Julia’s classes in teaching science utilized early childhood concepts and science methodology. Classes in her masters program combined hands-on activities as well as theory. The following excerpt from Julia’s Goal Statement in her Partner Portfolio for Professional Development supported the idea that Julia would like to add to her strong background or training in the area of science instruction. She writes that she would like “to be equipped with materials and ideas to ideally set up my classroom to implement the inquiry method in science.” An
excerpt from an Exit Slip in Julia’s Partner Portfolio for Professional Development supported and extended the idea that Julia would like to add to her science training. Julia wrote, “I’d like to read the [Douglas Llewellyn] book and better understand the inquiry process, more in depth.” In summary, learning more about the inquiry process and setting up her classroom to implement I-B methods interests Julia.

Julia explained in her pre PSI Professional Development Course interview that she uses a number of methods that all relate to the inquiry approach. Julia used the following methods in her post PSI Professional Development Course observation lesson: whole class instruction, small group work, center activities, discussion, questioning, experimentation, and use of science process skills including sorting and classification. Julia uses a large array of assessments to determine if students understand a concept, including: observation, written work, questioning, discussion, art, and paper and pencil tests. Julia’s pre (34) and post (32) CLES Student Negotiation scores were both in the high agreement range which indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas (Suters, 2004; Taylor et al., 1997). The following excerpt from Julia’s Invitation to Practice: Mapping My Classroom activity in her Partner Portfolio for Professional Development supported the idea that Julia places an emphasis on uses a number of methods that all relate to the inquiry approach. “I did not change my classroom because I already had a science table and observation areas in the classroom [bulletin boards, also]. We incorporate science throughout the classroom as well.” In summary, Julia used methods that relate to the
inquiry approach and allow students the opportunity to work together to explain ideas, make sense of ideas, and reflect on their ideas.

Last, data analysis for points of triangulation was conducted to examine Julia’s description of her own framework for understanding I-B methods. Pre PSI Professional Development Course interview data revealed that Julia defines inquiry science as taking yourself through the scientific method using a variety of hands-on methods to develop a deeper understanding as you arrive at a conclusion. Following the PSI Professional Development Course she further described inquiry science in this way, “the inquiry approach to science is a methodical plan which captivates the students. It incorporates the 5E’s and is very much hands on and exciting.” This idea was supported by the pre PSI Professional Development Course and post PSI Professional Development Course observation data. Throughout her mini unit plan Julia successfully implemented several forms of inquiry as described by Martin-Hansen (2002). Julia gradually moved from Structured Inquiry to Guided Inquiry, and then to Coupled Inquiry, Julia gradually lessened teacher control as she allowed students to asked questions about pushes and pulls, designed their own mini experiments, and discussed the results with their classmates and teacher. Julia has gradually moved toward the implementation using the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). Julia’s Outcome Expectancy subscale scores, from the STEBI analysis, were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes (Riggs, 1988; Riggs & Enochs, 1990). In a journal entry from her Partner Portfolio for Professional Development, Julia explained that she “planned and used an inquiry based
unit utilizing the 5E’s” In summary, Julia has successfully implemented several forms of inquiry including: Structured Inquiry, Guided Inquiry, and Coupled Inquiry. Julia has gradually moved toward the implementation using the model of Full or Open Inquiry. Julia has confidence in her ability to implement I-B methods into her classroom.

Summary of Julia’s Results for Research Question 2

Research Question 2 seeks information to explain the following: “How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?” To offer an explanation, one must understand that Julia’s cognitive framework incorporates her knowledge of science content and teaching methods. Her conceptions of science subject matter or content knowledge include ideas, facts, and concepts of the discipline, as well as the relationships among those concepts, facts, and ideas. Information related to Julia’s cognitive framework was exposed through data analysis. Julia is able to integrate her knowledge of teaching methods and content information. She feels confident and enthusiastic about teaching science. Julia is interested in learning more about the inquiry process and setting up her classroom to implement I-B methods. Julia alters the amount of student choice based on the age, grade level, or ability. Julia used methods that relate to the inquiry approach, allowing students to work together to explain ideas, make sense of idea, and reflect on their ideas. Julia has successfully implemented several forms of inquiry including: Structured Inquiry, Guided Inquiry, and Coupled Inquiry. Julia has gradually moved toward the implementation using the model of Full or Open Inquiry. Julia has confidence in her ability to implement I-B methods into her classroom.
Research Question 3 Analysis

What barriers to implementing I-B methods exist?

Interview analysis (see Appendix B for the instrument) for Research Question 3 includes an examination of Julia’s Goal Statement, and selected pre PSI Professional Development Course and post PSI Professional Development Course interview questions listed in Table 1. To build credibility, data findings were compiled through (a) STEBI surveys, (b) CLES surveys, (c) direct observation of the participant’s teaching, and data from the (d) Partner Portfolio for Professional Development, which included Lesson Plans for the mini-unit, Invitation to Practice: Mapping My Classroom activity, Exit Slips, Quick Writes, and various journal entries. The researcher made use of this data to study the teacher’s mental models in an effort to uncover patterns that shape teaching behavior as it relates to her Shared Identity (SI), the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents his or her shared identity or role as part of the professional community. In other words, the researcher has assembled the pieces to answer the teacher’s query, “How does Julia describe her abilities to produce desired or intended results in her science classroom as it relates to barriers to implementation of I-B science methods?”

Julia’s Goal Statement Analysis

A teacher’s attitudes and beliefs about science are key influences on how they teach the subject of science. The reality of the school classroom consists of lessons in which teachers transmit science as a set of facts, laws, and data. The teachers’ principles or attitude, their tendency to respond favorably or unfavorably toward the topic of
science, students or other objects, determines what students will see, hear, think, and do. The teachers’ styles, principles, are rooted in experience and develop into individual constructs slowly over time (Souza Barros & Elia, 1998). Based upon these ideas, Julia’s tendency to respond favorably or unfavorably towards a science topic, her students or other objects, determines what her students will see, hear, think, and do in her science classroom. During the PSI Professional Development Course, Julia set her own goal related to the implementation of I-B science instruction (Hammerness et al., 2005).

Examining Julia’s PSI Professional Development Course goal allowed the researcher to study her attitude towards implementation of I-B methods into her science classroom. Throughout the duration of the PSI Professional Development Course, Julia was interested in learning “how to implement inquiry using manipulatives, wondering, and questioning ideas for teaching children.” Julia noted that she would also like to gain further knowledge related to the following: “How to effectively set up my classroom to maximize learning potential for students.” Julia’s goal for the PSI Professional Development Course was to learn “to be equipped with materials and ideas to ideally set up my classroom to implement the inquiry method in science.” This goal reveals that Julia is interested in learning how to effectively implement inquiry science teaching methods or techniques, and that she is interested in setting up her science classroom to maximize learning potential for her children.

*Julia’s Interview Analysis: Pre and Post Professional Development Course*

Interview analysis for Research Question 3 included the analysis of the pre PSI Professional Development Course interview questions numbered 4, 7, 8, and 9. This allowed the researcher to gather information to provide a picture of what was happening
Julia’s science classroom and school building, thus providing information related to Julia’s knowledge and practice at the beginning of the research (Davis, 2002). As noted in Research Question 2 analysis, pre PSI Professional Development Course interview data analysis showed that Julia used a number of science teaching methods that all relate to the inquiry approach. The researcher observed, both prior to the PSI Professional Development Course and then again and following the PSI Professional Development Course, that Julia often utilizes a variety of strategies and techniques in her science classroom. Julia utilized the following teaching methods in her post PSI Professional Development Course observation lesson: whole class instruction, small group work, center activities, discussion techniques, questioning, experimentation, and the use of science process skills including sorting and classification. Julia uses a large array of assessment techniques or formats in each science lesson to determine if students understand a science concept, including: observation, written work, questioning, discussion techniques, art projects, and paper and pencil tests. Interview codes and transcript statements for Julia’s pre PSI Professional Development Course interview session and her post PSI Professional Development Course interview sessions are listed in Table 33.
Table 33.

Interview Codes and Transcript Statements for Julia (T8) Pre and Post – Research Question 3.

**Barriers to Implementation of I-B Methods**

<table>
<thead>
<tr>
<th>Time for Science Instruction and Time Related to Curriculum Guidelines</th>
<th>Support</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: Always assessment, because to me that is such a hard thing. I think that you really need to be assessing through observation and what not, but finding the time to log what you are observing while you are teaching has always been, I think, and overly difficult thing. Maybe I should say an easier way to assess. It’s not just their written work that you take home and look at. I feel when I make my assessments I know they’re valid because I know I’ve seen it. But, it’s showing someone else what did I base that upon. Finding the time to put that into writing I suppose has always been my hardest, to be able to document my assessment. I feel very comfortable with where I have them within that assessment and the different tools I use. But again, it’s finding the time to document all of that. No time. It’s the time constraint; if I could just go around and log it. But as I am going around, I am usually interacting. So that part is the hard part to me. (Testing) (Time)</td>
<td>Pre: No, if the school can’t supply it you’d just go out and get it. The only thing might be lack of supplies, the kids, or the parents. There is really no reason. It is satisfying to watch these kids grow. I don’t know how people do it who don’t love kids. I use a lot of creative open-ended activities. We keep going with a million different ideas. There is almost too much to choose from. (Supplies) (Students) (Parents)</td>
<td></td>
</tr>
<tr>
<td>Post: “They only determine what I teach. I feel total freedom that they have the confidence that I will select the best approach.” “I plot out the areas of study for the nine weeks. Unfortunately, there are time constraints and the calendar determines when I must move on. I try to select concepts that build upon one another.” (Time to teach) (Pacing)</td>
<td></td>
<td>Pre: Parents are a big influence. It’s like training parents to know not to expect worksheets, that the classroom is hands-on. Parents come in to help with the hands-on activities. Parental participation is essential. They send in science supplies. It takes a village. (Parents) (Supplies)</td>
</tr>
<tr>
<td>Post: When asked if there was anything that inhibits her from using I-B methods in her science classroom, Julia responded with one word, “Nothing.”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Julia’s teaching team at her school consisted of her CF, Sara, and four other teachers on their grade level. The other four teachers are not looping with their students; they work with each group of students for one school year. Julia teaches at the same school as Liz (T3). The excerpt below illustrates the level of support Julia indicates that she feels she has received from her administration and school team.

Our team, beginning with Warren Talbot [principal at the time], he encouraged multiage, stretching everything, and he fostered hands-on. He allowed us to venture out into uncharted territories. Those of us back in that time benefited from that. We had a good science lab. Liz was responsible for that. We had to give it up with the growing population because we needed the classroom space. We had gardens, and a shed for gardening tools. That was all before the SOL has come into play. I’d love to see them come back more.

The excerpt that follows shows how her administration has influenced Julia’s choice of teaching methods.

They want to see the kids engaged. We are fortunate to have administrators who want kids moving around the classroom. This impacts your freedom to design the classroom the way you best know how. Due to the SOL things have changed. We have PTO funds. If you show a need they come through. I am grateful that Warren Talbot encouraged us to stretch. He stressed multiage. I am grateful to see and be a part of that. He stretched, encouraged, supported, and got us materials. The subsequent administration has been supportive as well.

Julia states that one of her previous administrators “encouraged multiage, stretching everything and he fostered hands-on.” She further indicates that “subsequent administration” was also supportive. Research supports that it is important that administrators and teammates are supportive of teachers while they implement the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). In summary, data from the pre PSI Professional Development Course interview analysis showed that Julia is receiving the support she needs from teammates.
and administrators in order to successfully implement I-B science methods into her classroom.

Although Julia possesses the desire to implement I-B methods, feels confidence in her teaching ability, and believes her CF, colleagues and administration support her; there may be other barriers that inhibit Julia to fully carry out her science-teaching vision. Appropriately, the researcher next looked at likely threats to fidelity or barriers to use of I-B instruction besides lack of administrative and peer support. This task was completed using data gathered from interviews and classroom observation, thus allowing the researcher to identify connections or relationships between Julia’s perceptions and use of I-B instruction (Davis, 2002).

Analysis of the pre PSI Professional Development Course interview questions revealed that Julia feels confident that she faces no barriers as she works to implement I-B methods in her classroom. She did discuss a number of barriers that might prevent her from using I-B methods if her school climate were different. Julia feels that the only barriers that might exist include time related to assessing student work, a lack of supplies, the kids, or parents. Julia finds that the factor time related to assessing student work is a concern she feels when planning to teach science in her classroom. This excerpt from the pre PSI Professional Development Course interview outlining how she would like to improve as a teacher illustrates Julia’s beliefs about time constraints related to assessing inquiry instruction.

Always assessment, because to me that is such a hard thing. I think that you really need to be assessing through observation and what not, but finding the time to log what you are observing while you are teaching has always been, I think, and overly difficult thing. Maybe I should say an easier way to assess. It’s not just their written work that you take home and look at. I feel when I make my
assessments I know they’re valid because I know I’ve seen it. But, it’s showing someone else what did I base that upon. Finding the time to put that into writing I suppose has always been my hardest, to be able to document my assessment. I feel very comfortable with where I have them within that assessment and the different tools I use. But again, it’s finding the time to document all of that. No time. It’s the time constraint; if I could just go around and log it. But as I am going around, I am usually interacting. So that part is the hard part to me.

The excerpt that follows outlines Julia’s answer to the question, “Are there things that inhibit you from using inquiry science?”

No, if the school can’t supply it you’d just go out and get it. The only thing might be lack of supplies, the kids, or the parents. There is really no reason. It is satisfying to watch these kids grow. I don’t know how people do it who don’t love kids. I use a lot of creative open-ended activities. We keep going with a million different ideas. There is almost too much to choose from.

Julia clarifies her statement about the influence of parents and supplies on her classroom in the excerpt that follows.

Parents are a big influence. It’s like training parents to know not to expect worksheets, that the classroom is hands-on. Parents come in to help with the hands-on activities. Parental participation is essential. They send in science supplies. It takes a village.

In summary, Julia believed that she did not face any barriers to the implementation of I-B science instruction. She felt that if barriers existed they would be time related to assessing student work, a lack of supplies, the kids, or parents. The parents of Julia’s students support her by helping out in the classroom and sending in supplies for I-B science activities.

Interview analysis for Research Question 3 also included the analysis of the post PSI Professional Development Course interview questions numbered 3, 4, 6, and 7. Data analysis continued with the assumption that Julia might have encountered possible threats to fidelity or barriers to use of I-B instruction. This process allowed for further
identification of connections or relationships between Julia’s perceptions and use of inquiry instruction (Davis, 2002). Analysis of the post PSI Professional Development Course interview questions revealed that Julia believed that she did not face any barriers to the implementation of I-B instruction. Julia notes that the way she teaches is not influenced by any local, school, or state regulations. She explains in her post PSI Professional Development Course interview session, “They only determine what I teach. I feel total freedom that they have the confidence that I will select the best approach.” Julia feels pressured by time constraints, however this only influences the amount of time she spends on a concept, not the method she chooses to teach the concept. Julia notes she decides to move from one concept to another through the following process, “I plot out the areas of study for the nine weeks. Unfortunately, there are time constraints and the calendar determines when I must move on. I try to select concepts that build upon one another.” Julia is able to overcome the barriers she faced while implementing I-B methods. When asked if there was anything that inhibits her from using I-B methods in her science classroom, Julia responded with one word, “Nothing.”

In summary, analysis of the pre PSI Professional Development Course interview questions revealed that Julia believed that she did not face any barriers to the implementation of I-B instruction. She felt that if barriers existed they would be time related to assessing student work, a lack of supplies, the kids, or parents. Julia does not face any of these issues at the present time. In post PSI Professional Development Course interview questions Julia explained that she does not feel that anything at the local, school, or state level inhibits her from implementing I-B methods.
Science Teaching Efficacy Belief Instrument – STEBI Analysis: Pre and Post

Details of the STEBI results were noted in Research Question 1 analysis. Julia’s Personal Science Teaching Efficacy Belief subscale scores for the pre PSI and post assessments decreased notably, with 64 points and 56 points respectively (max=65 points) (see Figure 16); however, both scores were in the high efficacy category indicating that she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased slightly, with 54 points and 51 points respectively (max=60 points); however, both scores were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes in her science classroom (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). In her pre PSI Professional Development Course and post PSI Professional Development Course interview sessions, Julia explained that she believed that she did not face any barriers to the implementation of I-B instruction. Julia feels confident in her ability to integrate her knowledge of teaching methods and content information. This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled Julia’s Partner Portfolio for Professional Development Analysis.

Constructivist Learning Environment Survey – CLES Analysis: Pre and Post

Details of Julia’s CLES scores were noted in Research Question 1 analysis. Julia’s pre (35) and post (34) CLES Personal Relevance scores fell into the high agreement range which indicated that she placed a high emphasis on linking school science with students’ everyday experiences. Her pre (35) and post (35) CLES Critical
Voice scores were both in the high agreement range which indicated that she placed a high emphasis on encouraging students to question her plans and methods and express concerns about impediment to their learning. Julia’s pre (34) and post (32) CLES Student Negotiation scores were both in the high agreement range which indicated that she placed a high emphasis on providing opportunities for students to: explain their ideas to other students, make sense of other students’ ideas, and to reflect on the viability of their own ideas. Her pre (32) and post (30) CLES Attitude Scale scores were in the high agreement range which indicated that she felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997). Pre PSI Professional Development Course interview analysis supported survey findings, showing that Julia used a number of methods that all relate to the inquiry approach strategies in her science classroom.

Julia’s Scientific Uncertainty and Shared Control scores offer insight into her thoughts related to the age level of her students. Julia’s pre (25) and post (21) CLES Scientific Uncertainty scores fell into the high intermediate agreement range, which indicated that she often but not always emphasized engaging students in opportunities to learn to be skeptical and critical about the nature and value of science, in particular to learn that scientific knowledge is: evolving and provisional, shaped by social and cultural influences, and arises from human interests and values. The scores decreased slightly indicating that in the 2007-2008 class she provided fewer opportunities for students to engage in opportunities to learn to be skeptical and critical about the nature and value of science. Her pre (22) and post (17) CLES Shared Control scores decreased notably from a high to low agreement range. This indicates that during the 2007-2008 school year she
placed less emphasis on inviting students to: participate in designing their own learning activities, determine assessment criteria, and negotiate the norms for the classroom. Julia indicated that this decrease in score might have occurred because she was teaching a lower grade level of students. Julia indicated that she might have answered questions 4, 33, and 40 differently if she were teaching at a higher grade level (see Appendix D1 for instrument and D2 for scoring instructions) (Suters, 2004; Taylor et al., 1997). This comment supports Julia’s pre PSI Professional Development Course interview thought that one of the only barriers that might exist while implementing I-B methods is related to “the kids.” This data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003) in the section titled *Julia’s Partner Portfolio for Professional Development Analysis.*

*Julia’s Partner Portfolio for Professional Development Analysis*

Throughout the PSI Professional Development Course teachers were allowed the opportunity to reflect and take charge of their thoughts and behaviors through reflection, planned processing, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). This information was assembled in Julia’s Partner Portfolio for Professional Development. To confirm the previously mentioned data findings as triangulation of multiple data sources provides for multiple measures of the same phenomenon (Yin, 2003) the following data were analyzed: (a) the Invitation to Practice: Mapping My Classroom activity, (b) the Invitation to Practice: Collaboration activity, (c) Exit Slips, (d) Quick Writes, and (e) journal entries. Analysis of the pre PSI Professional Development Course interview questions revealed that Julia believed that she did not face any barriers to the implementation of I-B instruction. She felt that if barriers existed they
would be time related to assessing student work, a lack of supplies, the kids, or parents. Julia does not face any of these issues at the present time. In post PSI Professional Development Course interview questions Julia explained that she does not feel that anything at the local, school, or state level inhibits her from implementing I-B science methods.

Pre PSI Professional Development Course and Post PSI Professional Development Course interview data revealed that Julia believed that she did not face any barriers to the implementation of I-B science instruction. This was confirmed and explained further as Julia noted in one of her exit slips the answer to the question, “Is there anything you think you might have a difficult time implementing in your classroom?” Julia said, “no.” In fact, she answered that question the same way on two different occasions. Julia further noted that she was “anxious to create ready made usable centers and task cards.”

*Julia’s Classroom Observation: Pre and Post Professional Development Course*

A barrier to implementation of I-B science methods surfaced as the researcher attempted to schedule a date to conduct the post PSI Professional Development Course observation. The excerpt that follows, dated September 7, 2007 two weeks into the new school year, reveals that the teaching of social studies was a barrier, not just to the implementation of I-B methods, but, to the teaching of science in general.

Sara and I are doing social studies right now (citizenship), which was more conducive to starting off the year. We will be starting science in two weeks with the investigation and exploration SOL doing experiments. I will let you know the exact dates.
The amount of time in Julia’s schedule for teaching each subject served as a barrier to science instruction. The subject area of social studies instruction emerged as a barrier to science instruction.

As noted in Research Question 2 analysis, data from Julia’s science lesson plans, the pre PSI Professional Development Course lesson observation, and the post PSI Professional Development Course lesson observation revealed that she has successfully implemented several forms of inquiry as described by Martin-Hansen (2002). Structured Inquiry, in which the teacher directs the methods of inquiry, was observed during the pre PSI Professional Development Course lesson observation as students rotated through the frog themed centers exploring the concept of life cycles. Structured Inquiry is defined as inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience. Throughout the implementation of her mini unit plan, Julia gradually moved from the use of Structured Inquiry to Guided Inquiry, inquiry in which the teacher develops a question and allows the students to co-construct the experimental design, to the use of Coupled Inquiry, inquiry that starts as Structured Inquiry or teacher Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control. Julia gradually lessened teacher control as she allowed students to create and ask questions about the concept of pushes and pulls, designed their own mini experiments, and discussed the results with their classmates and teacher. Julia has gradually moved toward the implementation using the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002).
Summary of Julia’s Results for Research Question 3

Julia’s professional development goal revealed that she is interested in learning how to effectively implement inquiry into her science classroom. Julia is also curious about setting up her classroom to maximize learning potential for children. During the PSI Professional Development Course Julia worked with her CF, Sara, to create and implement an I-B science lesson plan, about pushes and pulls, into each of their classrooms. Classroom observation data revealed that Julia is successfully implementing inquiry teaching methods into her science classroom. Julia has implemented several forms of inquiry as described by Martin-Hansen (2002), including: Structured Inquiry, Guided Inquiry, Coupled Inquiry and Full or Open Inquiry. Analysis of the pre PSI Professional Development Course interview questions revealed that Julia believed that she did not face any barriers to the implementation of I-B instruction. She felt that if barriers existed they would be time related to assessing student work, a lack of supplies, the kids, or parents. Julia does not face any of these issues at the present time, however the age or readiness level of her students did affect the level of inquiry used. In post PSI Professional Development Course interview questions Julia explained that she does not feel that anything at the local, school, or state level inhibits her from implementing I-B methods, although the researcher observed that the amount of time in the schedule split between the teaching of science and social studies served as a barrier to science instruction.


Research Question 4 Analysis

What relationships exist between teachers’ perceptions and use of I-B methods?

Data were analyzed to address the query, “What relationships exist between Julia’s perceptions and use of I-B methods?” Interview analysis (see Appendix B for instrument) for Research Question 4 includes the examination of (a) post PSI Professional Development Course interview questions 2, 3, 6, and 7 listed in Table 1, (b) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (c) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (d) Partner Portfolio for Professional Development. Influences such as Julia’s culture, educated-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual and style have influenced her beliefs about I-B methods. The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI).

Dewey (1938, 1997) proposed that experience transpires from interrelationships of two principles, continuity and interaction. Continuity refers to how each experience a person has influences one’s future, for better or for worse. Interaction refers to the situational influence on one’s experience. The individual’s present experience is a function of the interaction between their past experiences and the present situation. No experience has a pre-destined value. Therefore, what might be a favorable experience for one individual could unfavorable for another. In other words, "positive experiences" motivate, encourage, enabling students to go on to have more valuable learning
experiences, whereas, "negative experiences" tend to lead to a student closing off from potential positive experiences in the future. Dewey believed learning experiences should be meaningful to students and teachers should act as facilitators (Dewey, 1938, 1997).

Going back to the bucket metaphor described in the researcher’s conceptual framework, Julia examined the shells and treasures introduced at the PSI Professional Development Course and made a decision to either keep each one and place it in her bucket, or place it back on the beach based on her own system of values. The unearthing of treasures of considerable value produced a positive influence on Julia’s motivation, attitude, caring, determination and effort. The discovery of treasure with modest value had a negative influence on Julia’s motivation, attitude, caring, determination and effort. Data findings were drawn on to illustrate Julia’s cognitive framework related to inquiry, her beliefs about inquiry teaching, and how this ties into her daily experiences. This information is vital to understanding teacher change related to inquiry (Keys & Bryan, 2000; Spillane et al., 2002).

Julia’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 4 includes the analysis of the post PSI Professional Development Course interview questions numbered 2, 3, 6, and 7. A qualitative research design served as an appropriate methodology to utilize to examine any relationships the might exist between Julia’s perceptions and use of I-B methods, seeing as qualitative research is concerned with the perceptions of the participants and with process rather than outcomes or products (Bogdan & Biklen, 1992; Marshall & Rossman, 2006). This design serves as an appropriate methodology to utilize to define inquiry as it is perceived and used by Julia. Data findings were drawn upon to first
illustrate Julia’s cognitive framework related to inquiry. As noted in Research Question 2, this excerpt from Julia’s pre PSI Professional Development Course interview reveals how she defines inquiry science.

For me I have a real positive feel because then you’re delving into it. You’re inquiring. Inquiring minds want to know. So when I think inquiry, I think you have something that you want to understand deeper and you are going to have to come to an understanding to acquire that knowledge. So, to me it’s a hands-on way to learn the end product. That’s what inquiry science means to me. You are inquiring and you are doing it through a variety of methods until you can come to a conclusion. Basically taking yourself through the scientific method.

Julia believes that inquiry science involves taking yourself through the scientific method using a variety of hands-on methods to develop a deeper understanding as you arrive at a conclusion. Julia describes her own framework for understanding I-B before the PSI Professional Development Course in her post PSI Professional Development Course interview, saying, “I knew what worked but did not have a systematic approach prior to the session.” She continues to explain, “I now have a systematic approach that organized my lessons and engages the students.” In her post PSI Professional Development Course interview session, Julia expanded her definition of inquiry science, “the inquiry approach to science is a methodical plan which captivates the students. It incorporates the 5E’s and is very much hands on and exciting.” In summary, Julia felt that I-B methods were effective. Julia has developed a systematic approach that she can use to design lessons and engage students through participation in the PSI Professional Development Course.

Then data findings were drawn on to reveal her beliefs about inquiry teaching. Julia gets excited when she thinks about science. Pre PSI Professional Development Course interview data showed that when she thinks about science she thinks about “…exploration, discovery, and challenge.” Julia was interested in inquiry and in
implementing I-B methods into her classroom. This is evident in the excerpt that follows in which Julia explains why she signed up for the PSI Professional Development Course.

I was interested in inquiry. I know about it based on what I read. I would like to come back and utilize it in the classroom. I am looking for ways to motivate children. I find make and take helpful. Also for me, I like to vary the disciplines. This time I was looking for science.

In summary, Julia is excited about inquiry science and looks forward to implementing it.

As a final point, data findings were examined to see how Julia’s cognitive framework related to inquiry and her beliefs about inquiry teaching tie into her daily experiences. This excerpt for Julia’s post PSI Professional Development Course interview session reveals information about Julia’s cognitive framework. “I already believed in engaging the students with “hands-on” learning, so I have always had a science center and area of investigation. It has provided me with more of a framework for designing my lessons.” Julia explains that she was already using teaching methods in her daily experiences that were appropriate for implementation of I-B methods.

In summary, Julia felt that she understood that I-B methods were effective. Julia has developed a systematic approach that she can use to design her lessons and engage students. Julia is excited about inquiry science and looks forward to implementing it into her classroom. Julia was already using teaching methods in her daily experiences that were appropriate for implementation of I-B methods. The PSI Professional Development Course provided her with a “framework for designing” her lessons.

*Julia’s Goal Statement Analysis*

Julia was interested in learning “how to implement inquiry using manipulatives, wondering, and questioning ideas for teaching children” through participation in the
course of the PSI Professional Development Course. Julia also wanted to gain knowledge of “how to effectively set up my classroom to maximize learning potential for students.” Julia’s goal for the PSI Professional Development Course was to learn “to be equipped with materials and ideas to ideally set up my classroom to implement the inquiry method in science.” This goal reveals that Julia is interested in learning how to effectively implement inquiry and setting up her classroom to maximize learning potential for children. Julia places a high value on inquiry, which, in turn, produces a positive influence on Julia’s motivation, attitude, caring, determination, and effort.

*Science Teaching Efficacy Belief Instrument - STEBI Analysis: Pre and Post*

Details of Julia’s STEBI results were noted in Research Question 1 analysis, *Science Teaching Efficacy Belief Instrument – STEBI analysis* (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Julia’s STEBI data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003). Julia’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre and post assessments decreased notably, with 64 points and 56 points respectively (max=65 points) (see Figure 16); however, both scores were in the high efficacy category indicating that she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores for the pre and post assessments decreased slightly, with 54 points and 51 points respectively (max=60 points); however, both scores were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes. This data supports Julia’s goal statement, which shows that Julia is interested in learning
how to effectively implement inquiry and setting up her classroom to maximize learning potential for children.

*Julia’s Partner Portfolio for Professional Development*

Julia took part in activities that allowed her to reflect upon and manage her thoughts and behaviors through strategic processing, reflection and collaboration throughout the PSI Professional Development Course (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Julia’s portfolio data provided additional pieces that were used to solve the query, “What relationships exist between Julia’s perceptions and use of I-B methods?” Analysis focused on relationships connecting Julia’s perceptions as they connected to her practice. Emic accounts, descriptions of behaviors in terms meaningful to the teacher, were used because these accounts are culture specific or are found in the context of the teacher’s classroom (Stake, 2006). The researcher completed three steps in analyzing the partner portfolio. First, Julia’s definition of inquiry, Julia’s methods of instruction, and the definition of inquiry used during the PSI Professional Development Course were reviewed for comparison. Julia’s definition of inquiry and choice of teaching methods was examined. Second, a review of the findings from Julia’s Interview analysis, Goal Statement analysis, and STEBI analysis was conducted. Third, emic accounts were compared to excerpts from Julia’s mini unit plan, the post PSI Professional Development Course lesson observation, and numerous journal entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). Each of these steps is discussed next.

First, the researcher examined Julia’s definition of inquiry. Julia believes that inquiry science involves taking yourself through the scientific method using a variety of
hands-on methods to develop a deeper understanding as you arrive at a conclusion. As noted in Research Question 2, this excerpt from Julia’s pre PSI Professional Development Course interview reveals how she defines inquiry science.

For me I have a real positive feel because then you’re delving into it. You’re inquiring. Inquiring minds want to know. So when I think inquiry, I think you have something that you want to understand deeper and you are going to have to come to an understanding to acquire that knowledge. So, to me it’s a hands-on way to learn the end product. That’s what inquiry science means to me. You are inquiring and you are doing it through a variety of methods until you can come to a conclusion. Basically taking yourself through the scientific method.

Pre PSI Professional Development Course interview data also revealed that Julia felt that she understood that I-B methods were effective. Julia has developed a systematic approach that she can use to design her lessons and engage students through her participation in the PSI Professional Development Course.

Through the course of the PSI instruction, Julia had the opportunity to develop an understanding of the following topics: What is inquiry, learning through inquiry, developing a mind for constructivism, constructivism, how children learn, designing I-B classrooms, integrating I-B activities, the scientific method, learning cycles, skills and knowledge of I-B teachers, questioning. Julia also participated in sample I-B lessons that were modeled during the PSI Professional Development Course. In the journal entry titled “What is Inquiry?” Julia writes that inquiry is “questioning, wondering, inquisitiveness, investigating, satisfying curiosity, manipulating, observing, hands-on, sensory, seeking knowledge, and delving in.” In her post PSI Professional Development Course interview session, Julia expanded upon her definition of inquiry science, “The inquiry approach to science is a methodical plan which captivates the students. It incorporates the 5E’s and is very much hands on and exciting.”
Next, the researcher looked at Julia’s methods of instruction. As noted in Research Question 2 analysis, Julia uses a number of methods that all relate to the inquiry approach. Julia uses a variety of assessments to determine if students understand a concept, including: observation, written work, questioning, discussion, art, and paper and pencil tests. An excerpt from the Invitation to Practice: Collaboration activity reveals that Julia and her CF both “share the same philosophy of hands-on instruction” and they both take their “learning outside the classroom…” This excerpt from post PSI Professional Development Course interview data illustrates Julia’s beliefs about science teaching methods and how children learn science. Julia states, “Science is an investigative course of study. I encourage students to be curious, unafraid when they are wrong, and to test and prove their experiments. Basically, to follow the scientific method and explore.” Classroom observation data showed that showing that Julia is successfully implementing Julia has implemented several forms of inquiry as described by Martin-Hansen (2002), including: Structured Inquiry, Guided Inquiry, Coupled Inquiry and Full or Open Inquiry. During the mini unit, the students were then given the opportunity to design their own mini experiments and discuss the results with their classmates and teacher.

Then, the definition of inquiry used during the PSI Professional Development Course was reviewed for comparison with Julia’s definition of inquiry and choice of teaching methods. During the PSI Professional Development Course, inquiry instruction was defined as referring to any teaching method focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations and discover answers to their
questions about the natural world. Students may plan systems to collect data and choose how to organize and represent the data (Carin et al., 2004). The National Research Council (1998) defines scientific inquiry as:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world” (p. 23)

In summary, pre PSI Professional Development Course interview data revealed that Julia believes inquiry science involves taking yourself through the scientific method using a variety of hands-on methods to develop a deeper understanding as you arrive at a conclusion. In her portfolio, Julia writes that inquiry is questioning, wondering, inquisitiveness, investigating, satisfying curiosity, manipulating, observing, hands-on, sensory, seeking knowledge, and delving in.” Julia’s definition of inquiry is aligned with the definition used in the PSI Professional Development Course. In her classroom Julia uses a number of methods that all relate to the inquiry approach. Post PSI Professional Development Course interview data illustrates Julia’s beliefs about science teaching methods and how children learn science. Julia explains, “Science is an investigative course of study. I encourage students to be curious, unafraid when they are wrong, and to test and prove their experiments. Basically, to follow the scientific method and explore.” Julia’s choice of methods allow for integration or use of I-B methods.

The next step in placing the pieces of the puzzle to solve the query, “What relationships exist between Julia’s perceptions and use of I-B methods?” consisted of a
review of the findings from Julia’s (a) Interview analysis, (b) Goal Statement analysis, and (c) STEBI analysis. Beginning with her pre PSI Professional Development Course interview, Julia believes she is learning when she is “seeing” and “doing” or when her teachers use a constructivist approach, they provided relevant experiences and opportunities that allowed teachers to construct knowledge (Piaget, 1929; Vygotsky, 1978). Julia’s goal statement shows that Julia is interested in learning how to effectively implement inquiry and setting up her classroom to maximize learning potential for children. Julia uses a number of methods that all relate to the inquiry approach in her classroom Julia’s STEBI data serves as a source for triangulation of multiple data sources and provides for multiple measures of the same phenomenon (Yin, 2003). Julia’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (64) and post (56) assessments decreased notably, however, both scores were in the high efficacy category indicating that she was comfortable with her ability to teach science. Her STEBI Outcome Expectancy subscale scores, for the pre (54) and post (51) assessments decreased slightly; however, both scores were in the high expectancy category indicating that she had confidence in her teaching ability to create desirable outcomes (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Pre PSI Professional Development Course interview data also revealed that Julia felt that she understood that I-B methods were effective. Julia has developed a systematic approach that she can use to design her lessons and engage students through her participation in the PSI Professional Development Course. Julia is interested in learning how to effectively implement inquiry and setting up her classroom to maximize learning potential for children. In an Exit Slip entry, Julia writes that she learned, “A
better way to formulate questions to promote inquiry.” She shows her interest in maximizing learning potential for children when she reveals that she will “set up the science center to better utilize the inquiry method.” Julia’s portfolio data support both her goal statement and her STEBI scores, which illustrate that she is interested in learning how to effectively implement inquiry and setting up her classroom to maximize learning potential for children, and that she is capable of choosing which methods she uses in her classroom. Julia’s attitude had an influence in her decision to choose to implement I-B methods into her science classroom.

**Summary of Julia’s Results for Question 4**

Research Question 4 asked, “What relationships exist between teachers’ perceptions and use of I-B methods?” The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI). Data analysis for Research Question 4 showed that Julia is interested in learning how to effectively implement inquiry and setting up her classroom to maximize learning potential for children. Pre PSI Professional Development Course interview data also revealed that Julia felt that she understood that I-B methods were effective. Julia has developed a systematic approach that she can use to design her lessons and engage students through her participation in the PSI Professional Development Course. The perception that I-B methods hold large or great value had a positive influence on Julia’s motivation, attitude, caring, determination and effort during implementation of the methods in her classroom. Julia’s definition and vision of inquiry matches her choice of methods for instruction. Julia’s choice of methods allow for integration or use of I-B methods.
Research Question 5 Analysis

How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Interview analysis (see Appendix B for instrument) for Research Question 5 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, 8 and 9 listed in Table 1, (b) post PSI Professional Development Course interview question 6, (c) post PSI Professional Development Course classroom observation analysis (see Appendix E for the Classroom Observation Protocol), and (d) the Partner Portfolio for Professional Development. This information was utilized to examine Teacher Choice (TC) in an attempt to disclose methods that encourage teachers like Julia to overcome resistance to implementing I-B teaching practices. When a teacher, like Julia, makes a choice she critically assesses the value of available options and chooses a course of action built on her own conceptual framework. Data analysis for Research Question 5 was completed through of a study of Julia’s conceptual framework composed of: her Individual Identity (II), the portion of the Julia’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or personal constructs (Scribner et al., 2002); Julia’s Subject Matter Knowledge (SMK), Julia’s knowledge of content matter and pedagogy (the art and science of being a teacher) and curriculum knowledge (Shulman, 1986); and Julia’s Shared Identity (SI), the portion of the Julia’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community.
Julia’s Interview Analysis: Pre and Post Professional Development Course

Interview analysis for Research Question 5 includes the analysis of the pre PSI Professional Development Course interview questions numbered 4, 5, 7, 8 and 9 as well as post PSI Professional Development Course interview question 6. Teacher Choice (TC) is influenced by mental models, “the images, assumptions, and stories, which we carry in our minds of our selves, other people, institutions, and every aspect of the world” (Senge, 1990). Interview analysis gave the researcher a glimpse of Julia’s Individual Identity (II). Julia describes herself as “enthusiastic.” Julia describes herself as “…excited to teach an I think they’re [the students] excited to learn.” As noted in Research Question 2, pre PSI Professional Development Course interview Julia reveals details about her teaching methods. One excerpt lists examples of the teaching methods Julia generally uses to teach science.

I would say inquiry approach, in that you set up your room so that it’s like a lab. The kids know the rules and regulations related to it. They know the information. They know where they’re going and they get to explore. I would say all of the methods that relate to the inquiry method being put into place in a classroom and allowing that opportunity to the kids is what works best.

Julia uses a variety of science teaching methods that all relate to the inquiry approach. In the following interview excerpt Julia details the science concepts she feels are the most important for her students to understand by the end of the school year.

I think that overall, they have to understand the scientific process. They learn to be good thinkers in science. Really, going through the scientific process. They know to look at a problem and think it through, observe, and record their observations. They do that in everything we teach in science and then come to a conclusion. No matter what we’re studying, I think it does hinge on the scientific process; that they go through all of those steps and then they are good critical thinkers. No matter what we’re studying in science I’d have to base it on that.
In summary, Julia feels it is important for students to understand the scientific process, to learn to be good thinkers, to think through problems, make observations, record data, and arrive at a conclusion. Julia uses a variety of science teaching methods that all relate to the inquiry approach. Julia is enthusiastic and excited about teaching science at her school.

Interview analysis also gave the researcher a glimpse into Julia’s early Subject Matter Knowledge (SMK). Undergraduate science courses usually convey science as a group of specifics and sets of laws to be memorized, instead of as a way of knowing about the natural world (NRC, 1998). Julia’s training experiences do not support this statement. Julia recalls a good training program while at a state university.

When I was training I thought we had a good program. We had to take a class in teaching science. This was in the state university of New York system and we had to do a methodology class in science but it was very much early childhood. I have a master’s degree in that. Everything in my masters program as well as that was very hands-on. It was not just theory. It was always emphasizing the importance of getting in there and having the kids participate in multi-sensory ways. So I feel very grateful because I know some preparation is not that way or are not that way now and I’m just glad that I got to see how well that did work. So I’m really happy that I had the opportunity to do that. That was good.

Julia’s classes in teaching science utilized early childhood concepts and science methodology. Classes in her masters program combined hands-on activities as well as theory.

Interview analysis also gave the researcher a glimpse of Julia’s Shared Identity (SI). Data analysis shows that her CF, her teammates, her administrators, her students, and the student’s parents influenced her choice of science teaching methods. Julia believed support from her administration and grade level team was positive. Julia explains, “They want to see the kids engaged. We are fortunate to have administrators
who want kids moving around the classroom. This impacts your freedom to design the classroom the way you best know how.” Julia’s Pre PSI Professional Development Course interview data showed that her CF and her teammates influence her science teaching.

Julia’s students and their parents also have an influence on her choice of science teaching methods. This excerpt from Julia’s pre PSI Professional Development Course interview session explains why Julia is motivated to choose inquiry methods. She reveals that her motivation is the excitement of her students.

Seeing the excitement of the students and knowing that’s what works. I wouldn’t do it any other way. The inquiry approach works for kids with special needs. A few examples are the frog activities that you observed, providing frog words at the center, the kids are mobile and able to move around, they have opportunities to display knowledge, think outside the box. It is exciting to have them display knowledge in a unique way. Inquiry allows that.

Julia is motivated to keep going because she wants finds it exciting when students are learning. The parents of her students are an important influence on her use of I-B methods.

Parents are a big influence. It’s like training parents to know not to expect worksheets, that the classroom is hands-on. Parents come in to help with the hands-on activities. Parental participation is essential. They send in science supplies. It takes a village.

Julia depends on parental support to facilitate a hands-on inquiry approach in her science classroom. She takes time to educate the parents so they understand her method of science instruction. Julia explained in her pre PSI Professional Development Course interview that local, school, or state regulations do not influence the way she teaches science. She explains in her post PSI Professional Development Course interview
They only determine what I teach. I feel total freedom that they have the confidence that I will select the best approach.”

Post PSI Professional Development Course interview data revealed that county and state curriculum standards only influence what she teaches. The standards do not influence her choice of science teaching methods. Julia explains, “…They only determine what I teach. I feel total freedom that they have the confidence that I will select the best approach.”

In summary, Interview data revealed that Julia makes choices about which methods to use to teach science in her classroom based upon the influences of her CF and her teammates, her students, and her students’ parents. Julia is motivated to keep going because she wants finds it exciting when students are learning about science. Post PSI Professional Development Course interview data revealed that county and state curriculum standards only influence what she teaches in her science classroom, not how she teaches science.

*Julia’s Partner Portfolio for Professional Development*

To provide triangulation of multiple data sources (Yin, 2003) the researcher studied pieces from Julia’s Partner Portfolio for Professional Development including Julia’s (a) post PSI Professional Development Course lesson plan, (b) Invitation to Practice: Science Learning Personal History, (c) the post PSI Professional Development Course lesson plan, and (d) the journal entry titled “What is Inquiry?” This study leads to a more meaningful understanding of Julia’s perceptions as they connect to Teacher Choice (TC) framed by her mental models, conceptions of science subject matter, and barriers related to science teaching and learning. Throughout the course of this study,
Julia made use of on her own education and teaching experiences, analyzed what she learned during the staff development training and made a decision whether or not to hang on to the ideas based on her own system of values. Following the pattern for data analysis used for the pre PSI Professional Development Course interview analysis, this portion of the data analysis consists of a study of Julia’s conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI).

First, interview analysis gave the researcher a view of Julia’s Individual Identity (II). Pre PSI Professional Development Course interview data revealed that Julia describes herself as “enthusiastic.” She explains that she is “…excited to teach and I think they’re [the students] excited to learn.” Julia uses a variety of science teaching methods that all relate to the inquiry approach. Julia learned best through active engagement, observation and participation, by doing hands-on activities. Her memories of her early schooling had an impact on her teaching style and her choice of science teaching methods, when her teachers use a constructivist approach. The following excerpt shows how Julia views herself as a learner. “I learn by doing. You best learn it through the instruction and through observation and participation. It’s a real combination, it has to all meld together.”

When learning, Julia uses multiple methods, including “doing,” “observation,” and “participation.” Julia uses many of the methods that helped her learn in her own teaching. This excerpt from pre PSI Professional Development Course interview data illustrates Julia’s beliefs about how she models learning situations in her classroom after her own learning style.
Just like the last science unit, now we’re in social Studies with Egypt, the life cycle. We sit in whole group. We go over the information. We discuss the vocabulary. We introduce that. What is a life cycle? And then after we have discussed it and reviewed vocabulary the kids read about it but they also start immediately participating in it and it’s having the butterflies in the classroom, the frogs and toads, observing. We do dandelions, so we do plants, we do insects and we do the amphibians. Then they go over and record in their journals and watch and observe. In the end we do a written assessment, but it’s a little bit of everything. We’re outdoors with it, it’s really hands-on, but it’s combined. They’re getting reading and so forth and they’re writing about it. As you saw when you were here for life cycles the other day, they’re doing readers theater, they’re acting out. Which is giving them their reading and their science and they’re not even aware, they’re just enjoying putting on a show. Then they make props that go with it that also shows they understand. Through their art, we’ll do art centers. We’ll incorporate all the disciplines. That will allow me to use multiple intelligences and other ways to see and check their understanding. It’ll be not only paper pencil, but I’ll check how they visually demonstrated the life cycle and then in observing them in their work throughout the unit. So it’s a little bit of everything.

Julia explains, “Because over the years you learn what works best for kids and that’s your ultimate goal.” She feels it was important for her students to “learn to remember, not for it to just be rote, not to just learn for the test.”

As noted in Research Question 1 analysis, an excerpt from the Invitation to Practice: Science Learning Personal History (see Appendix G) activity supported the idea that Julia believes that she needs to participate, use hands-on and inquiry type methods, when learning. Her first reflection entry described a painful elementary experience. The excerpt below gives insight into Julia’s beliefs about her science teaching methods.

In elementary school (parochial) we had a visiting science teacher. I remember “inquiring” as to why if air was invisible I could see a “wavy motion” of air above the radiator. Her response was “ask that question in 2 years” and moved on. I was so frustrated and learned never to so that to my students. If I don’t know the answer to a question, I respond eagerly “great question, I wonder why…let’s investigate!”
Julia is motivated to find the answers to their questions. Julia encourages all of her students to ask questions and to ‘wonder why’ as they investigate in her science classroom.

Next, the researcher learned that Partner Portfolio for Professional Development data analysis findings supported and extended previous findings related to Julia’s Subject Matter Knowledge (SMK). Excerpts from Julia’s pre PSI Professional Development Course interview analysis revealed that Julia recalls a good training program while at a state university. Julia’s classes in teaching science utilized early childhood concepts and science methodology. Classes in her masters program combined hands-on activities as well as theory. As noted in Research Question 1 analysis, an excerpt from the Invitation to Practice: Science Learning Personal History, Julia continues explaining how her college courses shaped her belief that students need to participate in their learning in the excerpt that follows.

In college I took a few biology classes and the contrast drove the point of interaction home clearly. One was on predator and prey and the professor was renowned for his study of raptors, which he brought to class. Another, organisms and evolution was strictly memorizing the Latin term and classifying. It was dry and boring to do.

Julia participated in a number of science classes in college that were interactive. Her biology class was an example of an interactive class in which Julia feels she learned a great deal.

Last, data analysis was conducted to investigate findings related to Julia’s Shared Identity (SI). Data from interview analysis related to Julia’s Shared Identity (SI) revealed that Julia believed her administration and school team has an influence on her choice of science teaching methods. Data from Julia’s portfolio supports findings that Julia’s
teammates have an influence on her science teaching. Julia writes during her Invitation to Practice: Collaboration activity how she and her CF work together in the area of science. She explains, “We are like a flow chart! We start with an idea and then it sprouts from there. We bounce ideas off each other, divide responsibilities and more, to achieve a goal.” Julia explained in her pre PSI Professional Development Course interview that local, school, or state regulations do not influence the way she teaches, only what she teaches.

Another large motivator or influence on Julia’s choice of science teaching methods is her students. Julia depends on parental support to facilitate a hands-on inquiry approach in her science classroom. She deliberately takes time to educate the parents to make sure that they understand her method of science instruction. Julia sets up her room to facilitate hands-on learning and interactive science activities. She encourages parents to assist in the science classroom. During the pre PSI Professional Development Course observation, the researcher observed a parent volunteer helping with students with the frog art project.

Summary of Julia’s Results for Question 5

Data were used to examine Julia’s choices related to science teaching in an effort to reveal methods that encourage teachers like her to overcome resistance to implementing I-B science teaching practices. Julia made decisions about her choice of science teaching methods by assessing the value of the options available to her and deciding upon a course of action based on her own conceptual framework for science teaching an learning. Data analysis for Research Question 5, “How do teachers choose to use I-B methods as opposed to teacher-centered activities?” consisted of an examination
of Julia’s conceptual framework for science teaching and learning made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI). Partner Portfolio analysis supported previous findings related to Julia’s Individual Identity (II). Excerpts from Julia’s pre PSI Professional Development Course interview analysis, supported by secondary data, showed that Julia describes herself as “enthusiastic.” Julia learns science through use of multiple methods, including “doing,” “observation,” and “participation.” Julia uses many of the science teaching methods that helped her learn when planning her science teaching instruction for the students in her science classroom. Partner Portfolio analysis clarified previous findings related to Julia’s Subject Matter Knowledge (SMK) where it was revealed that Julia participated in what she feels was a good science teacher training program while attending college at a state university. Her undergraduate classes in teaching science utilized early childhood concepts and science methodology. Classes in her college masters program combined hands-on activities as well as theory. Data from interview analysis related to Julia’s Shared Identity (SI) revealed that Julia believed support from her administration and grade level team was positive and that they had a large influence on her choice of science teaching methods. In conclusion, Julia acknowledged that her CF and her grade level teammates, her students, and the student’s parents all had an influence her choice of science teaching methods. Julia noted that the Milton County curriculum map and Virginia curriculum standards influence what she teaches, not the way in which she teaches.
Cross-Case Analysis

Each of the cases or teacher portraits is meaningful because it belongs to a collection of cases. The individual cases share a common characteristic or condition. In this case, the condition is implementation of I-B science into the classroom. This common condition, a quintain (pronounced kwin’ton), serves to categorically bond the cases together. To better understand the quintain, this section of the chapter will consist of a study of similarities and differences across cases (Stake, 2006). This section of the chapter is organized five sections, one section for each research question. Each section contains:

1. A presentation of cross-case analysis of the eight teacher participants arranged by the five research questions.
2. A presentation of themes developed from interview data.
3. A segment that presents triangulation across cases.

A summary of STEBI survey and CLES survey results is contained in the Research Question 1 cross-case analysis.

First, the researcher reviewed each case or teacher portrait. Next, taking one research question at a time, the researcher identified themes or findings using each teacher’s interview analysis data. Stake (2006) defines themes as central ideas having importance related to its situation. As the researcher reviewed the multi-case themes she visualized the multi-case project as a whole while moving towards a number of cross-case assertions based on the data gathered from the case reports or teacher portraits. The themes or findings were converted into factors. A factor is defined as a widely found, sometimes influential variable of interest well beyond its situation. Next, factors were
merged into clusters according to similarities. Each factor cluster was ranked according to its importance for understanding the quintain, the common condition of the implementation of I-B science into the classroom. The factor clusters give rise to assertions that describe the quintain. Triangulation across cases occurred throughout the cross-case analysis to make sure the picture is clear and meaningful. At times multi-case themes were added to the themes created during interview data analysis (Stake, 2006). I next present the data to answer the query, “In light of science standards based reform, what is required to implement inquiry-based methods in elementary science classrooms?”

Research Question 1 Cross-Case Analysis

What do elementary teachers believe about learning and teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?

Information was utilized to examine the beliefs of the participants related to teaching science, how children learn science, and science teaching methods to uncover patterns that influence their teaching behavior as it relates to their autonomy or her Individual Identity. Cross-case analysis started with an examination of the participants’ memories of early science learning. The constructivist approach to how people learn focuses on providing relevant experiences and opportunities that allow students to construct knowledge (Piaget, 1929; Vygotsky, 1978). All eight participants feel they learn science best through seeing and doing. They remember learning best when they
were actively engaged or participated in hands-on activities throughout the learning process.

Ariel (pre): I remember dissecting the frog. I guess I did that in high school. So I remember that lesson. I don’t remember a lot of what the teacher told us to do. I just remember doing it, the frog, and I thought it was gross. I remember pinning back certain parts of the frog and going into and seeing all of the organs and things inside of the frog. So, that stands out.

Jo (pre): Dad was a big influence too, because he was an orthodontist. He was real into math and science. He was a big influence, and so was mom, with the baking. Dad’s hobby was color photography and in the basement he had a darkroom. He would sit down there after dark and after dinner and he would be trying to get the light and the color correct. He explained to me that because of all of the electricity running in the neighborhood, it would mess up the chemicals. So that was really awesome to me. I would ask, “What?” So, I’d pull up a stool next to him and he would try to explain. That was really neat.

Liz (pre): Probably most of my science knowledge came from a love of science. I was always outside. I was always investigating something in nature, bringing things home, growing this, or raising that. The science background that I remember is all of the investigating that I did…

Hailey explained in her pre PSI Professional Development Course interview that she feels she learns best, “definitely by seeing and doing.” Hailey remembers a content training session in which she participated in hands-on activities throughout the learning process.

Hailey (pre): That was last summer and definitely very hands-on and was pertinent to the curriculum. I’ve taken some of it and used it in the classroom. The first one I remember using was the globe, showing them how much of the Earth was ocean and how much was land.

Prior to the PSI Professional Development Course Robin felt, “not just with science, but with any subject. I am a very visual, hands-on learner. I like to see it and play with it myself.”

Lucy (pre): I do remember as a kid being curious about things and I remember one time I conducted my own little experiment in secret. The reason I remember this, this is kind of funny. I don’t know where I saw this. I got a wire, and a battery, and a light bulb. I knew I could put them together and make the light bulb
light up, and I just thought that was the neatest thing, but I didn’t think my Mom would let me do it. So I snuck the battery and the wire and I got this funny looking light bulb that had all these lines through it. Little did I know it was a flashbulb! So when I put it all together, it worked. I rigged it all up, made it go off. It went off in my hand and I remember I burned myself and everything! I still didn’t tell because I thought I’d get in trouble. I do remember investigating things, being younger.

Anna (pre): I think that the best way I actually learn anything is I have to feel it, touch it, and do it. I am not one that has to remember this, I teach first grade reading, I am not one that can read and comprehend. I need to have it shown, like show and tell. Next, I have to actively do it with somebody beside me. Then, maybe I can do it the third time. That’s my learning style for almost anything.

In the pre PSI Professional Development Course interview data revealed that Julia feels she learns science best by “doing.” She clarifies her beliefs, “You best learn it through the instruction and through observation and participation. It’s a real combination, it has to all meld together.” In summary, all eight participants learn best by seeing and doing, observing and participating, or when they are actively engaged in the learning experience.

All eight of the participants learn best through active engagement, observation and participation. They learned best doing hands-on activities. When asked to remember science learning situations that influenced their teaching and learning all eight recalled multi-sensory, hands-on experiments or activities.

Ariel (pre): I remember dissecting the frog. I guess I did that in high school. So I remember that lesson. I don’t remember a lot of what the teacher told us to do. I just remember doing it, the frog, and I thought it was gross. I remember pinning back certain parts of the frog and going into and seeing all of the organs and things inside of the frog. So, that stands out.

Jo (pre): I liked to collect rocks. I learned a lot, really, from my parents, even way before I entered school. I’d bring rocks home. I learned from cooking and baking. Cooking was different from baking. Baking was more like doing a science experiment.

Liz (pre): Probably most of my science knowledge came from a love of science. I was always outside. I was always investigating something in nature, bringing
things home, growing this, or raising that. The science background that I remember is all of the investigating that I did…

Hailey (pre): The only one I remember is when we were hatching baby chicks and we had an incubator in the classroom. That was exciting. Most of my classes as a child, the rest of my memory is just opening a textbook and reading.

Robin (pre): I don’t remember a lot of the activities. I remember a biology professor. No, it wasn’t biology, it was physics. We used those cars with the ticker tape. I remember we were collecting all of the data to analyze the speed of the car down the ramp. I remember actually enjoying that. It was a long time ago. I can’t tell you exactly what the outcome was or any data or anything like that. I just remember doing it. It was experimental, hands-on.

Lucy tells us in her Pre PSI Professional Development Course interview that she began to like science when she took a teaching science class in college that was “all hands on.” The professor first talked about each topic. Then students performed experiments. Last, the professor showed the students the connection between the topic and the experiment. She also remembers sitting “in the outdoors and just writing stuff down,” as well as competitive game-like activities. “I got the second highest grade in the class and I was like a straight C student. I just got it then. I was able to do stuff and learn about it that way. I got it!“

Anna (pre): I remember taking a class and it was one of those weekend classes, a Friday Saturday certification. Mrs. Caraway taught it in 5th grade and everything was hands-on and we got to play with everything, we made light bulbs light up, we made our own batteries and made the light bulbs light up. I remember doing that kind of stuff. Everything there was hands-on whether we failed or whether we succeeded, but we did everything that we talked about. But I remember the battery lighting up the light bulb.

Julia (pre): When I was training I thought we had a good program. We had to take a class in teaching science. This was in the state university of New York system and we had to do a methodology class in science but it was very much early childhood. I have a master’s degree in that. Everything in my masters program as well as that was very hands-on. It was not just theory. It was always emphasizing the importance of getting in there and having the kids participate in multi-sensory ways. So I feel very grateful because I know some preparation is not that way or
are not that way now and I’m just glad that I got to see how well that did work. So I’m really happy that I had the opportunity to do that. That was good.

A teacher’s principles or attitude, her tendency to respond favorably to a topic, students or other objects, determines what students will see, hear, think, and do (Souza Barros & Elia, 1998). The participants had positive reactions to hand-on interactive learning. Ariel’s experience really “stands out.” Jo “learned a lot.” Liz credits her science knowledge to “a love of science.” Hailey was “excited” and Robin “enjoyed” their experiences. Lucy excitedly remarked, “I was able to do stuff and learn about it that way. I got it!” Anna remembers because it “…was hands-on and we got to play with everything.” Julia feels “happy” and “grateful for the opportunity” to participate in multi-sensory activities.

All eight participants remembered lessons when they were active participants. They all had a difficult time remembering the science information taught to the when they were not actively engaged in their learning.

Jo (pre): I just remember my sixth grade teacher. She had all kinds of hands-on things like barometers. We’d watch the barometer and check it to how the weather was. Then in middle school it was starting to go towards looking through microscopes at slides and things like that.

Liz (pre): I really cannot remember any particular science lesson I had in school. I mean, obviously I was taught science, I don’t remember that as being a subject that teachers really focused on. I’ve always been fascinated with science. I mean I did learn things from school, but I can’t tell you particular science that I learned at different grade levels… The science background that I remember is all of the investigating that I did. Now maybe it was spurred by some teachers who were really into science and led me into that direction, but I can’t remember any particular class, lessons or anything. That’s because I’m old too.

Hailey (pre): The only one I remember is when we were hatching baby chicks and we had an incubator in the classroom. That was exciting. Most of my classes as a child, the rest of my memory is just opening a textbook and reading.
Robin (pre): I don’t remember a lot of the activities. I remember a biology professor. No, it wasn’t biology, it was physics. We used those cars with the ticker tape. I remember we were collecting all of the data to analyze the speed of the car down the ramp. I remember actually enjoying that. It was a long time ago. I can’t tell you exactly what the outcome was or any data or anything like that. I just remember doing it. It was experimental, hands-on.

Although the participants were actively engaged and active participants in their own learning, not all of their learning experiences were positive. Lucy explains in the Pre PSI Professional Development Course interview that she did not like science in school as a child…because they “read out of a book and memorized stuff” and she didn’t understand it. When she reached high school and took chemistry she still “didn’t get it.” Lucy’s early college science training was mostly reading, “doing a lot of reading out of the book.”

Ariel (pre): I do remember the anatomy class because I do remember seeing cats. I am a cat person and I see all of the cats and I did not want to do that. And the chemistry, I don’t remember doing a lot in there except I was surprised because I did so much better in that than I did in high school. I realize I probably talked a lot in high school during the class. Do you know what I’m saying? And didn’t do what I was supposed to. I was more focused in college at that point. I remember anatomy and thinking it was very hard. I had to remember all of the bones of the human body. I just remember struggling with that.

Anna (pre): I don’t remember when I was young. I’ve been teaching for thirty years. Unfortunately my one recollection of high school science is chemistry and we had cheat cards because I could never remember all of those chemical equations. That’s what I remember, and plunging sinks, that’s what I remember. I do not have recollections of interactive science, so that tells you right now probably there wasn’t a whole lot of interaction going on. So other than that I don’t remember much. I remember a nasty smell in one science class. Oh, I remember too, trying to prick my finger to get my blood type. I was too chicken to do it so somebody else had to do it.

Julia (pre): For me, because I went to parochial school and we didn’t have the science like we do now in the elementary school, I’d have to go to high school. The thing that comes to mind to me immediately was high school biology and it was dissecting a frog. It was definitely hands-on experience. That’s what comes to mind.
Four of the participants noted that they struggled with or felt uncomfortable with science in school: Ariel, Hailey, Lucy, and Anna.

Ariel (pre): I do remember the anatomy class because I do remember seeing cats. I am a cat person and I see all of the cats and I did not want to do that. And the chemistry, I don’t remember doing a lot in there except I was surprised because I did so much better in that than I did in high school. I realize I probably talked a lot in high school during the class. Do you know what I’m saying? And didn’t do what I was supposed to. I was more focused in college at that point. I remember anatomy and thinking it was very hard. I had to remember all of the bones of the human body. I just remember struggling with that.

Hailey (pre): We had a wonderful professor, very outgoing and understood that a lot of people felt uncomfortable teaching science. Most of the class really did admit they felt uncomfortable teaching it and we, it was so long ago. I do remember putting together lessons and demonstrating them to the class and providing lessons for everybody so that they could all take them home.

Lucy explains in her pre PSI Professional Development Course interview, “Although she remembers investigating things when she was younger, Lucy did not like science in school as a child. Interview data revealed she did not like science because they “read out of a book and memorized stuff” and she didn’t understand it. When she reached high school and took chemistry she still “didn’t get it.” Lucy’s early college science training was mostly reading, “doing a lot of reading out of the book.” Anna explains, “Unfortunately my one recollection of high school science is chemistry and we had cheat cards because I could never remember all of those chemical equations.”

In summary, data from the pre PSI Professional Development Course interviews revealed information to answer the question, “What do teachers believe about learning and teaching science?” Data analysis started with a look at how each of the eight participants feels she best learns science. All eight participants feel they learn science best through seeing and doing, through multi-sensory hands-on experiments and
activities. All eight participants had difficulty remembering science they were taught in school when they were not actively engaged in their learning. Four of the participants noted that they struggled with science in school, Ariel, Hailey, Lucy, and Anna.

The participants manipulate their classroom environment based on their beliefs about how children learn science and science teaching methods. Cross-case analysis of the participants’ pre and post PSI Professional Development Course interviews continued to examine, “What are teachers beliefs about how children learn science? What are teachers beliefs about science teaching methods?” These questions are discussed together because the researcher found considerable overlap in teacher beliefs about how children learn science and teacher beliefs about science teaching methods. Liz explains, “I think most teachers probably teach the way they like to learn.”

Jensen (1998) asserts that changes in location, circumstances, use of emotions, movement, and novel classroom positions are examples of why students recall a large part of their learning. The views of the eight participants support this assertion. The use of episodic strategies is discussed next. All eight teachers used positive emotions as descriptors of student learning. Ariel and Liz explain in their post PSI Professional Development Course interview that they want their kids to be excited about science. Ariel says, “I think the students enjoyed the activity and I like to see that they were involved, even excited about learning.” Liz explains that her students will talk about her classroom saying, “We did fun things in science. I learned to love science. Science is more exciting than I realized.” Jo’s post PSI Professional Development Course interview shows that she believes, “A good learner shows enthusiasm, curiosity, and perseverance.” Hailey, Robin, and Julia explain in their pre PSI Professional Development Course interview that a sense
of humor is important to them. Hailey explains. “I try to maintain a sense of humor.”

Julia says, “I think I’d have to say being able to integrate everything is a strength, enthusiasm, again. A sense of humor, I think the kids really need that.”

Robin (pre): I think I tend to be strict but my way of disciplining is that I use more of a sense of humor way to deal with behavior issues, showing the ridiculous rather than the negative. I try to be positive rather than negative.

Robin also explains, “I ask students to think about the concept and how it relates to the world around them. I try to get them interested in the concept by showing enthusiasm and interest in it myself.” Lucy and Anna both explain in their pre PSI Professional Development Course interview that they want learning to be fun. Lucy says, “I think I’m creative. I think I’m good at coming up with fun activities that get the point across.” Anna says, “I try to make as much of it as I can fun…” Emotions play a role in the science instruction of all eight teachers.

Four of the teachers (Hailey, Robin, Anna, and Lucy) explained that novelty was a characteristic of their teaching. In her pre PSI Professional Development Course interview Hailey said, “We performed experiments, move around in silly ways to remember concepts, did more than read out of a book and complete worksheets.” Robin also takes a silly approach.

Robin (pre): I’m kind of crazy, I guess, kind of silly. I take a real silly approach, a sense of humor approach. For the hard concepts to understand, I make them think about something crazy so it’s going to stick in their head. When they think about it, they’re going to say, “I remember when she did that.” It might be embarrassing for me, but the kids laugh and they get it. So, it makes more of a point to them if I can bring humor into it.

In their pre PSI Professional Development Course interviews Lucy and Anna explained that having fun helps their students learn. Lucy often tricks her students. She explains, “I
think I try to make things fun. It’s not so easy to learn some of the things, but if you make it fun somehow they are like tricked into learning.” Anna explains, “I am strict, but like to be funny because I feel like if you are funny or you d something that clicks they are going to remember it more.

Four of the teachers (Ariel, Jo, Hailey, and Julia) emphasized providing a comfortable learning atmosphere or comfort zone in their science classroom.

Jo (pre): I think that I stick to a schedule. I feel that I provide the children with that safety net that there are bounds, there are limitations and they pretty much know by the second week of school those boundaries. I just feel that it’s very important to keep that structure because it’s needed. They need those boundaries and to know that it is a safe…

Julia pre I do as much as possible to meet the individual needs of the child. Come up with activities in which they can be stretcher as well as those that need help to make it and atmosphere that there’s a lot of collaboration as well. Ariel is careful to monitor student time on task. In her pre PSI Professional Development Course interview Ariel explains, “Sometimes it gets chaotic with the kids, making sure everybody is on task.” Hailey chooses learning methods that make her children feel comfortable. Hailey explains in her post PSI Professional Development Course interview, “We performed experiments, move around in silly ways to remember concepts, did more than read out of a book and complete worksheets. They felt comfortable.”

All eight of the teachers are careful to monitor the level of engagement of their students. Ariel explains in her pre PSI Professional Development Course interview, “Sometimes it gets chaotic with the kids, making sure everybody is on task.” In her post PSI Professional Development Course interview she further explains, “Investigating questions and finding answers that are important to them as far as making science
something they can relate to in their lives.” Jo believes her students will say, “We got to play!” She feels they value the opportunity to engage in “hands-on and sharing out their thinking.” Jo enjoys the transition from “when they are clueless at the beginning of a lesson and then –ah ha- the light comes on!” Robin explains in her post PSI Professional Development Course interview, “I give them a variety of ways to explore a concept. I give them meaningful and engaging activities. We have fun and learn at the same time.”

Liz (pre): …I like to extend their learning…I like doing the higher level thinking activities with the kids and I think science gives you a real good way to use that. I think the other kids benefit too. I have, especially this year, some really smart kids, and they came up with all sorts of connections with things…

Hailey (pre): Sometimes I use inquiry, but I think sometimes I forget to. I catch myself just explaining things. I definitely use hands-on as much as possible because I know that there’s so many concepts that a lot of students won’t get unless they are hands-on sometimes songs work well too.

Lucy (pre): I’m always busy… “if you want to get to do the fun thing. We’ve got to do this, you know.” I’m very busy and always on the go. I’m not as organized as other teachers you might see because I always feel like we’re doing activities, piling up the stuff, and moving on to the next thing. I’m very busy.

Anna (pre): I am strict, but I like to be funny because I feel like if you are funny or you do something that clicks they are going to remember it more. With any subject, not just science, if I can get it into a game then I can create that type of an atmosphere or a learning experience they’re going to remember it more. In my class I don’t believe in just sitting there. We have to get up and move because I can’t stand sitting and doing stuff. So I try to read stories that go along with whatever concept we’re talking about and not science type books or social studies type books, I’m talking a story like Swimmy for fish, those literature type books. I try to make as much of it as I can fun because there was a time in my life when I was teaching up in Slate City, planning was page this in math, and that page this in science. I got so bored I couldn’t stand it. I though, my god, if I am this bored, what are the kids thinking? That was probably right around the time that whole language came out. I really didn’t jump into whole language, but I liked the literature based learning where everything came from the literature because I always believed in reading. So, that’s basically how I do most of my teaching, including math.
Julia (pre): I think I’d have to say being able to integrate everything is a strength, enthusiasm, again. A sense of humor, I thing the kids really need that. Making as much as possible a lot of interaction with their learning environment. I use a lot of hands-on learning, a lot of manipulatives and so forth, taking the learning outside of these four walls as well. Be it the outdoors or the halls. Our halls will be alive with whatever it is we are learning.

All of the teachers emphasized that they believed it was important for the students to be actively engaged in their learning. They encouraged investigation, exploration, and searching for answers.

Each of the participants expressed their own teaching style, however they shared many similar characteristics. They spoke of structure or routine mixed with flexibility, humor, creativity, and fun. They all incorporated a variety of methods throughout each science lesson. Ariel explains in her pre PSI Professional Development Course interview, “I like it organized. I like it structured, for the most part. I do go off, like what we did the other day.” Post “I try to use different methods to hopefully reach all students. I use the interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments.” Hailey explained in her pre PSI Professional Development Course interview, “I think I try to find different ways to teach subjects, like using the MI [multiple intelligences]…I feel like I am fairly strict but the children know they can kid around with me. I try to maintain a sense of humor.”

Jo (pre): I tend to be, quite a mix actually. I tend to be very structured and I can also be very flexible. It is important to keep a sense of humor…I think I tend to be strict but my way of disciplining is that I use more of a sense of humor way to deal with, showing the ridiculous rather than the negative. I try to be positive rather than negative. I try to do it that way.

Liz (pre): Well I think sometimes I am unorganized. But I have my own type of organization…I think I’m very active. I think I’m encouraging. I like to think that I’m helping the kids learn in ways that maybe they haven’t before. I like to extend their learning…
Robin (pre): I’m kind of crazy, I guess, kind of silly. I take a real silly approach, a sense of humor approach. For the hard concepts to understand, I make them think about something crazy so it’s going to stick in their head. When they think about it, they’re going to say, “I remember when she did that.” It might be embarrassing for me, but the kids laugh and they get it. So, it makes more of a point to them if I can bring humor into it.

Lucy (pre): I think I’m creative. I think I’m good at coming up with fun activities that get the point across. I think I’m hard working. I am usually the first one here and I’m usually one of the last ones to leave… I think I try to make things fun. It’s not so easy to learn some of the things, but if you make it fun somehow they are like tricked into learning.

Anna (pre): Unfortunately, I don’t really think I have specific methods, again I try to read stories and then we discuss. Then when we can we do things, hands-on. There aren’t a whole lot of hands-on activities in the first grade science curriculum… But, AIMS [Activities Integrating Mathematics and Science] was a great way of incorporating things. That’s one thing I enjoyed in Slate City, we were big into AIMS and we took AIMS courses all of the time. They were so cool. I remember this one we had to have critters, everything we learned was about animals, so we had to have critters. There I was, I had every kind of animal that we taught, I had a mammal, and I had an amphibian. Unfortunately, the classroom stunk and the rabbit peed all of the time. When teaching, I always start off with the talking and then, if I can, I go into different ways of dealing with things. Like I said, I incorporate animals and plants because they are the easiest I can think of. Actually touching, feeling and doing are important parts of my classroom instruction.

Julia (pre): I think I’m enthusiastic. I hope I am. I do feel like I have a good rapport with my students. They are always excited when they come in and the day flies by. I think because I love what I do they love learning. I think there’s always the down days, occasionally, but overall I feel I’m always happy to come to work. I am excited to teach and I think they’re excited to learn. It’s really mutually beneficial. I think we really feed off of each other. I love it.

In summary, all eight teachers held unique beliefs related to science teaching methods.

The participants shared many common beliefs, including: use of a variety of teaching methods, flexibility when necessary, humor, and enthusiasm for the topic.

Scientists share beliefs and attitudes about the things they do and the way in which they view their work. These beliefs are related to the nature of the world and what
scientists can learn about it (AAAS, 1990). Seven out of the eight participants spoke about extending learning outside of the classroom. In her post PSI Professional Development Course interview Ariel shared what she felt was important for her students to know or learn about science, “Investigating questions and finding answers that are important to them as far as making science something they can relate to in their lives.”

Liz (post): Students should know how to set up and perform an experiment and be able to make conclusions about the results. They should also be able to use tools such as: balance, thermometer, meter and centimeter in measuring tools, and hand lenses.

Hailey (post): …my main goal is for them to walk away from the classroom understanding that this is the only Earth we’ve got and we’ve got to take care of it. It is important for them to learn some of the things that we can do to take care of the Earth, to understands what it means to be a scientist, what it means to investigate something, and to explore and ask questions and discover things.

Robin explained in her post PSI Professional Development Course interview she believes it is important for students to understand the “scientific method, including “parts of experiments” like “variables and constants,” and the “tools used in science to gather data.” She also believes students should understand “how science is everywhere.” Anna Lucy (pre): I guess it would be the stuff that they’re going to take and use daily to understand the world. They should learn things like measurement and the process skills, observing, creating graphs and charts, and communicating. I think those are the most important. Some other things, like the cycles and the seasons, are also important for them to learn about. Some of the concepts are a little bit harder for them and I think they’ll eventually get because the science seems to wrap up or spiral every year.

Ariel, Liz, Hailey, Robin, and Lucy all explain that they stress scientific process skills and exploring to discover more about the world around them. All of these teachers set up their classrooms to maximize student learning. Julia also manipulates her classroom environment and extends learning outside of the classroom.
Julia (pre): I definitely try to manipulate the environment as much as I can and change it constantly as I can. As you know, in elementary school you are teaching so many things all of the time, that it is a constant change over. Fortunately parent volunteers are a big part of my classroom. I have someone here all of the time that helps me to do that and make it interactive. That’s been a big asset, having people to assist you because you want to make it exciting for the kids. Again, time constraints, without the help it would be hard to do that as we are able to do that here. And manipulating it also in terms of taking them out of the classroom as much as possible, be it field trips, extension trips or not just in our school to maximize it, and other parts as well.

Julia (pre): I think in terms of, certainly how you arrange your room and make it come alive to make sure you have all of these centers and hands-on learning for the kids, and make it exciting and make it interactive. Again, it’s how you want your dream classroom with a lot more storage and a lot more space to do that. I definitely try to manipulate the environment as much as I can and change it constantly as I can.

Anna incorporates literature and creates an atmosphere that helps students remember science concepts. Anna explained in her pre PSI Professional Development Course interview, “I begin a concept by reading children’s literature or watching a video.” Anna shares this thought again when answering another question in the excerpt that follows.

Anna (pre): I am strict, but I like to be funny because I feel like if you are funny or you do something that clicks they are going to remember it more. With any subject, not just science, if I can get it into a game then I can create that type of an atmosphere or a learning experience they’re going to remember it more. In my class I don’t believe in just sitting there. We have to get up and move because I can’t stand sitting and doing stuff. So I try to read stories that go along with whatever concept we’re talking about and not science type books or social studies type books, I’m talking a story like *Swimmy* for fish, those literature type books…

**Research Question 1 Cross-Case Analysis Summary**

Information was utilized to examine the beliefs of the participants related to teaching science, how children learn science, and science teaching methods to uncover patterns that influence their teaching behavior as it relates to their autonomy or her Individual Identity (II). All eight participants learn best by seeing and doing, when they
are actively engaged in the learning experience. When asked to remember science learning situations that influenced their teaching and learning all eight recalled multi-sensory, hands-on experiments or activities. They all had a difficult time remembering the science information taught to them when they were not actively engaged in their learning. Four of the participants (Ariel, Hailey, Lucy, and Anna) noted that they struggled with or felt uncomfortable with science in school.

Data analysis continued, with an examination of teacher beliefs about how children learn and teaching methods. All eight teachers used positive emotions as descriptors of student learning. Four of the teachers (Hailey, Robin, Lucy, and Anna) explained that novelty was a characteristic of their teaching. Four of the teachers (Ariel, Jo, Hailey, and Julia) emphasized providing a comfortable learning atmosphere or comfort zone in their classroom. All of the teachers emphasized that they believed it was important for the students to be actively engaged in their learning. They encouraged investigation, exploration, and searching for answers. Each of the participants expressed their own teaching style, however they shared many similar characteristics. They spoke of structure or routine mixed with flexibility, humor, creativity, and fun. All incorporated a variety of methods throughout each science lesson. Seven out of the eight participants spoke about extending learning outside of the classroom in interview sessions.

**Research Question 1: Themes Developed from Interview Questions**

I next present an explanation related to themes developed from interview question data to answer the query, “What do elementary teachers believe about learning and teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?” Data findings
were utilized to examine the beliefs of the participants related to teaching science, how children learn science, and science teaching methods to uncover patterns that influence their teaching behavior as it relates to their autonomy or her Individual Identity (II). First, the researcher reviewed Research Question 1 analysis from each case or teacher portrait. Next, beginning with Research Question 1, the researcher identified themes or findings using each participants interview analysis data (see Tables 34, 35, 36, and 37 for a breakdown of themes and factors grouped by clusters). Stake (2006) defines themes as central ideas having importance related to its situation. When analyzing data for Research Question 1 the researcher assembled findings related to teacher beliefs about science learning, beliefs about how children learn and teaching methods. As the researcher reviewed the multi-case themes she visualized the multi-case project as a whole while moving towards a number of cross-case assertions based on the data gathered from the case reports or teacher portraits. The themes or findings were converted into factors. A factor is defined as a widely found, sometimes influential variable of interest well beyond its situation. The following factors emerged from the data analysis findings: Memory, See and Do, Struggles with Science, Events, Emotions, Novelty, Comfort Zone, Actively Involved, Investigating, Organization, and Methods.

Next, factors were merged into clusters according to similarities. Each factor cluster was ranked according to its importance for understanding the quintain, the common condition of the implementation of I-B science. The factor clusters give rise to assertions that describe the quintain. Memory, See and Do, Struggles, and Events were all arranged into the factor cluster of Beliefs about Science Learning. Emotions, Novelty, and Comfort Zone were arranged into the factor cluster of Episodic Strategies.
Table 34.

Research Question 1 Cross-Case Analysis
Teacher’s Experiences: Beliefs About Learning and Teaching Science

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<thead>
<tr>
<th>Teacher</th>
<th>Factor Cluster: Beliefs about Learning Science</th>
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<tr>
<td></td>
<td>Factor: Memory</td>
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<tr>
<td>High</td>
<td>High</td>
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<tr>
<td>1</td>
<td>Don’t remember</td>
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<tr>
<td>2</td>
<td>Remembers 6th grade</td>
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<td></td>
<td>Remembers family</td>
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<tr>
<td>3</td>
<td>Don’t remember</td>
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<tr>
<td>4</td>
<td>Remembers textbook</td>
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<tr>
<td>5</td>
<td>Don’t remember</td>
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<tr>
<td></td>
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<tr>
<td>6</td>
<td>Read out of book and memorized facts</td>
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<td></td>
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<tr>
<td>7</td>
<td>Don’t remember</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>No science in lower grades</td>
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Table 35.

Research Question 1 Cross-Case Analysis
Beliefs About How Children Learn and Teaching Methods (1 of 3)

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Factor Cluster: Episodic Strategies</th>
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<tr>
<td></td>
<td><strong>Factor: Emotions</strong></td>
</tr>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>1</td>
<td>Excited</td>
</tr>
<tr>
<td></td>
<td>Joy</td>
</tr>
<tr>
<td>2</td>
<td>Enthusiasm</td>
</tr>
<tr>
<td></td>
<td>Humor</td>
</tr>
<tr>
<td>3</td>
<td>Fun</td>
</tr>
<tr>
<td></td>
<td>Exciting</td>
</tr>
<tr>
<td>4</td>
<td>Humor</td>
</tr>
<tr>
<td>5</td>
<td>Silly</td>
</tr>
<tr>
<td></td>
<td>Crazy</td>
</tr>
<tr>
<td></td>
<td>Fun</td>
</tr>
<tr>
<td>6</td>
<td>Fun</td>
</tr>
<tr>
<td></td>
<td>Creative</td>
</tr>
<tr>
<td>7</td>
<td>Fun</td>
</tr>
<tr>
<td></td>
<td>Vivacious</td>
</tr>
<tr>
<td></td>
<td>Funny</td>
</tr>
<tr>
<td>8</td>
<td>Enthusiastic</td>
</tr>
<tr>
<td></td>
<td>Excited</td>
</tr>
<tr>
<td></td>
<td>Humor</td>
</tr>
<tr>
<td></td>
<td>Love</td>
</tr>
</tbody>
</table>
Table 36.

**Research Question 1 Cross-Case Analysis**  
**Beliefs About How Children Learn and Teaching Methods (2 of 3)**

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Factor Cluster: Level of Engagement</th>
<th>Factor Cluster: Teacher Style</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Factor:</strong> Actively Involved</td>
<td><strong>Factor:</strong> Investigating</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>1</td>
<td>Involved Everybody on task</td>
<td>Investigating Questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Finding answers</td>
</tr>
<tr>
<td>2</td>
<td>Hands-on Perseverance Sharing out</td>
<td>Curiosity Questioning</td>
</tr>
<tr>
<td></td>
<td>Thinking</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Active</td>
<td>Inquiry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Allow for discovery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Make connections</td>
</tr>
<tr>
<td>4</td>
<td>Experiment Willing to work</td>
<td>Ask questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inquiry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>See relationships</td>
</tr>
<tr>
<td>5</td>
<td>Meaningful Engaging</td>
<td>Crazy and silly</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Busy</td>
<td>Connections</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Hands-on Games Movement Discuss</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Centers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hands-on</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interactive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collaborative</td>
<td></td>
</tr>
</tbody>
</table>
Table 37.

*Research Question 1 Cross-Case Analysis  
Beliefs About How Children Learn and Teaching Methods (3 of 3)*

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Factor Cluster: Nature of Science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Factor: Process Skills</em></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Students learn to use process skills Tools</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Students learn to use process skills</td>
</tr>
<tr>
<td>6</td>
<td>Use daily Students learn to use process skills</td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>
**STEBI Cross-Case Analysis**

Figure 18 displays the pre and post STEBI PSTEB scores by participant. T1-Ariel and T2-Jo’s scores increased notably, moving from an average efficacy score to a high efficacy score indicating that they were comfortable with their own abilities to teach science. T6-Lucy’s scores increased notably, both pre and post assessments were in the high efficacy category. T7-Anna’s scores increased notably, both scores were in the average efficacy range. T3-Liz, T4-Hailey, and T5-Robin’s scores decreased slightly, but remained in the high efficacy category. T8-Julia’s scores decreased notably, but remained in the high efficacy category (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).

Figure 19 displays the pre and post STEBI Outcome Expectancy scores by participant. T1-Ariel and T5-Robin’s STEBI Outcome Expectancy scores decreased notably, both scores fell within the average expectancy range. T2-Jo and T8-Julia’s scores decreased slightly, both scores fell within the high expectancy range. T3-Liz’s scores decreased notably, scores moved from the high expectancy to the average expectancy category. T4-Hailey and T6-Lucy’s scores increased notably, both post assessment scores were in the high expectancy category indicating that they had confidence in their teaching abilities to create desirable outcomes. T7’s scores increased slightly, remaining in the average expectancy category. Figure 19 displays the pre and post STEBI Outcome Expectancy scores by participant (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990).
Figure 18. Participant’s STEBI Personal Science Teaching Efficacy Belief Scale Scores

Figure 19. Participant’s STEBI Outcome Expectancy Scores
**CLES Cross-Case Analysis**

**CLES Personal Relevance Scores by Participant.** Figure 20 displays the pre and post CLES Personal Relevance scores by participant. T2-Jo, T5-Robin, and T7-Anna showed a slight increase. T1-Ariel and T6-Lucy showed a significant increase. T1-Ariel did not score one of the items on the pre assessment instrument. T2-Jo, T3-Liz, T6-Lucy, and T8-Julia had scores in the high agreement range indicating that they placed more emphasis on engaging students in opportunities to experience the relevance of school science to their everyday interests and activities and to use their everyday experiences as a meaningful context for the development of their formal scientific knowledge (Suters, 2004; Taylor et al., 1997). T3-Liz and T4-Hailey showed a slight decrease in their CLES Personal Relevance scores.

![Figure 20. Participant’s CLES Personal Relevance Scores](image)

**Figure 20.** Participant’s CLES Personal Relevance Scores
CLES Scientific Uncertainty Scale Scores by Participant. All of the participants except two teachers showed an increase in their CLES Scientific Uncertainty Scale scores. T1-Ariel and T8-Julia showed a significant decrease in their scores. T1-Ariel’s scores fell into the high average category and T4-Hailey’s scores remained in the low intermediate category. All of the other teachers post assessment scores fell into the high intermediate category. The scientific uncertainty scores address teacher emphasis on engaging students in opportunities to learn to be skeptical and critical about the nature and value of science. They speak to learning about scientific knowledge as: evolving and provisional, being shaped by social and cultural influences, and how it arises from human interests and values (Suters, 2004; Taylor et al., 1997). Figure 21 displays the pre and post CLES Scientific Uncertainty Scale scores by participant.

![CLES Scientific Uncertainty Scale Scores](image)

Figure 21. Participant’s CLES Scientific Uncertainty Scores
**CLES Critical Voice Scale Scores by Participant.** There was little change in the participants’ beliefs with respect to the CLES Critical Voice Scale. T1-Ariel, T3-Liz, T5-Robin, and T6-Lucy each showed a one-point decrease in score. The scores of the other participants remained the same. T2-Jo and T8-Julia both had a score of 35, the highest measurement possible on the scale. This scale indicates the emphasis placed on encouraging students to question her plans and methods and express concerns about impediments to their science learning (Suters, 2004; Taylor et al., 1997). All of the participants CLES Critical Voice scale scores fell into either the high intermediate or high agreement range. Figure 22 displays the pre and post CLES Critical Voice scores by participant.

![bar chart showing CLES Critical Voice Scale Scores by Participant](image)

**Figure 22.** Participant’s CLES Critical Voice Scores
**CLES Shared Control Scale Scores by Participant.** There was quite a significant variation between participant scores for this scale. Ranging from a low of 14 to a high of 24. There was no change in T1-Ariel’s CLES Shared Control Scale score; her score fell into the low intermediate category. T2-Jo and T4-Hailey showed a slight increase and T6 showed a significant increase. T3-Liz, T5-Robin, and T7-Anna showed a slight decrease and T8-Julia showed a significant decrease. T8 explained to the researcher that her drop in score was related to her switch from second grade down to first grade. This scale indicated whether students are invited to participate in the designing of their own learning activities, determine assessment criteria, and negotiate the norms of the classroom (Suters, 2004; Taylor et al., 1997). Figure 23 displays the pre and post Shared Control Scale scores.

![CLES Shared Control Scale Scores](image)

**Figure 23.** Participant’s CLES Shared Control Scores
CLES Student Negotiation Scale Scores by Participant. There was an increase in six of the eight participants CLES Student Negotiation Scale scores. T8-Julia’s scores remained the same. T3-Liz’s scores only decreased by one point and they remained in the high intermediate category. All of the participants post assessment scores fell into either the high intermediate or high agreement categories. T4-Hailey, T5-Robin, and T6-Lucy’s scores increased significantly. The Student Negotiation Scale measures the emphasis placed on providing opportunities for students to explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas (Suters, 2004; Taylor et al., 1997). Figure 24 displays the pre and post Student Negotiation Scale scores.

Figure 24. Participant’s CLES Student Negotiation Scores
**CLES Attitude Scale Scores by Participant.** There was little change in the participants CLES Attitude Scale scores. T1-Ariel, T3-Liz, and T8-Jullia showed a slight decrease. T2-Jo, T4-Hailey, T5-Robin, and T6-Lucy showed a slight increase. The seven participants all had post assessment scores that fell within the high agreement range. T7-Anna’s scored remained the same, falling within the high intermediate category. Figure 25 displays the pre and post Attitude Scale scores for each of the teacher participants.

![Scores chart](chart.png)

*Figure 25. Participant’s CLES Attitude Scale Scores*

**Triangulation Across Cases**

Triangulation across cases occurred throughout the cross-case analysis to make sure the picture is clear and meaningful. Data were utilized to examine the beliefs of the participants related to teaching science, how children learn science, and science teaching methods to uncover patterns that influence teaching behavior as it relates to autonomy or Individual Identity (II). All eight participants learn best by seeing and doing, when they
are actively engaged in the learning experience. Excerpts from the Partner Portfolio for Professional Development supported interview data. When asked to remember science learning situations that influenced their teaching and learning all eight recalled multi-sensory, hands-on experiments or activities. They all had a difficult time remembering the science information taught to them when they were not actively engaged in their learning. Excerpts from the Partner Portfolio for Professional Development supported interview data. An excerpt from Ariel’s Invitation to Practice: Science Learning Personal History activity supported the idea that Ariel believes that she needs to see or visualize her learning. Ariel explains “…As a learner myself, I think I am more of a visual learner. I need to be able to see whatever it is we are learning about.” Jo explains in her Invitation to Practice: Science Learning Personal History, “…I learned because it was visual and hands-on.” In one of her Partner Portfolio for Professional Development journal entries, Liz explains that she learns when “sharing ideas with others and being open-minded.” An excerpt from Hailey’s Invitation to Practice: Science Learning Personal History activity supported the idea that she is a visual learner and needs to learn through hands-on interactions. An excerpt from Robin’s Invitation to Practice: Science Learning Personal History activity showed that Robin believes that she needs to see and do something in order to truly learn a concept, “…reading about it was just not enough. It gave me a foundation but actually seeing it and doing it helped solidify my learning.” An excerpt from Anna’s Invitation to Practice: Science Learning Personal History activity supported the idea that Anna believes that she needs to actively engaged using hands-on interactive methods while learning. An excerpt from Julia’s Invitation to Practice: Science Learning Personal History activity supported the idea that Julia believes that she needs to
participate, use hands-on and inquiry type methods, when learning. All eight teachers noted that they learned best through multi sensory, hands-on, minds-on engagement. Data from the Partner Portfolio for Professional Development supported this idea.

This excerpt from Lucy’s Invitation to Practice: Science Learning Personal History illustrates her beliefs about teaching and learning.

What I realize now is that in order to develop students who will do well in understanding the world around them you have to teach them how to become thinkers. In school I learned how to read out of a textbook and memorize facts. I had no idea how to think. I didn’t have much experience to draw from either. When I am planning my science lessons now I keep this in mind. I do my best to come up with thoughtful active lessons that will provide the kids with experience on topics that they can fall back on.

Lucy, Ariel, Hailey, and Anna noted in the pre PSI Professional Development Course interview that they struggled with or felt uncomfortable with science in school. Excerpts from the Partner Portfolio for Professional Development supported interview data.

Ariel (Invitation to Practice: Science Learning Personal History): During a college anatomy course, we had to learn all the names of the bones in the body. I thought I would never be able to do that. I had to use different methods to achieve this goal. We not only had to name them but also be able to label them correctly on a diagram of the body. As a learner myself, I think I am more of a visual learner. I need to be able to see whatever it is we are learning about. So to learn the names of the bones, I wrote them down many, many times. Then to label, I used a blank diagram, practiced writing the names of the bones on the diagram.

An excerpt from an Exit Slip from Hailey’s Partner Portfolio for Professional Development shows she was willing to try to improve as a teacher, but is unsure about carrying out the process. Hailey wrote, “I am still unsure about how I will manage centers, but want to try.” In Hailey’s Partner Portfolio for Professional Development, when describing what’s in her bucket, Hailey indicated that she felt “less pressure, with “baby steps,” to do it all at once.”
Data analysis continued, with an examination of teacher beliefs about how children learn and teaching methods. All eight teachers used positive emotions as descriptors of student learning. Jo writes in her Invitation to Practice: Mapping My Classroom activity that she wants to create a learning culture that inspires “wonder and excitement” in her students. In the Invitation to Practice: Collaboration entry, Robin and Hailey write that they are both “willing to embarrass themselves in order for students to learn.” Lucy likes to “be very animated and goofy sometimes to keep them interested.” Anna creates an atmosphere that encourages learning. Julia feels confident and enthusiastic about teaching science. There was an increase in six of the Student Negotiation Scale scores; Julia’s scores remained the same. Liz’s scores decreased by only one point and remained in the high intermediate category. All of the participants post assessment scores fell into either the high intermediate or high agreement categories. Hailey’s, Robin’s, and Lucy’s scores increased significantly. The CLES Student Negotiation Scale measures the emphasis placed on providing opportunities for students to explain their ideas to other students, make sense of other students’ ideas, and reflect on the viability of their own ideas.

Hailey, Robin, Lucy, and Anna explained that novelty was a characteristic of their teaching. In their Invitation to Practice: Collaboration entry, Robin and Hailey write that they are both “not afraid to try new things.” Lucy likes to “do something shocking or intriguing to help them remember the concept.” For example, when describing liquids she “dumped the water out on the table to show them it changed shape.” Her students had no idea she was going to do that and she exclaims, “They never forgot it!” Anna feels being funny or doing things that click will help students remember more.
Ariel, Jo, Hailey, and Julia emphasized providing a comfortable learning atmosphere or comfort zone in their science classroom. All eight of the teachers emphasized that they believed it was important for the students to be actively engaged in their learning. They encouraged investigation, exploration, and searching for answers. Ariel explains that she allows her students to “see, write, and practice.” Data from Jo’s Invitation to Practice: Mapping My Classroom activity reveals that she feels others might see her “as a facilitator leading students across bridges making discoveries along the way.” In one of her Partner Portfolio for Professional Development journal entries Jo believes her students will say, “We got to play!” She feels they value the opportunity to engage in “hands-on and sharing out their thinking.” In her Invitation to Practice: Mapping My Classroom activity Liz writes that she wishes to “implement more Inquiry-Based instruction” into her classroom. In one of her Partner Portfolio for Professional Development journal entries Hailey explains that she chose a glove as an artifact to represent her science teaching “to represent how I try to provide hands-on lessons in science. So much is abstract for fifth graders that unless it is hands-on or equated with something you feel they know, they can’t grasp it.” Lucy notes that her students “look forward to the activities” that they do in her classroom. They are “always busy.” Anna feels that “actually touching, feeling, and doing” are important in her classroom instruction. Julia believes her students are learning when they observe, manipulate, investigate, interact with peers, and can explain concepts. Ariel’s, Jo’s, Liz’s, Robin’s, Lucy’s, and Julia’s CLES Attitude Scale scores were in the high agreement range, which indicated that they felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities. Hailey’s CLES Attitude
Scale scores, pre (26) and post (28), increased slightly from a high intermediate to a high agreement level. Anna’s pre (25) and post (25) CLES Attitude Scale scores were in the high intermediate agreement range.

Each of the participants expressed their own teaching style, however they shared many similar characteristics. They spoke of structure or routine mixed with flexibility, humor, creativity, and fun. They all incorporated a variety of methods throughout each science lesson. Seven out of the eight participants spoke about extending learning outside of the classroom in their interview sessions. In their Invitation to Practice: Collaboration activity, Jo and her CF, Ariel, both saw themselves as “very structured.” Although Jo sees herself as very structured, she will lead her children in investigations that allow them to stray from the routine to explore and discover for themselves. The following excerpt from Hailey’s Goal Statement in her Partner Portfolio for Professional Development supported this idea. Hailey explains, “I would like to use inquiry in every science unit, particularly in those that currently seem like it would not lend itself to it.” The following excerpt shows Anna’s goal for the PSI Professional Development Course.

I want to become a more interesting and exciting teacher, in all areas, not just in science. I would like to bring in new ways of teaching the same ‘ole stuff so I want to teach it and they want to learn it!

In one of Julia’s Partner Portfolio for Professional Development Invitation to Practice: Collaboration entries she explains that she and her CF, Sara both “plan together” and “take our learning outside the classroom [bluebird houses, Red Fox Trail, etc.].” Portfolio data showed that all eight teachers use some form of inquiry, investigation, questioning, hands-on, and activity-based methods their lessons.
Research Question 2 Cross-Case Analysis

How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?

Interview analysis (see Appendix B for instrument) for the cross-case analysis of Research Question 2 includes the examination of (a) pre PSI Professional Development Course interview questions 4, 5, 7, and 8 listed in Table 1, and (b) post PSI Professional Development Course interview questions 3 and 4. The (c) Classroom Observation analysis (see Appendix E for the Classroom Observation Protocol), (d) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), (e) CLES analysis (see Appendix D1 for instrument and D2 for scoring instructions), and the (f) Partner Portfolio for Professional Development serve as sources for triangulation and provides for multiple measures of the same phenomenon (Yin, 2003). The interview information was examined to uncover patterns related to the participants’ knowledge of science subject matter and science pedagogical knowledge associated with their abilities to produce desired results in their science classroom according to their beliefs and self-efficacy. In other words, the researcher has assembled the pieces to uncover patterns that are associated with the query, “How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?”
**Themes Developed from Interview Data**

The researcher next presents an explanation related to themes developed from Interview Question 2 data cross-case analysis. Interview data findings were utilized to examine the beliefs of the participants related to science content knowledge, pedagogical science knowledge, and understanding of I-B methods in an effort to uncover patterns related to self-efficacy and the participants’ abilities to produce desired or intended results in their science classrooms. First, a review of Research Question 2 analysis from each case or teacher portrait was conducted. Next, beginning with Research Question 2 data analysis, themes or findings were identified using each participants interview analysis data (see Tables 38, 39, and 40 for a breakdown of themes and factors grouped by clusters). Stake (2006) defines themes as central ideas having importance related to its situation. When analyzing data for the cross-case analysis of Research Question 2, findings were assembled related to science content knowledge, pedagogical science knowledge, and understanding of I-B methods. As the researcher reviewed the multi-case themes she visualized the multi-case project as a whole while moving towards a number of cross-case assertions based on the data gathered from the case reports or teacher portraits. The themes or findings that emerged from the data analysis were converted into factors. A factor is defined as a widely found, sometimes influential variable of interest well beyond its situation. The following factors emerged from data analysis findings: Negative Emotions, Sit n’ Git, Make Better, Love (Transition Towards) or (Positive Influences), Methods, Motivation, Reach All, Apply and Connect, Components, World View, SOL, and Emotions.
Next, factors were merged into clusters according to similarities. Each factor cluster was ranked according to its frequency of occurrence and importance for understanding the quintain (Stake, 2006), the common condition of the implementation of I-B science into the classroom. The factor clusters give rise to assertions that describe the quintain. For example, the factors of Negative Emotions, Sit n’ Git, Make Better, and Love (Transition Towards) or (Positive Influences) were all arranged into the factor cluster of Self-Efficacy Related to Understanding of Science Content. The factors of Methods, Motivation, Reach All, and Apply and Connect were all arranged into the factor cluster of Self-Efficacy Related to Pedagogical Science Knowledge. The factors of Components, World View, SOL, and Emotions were all arranged into the factor cluster of Science.

Analysis for triangulation of multiple data sources provided for multiple measures of the same phenomenon, data analysis was conducted using a pattern matching technique. A link between themes and concepts from pre and post PSI Professional Development Course interviews, pre and post PSI Professional Development Course observations, and the Partner Portfolio for Professional Development was obtained through a number of onsite visits over a period of seven months (Yin, 2003). During this data analysis the factor clusters (Stake, 2006) of Level of Inquiry Implementation and Items Added to the Bucket emerged.
Table 38.

Research Question 2 Cross-Case Analysis
Self-Efficacy: Science Content Knowledge

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Factor Cluster: Self-Efficacy Related to Understanding of Science Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factor: Negative Emotions</td>
</tr>
<tr>
<td></td>
<td>(Medium Occurrence)</td>
</tr>
<tr>
<td></td>
<td>Factor: Sit n’ Git</td>
</tr>
<tr>
<td></td>
<td>(High Occurrence)</td>
</tr>
<tr>
<td></td>
<td>Factor: Make Better</td>
</tr>
<tr>
<td></td>
<td>(Low Occurrence)</td>
</tr>
<tr>
<td></td>
<td>Factor: Love (Transition) or (Positive Influences) (Medium Occurrence)</td>
</tr>
<tr>
<td>1</td>
<td>Fear</td>
</tr>
<tr>
<td></td>
<td>Limited training</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Textbook</td>
</tr>
<tr>
<td></td>
<td>Read then tested</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
</tr>
<tr>
<td></td>
<td>Desire to become</td>
</tr>
<tr>
<td></td>
<td>better science</td>
</tr>
<tr>
<td></td>
<td>teacher</td>
</tr>
<tr>
<td></td>
<td>Bake and Cook</td>
</tr>
<tr>
<td></td>
<td>(Positive Influences)</td>
</tr>
<tr>
<td></td>
<td>(Love)</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Don’t remember</td>
</tr>
<tr>
<td></td>
<td>Not really a focus</td>
</tr>
<tr>
<td></td>
<td>Fascinated</td>
</tr>
<tr>
<td></td>
<td>Investigate</td>
</tr>
<tr>
<td></td>
<td>Outside</td>
</tr>
<tr>
<td></td>
<td>(Positive Influences)</td>
</tr>
<tr>
<td></td>
<td>(Love)</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Felt uncomfortable</td>
</tr>
<tr>
<td></td>
<td>Opening a text and reading</td>
</tr>
<tr>
<td></td>
<td>Look for new ways</td>
</tr>
<tr>
<td></td>
<td>Wish she had more time</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Leery</td>
</tr>
<tr>
<td></td>
<td>Don’t remember</td>
</tr>
<tr>
<td></td>
<td>specific directions</td>
</tr>
<tr>
<td></td>
<td>Leery but loved</td>
</tr>
<tr>
<td></td>
<td>(Transition to Love)</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Didn’t like</td>
</tr>
<tr>
<td></td>
<td>Read out of a book and memorized</td>
</tr>
<tr>
<td></td>
<td>Began to love</td>
</tr>
<tr>
<td></td>
<td>(Transition to Love)</td>
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<tr>
<td></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Cringe</td>
</tr>
<tr>
<td></td>
<td>Don’t remember</td>
</tr>
<tr>
<td></td>
<td>Desire to improve</td>
</tr>
<tr>
<td></td>
<td>skills</td>
</tr>
<tr>
<td></td>
<td>Good Training</td>
</tr>
<tr>
<td></td>
<td>(Positive Influences)</td>
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<tr>
<td></td>
<td>(Love)</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>No Science</td>
</tr>
<tr>
<td></td>
<td>No science in parochial school liked in high school and college</td>
</tr>
</tbody>
</table>
Table 39.

Research Question 2 Cross-Case Analysis
Self-Efficacy: Pedagogical Science Knowledge

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Factor Cluster: Self-Efficacy Related to Science Pedagogical Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factor: Methods (High Occurrence)</td>
</tr>
<tr>
<td>1</td>
<td>Different Hands-on</td>
</tr>
<tr>
<td>2</td>
<td>Mix Question Doing</td>
</tr>
<tr>
<td>3</td>
<td>Inquiry Do Investigation Hands-on Questioning</td>
</tr>
<tr>
<td>4</td>
<td>Engaged Ask questions</td>
</tr>
<tr>
<td>5</td>
<td>Journal Experiment Ask Questions</td>
</tr>
<tr>
<td>6</td>
<td>Activities Process Skills Revolved (movement) Sing Songs</td>
</tr>
<tr>
<td>7</td>
<td>Doing Activity Demonstration Make Mistakes</td>
</tr>
<tr>
<td>8</td>
<td>Inquiry in classroom Explore Students explore</td>
</tr>
</tbody>
</table>
Table 40.

**Research Question 2 Cross-Case Analysis**

**Definitions of Science and Inquiry Science**

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Factor Cluster: Science</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Factor:</strong> Components (High Occurrence)</td>
</tr>
<tr>
<td>1</td>
<td>Investigation Questioning</td>
</tr>
<tr>
<td>2</td>
<td>Exploring Questioning Reasons Why</td>
</tr>
<tr>
<td>3</td>
<td>Investigate Question</td>
</tr>
<tr>
<td>4</td>
<td>Discover Difficult Concepts Questioning</td>
</tr>
<tr>
<td>5</td>
<td>Teacher asks questions Explore</td>
</tr>
<tr>
<td>6</td>
<td>Experiments Fun</td>
</tr>
<tr>
<td>7</td>
<td>Teacher answers questions Teacher Explains</td>
</tr>
<tr>
<td>8</td>
<td>Excitement Fun Explore Discover Challenge</td>
</tr>
</tbody>
</table>
Interview Data Cross-Case Analysis

Interview data findings were utilized to examine the beliefs of the participants related to science content knowledge, pedagogical science knowledge, and understanding of I-B methods to uncover patterns related to self-efficacy and teachers’ abilities to produce desired or intended results in their science classrooms. Cross case analysis started with an examination of pre and post interview data, which was useful in describing patterns found in the teachers’ frameworks for understanding science related to their abilities to produce desired results according to their beliefs and self-efficacy. The following interview questions were found useful in providing data for triangulation for Research Question 2: (a) pre PSI Professional Development Course interview questions 4, 5, 6, 7, and 8 listed in Table 1, and (b) post PSI Professional Development Course interview questions 3 and 4.

All eight participants noted that they had a difficult time remembering science in school either because their science learning was not hands-on, the method of instruction used by their teachers was limited to reading out of a book, or science was not emphasized at their school. As an example, Lucy revealed in her pre PSI Professional Development Course interview that she did not like science in school because they “read out of a book and memorized stuff.” Others told similar stories. Liz explains, “I really cannot remember any particular science lesson I had in school. I mean, obviously I was taught science, I don’t remember that as being a subject that teachers really focused on.” The others had similar experiences.

Jo (pre): They were very poor, to be honest with you. I was basically given a textbook. I don’t remember doing any hands-on. It was basically read and you’re going to be tested. Read, you’re going to be tested. It was very poor.
Hailey (pre): The only one I remember is when we were hatching baby chicks and we had an incubator in the classroom. That was exciting. Most of my classes as a child, the rest of my memory is just opening a textbook and reading.

Like the other teachers, Julia, Ariel, Robin, and Lucy explained that they have limited training experience in the area of science. Julia explains, “I went to parochial school and we didn’t have science like we do now in the elementary school.”

Many college science laboratories overlook the pedagogy of science as inquiry. Hands-on methods do not necessarily equate with teaching science as inquiry. What is more, teacher preparation courses and professional development training activities in methods of teaching science repeatedly put emphasis on technical skills rather than reasoning, decision-making, and theory. If standards-based reform is to be achieved, professional development activities need to include practices that engage potential and practicing teachers in active learning that fosters their comprehension, knowledge and ability (NRC, 1998). The experiences of the participants support this assertion. In college, Ariel remembers taking only one course in each of the following subjects: chemistry, anatomy, and biology. Robin doesn’t recall any specific directions that she learned for teaching science. She remembers her college science training as more of a broad teaching. Lucy’s early college science training consisted of “doing a lot of reading out of the book.”

Five of the participants explained in their pre PSI Professional Development Course interviews that they either disliked science or felt uncomfortable with science. Ariel, Hailey, Robin, Lucy, and Anna all felt negative emotions when thinking about science. Ariel explains, “Science would be one [fear] and math another.” Hailey noted
that, “A lot of the people felt uncomfortable teaching science. Most of the class really did admit they felt uncomfortable teaching it…” Lucy did not like science. She didn’t understand it. When she took chemistry in high school she still “didn’t get it.” Anna cringes when she thinks about science.

Anna (pre): I cringe about science and math because I was never good at science or math in school and I always wanted to be. This is a sad story, if I was good at math and science, I wouldn’t be a teacher. I would have gone into a totally different field. I blame it on the teachers. I don’t think they taught their subject well.

She also notes that she had a difficult time remembering science concepts in high school chemistry. She explains, “…We had cheat cards because I could never remember all of those chemical equations.”

The other three participants (Jo, Liz, and Julia) had positive experiences related to their early science learning. Jo believes she learned a lot about science by cooking and baking with her mom and working with photography in the basement with her dad. Liz has “always been fascinated with science.” She believes most of her science learning “came from a love of science.” She explains, “I was always outside. I was always investigating something in nature, bringing things home, growing this, or raising that…” Robin was also “a little leery about teaching science.”

Whether positive or negative, when placed in a learning experience that was hands-on or interactive, the teachers were able to remember the activity. The teachers remembered learning when they were “seeing” and “doing” or when their teachers used a constructivist approach. The constructivist approach to how people learn focuses on providing relevant experiences and opportunities that allow students to construct knowledge (Piaget, 1929; Vygotsky, 1978). Hailey remembered, “…hatching baby
chicks.” Julia remembers, “The thing that comes to mind for me immediately was high
school biology and it was dissecting a frog. It was definitely hands-on experience. That’s
what comes to mind.” Several teachers who feared or disliked science transitioned to
liking or even loving science because they were exposed to hands-on interactive activities
or lessons. Lucy explains that she began to like science when she took a teaching science
class in college that was “all hands-on.” She talked about a professor who first introduced
a topic by talking about it, then he allowed the students to perform experiments, finally
he showed the teachers how the topic he spoke about and the experiments were
connected. Robin explains her transition in the excerpt that follows.

Robin (pre): …At first, to be truthful, I think I was a little leery about teaching
science. When we first decided we were going to do team teaching we asked,
“Well which subject are you going to teach?” I feel I’m more of a math person
than science. Then I thought about it and I said, “No it’s not that hard. I’m kind of
a science person.” So, I tried it. I am definitely loving it! I’m teaching all science
now. I don’t think there was specifically a mentor that helped me, just seeing
some of the other teachers and seeing that it [teaching science] was not that
difficult for them and their interest in it. That made me see.

When speaking about their understanding of science content information three of the
teachers (Jo, Hailey, and Anna) brought up the topic of improving or making their
teaching better.

Jo (pre): I would like to be a better science teacher. That’s why I signed up for
this course. I feel like my strength is in math and I think that’s because I like
math. I think I was better with science before, I hate to say this, but before the
SOL. I feel like I now have a time limitation…and not I feel like I’ve got to cut
everything short. I feel like that’s a limitation…

Hailey (pre): I think that one of my strengths is my willingness to look for new
ways of teaching something. Looking for new things and as a science teacher, the
mess doesn’t seem to bother me. That disorganized side of my self does come into
play in a positive way. I think I maintain a classroom where the students are
engaged and it’s not, but they know their limitations in behavior and all of that.
Anna (pre): I would like to improve my students’ critical thinking skills. I don’t think I question them the correct way well enough. I don’t ask enough questions like, “How do you know this?” “How did you think this?” I would like to pull out their ways of thinking and explanations instead of I just know it…

Although they were all veteran teachers, the participants were willing to learn new things and improve their teaching practice.

Interview data analysis was useful in uncovering patterns across the participants’ frameworks for understanding science related to each teacher’s ability to produce desired results according to their individual beliefs and self-efficacy. All eight of the teachers spoke of encouraging their students to question or investigate how science applies to their own lives. In her pre PSI Professional Development Course interview, Ariel defines Science as “investigation, questioning everything I have to teach, SOL tests, applying science concepts to their lives.” In her post PSI Professional Development Course interview, Ariel takes a worldview as she explains that she defines science as, “…answering questions about what goes on in the world.” In her Jo pre PSI Professional Development Course interview, she defines science as being similar to cooking or baking. She also tells about her hands-on experiences with photography with her father.

Jo (pre): “Also dad was a big influence too because he was an orthodontist so he was real into math and science and he was a big influence… his hobby was color photography and in the basement he had a darkroom…so that was really awesome to me, ‘what?’ So I’d pull up a stool next to him and he would try to explain. That was really neat.”

Like Ariel and Jo, Liz, Hailey, Robin, Lucy, and Julia all encourage their students to relate science to their own lives. They all mention discovery or investigation of the world around them when defining science. Ariel defines science in her post PSI Professional Development Course interview, “…answering questions about what goes on in the
world.” Jo defines science in her post PSI Professional Development Course interview as “exploring, questioning, and experimenting to discover the reasons things are what they are or why they happen.” Liz defines Science in her pre PSI Professional Development Course interview as “investigation, questioning everything I have to teach, SOL tests, applying science concepts to their lives.” Lucy defines science in her post PSI Professional Development Course interview as, “Science is a way of helping us understand and explain the world around us.” In her pre PSI Professional Development Course interview Hailey explains that when she thinks about science, “I think discovery. I think difficult concepts and questioning.” Hailey explains in her post PSI Professional Development Course that she believes it is important for students to “see relationships, ask questions, and be willing to complete work.”

Robin (pre): “Science is everywhere. We start the year with it. I start telling the kids, to start thinking about science…I’ll tell them, ‘Science is all around. It’s everywhere. It’s all around you. I think about in science, it’s not just a lab, a man in a white coat or a woman in a white coat. It’s all around you. You could be a scientist without having to be in a lab coat. You just explore your back yard and science is there.’ …You’ll probably be exploring that now, middle school and beyond. It really is everywhere.”

Julia (pre): “Excitement! To me it’s alive, it’s just life. When I think of science I think exploration, discovery, challenge. To be honest, it’s the most exciting of all of the classes because, it is, it really is, I’m always excited and so are the kids when you’re doing science, because it’s life and the kids can bring in and observe and just do so much. It’s not abstract. It’s real. It’s just a pleasure to teach because it’s so exciting. It’s so interactive. Those are the words that come to my mind, exploration, and life. It’s just multisensory. It’s fun, fun, it’s fun!”

Like Julia, Lucy uses emotions to explain science. Lucy explains in her pre PSI Professional Development Course interview the she defines science as, “Experiments and fun. Kids love it. That’s it.”
Cross-case data analysis continued with an examination of the descriptions of each participant’s framework for understanding pedagogical science knowledge. All eight of the teachers used a variety of different methods including hands-on, experimenting, or doing. In her pre PSI Professional Development Course interview, Ariel explains, “I try to use different methods to hopefully reach all students. I use the interactive notebook, hands-on activities, demonstrations, whole class teaching, partner, and small group experiments.”

Ariel (pre): I do a lot of hands-on, not experiments that they design themselves, but like building things like the atom. I would hope they would say it was fun and they learned a lot. I think I have a long way to go with that too.

Ariel (pre): I have a lot of those kids, LD and kids with autism. I use hands-on, shorter assignments, and give them more time to complete assignments. If they can’t write well, I allow them to use pictures for their evaluation. I break down the content so that it is appropriate for their level. I put them with another student who understands and will help them.

Like Ariel, Jo, Liz, Lucy, Robin, and Anna try to reach all of their students through a variety of activities.

Jo (pre): I manipulate all the time. Sometimes I find it better to group them together and we focus on that. Other times I focus on, mix it up, where you’ve got somebody that’s strong visually, strong with hands-on, put them together to work and give them the job that they are strong in and then come back together as a group.

Liz (pre): I use inquiry and investigation, hands-on, I do a lot of that. I use questioning, with me questioning them and with them questioning me. My lessons are activity based. We play games in science. I even bring PE into it. We’ll take something we’re learning in science and it becomes a relay race or something outside. That’s really fun for the kids and you can kind-of do PE and science at the same time. That’s your PE for the day but you were also doing another 20 minutes of science! That’s fun to do to.

Robin (pre): I guess it would be the stuff that they’re going to take and use daily to understand the world. They should learn things like measurement and the process skills, observing, creating graphs and charts, and communicating. I think
those are the most important. Some other things, like the cycles and the seasons, are also important for them to learn about. Some of the concepts are a little bit harder for them and I think they’ll eventually get because the science seems to wrap up or spiral every year.

Anna (pre): Oh, I remember when we did this. I also try to make sure if we do things with plants…But, if you put the seed in the paper towel and it rots, that’s OK. I tell the students, “It’s OK. Do you think that all of those scientists knew that the first time?” I want to make sure they know that mistakes are good, you learn from them. If things fail, it’s OK, you learn from that too.

Anna (pre): I tell them the same thing about writing a book. I ask students, “Do you thing Eric Carle sat down and wrote the book the very first time he tried? No, it took hundreds of times. He wrote and rewrote and rewrote.” They don’t get that very easily at this age. They want it done the first time. It’s done. Immediate action. They feel they don’t need to improve.

Julia (pre): I would say inquiry approach, in that you set up your room so that it’s like a lab. The kids know the rules and regulations related to it. They know the information. They know where they’re going and they get to explore. I would say all of the methods that relate to the inquiry method being put into place in a classroom and allowing that opportunity to the kids is what works best.

Lucy and Julia explain why they feel motivated to use a variety of activities in her teaching. She explains in her pre PSI Professional Development Course interview, “I think because of the bad experience I had, I just always want to make the kids have a better experience.” Julia explains that her motivation is “what works best for the kids.”

Julia (pre): It’s because I know that’s what works best for the kids. They can go over and pick up a magnifying glass and make observations and I’ve got words there to help them put their thoughts together and explain what they’re seeing.

Six of the teachers discussed applying the science content information or making connections within the context of the science lesson through questioning or offering explanations (Jo, Liz, Hailey, Robin, Lucy, and Julia). In her pre PSI Professional Development Course interview, Hailey explains that she knows when her students understand a concept, “If they are able to, not just list, but explain their answer and
maybe take another example to demonstrate the concept worked outside of what they’ve already learned.”

Jo (pre): When they can apply it to something else. That’s in all subject areas, especially in math and science. When they can carry it over into something else and say, “hmmm, it worked for that, maybe it’ll work for this, let’s try it.

Liz (pre): I know if they understand a science concept if they make a connection to something else and bring that back in and share it. You can tell they understand it because they made that connection. If they can explain it to someone else. If they can take what they’ve learned and go beyond that then you know that they’ve grasped that concept and they’ve made a connection to something being a little bit further.

Anna (pre): That would probably be with different learning centers, or with different examples or activities. I think if they’re actually doing it rather than just hearing it they’re going to remember it more… they understood what dissolving meant because we actually stirred up the glass of water with the dirt in it or the rocks in it…I try to do things that they are going to remember.

Julia (pre): Sometimes it’s easy to know because they say, “oh, I get it!” They let you know. I’ll have that with my inquisitive learners particularly. They will ask and inquire. Then suddenly the light bulb goes off and you can see it in their face. You can see it through their work, through observation, of course, through the written work as well, when you’re checking them. It is a multitude. You can see it by the way they respond to your questions and your discussions. You can figure out where they are in the spectrum. Then there are verbal responses and the way they create. It could be through art, showing that this is my understanding of the life cycle and they create it. This was one of their assessments this last time. We used a pencil to paper test to just show a life cycle, being able to create it and explain it. There is a true multiple intelligences at work there. That’s how they can demonstrate their knowledge.

Robin emphasizes demonstration of learning in science through writing.

Robin (pre): Well, there’s paper and pencil tests and things like that, but really what we’ve tried to do this year is some journal writing. I believe they show through their writing if they really understand the concept. We try to do that in science and math. To see, yes, you can answer a question on it, but if you’re writing to explain it then they are really able to show more of a deeper understanding. If they can explain in their own words what is happening and why.
All eight teachers spoke of motivation either related to interest level (Ariel, Liz, Hailey, and Robin), curiosity (Jo and Julia), or helping students to remember (Lucy and Anna).

Ariel explains in her pre PSI Professional Development Course interview, “I want it to be interesting to them and learn why they are supposed to learn. You try different ways. I don’t want them to be bored.” In her pre PSI Professional Development Course interview, Robin explains, “Because it’s fun and they enjoy it and I think they learn better from it.” Julia explained her excitement when students discover new concepts saying, “Then suddenly the light bulb goes off and you can see it in their face.” The excerpts that follow outline more thoughts related to motivation.

Jo (pre): The way I teach? Well, you’re going to laugh, but the food channel, the food network. Alton Brown, I love him. In fact, I even had my kids watch him. I looked to see what he was doing and he was describing why something, maybe why water does certain things like surface tension. He got into the water molecules and all of that. The gas is expanding and the molecules moving apart and why things work. That’s true though.

Liz (pre): Again that’s the way I’d like to learn. If it’s boring to me it’s probably boring to them. I take any chance to get out and do something, not just to sit there. I like to be active too; it’s just more fun.

Lucy (pre): I always want the kids to have the memory of the activity to fall back on. So if they were going to try to answer the question about why we have seasons. I want them to remember how we revolved around the room, or sang a song. And I want them to look back and say I remember it that way. I want them to make a connection.

Robin and Hailey feel somewhat limited by their knowledge of pedagogical science knowledge and the amount of time available to apply science teaching methods. Both teachers are interested in learning more. Robin would like learn more about helping students understand what they are learning.

Robin (pre): I think with science, if I’m going to go that route, I would say, I would like to improve my skills to plan so that when I do an experiment with
students or show that they are going to have to apply more of that self learning that they are used to doing. That they understand it, it’s not just me telling them what to do. To ask, “Why is this experiment working this way?” I want them to be able to do that. Maybe even looking for more of those lessons where that light bulb will go off in their head on their own.

Hailey describes her own framework for understanding I-B methods before the PSI Professional Development Course as “limited to asking questions to gain understanding.”

She also feels limited by time.

Hailey (pre): I wish I could do lots of things; it’s the time thing. I thought about making a whole big plant cell out of the classroom. I’ve got the idea in my head but I just haven’t been able to do it. So I wish I could just turn the classroom into whatever I am studying. That would be great. But, time is an issue.

Last, data analysis focused on the participants’ descriptions of their own frameworks for understanding I-B science methods as reported during their interviews. Seven of the eight teachers held some knowledge of inquiry science prior to the PSI Professional Development Course. The teachers (Ariel, Jo, Liz, Hailey, Robin, Anna, and Julia) included the following concepts in their definitions of inquiry science: questioning, investigating, exploring, and making connections. Prior to the PSI Professional Development Course Ariel defines inquiry science as “questioning, looking into something more thoroughly, and lots of questions, more observing.” Following the PSI Professional Development Course Ariel’s Inquiry definition includes “questioning, investigating, figuring out answers, exploring.” Prior to the PSI Professional Development Course, Jo defines inquiry science as “questioning, answers to puzzles.” Following the PSI Professional Development Course, Jo defines inquiry science by saying, “Inquiry science is a combination of scientific method and further exploration to
figure out the ‘How’s?’ It is a chance to wonder about life and ‘play,’ to maybe make sense of it all.”

Liz (pre): “I take that [I-B methods] to mean you’re exploring, you’re investigating things. You are taking the unknown and learning a little more about what you don’t know. Or making connections to things that were not there before.”

In her post PSI Professional Development Course interview Liz added, “Using investigative methods to learn science concepts,” to her definition of inquiry science.

Robin (pre): “To define Inquiry science I would say questions…So inquiry is having the students, or whomever it is, exploring for that lab trying to understand the question that was asked and trying to explain further. They might ask, ‘what if we were to make these changes?’ and ‘why is it doing that?’ So it’s more exploring for themselves and trying to understand on their own, with guidance, how they arrived at the answers.”

Anna (pre): [I-B] “I think it’s basically a question, you ask, I tell. The kids ask what they want to know and the teacher spends time answering things that they want to know about a subject. It’s showing them the answers; again, it’s hands-on. It’s got to be able to get down to their level and explain things at their level. A lot of that is with show and tell type things.”

Julia (pre): “[Inquiry] For me I have a real positive feel because then you’re delving into it. You’re inquiring. Inquiring minds want to know. So when I think inquiry, I think you have something that you want to understand deeper and you are going to have to come to an understanding to acquire that knowledge. So, to me it’s a hands-on way to learn the end product. That’s what inquiry science means to me. You are inquiring and you are doing it through a variety of methods until you can come to a conclusion. Basically taking yourself through the scientific method.”

Julia explained in her post PSI Professional Development Course interview that through the course she learned a systematic approach to inquiry. She explains, “I knew what worked but did not have a systematic approach prior to the session.” She continues to explain, “I now have a systematic approach that organized my lessons and engages the students.” In her post PSI Professional Development Course interview, Julia added the following to her definition of inquiry science, “the inquiry approach to science is a
methodical plan which captivates the students. It incorporates the 5E’s [from the 5E Model of science teaching (Bybee, 1993, 2000; Carin et al., 2004)] and is very much hands on and exciting.” Hailey explained in her pre PSI Professional Development Course that she feels inquiry science includes, “providing exploration so that students will ask the questions and solve the problems through discovery.” In her post PSI Professional Development Course interview, Hailey says, “It [inquiry science] is a process. It can be achieved by writing a lesson using the 5E’s.” She further explains that she will use “engagement,” the “5E’s template to write lessons” and “try to pose a problem” in her lessons.

Lucy was not familiar with Inquiry science before the PSI Professional Development Course. Lucy explains that she “hadn’t even heard of it [I-B] before. It sounded like another buzz word for hands-on.” Lucy shares what she learned in her post “A method of teaching that enables students to explore, manipulate, and experiment in order to truly build and lay the foundation of scientific understanding.”

Ariel, Hailey, Robin, Lucy, Anna, and Julia all discussed the point of view of the learner or student when defining inquiry science. Hailey explains in her post PSI Professional Development Course interview, “She believes it is important for students to “see relationships, ask questions, and be willing to complete work.” Lucy defines inquiry in her post PSI Professional Development Course interview as, “A method of teaching that enables students to explore, manipulate, and experiment in order to truly build and lay the foundation of scientific understanding.”

Julia Pre: “[Inquiry] For me I have a real positive feel because then you’re delving into it. You’re inquiring. Inquiring minds want to know. So when I think inquiry, I think you have something that you want to understand deeper and you are going
to have to come to an understanding to acquire that knowledge. So, to me it’s a hands-on way to learn the end product. That’s what inquiry science means to me. You are inquiring and you are doing it through a variety of methods until you can come to a conclusion. Basically taking yourself through the scientific method.”

Anna Pre: [I-B] “I think it’s basically a question, you ask, I tell. The kids ask what they want to know and the teacher spends time answering things that they want to know about a subject. It’s showing them the answers; again, it’s hands-on. It’s got to be able to get down to their level and explain things at their level. A lot of that is with show and tell type things.”

Robin holds a view that gives the teacher more control. In her post PSI Professional Development Course interview Robin explains, “Inquiry science is allowing students to take ownership and generate questions about ideas or concepts that are presented by the teacher.” In her post PSI Professional Development Course interview Ariel noted that she probably avoids “giving them something and letting them discover on their own,” The reason she does not “do as much of that” is because she doesn’t “feel comfortable doing that.”

Teachers associated emotions with science learning, both positive and negative. Ariel and Anna reported uncomfortable emotions associated with their definitions of science learning. In her post PSI Professional Development Course interview, Ariel noted that she probably avoids “giving them something and letting them discover on their own,” The reason she does not “do as much of that” is because she doesn’t “feel comfortable doing that.” Anna explained her feelings in her pre PSI Professional Development Course interview, “I cringe about science and math because I was never good at science or math in school and I always wanted to be…” Lucy and Julia expressed positive emotions when defining science. Lucy excitedly explains in her pre PSI
Professional Development Course interview, “Experiments and fun. Kids love it. That’s it.”

Julia (pre): “Excitement! To me it’s alive, it’s just life. When I think of science I think exploration, discovery, challenge. To be honest, it’s the most exciting of all of the classes because, it is, it really is, I’m always excited and so are the kids when you’re doing science, because it’s life and the kids can bring in and observe and just do so much. It’s not abstract. It’s real. It’s just a pleasure to teach because it’s so exciting. It’s so interactive. Those are the words that come to my mind, exploration, and life. It’s just multisensory. It’s fun, fun, it’s fun!”

Teachers associated both positive and negative emotions related to science teaching and learning.

*Triangulation Across Cases*

Triangulation across cases occurred throughout the cross-case analysis to make sure the picture is clear and meaningful. At times multi-case themes were added to the themes created during interview data analysis (Stake, 2006). Cross case analysis began with an examination of pre and post interview data, which was useful in describing patterns found in the teachers’ frameworks for understanding science related to their abilities to produce desired results according to their beliefs and self-efficacy. The following was found useful in providing data for triangulation for Research Question 2: the (a) Partner Portfolio for Professional Development, (b) STEBI analysis, (c) CLES analysis, (d) Classroom Observation analysis (see Appendix E for the Classroom Observation Protocol).

*Efficacy.* Data analysis for points of triangulation started with an examination of each participants description of her own efficacy and ability to produce a desired or intended result as it related to their understanding of science content. Interview data revealed that all eight participants noted that they had a difficult time remembering
science in school either because their science learning was not hands-on, the method of instruction used by their teachers was limited to reading out of a book, or science was not emphasized at their school. Interview data revealed that five of the participants explained in their pre PSI Professional Development Course interviews that they either disliked science or felt uncomfortable with science. Ariel, Hailey, Robin, Lucy, and Anna all felt negative emotions when thinking about science. Liz, and Julia reported in their interviews that they had positive experiences related to their early science learning. Jo describes a mix of positive and negative experiences. When describing her own framework for understanding science content and teaching methods in a mixed fashion, ranging from “poor” to “awesome.” Whether positive or negative, when placed in a learning experience that was visual, hands-on or interactive, the teachers were able to remember the activity. Examples of such teacher experiences are outlined next.

Lucy uses her negative experience as an example that demonstrates why she is careful to provide positive learning experiences in science for her students. Data from Lucy’s Portfolio for Professional Development shows that Lucy had a difficult time learning science in high school. The excerpt that follows shows her experience.

Lucy: My junior year of high school I took a chemistry class. I was just what you took if you were in the college prep classes. I was completely lost in that class. I felt like we were already supposed to know certain things in order to understand what was going on. I have no experience what-so-ever with the topic. What I realize now is that in order to create students who will do well in understanding the world around them you have to teach them how to become thinkers. In school I earned how to read out of a textbook and memorize facts. I had no idea how to think. I didn’t have much experience to draw from either. When I am planning my science lessons now I keep this in mind. I do my best to come up with thoughtful active lessons that will provide the kids with experience on topics that they can fall back on.
Lucy did not learn by reading out of a textbook and memorizing facts. She had no prior knowledge to build upon when learning about science concepts. Lucy remembers her difficult experience and explained that this influences the way she teaches her students, she is careful to provide them with active lessons and experiences that will help facilitate learning.

Hailey shares a vivid experience that had a big impact on her learning in her
Invitation to Practice: Science Learning Personal History.

Hailey: While I grew up in a town that revered education, I only remember hatching baby ducks in elementary school. I remember working straight out of the book. Science really didn’t grab my attention until college when we had more labs. I know I am a visual learner and learn by hands-on. I would never remember Newton’s law of equal and opposite reaction if the professor hadn’t demonstrated it for me. Perhaps if he had actually thrown the ball, I would have better understood how to solve those acceleration problems. This inquiry helps me to understand how important the visual and actually doing the experiment is to understanding. I’m sure my students have gotten more out of lessons that are visual as opposed to those dull lessons of reading, taking notes, and explain orally. The most vivid moments of a science lesson in my mind is when my physics professor taught us about Newton’s law of how for every reaction there is an equal and opposite reaction. It was a typical morning in Philip’s Hall. Students had meandered in, many reading the school newspaper, myself included. In walks the professor with a helmet on and a scooter in one hand and a fire extinguisher in the other. He said, “Good morning,” to capture our attention. Once we looked up, he definitely had our attention. Without saying anything else, he sat on the scooter, faced the wall, and sprayed the fire extinguisher against the wall. This sent him flying across the auditorium. He then stood up and said, “Newton discovered that for every action there is an equal and opposite reaction.” I really can’t come up with his other laws at the top of my head, but I never forgot that one.

Positive and negative events in the lives of each teacher had an impact on their beliefs about science teaching and learning. All eight of the teachers spoke of encouraging their students to question or investigate how science applies to their own lives in their interview sessions. The CLES Personal Relevance scale relates to students’ experience of
the personal relevance of school science as perceived by teachers (Suters, 2004; Taylor et al., 1997). The teachers’ CLES Personal Relevance scores support this finding. All of the teachers’ post CLES Personal Relevance scores fell into the high intermediate (T1-Ariel, T4-Hailey, and T7-Anna) agreement range or the high (T2-Jo, T3-Liz, T5-Robin, T6-Lucy, and T7-Anna) agreement range, which indicated that the teachers placed a high emphasis on linking school science with students’ everyday experiences.

Interview data analysis was useful in uncovering patterns across the participants’ frameworks for understanding science related to each teacher’s ability to produce desired results according to their individual beliefs and self-efficacy. Bandura (1997) states that knowledge of self-efficacy beliefs can have the ability to predict behavior. Based upon Bandura’s (1977) theory of social learning, the researcher asserts that a teacher who possesses a high sense of self-efficacy is more likely to use student-centered, constructivist teaching practices than teachers who have a low sense of self-efficacy. The STEBI (Appendix C) was designed by Riggs (1988) and Riggs and Enochs (1990) for elementary in-service teachers and is used to assess attitudes and beliefs toward science. All of the teachers’ scores fell into the average efficacy (T1-Ariel, T2-Jo, and T7-Anna) or high efficacy (T3-Liz, T4-Hailey, T5-Robin, T6-Lucy, and T8-Julia) range for the pre STEBI Personal Science Teaching Efficacy Scale. Scores for the post STEBI Personal Science Teaching Efficacy Scale all fell into the high efficacy category with the exception of one teacher (T7-Anna), her score was in the average efficacy category. This is an indication that all of the participants were comfortable with their ability to teach science. All of the teachers’ scores fell into the average expectancy (T1-Ariel, T5-Robin, and T7-Anna) or high expectancy (T2-Jo, T3-Liz, T4-Hailey, T6-Lucy, and T8-Julia)
range for the pre STEBI Outcome Expectancy scale. All of the teachers’ scores for the post STEBI Outcome Expectancy fell into the average (T1-Ariel, T3-Liz, T5-Robin, and T7-Anna) or high (T2-Jo, T4-Hailey, T6-Lucy, and T8-Julia) expectancy category. This is an indication that they had confidence in their teaching abilities to create desirable outcomes (Riggs, 1988; Riggs & Enochs, 1990).

Data from the participants’ portfolio supports the findings from the STEBI instruments indicating that following the PSI Professional Development Course all of the teachers feel comfortable with their abilities to teach science and had confidence in their teaching abilities to create desirable outcomes. All of the teachers feel comfortable utilizing a variety of methods to teach science. Jo feels comfortable with all methods of teaching science, she “tries to use them all.” Jo uses a variety of methods to teach science, she notes, “I try to use all of them, everything from textbook or old school, to hands-on and experimentation. We use the computer, the computer lab, and technology.”

In their Invitation to Practice: Collaboration activities, Liz and Lucy, both reveal that they are comfortable using “hands-on” methods in their classrooms. Hailey feels comfortable engaging her students in learning through hands-on activities, experimenting, songs, and movement. Hailey explains what she believes are her main strengths as a teacher in the pre PSI Professional Development Course interview excerpt that follows.

Hailey: I think that one of my strengths is my willingness to look for new ways of teaching something. Looking for new things and as a science teacher, the mess doesn’t seem to bother me. That disorganized side of myself does come into play in a positive way. I think I maintain a classroom where the students are engaged and it’s not, but they know their limitations in behavior and all of that.

Hailey feels she is open to learn and try new ways of teaching. Her students are allowed to get messy, but understand limits as they are engaged in learning activities.
Although the teachers were not always confident with the subject of science, after being exposed to visual, hands-on, lessons or events their confidence increased. When Robin started teaching science she was a “little leery on doing science.” After she observed others teaching science, Robin excitedly explains, “So, I tried it. I am definitely loving it! I’m teaching all science now.” PSI Professional Development Course interview data shows that prior to the professional development session Ariel explains that she was not always comfortable with science or mathematics, and feared her discomfort might be visible to her students. She admits that she is not always comfortable with science or mathematics, and fears her discomfort will be visible to her students. Ariel’s Personal Science Teaching Efficacy Belief subscale scores, from the STEBI analysis pre (45) and post (52), increased notably, indicating that after the professional development session she became more comfortable with her ability to teach science. Like Ariel and Robin, Lucy had some discomfort related to science. Lucy’s STEBI Personal Science Teaching Efficacy Belief subscale scores for the pre (55) and post (64) assessments increased notably, indicating that her level of comfort with her ability to teach science increased (Riggs, 1988; Riggs & Enochs, 1990).

*Pedagogical Science Knowledge.* Although they were all veteran teachers and felt confident in their teaching abilities, the participants were willing to learn new things and improve their teaching practice. When speaking about their understanding of science content information in their interview sessions, Jo, Hailey, and Anna brought up the topic of improving or making their teaching better. Hailey mentions the idea that she was willing to try to improve as a teacher again in her portfolio. She indicates that she is unsure about carrying out the process. Hailey wrote, “I am still unsure about how I will
manage centers, but want to try.” Jo’s Goal Statement in her Partner Portfolio for Professional Development supported the idea that Jo would like to improve as a teacher. She writes that she would like to “learn how to implement inquiry in my science teaching to get all the kids engaged and enjoying the activities to increase retention of the lessons objectives.” Jo wrote in an Exit Slip in Jo’s Partner Portfolio for Professional Development, “I would still like to learn how to better teach the concept of matter.” Portfolio data revealed that other teachers (Robin, Liz, Julia, and Ariel) felt the same way.

Robin, Hailey, Ariel, Liz, Lucy, and Julia all felt limited by their pedagogical science knowledge and wished to learn more. Robin and Hailey explained in their interview sessions that they feel somewhat limited by their knowledge of pedagogical science knowledge and the amount of time available to apply science teaching methods. Both teachers are interested in learning more. In their Invitation to Practice: Collaboration entries, Robin and Hailey write that they are both “not afraid to try new things.” Robin’s goal for the professional development session states, “I would like to have several lessons to implement in the classroom. I want to be comfortable in my knowledge of inquiry to use it effectively.” Ariel shared her uncertainty in her pre PSI Professional Development Course interview session.

Ariel: I do a lot of hands-on, not experiments that they design themselves, but like building things like the atom. I would hope they would say it was fun and they learned a lot. I think I have a long way to go with that too.

Ariel’s Goal Statement in her Partner Portfolio for Professional Development supports the idea that Ariel would like to improve as a teacher. It states that she would like to learn “how to better implement experiments and scientific process in my classroom.” She
would also like to learn “how to use the inquiry process in the classroom.” Liz reveals in her Goal Statement that she would like to improve as a teacher, “I want to leave here with some great ideas to use and improve my science instruction this year.” Liz wished to learn how she could use “inquiry more often and successfully” in her science classroom. Julia writes in an excerpt from an Exit Slip in her Partner Portfolio for Professional Development, “I’d like to read the [Douglas Llewellyn] book and better understand the inquiry process, more in depth.” In summary, although they were all seasoned teachers that had confidence in their teaching abilities, the participants were willing to learn new things and improve their teaching practice. In her goal statement for the PSI Professional Development Course, Lucy writes, “I would like to learn some new ways to enhance my science teaching. I would especially like to improve on two units that I feel I could teach in a better way.”

Cross-case interview data analysis continued with an examination of the descriptions of each participant’s framework for understanding pedagogical science knowledge. All eight of the teachers used a variety of different methods including hands-on, experimenting, or doing. Portfolio and classroom observation data supported the idea that all of the teachers use a variety of methods in their science classrooms. In their Invitation to Practice: Collaboration, Liz and Lucy both reveal that they use “hands-on” methods in their classrooms. When learning, Robin needs “to read about it as well as do something” and she also notes that she feels, “My learning style is reflected in the way I teach.” The Attitude Scale scores provide a measure of the concurrent validity of the CLES. It is used to measure teachers’ interpretations of students’ attitudes towards the classroom environment (Suters, 2004; Taylor et al., 1997). The teachers’ CLES Attitude
Scale scores support these findings. All of the teachers’ post CLES Attitude Scale scores fell into the high intermediate (T7-Anna) agreement range or the high (T1-Ariel, T2-Jo, T3-Liz, T4-Hailey, T5-Robin, T6-Lucy, and T8-Julia) agreement range, which indicated that they felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997).

Interview data revealed that six of the teachers (Jo, Liz, Hailey, Robin, Lucy, and Julia) discussed applying the science content information or making connections within the context of the science lesson through questioning or offering explanations. All eight teachers spoke of motivation during the interview sessions, either related to interest level (Ariel, Liz, Hailey, and Robin), curiosity (Jo and Julia), or helping students to remember (Lucy and Anna). Examples of motivation, making connections, and helping students remember science concepts are outlined next. Ariel, Jo, Liz, Hailey, Robin, Lucy, Anna, and Julia all bring real objects into their classrooms to make science meaningful. In Liz’s lesson for the pre PSI Professional Development Course observation she incorporated activities that involved the students traveling outside to collect leaves, observe evidence of transpiration, and check on the progress of flowers that they planted in an earlier lesson. Robin’s students were also growing and monitoring the progress of seeds or plants. Anna’s students explored pumpkin seeds and pumpkin plants. In a portfolio journal entry Lucy writes that she feels I-B science “makes science exciting and meaningful” and “creates thinkers and problem solvers.” Ariel, Jo, Hailey and Robin all had rocks and fossils on display in their classrooms. Julia had students bring objects from home to represent the concept of push and pull. Jo notes that she applies methods that helped her as a student, participating in visual and hands-on activities and making
connections to her life. In her goal statement Jo explains that she believes getting the students activity engaged will increase retention when she says, “I want to learn how to implement inquiry in my science teaching to get all the kids engaged and enjoying the activities to increase retention of the lessons objectives.” All of the teachers believe their students should enjoy the activities.

Many of the teachers used humor and novelty to help students remember concepts. Pre PSI Professional Development Course interview data shows that Robin uses humor and novelty in her teaching. Robin does this because she believes it will “stick in their head.” In one of Robin’s Partner Portfolio for Professional Development Invitation to Practice entries she explains that she brought a frog with wacky hair to class because it says something about her as a science teacher. Robin writes, “I love frogs and science and this one is a little wacky, which is how I approach most of my lessons.” Jo replicates this thought when writes in her Invitation to Practice: Mapping My Classroom (see Appendix H) activity that she wants to create a learning culture that inspires “wonder and excitement” in her students. In summary, all eight of the teachers used methods that relate to the inquiry approach and allow students the opportunity to work together to explain ideas, make sense of idea, and reflect on their ideas.

_Framework for Understanding I-B Science Methods._ Last, data analysis focused on the participants’ descriptions of their own frameworks for understanding I-B science methods as reported during their interviews. Seven of the eight teachers held some knowledge of inquiry science prior to the PSI Professional Development Course. During the interview sessions, the teachers (Ariel, Jo, Liz, Hailey, Robin, Anna, and Julia) included the following concepts in their definitions of inquiry science: questioning,
investigating, exploring, and making connections. Examples to support the teachers’ definitions and evidence of use of inquiry in the teachers’ classrooms are outlined next. Lucy defines inquiry science as, “A method of teaching that enables students to explore, manipulate, and experiment in order to truly build and lay the foundation of scientific understanding.” Ariel, Hailey, Robin, Lucy, Anna, and Julia all discussed the point of view of the learner or student when defining inquiry science.

**New Multi-Case Clusters Related to Participants Framework for Understanding I-B Science Methods.** At times multi-case themes were added to the themes created during interview data analysis (Stake, 2006). Classroom observations supported by lesson plan data from the teachers Partner Portfolio for Professional Development revealed that teachers were all working at different levels or stages of inquiry implementation. Llewellyn (2002) cautions that teachers should not expect to become inquiry-based teachers overnight. In fact, he suggests that it takes 3 to 5 years to perfect inquiry-teaching techniques. Martin-Hansen (2002) illustrates four models of inquiry that are frequently utilized for instruction consisting of Structured Inquiry, Coupled Inquiry, Guided Inquiry, and Full or Open Inquiry. They range from student-centered to teacher-centered in that order. Each teacher moved at her own pace along continuum towards the implementation of full or open inquiry. A summary of each teacher’s progress as revealed during Research Question 2 analysis is outlined next.

This idea was supported by Ariel’s pre PSI Professional Development Course observation data. During the lesson the students followed directions to create a rubber band banjo. This observation serves as evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not
considered to be an authentic inquiry experience (Martin-Hansen, 2002). Throughout her mini unit plan Ariel gradually moved from Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design, to Coupled Inquiry, inquiry that starts as Structured Inquiry or teacher Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control. Ariel gradually lessened teacher control. Ariel has slowly started using the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). Ariel allowed students the opportunity to discover the answers to many of their questions on their own as they moved through the unit. In summary, the researcher observed some evidence of Full or Open inquiry in the post PSI Professional Development Course observation as students used a KWL chart to gather information and generate questions that they utilized to guide their investigations as they moved through the unit.

Throughout her mini unit plan Jo gradually implemented several forms of inquiry as described by Martin-Hansen (2002). She moved from Guided Inquiry to Coupled Inquiry. Jo has slowly started using the model of Full or Open Inquiry. Jo allowed students the opportunity to discover the answers to many of their questions on their own as they moved through the unit. The researcher observed evidence of Full or Open inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), in the post PSI Professional Development Course observation as students used a KWL chart to gather information and generate questions that they utilized to guide their own investigations as they moved through the unit.
Throughout her science mini unit plan Liz gradually moved from Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design, to Coupled Inquiry, inquiry that starts as Structured Inquiry or Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002). In the post PSI Professional Development Course observation session the researcher observed evidence of Full or Open inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). In the post PSI Professional Development Course observation as students created “what happens if?” questions throughout the design process while creating their solar cookers.

During Hailey’s classroom observation sessions the researcher observed evidence of Guided Inquiry, inquiry in which the teacher develops the question and allows the students to co-construct the experimental design (Martin-Hansen, 2002). During the post PSI Professional Development Course observation the researcher observed students sitting in groups during the science lesson. Hailey encouraged the students to work as a team to design their own observation in order to determine how the rocks might be classified. Hailey was experiencing some success while taking baby steps to accomplish implementation of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), into her science lessons.

In her pre PSI Professional Development Course observation lesson, Robin used the following: discussion, questioning, accessing background knowledge, hands-on, and reinforcement. In her post PSI Professional Development Course observation lesson,
Robin used: questioning, the reading of children’s literature, use of manipulatives, recording, representing and analyzing data, evaluation of the validity of claims or looking for evidence, writing or reflections in a journal. Prior to the PSI Professional Development Course, Robin was using some elements of inquiry in her classroom already, evidence of Structured Inquiry described by Martin-Hansen (2002), was observed. Post PSI Professional Development Course interview and post PSI Professional Development Course observation data showed that Robin felt comfortable with Guided Inquiry and Coupled Inquiry. Guided Inquiry, inquiry in which the teacher develops a question and allows the student to co-construct the experimental design, was observed as students created questions and used their observation skills to guess what object was inside of a brown paper bag during an activity called, “What’s in the bag?” The researcher also observed evidence of Coupled Inquiry, inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002) as Robin reduced teacher control and allowed students to work as individuals or pairs to piece together foam pieces of Pangaea. Robin felt she had a hard time implementing the activities presented in the PSI Professional Development Course that were related to having students form their own investigable questions, student created I-B investigation questions, because of time constraints.

Lucy gradually lessened teacher control as she allowed students to ask questions about physical properties and the states of matter, design their own mini experiments, and discuss the results with their classmates and teacher. During their exploration portion of the science lesson, students asked questions, designed their own mini experiments to
discover the answers to their questions, and discussed the results with their classmates and teacher. They created their own “plan” for examining the physical properties of the objects and recorded results on a worksheet. For example, students asked a question like, “What will happen if I pour this green liquid into this container of clear liquid?” Then they poured, discussed, and recorded what happened. Lucy has successfully implemented the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), into her science classroom.

Anna reported that her framework for understanding I-B methods before the PSI Professional Development Course was, “Nada!” She reports that following the PSI Professional Development Course, “I am still sketchy about it, but the more I implement it the better I’ll understand it.” This idea was supported by the observation data. During the post lesson the students were guided by Anna to discover the answers to their questions during the sink or float activity and during the pumpkin observation and exploration activity. Both activities can be described as Structured Inquiry. Anna was comfortable implementing Structured Inquiry and Guided Inquiry as described by Martin-Hansen (2002).

As demonstrated in Julia’s science lesson plans, pre PSI Professional Development Course classroom observation, and post PSI Professional Development Course classroom observation data, she has successfully implemented several forms of inquiry as described by Martin-Hansen (2002). Structured Inquiry, in which the teacher directs the methods of inquiry, was observed during the pre PSI Professional Development Course observation as students rotated through the frog themed centers.
exploring the concept of life cycles. Structured Inquiry is inquiry based on teacher-directed methods and usually is not considered to be an authentic inquiry experience. Throughout her mini unit plan Julia gradually moved from Structured Inquiry to Guided Inquiry, inquiry in which the teacher develops a question and allows the students to co-construct the experimental design. She then moved towards Coupled Inquiry, inquiry that starts as Structured Inquiry or teacher Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control. Julia gradually lessened teacher control as she allowed students to ask questions about pushes and pulls, design their own mini experiments, and discuss the results with their classmates and teacher. Julia has successfully implemented the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), into her science classroom.

For the purposes of this study, each participant or teacher was looked upon as a case. Stake (2006) writes:

The case researcher needs to generate a picture of the case and then produce a portrayal of the case for others to see. In certain ways, the case is dynamic. It operates in real time. It acts purposefully, encounters obstacles, and often has a strong sense of self. It interacts with other cases, playing different roles, vying and complying. It has stages of life—only one of which may be observed, but the sense of history and future are part of the picture. (p. 3)

Emic accounts, descriptions of behaviors in terms meaningful to the teacher, were used because these accounts are culture specific or are found in the context of the teacher’s classroom (Stake, 2006).
Each teacher moved at her own pace along continuum towards the implementation of Full or Open Inquiry into their science classrooms. This finding supports Llewellyn’s (2002) assertion that perfecting inquiry-teaching techniques takes time. Each teacher reported that they gained from the PSI Professional Development Course related to I-B teaching. Examples are listed next. Julia explained in her post PSI Professional Development Course interview that through the course she learned a systematic approach to inquiry 5E’s. Jo notes that she will use many of the methods presented at the professional development session in her classroom including: procedures designed to help students choose investigable questions; the 5 E model of science instruction; hands-on I-B centers on hangers; integration of children’s literature with science; 10-minute science motivational activities; and converting cookbook labs to “uncookbook” labs through techniques like mixing-up the steps. Lucy shares similar thoughts in one of her exit slips, “I think that I am getting the hang of writing the lessons. I’m working on rewriting some of my experiments to make them more inquiry based and less “cookbook.” Hailey’s also notes in her Partner Portfolio for Professional Development that she has gained a number of “ideas for engagement.” When describing what’s in her bucket, what ideas she gained from the PSI Professional Development Course, Hailey indicated that that she felt “less pressure, knowing that she can take time while moving towards the implementation of I-B methods in her classroom. She felt the idea of taking “baby steps,” [not having] to do it all at once” was helpful. As another example, Hailey also she learned to put more “emphasis on engagement,” which added to her confidence in her teaching ability to create desirable outcomes. Teachers were comforted by the knowledge that implementing I-B was a process that did not need to
take place overnight. Llewellyn (2002) emphasized this idea, asserting that perfecting inquiry techniques takes time.

Teachers’ felt that they gained pedagogical science content knowledge related to 1-B science instruction through participation in the PSI Professional Development Course. For example, interview data from Anna’s post PSI Professional Development Course interview reveals that she learned, “inquiry science gets the students involved from the beginning because of the questions used and because they become actively engaged because of the [5]E’s. It helps the children have more of an ownership and excitement in what they’re learning.” Following the PSI Professional Development Course Julia described inquiry science in this way, “the inquiry approach to science is a methodical plan which captivates the students. It incorporates the 5E’s and is very much hands on and exciting.” In their Invitation to Practice: Collaboration activities, Jo and Ariel, both saw themselves as “very structured” science teachers. Data from Jo’s Invitation to Practice: Mapping My Classroom activity reveals that she feels others might see her “as a facilitator leading students across bridges making discoveries along the way.” The PSI Professional Development Course gave the teachers’ the necessary time and the opportunity to plan lessons for their science mini-units. Liz reports that she uses inquiry when teaching science; however, she has not planned any other 5E lessons or mini units.
Research Question 3 Cross-Case Analysis

What barriers to implementing I-B methods exist?

Cross-case analysis for Research Question 3 includes analysis of the teachers’ (a) goal statements. The goal statement analysis is followed by a presentation of data associated with the level of support the teachers feel they receive from their administrators and teammates from (b) selected pre PSI Professional Development Course and post PSI Professional Development Course interview questions listed in Table 1. To build credibility, information was compiled from (c) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (d) CLES analysis (see Appendix D1 for instrument and D2 for scoring instructions), through direct observation of the participants teaching, and the (e) Partner Portfolio for Professional Development, which included lesson plans for the science mini-units and the Invitation to Practice: Mapping My Classroom activities, Exit Slips, and journal entries. The researcher made use of this data to study the teachers’ mental models in an effort to uncover patterns related to patterns that shape teaching behavior as it relates to her Shared Identity (SI), the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents his or her shared identity or role as part of the professional community. Themes or findings were identified using each participants interview analysis data (see Tables 41, 42, and 43 for a breakdown of themes and factors grouped by clusters). In other words, we have assembled the pieces to answer the teacher’s query, “How does the teacher describe her abilities to produce desired or
intended results in her science classroom as it relates to barriers to implementation of I-B science methods?"

Teachers’ Goal Statement Cross-Case Analysis

First, an analysis of each teacher’s goal statement was conducted to study the teacher’s attitudes towards implementation of I-B science methods into their classrooms. A teacher’s attitudes and beliefs about science are key influences on how they teach the subject. The reality of the school classroom consists of lessons in which teachers transmit science as a set of facts, laws, and data. The teachers’ principles or attitudes, their tendency to respond favorably or unfavorably toward the topic, students or other objects, determines what students will see, hear, think, and do. The teachers’ styles, principles, are rooted in experience and develop into individual constructs slowly over time (Souza Barros & Elia, 1998). Based upon these ideas, the researcher studied the teacher’s tendency to respond favorably or unfavorably towards a science topic, her students, or other objects determines what her students will see, hear, think, and do. Participants were given the opportunity to set their own goals for I-B science instruction during the PSI Professional Development Course (Hammerness et al., 2005). The teacher’s goals, as related to the barriers they perceived in implementing I-B science methods into their classrooms, read as follows:

Ariel: I want to be able to implement the Inquiry process into my classroom and the other things [how to better implement experiments and scientific process” and “how to use the Inquiry process in the classroom] under [the section] ‘What I Want to Learn.’

Jo: I want to learn how to implement inquiry in my science teaching to get all the kids engaged and enjoying the activities to increase retention of the lessons objectives.
Liz: I want to leave here with some great ideas to use and improve my science instruction this year....use inquiry more often and successfully....by sharing ideas with others and being open-minded to do some things differently in my classroom.

Hailey: I would like to use inquiry in every science unit, particularly in those that currently seem like it would not lend itself to it.

Robin: I would like to have several lessons to implement in the classroom. I want to be comfortable in my knowledge of inquiry to use it effectively....how to use it effectively, ideas for using it, how it is not effective, and when and how often it would be used....use the tips and lessons that [the researcher] teaches [shares] with us, finding resources that will help, and collaborating with other teachers.

Lucy: I would like to learn some new ways to enhance my science teaching. I would especially like to improve on two units that I feel I could teach in a better way.

Anna: I want to become a more interesting and exciting teacher, in all areas, not just in science. I would like to bring in new ways of teaching the same ‘ole stuff so I want to teach it and they want to learn it! I want to learn: hands-on ways to teach the science SOL, how to “hook” kids, how to teach the information in a more exciting way, how to incorporate science with other subjects, and how to manage time so all is covered!

Julia: [I want to learn] how to implement inquiry using manipulatives, wondering, and questioning ideas for teaching children....how to effectively set up my classroom to maximize learning potential for students...to be equipped with materials and ideas to ideally set up my classroom to implement the inquiry method in science.

Looking across the teachers’ written goal statements allowed the researcher to study their attitudes towards implementation of I-B methods into their classrooms. The teachers’ goals reveal that they all respond favorably and are interested in learning how to implement inquiry into their science teaching. In addition, Ariel is also interested in learning how to implement experiments, the scientific process, and I-B methods into her classroom. Liz is also interested in leaving “with some great ideas to use and improve” her science instruction and she is “open-minded” or willing to try some different things in
her classroom. Julia expressed similar goals. Anna is also interested in becoming a more interesting and exciting teacher. She wants to learn more about hands-on methods, gaining students interest, integration of other subject areas into science, and time management.

**Teachers’ Interview Cross-Case Analysis**

Teachers’ cross-case interview analysis for Research Question 3 includes the analysis of the pre PSI Professional Development Course interview questions numbered 3, 4, 7, 8, and 9. This allows the researcher to gather information to provide a picture of what is happening in the teachers’ classrooms and schools, thus providing information related to the teachers’ knowledge and practice at the beginning of the research (Davis, 2002). The cross-case analysis includes a review of the (a) descriptions of each participant’s framework for understanding pedagogical science knowledge and use in their science classrooms as revealed in Research Question 2 analysis and (b) level of support the teachers felt they received from their administrators and peers. Last, analysis included an examination to determine (c) possible threats to implementation of I-B science methods as perceived by the teachers both prior to and following the PSI Professional Development Course.

**Pedagogical Science Knowledge. Analysis of Pre PSI Professional Development Course interview data and the teachers’ written goal statements resulted in supporting evidence indicated that teachers are interested in learning how to implement inquiry into their science teaching. Given that the teachers were all interested in learning how to implement I-B methods into their classroom, the researcher next examined data related to their framework for understanding pedagogical science knowledge to discover if the
teachers hold an understanding of Subject Matter Knowledge (SMK). Subject Matter Knowledge (SMK) is defined as the teacher’s knowledge of content matter and pedagogy (the art and science of being a teacher), and curriculum knowledge (Shulman, 1986). Cross-case data analysis from Research Question 2 included an examination of the descriptions of each participant’s framework for understanding pedagogical science knowledge.

All eight of the teachers felt comfortable using a variety of different methods including hands-on, experimenting, or doing. The teachers try to reach all of their students through this use of a variety of activities. Six of the teachers discussed applying the science content information or making connections within the context of the science lesson through questioning or offering explanations (Jo, Liz, Hailey, Robin, Lucy, and Julia). All eight teachers spoke of motivation either related to interest level (Ariel, Liz, Hailey, and Robin), curiosity (Jo and Julia), or helping students to remember (Lucy and Anna). Seven of the eight teachers held some limited knowledge of inquiry science prior to the PSI Professional Development Course (Lucy being the exception). Although they were all veteran teachers and felt confident in their teaching abilities, the participants were willing to learn new things and improve their teaching practice. Robin, Hailey, Ariel, Liz, Lucy, and Julia all felt limited by their pedagogical science knowledge and wished to learn more. Robin and Hailey explained in their interview sessions that they feel somewhat limited by their knowledge of pedagogical science knowledge and the amount of time available to apply science-teaching methods. The Attitude Scale scores provide a measure of the concurrent validity of the CLES. It is used to measure teachers’ interpretations of students’ attitudes towards the classroom environment (Suters, 2004;
Taylor et al., 1997). The teachers’ CLES Attitude Scale scores support these findings. All of the teachers’ post CLES Attitude Scale scores fell into the high intermediate (T7-Anna) agreement range or the high (T1-Ariel, T2-Jo, T3-Liz, T4-Hailey, T5-Robin, T6-Lucy, and T8-Julia) agreement range, which indicated that they felt students: anticipated the activities within her classroom, found activities worthwhile, and understood and enjoyed the activities (Suters, 2004; Taylor et al., 1997).

Teaching Team Shared Identity. Shared Identity (SI) is the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents his or her shared identity or role as part of the professional community. Research supports that it is important that administrators and teammates are supportive of teachers while they are implementing the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). Interview data from the pre PSI Professional Development Course interview analysis showed that seven of the eight teachers are receiving the support from teammates and administrators while they are implementing the I-B process into their science classrooms. Anna feels pressure from her administrators to place more emphasis and time on reading instruction than on science instruction. The following excerpts from the individual teacher data analysis sections illustrate the level of support each teacher feels she has received from her teammates and administrators.

Ariel’s level of support from administrators and team. Data analysis of the interview excerpts focused on the theme of support from Ariel’s administrators and teammates. Her teaching team at her school consisted of her CF, Jo, and three other fifth grade teachers. The excerpt that follows illustrates the level of support Ariel feels that she
has received from her team. “Jo and I have been teaching together since 1988. She
influences me. When talking to the others, we share ideas on lessons that worked for
them. This influences me to try something different.” Ariel states that her administration
has “encouraged us to use hands-on science kits.” She further indicates that they have
provided “any material we want. They will listen to our request and try to get the
materials.” Ariel continues by assuring that her administration has “been very
supportive.” In summary, data from the pre PSI Professional Development Course
interview analysis showed that Ariel is receiving the support she needs from teammates
and administrators in order to successfully implement I-B science methods into her
classroom.

**Jo’s level of support from administrators and team.** Jo’s teaching team at her
school consisted of her CF, Ariel, and three other fifth grade teachers. The following
excerpt illustrates the level of support Jo indicates that she feels she has received from
her team. “We share ideas. Ariel and I share a lot. We plan activities together.” Jo states
that her administration “pretty much let us do and trust that we do what we feel will best
help the children learn.” It is important that Jo feels supported by her administrators and
teammates while she is implementing the I-B process. Research supports that it is
important that administrators and teammates are supportive of teachers while they are
implementing the I-B process and as they change to new or unfamiliar methods (Keller,
2004; Richardson & Placier, 2001). In summary, data from the pre PSI Professional
Development Course interview analysis showed that Jo is receiving the support she needs
from teammates and administrators in order to successfully implement I-B science
methods into her classroom.
Liz’s level of support from administrators and team. Liz’s teaching team at her school consisted of other fourth grade teachers. The excerpt below illustrates the level of support Liz indicates that she feels she has received from her team.

We work together so we share any new ideas that we have. Somebody comes up with a new idea. One of the games I was telling you about, the PE game, another teacher came up with. That’s one thing we are really strong on sharing. We are not competitive at all. We share, if I’ve got a good idea, I’ll share with someone else.

Liz states that she has had three administrators and “they were all, I think, wonderful administrators.” She spends her own time sponsoring a science club. She further indicates, “I think just being happy in the school, you’re willing put out a little more” Liz continues by assuring that “if I was unhappy and I felt like I wasn’t being supported in other ways I wouldn’t do that.” Research supports that it is important that administrators and teammates are supportive of teachers while they are implementing the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). In summary, data from the pre PSI Professional Development Course interview analysis showed that Liz is receiving the support she needs from teammates and administrators in order to successfully implement I-B science methods into her classroom.

Hailey’s level of support from administrators and team. Hailey’s teaching team at her school consisted of her CF, Robin, and four other fifth grade teachers. Robin and Hailey each teach science to two different groups of students. The excerpt below illustrates the level of support Hailey indicates that she feels she has received from Robin.
This other teacher I work with, she and I will both get excited about it. She will come up with ideas and I’ll come up with ideas. Sometimes we’ll work on it together. Definitely, having someone else who is just as excited and wants to come up with new ideas definitely can motivate you.

Hailey states that her administration has been supportive of Hailey’s teaching methods, especially hands-on activities.

When they come in and observe and give you kudos for it. They’re glad to see you doing hands-on. Sometimes when you get a student that you feel like just didn’t want to learn and it’s a student that’s been uncooperative. Then that student does well in a science lesson they get excited.

Research supports that it is important that administrators and teammates are supportive of teachers while they are implementing the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). In summary, data from the pre PSI Professional Development Course interview analysis showed that Hailey is receiving the support she needs from teammates and administrators in order to successfully implement I-B science methods into her classroom.

Robin’s level of support from administrators and team. Robin’s teaching team at her school consisted of her CF, Hailey, and four other fifth grade teachers. Robin and Hailey each teach science to two different groups of students. The excerpt below illustrates the level of support Robin indicates that she feels she has received from Hailey.

I’ve always known it myself, but seeing Hailey, I think she’s very similar to me. We use lots of the hands-on methods and we use a variety of different ways. We both say, “Well they still haven’t go it. What else can we do to help them?” I think she and I feed off of one another. We say, “Well this works” and “well, this didn’t work, but this will.” I don’t think we’re limited in our methods. We influence each other, like I said, in that we have the same interests, the same way of approaching science, and the same interest in science. We both love science, so it really helps having somebody like that here. It’s kind of crazy.
Robin and Hailey share similar teaching styles. They love science, share ideas, and influence each other’s approach to science.

When first asked about support from her administrators, Robin explained that she thought her administration has not influenced her choice of teaching methods. As she continued to speak she came to the realization that her administrators were very open to help when she needs them and supportive by allowing them to conduct experiments and try new things. She explains this in the excerpt that follows.

I don’t think they [her administrators] really have influenced me. I mean we’re kind of doing our own thing here. I think they’re very supportive with materials if we needed anything. I know that they are easy to approach. I know that they are able to get a lot of things. That is a drawback too, when you don’t have supplies or equipment, that’s frustrating. We say, “Well, how can we do this?” Before we had these outdated microscopes. How can you look at a cell without a microscope? That’s crazy. You know, you can’t just talk about it. You have to see it. We went around and we made sure we got more of the science equipment we needed. That’s kind of away from you question, but, as far as how they help us, I think they are very open to help us. They ask us what we need to get help from them. I guess that is influencing. In a way it has influenced us because it allows us to use those methods where we are doing.

Research supports that it is important that administrators and teammates are supportive of teachers while they are implementing the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). In summary, data from the pre PSI Professional Development Course interview analysis showed that Robin does feel the support she needs from teammates and administrators in order to successfully implement I-B science methods into her classroom.

Lucy’s level of support from administrators and team. Lucy’s teaching team at her school consisted of young or new teachers who have given her ideas and helped her with activities. Lucy has been at her school “the longest of any of them, this is the first year for two of them.” They do not have a large influence on Lucy’s choice of teaching methods
but they have given her “a new perspective” on the things she does. Her administration has been “supportive of anything” she has done. When they heard that third grade was team teaching the administrators were “really excited.” One administrator commented that Lucy “does a really good job with that.” Research supports that it is important that administrators and teammates are supportive of teachers while they implement the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). Data from the pre PSI Professional Development Course interview analysis showed that Lucy is receiving the support she needs from teammates and administrators.

*Julia’s level of support from administrators and team.* Julia’s teaching team at her school consisted of her CF, Sara, and four other teachers on their grade level. The other four teachers are not looping with their students; they work with each group of students for one school year. Julia teaches at the same school as Liz (teacher three). The excerpt below illustrates the level of support Julia indicates that she feels she has received from her administration and school team.

Our team, beginning with Warren Talbot [principal at the time], he encouraged multiage, stretching everything, and he fostered hands-on. He allowed us to venture out into uncharted territories. Those of us back in that time benefited from that. We had a good science lab. Liz was responsible for that. We had to give it up with the growing population because we needed the classroom space. We had gardens, and a shed for gardening tools. That was all before the SOL has come into play. I’d love to see them come back more.

The excerpt that follows shows how her administration has influenced Julia’s choice of teaching methods.

They want to see the kids engaged. We are fortunate to have administrators who want kids moving around the classroom. This impacts your freedom to design the classroom the way you best know how. Due to the SOL things have changed. We
have PTO funds. If you show a need they come through. I am grateful that Warren Talbot encouraged us to stretch. He stressed multiage. I am grateful to see and be a part of that. He stretched, encouraged, supported, and got us materials. The subsequent administration has been supportive as well.

Julia states that one of her previous administrators “encouraged multiage, stretching everything and he fostered hands-on.” She further indicates that “subsequent administration” was also supportive. Research supports that it is important that administrators and teammates are supportive of teachers while they implement the I-B process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). In summary, data from the pre PSI Professional Development Course interview analysis showed that Julia is receiving the support she needs from teammates and administrators in order to successfully implement I-B methods into her classroom.

Anna’s level of support from administrators and team. Anna feels pressure from her administrators to place more emphasis and time on reading instruction than on science instruction. Interview data revealed that a lack of administrative support was a barrier Anna faced as she attempted to implement I-B methods into her science classroom. Data analysis for triangulation was conducted to examine the barrier of a lack of administrative support. Pre PSI Professional Development Course data revealed that Anna’s school administration placed emphasis on reading. Interview data analysis also revealed that Anna struggles to find enough time to implement I-B in her classroom. Anna explains, “I think I would enjoy teaching many of the science concepts using the I-B approach. Unfortunately, in first grade more emphasis is placed on reading than on science or social studies.” In her Invitation to Practice: Mapping My Classroom activity, Anna makes plans to change her “literacy corners, to expand to include some math,
science and social studies.” She has attempted to integrate science and other subjects into her reading program.

In pre PSI Professional Development Course interview excerpts Anna explained that her administrators “…haven’t influenced my choice of teaching methods…” This finding from pre PSI Professional Development Course interview data is not supported by data from the post PSI Professional Development Course interview. It is evident from the interview excerpts, a lack of administrative support for science instruction time, did serve as a barrier to Anna’s implementation of I-B science. Anna explains that emphasis placed on reading by school administration inhibits her from using I-B methods. Anna outlines her struggle with finding enough time to implement I-B in her post PSI Professional Development Course interview, explaining, “I think I would enjoy teaching many of the science concepts using the I-B approach. Unfortunately, in first grade more emphasis is placed on reading than on science or social studies.” Pre PSI Professional Development Course interview data suggests that Anna’s administrators have set reading is a priority so “…nothing is said or done about social studies or science.” This lack of concern or support for science was in fact a barrier in Anna’s attempt to implement I-B science into her classroom. Anna notes in the post PSI Professional Development Course that local, county, and state levels do influence her teaching. She explains, “Of course! They tell us what to teach and county level tells us when to teach it.”

*Themes Developed from Interview Data*

The researcher next presents an explanation related to themes developed from interview data cross-case analysis. Interview data findings were utilized to examine the mental models of the participants related to their Shared Identity (SI) to uncover patterns
related to barriers faced by teachers as they go about the process of implementation of I-B methods in their science classrooms. Stake (2006) defines themes as central ideas having importance related to its situation. When analyzing data for Research Question 3, findings were assembled related to barriers to implementation of I-B science methods. As the researcher reviewed the multi-case themes she visualized the multi-case project as a whole while moving towards a number of cross-case assertions based on the data gathered from the case reports or teacher portraits. The themes or findings were converted into factors. A factor is defined as a widely found, sometimes influential variable of interest well beyond its situation. The following factors emerged from data analysis findings: Time to Teach, Share with Other Subjects, Assessing Student Work, Time to Plan, Standards (What), Pacing (When), Testing, People, Materials, Teacher Knowledge, and Teacher Relationship with Students.

Next, factors were merged into clusters according to similarities. Each factor cluster was ranked according to its frequency of occurrence and importance for understanding the quintain (Stake, 2006), the common condition of the implementation of I-B science into the classroom. The factor clusters give rise to assertions that describe the quintain. The factors of Time to Teach, Share with Other Subjects, Assessing Student Work, and Time to Plan were all arranged into the factor cluster of Time for Science Instruction. The factors of Standards (What), Pacing (When), and Testing were all arranged into the factor cluster of Time Related to Curriculum Guidelines. The factors of People and Materials were arranged into the factor cluster of Support. The factors of Teacher Knowledge, and Teacher Relationship with Students were arranged into the factor cluster of Teacher.
Table 41.

Research Question 3 Cross-Case Analysis

Barriers to Implementation of I-B Methods (1 of 3)

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Factor Cluster: Time for Science Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Factor: Time to Teach</strong></td>
</tr>
<tr>
<td></td>
<td>High Occurrence</td>
</tr>
<tr>
<td>1</td>
<td>Pre: Time to teach Post: Time to implement</td>
</tr>
<tr>
<td>2</td>
<td>Pre: Time for instruction Post: Lack of time</td>
</tr>
<tr>
<td>3</td>
<td>Pre: Amount of time can spend Post: (remained)</td>
</tr>
<tr>
<td>4</td>
<td>Pre: Time Post: (remained)</td>
</tr>
<tr>
<td>5</td>
<td>Pre: Instructional time Post: (remained)</td>
</tr>
<tr>
<td>6</td>
<td>Post: Pressure to teach last</td>
</tr>
<tr>
<td>7</td>
<td>Pre: Time to teach Post: Lack of time</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>
Table 42.

Research Question 3 Cross-Case Analysis

Barriers to Implementation of I-B Methods (2 of 3)

<table>
<thead>
<tr>
<th>Teacher Factor Cluster: Time Related to Curriculum Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor:</strong> Standards (What)</td>
</tr>
<tr>
<td><strong>Factor:</strong> Pacing (When)</td>
</tr>
<tr>
<td><strong>Factor:</strong> Testing</td>
</tr>
<tr>
<td>High Occurrence</td>
</tr>
<tr>
<td>High Occurrence</td>
</tr>
<tr>
<td>Medium Occurrence</td>
</tr>
<tr>
<td>1 Post: Curriculum framework</td>
</tr>
<tr>
<td>Post: Curriculum map</td>
</tr>
<tr>
<td>Cover for SOL</td>
</tr>
<tr>
<td>Post: Curriculum pacing guide</td>
</tr>
<tr>
<td>Post: Curriculum map</td>
</tr>
<tr>
<td>Pacing guide</td>
</tr>
<tr>
<td>Post: Benchmark</td>
</tr>
<tr>
<td>SOL</td>
</tr>
<tr>
<td>2 Pre: What SOL fell cut short</td>
</tr>
<tr>
<td>Pre: When</td>
</tr>
<tr>
<td>Curriculum maps</td>
</tr>
<tr>
<td>Post: (remained)</td>
</tr>
<tr>
<td>Pre: Benchmark</td>
</tr>
<tr>
<td>Post: Benchmark Tests</td>
</tr>
<tr>
<td>SOL data</td>
</tr>
<tr>
<td>3 Pre: no bats</td>
</tr>
<tr>
<td>Pre: Curriculum map</td>
</tr>
<tr>
<td>Time we can spend</td>
</tr>
<tr>
<td>Post: Concepts-time</td>
</tr>
<tr>
<td>Follow curriculum map</td>
</tr>
<tr>
<td>Pre: Stupid benchmarks</td>
</tr>
<tr>
<td>Post: Ready to take Benchmarks</td>
</tr>
<tr>
<td>4 Pre: Curriculum map-too much in it</td>
</tr>
<tr>
<td>Pre: Curriculum map-time</td>
</tr>
<tr>
<td>to focus-material</td>
</tr>
<tr>
<td>5 Pre: SOL-need to know</td>
</tr>
<tr>
<td>Pre: SOL curriculum map</td>
</tr>
<tr>
<td>Time crunch</td>
</tr>
<tr>
<td>Post: (remained)</td>
</tr>
<tr>
<td>6 Pre: State standards</td>
</tr>
<tr>
<td>Pre: Time-amount of info</td>
</tr>
<tr>
<td>Curriculum</td>
</tr>
<tr>
<td>State standards</td>
</tr>
<tr>
<td>Post: Benchmarks</td>
</tr>
<tr>
<td>7 Pre: SOL-reading emphasized</td>
</tr>
<tr>
<td>Pre: Curriculum map-time</td>
</tr>
<tr>
<td>Post: (remained)</td>
</tr>
<tr>
<td>8 Pre: Assessment</td>
</tr>
</tbody>
</table>
Table 43.

Research Question 3 Cross-Case Analysis

Barriers to Implementation of I-B Methods (3 of 3)

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Factor Cluster: Support</th>
<th>Factor Cluster: Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Factor: People</strong></td>
<td><strong>Factor: Materials</strong></td>
</tr>
<tr>
<td></td>
<td>Low Occurrence</td>
<td>Medium Occurrence</td>
</tr>
<tr>
<td>1</td>
<td>Pre: Materials</td>
<td>Post: (remained)</td>
</tr>
<tr>
<td></td>
<td>Time to gather materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Materials being available</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Pre: Kits</td>
<td>Post: (remained)</td>
</tr>
<tr>
<td>3</td>
<td>Post: Materials</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pre: Lack of materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post: (remained)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Pre: Space</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post: Space</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Pre: Administration- not emphasize reading</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post: (remained)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Parents (might)</td>
<td>Supplies (might)</td>
</tr>
</tbody>
</table>
Connections or Relationships Between Teacher’s Perceptions and Use of I-B Instruction

While each of the teachers hold the desire to implement I-B methods, feel self-assurance in their teaching abilities, and think their critical friends, colleagues, and administrators (Anna being the exception) support their efforts; it is likely that each teacher might not be able to completely accomplish her science teaching dream. Appropriately, the researcher next looked at likely threats to fidelity or barriers to use of I-B instruction. This task was completed using data gathered from interviews and classroom observation, thus allowing the researcher to identify connections or relationships between each of the teacher’s perceptions and use of I-B instruction (Davis, 2002). Analysis of the pre PSI Professional Development Course interview questions revealed that the teachers faced numerous barriers as they went about the process of teaching science in their classrooms, including the following: time related to time to teach, sharing science with other subjects, planning, and curriculum guidelines; support related to instructional assistance, space, and materials; and teacher knowledge.

All eight teachers noted that time served as a barrier towards implementation of I-B methods in their science instruction. The factor of time included a number of themes that were noted by teachers as they went about the process of implementing I-B methods into their science classrooms, including: time to teach, sharing science with other subjects, planning, and curriculum guidelines. Each of the themes is discussed next.

Time related to time to teach. Ariel, Liz, Hailey and Anna all viewed the factor of time related to the amount of time available to teach science as a barrier to the implementation of I-B science methods in their classrooms. As an example, Ariel explains in her post PSI Professional Development Course interview that “time and
materials being available” inhibit her from using I-B methods. In post PSI Professional Development Course interview excerpts Liz also notes that “time and materials” might inhibit her from using more inquiry based learning in her science curriculum. Ariel, Hailey, and Anna explained that although they wish to implement I-B methods and activity-based lessons, they find it difficult to do because of time constraints. Ariel notes in her post PSI Professional Development Course interview the reasons she may not have implemented many I-B “extension activities” is “because of time constraints.” The excerpt that follows outlines Hailey’s feelings.

Hailey (pre): I wish I could do lots of things; it’s the time thing. I thought about making a whole big plant cell out of the classroom. I’ve got the idea in my head but I just haven’t been able to do it. So I wish I could just turn the classroom into whatever I am studying. That would be great. But, time is an issue.

In her post PSI Professional Development Course interview Anna also explained that time served as a barrier to implementation of I-B methods. Anna notes, “I am trying to” implement the methods outlined in the professional development course because “I try to find new and better ways to teach. I get tired of teaching the same old way.” Anna also feels that “time” inhibits her from using I-B methods because “I know I have to cover all topics!” Anna had not implemented many of the concepts introduced through the PSI Professional Development Course. Anna notes the reasons she may not have implemented many I-B, “I’m not really using a lot of it for science because of time or a lack there of.”

Time related to sharing with other subjects. Ariel, Liz, Anna, noted that daily scheduling of science in relation to other subject areas served as a barrier to the
implementation of I-B methods in their science classrooms. The excerpts that follow outline the teachers’ discussions prior to the PSI Professional Development Course.

Liz (pre): And even time. Fortunately in our school, which is not the same in other schools, we really value science. I know some schools don’t. We’ve heard of some schools that have only 45 minutes a day for social studies and science. You can’t do that. We switch and we have an hour. She has my kids for an hour for social studies. I have her kids for an hour for science. You can’t do things like that [hands-on activities] if you’ve got twenty minutes, there’s no point. That’s where you just say. “Well, lets just crack open the book.” The reason is because to set up the experiment and discuss the conclusion, to make it worthwhile, you can’t do something like that in twenty minutes. Certainly time, the time factor would limit you. I don’t let it because I just take an hour for science because I think it’s important.

Anna (pre): We try to feel, touch, and actively do things in the classroom, but unfortunately, our time is so limited. Our science and social studies time is the last half hour of the day. So, we did do some hands-on type things, but not that many. Not that many, because we didn’t have a whole lot of time and we were rushing so much at the end of the year. I usually do an animal thing where we touch, it’s not even animals stuff, but it’s feeling like scaly skin, which is an onion bag. We didn’t even get to that because, oh my gosh, we have to hurry up and get to the next unit, and the next. So, this year has not been very good, conducive for teaching any hands-on type things, unfortunately.

Anna explains why science and social studies are not a priority in her school,

“Unfortunately with the thrust of the SOL with us, is to teach them to read more than even math, science, social studies, any of those subjects. So we base most of our day on reading.” Anna explains further, “I think I would enjoy teaching many of the science concepts using the I-B approach. Unfortunately, in first grade more emphasis is placed on reading than on science or social studies.” Data collection revealed that sharing time with other subjects served as a barrier to the implementation of I-B methods. Reading is a priority in Anna’s school and serves as a barrier to science instruction. Social studies also served as a barrier to science instruction. Anna notes on October 15, 2007, which is seven weeks into the new school year, that she has just started her first science unit. She
explains, “This pumpkin unit is my first science unit this year!” Ariel also noted that she had a difficult time balancing all of the new things she is trying to implement this year.

Ariel (post): I understand the method, but the implementing of it is going very slowly. I find myself having to reread the 5E strategy often. Again, time constraints, the fact that there are so many new things we have to do this year [a new computer system, C.O.W.’s, Elmo’s, SMART Boards, et cetera]. They’re all good; they just all take time to implement.

Time related to time to plan. Liz and Robin both noted time for planning instruction served as a barrier towards implementation of I-B methods in their classrooms. Following the PSI Professional Development Course Liz noted, “I will use them as I have time to plan so that I can implement them.” Robin explains, “Sometimes time is a factor in planning the activities.”

Time related to pacing and standards. Time related to curriculum guidelines including the factors of pacing and standards emerged as a significant issue as it related to the implementation of I-B methods in teachers classrooms. All eight teachers gave multiple accounts of instances where curriculum guidelines served as a barrier to the implementation of I-B science methods in their classrooms. The excerpts that follow outline examples noted by each teacher.

Ariel feels pressure from curriculum guidelines, including the Milton County curriculum map and benchmark tests, along with the Virginia Standards of Learning, which also includes the curriculum framework and SOL tests.

Ariel (pre): I watch the pacing guide. I also pace according to the curriculum. I also would like them to show me that they learned and understand. But, you know we have to split it with health so time is also a factor unfortunately.

Ariel notes in her post PSI Professional Development Course interview that the way she teaches is influenced by “the curriculum map, curriculum framework, benchmarks, and
Virginia SOL tests.” Ariel felt that the amount of subject matter to be covered in a limited amount of time served as a barrier to implementation of I-B methods.

Jo outlines her struggles with pacing related to the Milton County curriculum map and benchmark tests.

Jo (pre): We were trying to incorporate those hands-on science kits without following the curriculum map. But then the benchmarks come out, we didn’t teach that and they’re tested on it. So next year, I’m going to follow the map. That pretty much tells me what to teach and when to teach for this county.

Jo (pre): I think I was better with science before I hate to say this, but before we had the SOL. I feel like I’ve got a time limitation if I want to carry on a science experiment. (I’m back when I taught the fourth grade.) When I taught fourth, I could do science all day long. You know with the kits and the AIMS activities and things like that. And now I feel like I’ve got to cut everything short. I feel like that’s a limitation.

Analysis of the post PSI Professional Development Course interview questions showed that Jo notes that the way she teaches is influenced by “the curriculum map, curriculum framework, benchmark tests, and past SOL data.”

Liz notes that the amount of time available for teaching concepts and pacing constraints because of the Milton County benchmark testing had an impact on her science instruction.

Liz (pre): We are limited on the amount of time we can spend on something. Anyway we’ve got the stupid benchmark tests. It is not nearly as flexible as it used to be. Even when I was going through some stuff today, organizing, I found a wonderful unit on bats that I used to do in October. We learned all about these different kinds of bats, the location how they survived, all of these things that you could tie into science, adaptations, and habitats and all of that. But, we don’t have time to spend two weeks or whatever on bats. It’s really say, it’s because of the curriculum map.
Following the PSI Professional Development Course, Liz shares in her interview, “unfortunately I can only take so much time to teach a concept. I must follow the curriculum map and have students ready to take benchmark tests.”

The Milton County curriculum map and concept material also influences Hailey as it relates to pacing.

Hailey (pre): I have definitely gotten to the point where I follow the curriculum map. For a while when we taught vertebrates and invertebrates we went into some depth. But, we were really running out of time because we have to review fourth grade material. This year we just stuck with vertebrates and invertebrates and moved on. So, basically, I just have to focus on whatever is the objective. I try not to with some things, but there is just too much in it.

Hailey explains in her post PSI Professional Development Course interview that “time constraints and the curriculum map” inhibit her from using I-B methods.

Robin also mentions the influences of time, subject matter, students, the Milton County curriculum map and the Virginia SOL on her science teaching.

Robin (pre): Well, it’s all spelled out for me on the curriculum map. This year we did cut out a lot, actually in the vertebrates and the invertebrates. We knew what we had to focus on, but as far as time went, we kind of looked at the curriculum map. We asked, “What are we going to need for the SOL?” There was a lot in there that was not necessary, so to speak, for information they would need to know to answer the questions on the SOL. It is important to know those things, but when it comes down to the time crunch and we’ve got so much packed in there, then we need to look at where we have things chopped up so that we can fit it into our schedule. There is, if you want my opinion, a lot in that curriculum map that we have to include. Especially when it is the fourth grade material as well that is also covered on that fifth grade SOL test information that we have to cover and review at the end of the year. So, yes, we go with the map and try to keep up with their time schedule, but a lot of times it doesn’t work [and] quick thinking.

In her pre PSI Professional Development Course interview Robin explains, “I think the subject matter certainly lends itself to how I’m going to approach it. Some things are much more geared toward the hands-on experiments than others. So, I guess, subject
matter will influence how I approach it.” Following the PSI Professional Development Course, Robin explains that these factors continue to impact her choice of teaching methods. This is illustrated in the following excerpt, in which Robin discusses how she decides what to teach and what not to teach. “I go first by the curriculum map and then pick and choose from the materials that I feel will best suit my students’ needs.”

Lucy notes that pacing related to the Virginia SOL might hinder opportunities for her to use I-B methods in her classroom.

Lucy (pre): Sometimes I think the standards hinder us a little bit. They tell us what we have to teach and what has to get done, but at the same time I think they put too much into it. You can go so much more in depth with some of the topics that we have to teach but I think we have to rush, rush, rush and get it done for the test. I think it also hurts us.

Following the PSI Professional Development Course session, Lucy notes that she still feels pressure.

Lucy (post): I feel pressured to teach fast so as to get all of the information taught before the benchmarks. This causes me to throw out some worthwhile activities in order to comply with county requirements. I feel like the students miss out.

Similarly, Anna explains that she decides to move from one concept to another based upon, “unfortunately curriculum maps, just time allotted in a day. I know things I have got to get done, so unfortunately I push on. It’s terrible.” Both Lucy and Anna are unhappy about the pressure imposed by time.

Julia explained that she had no true barriers to implementation of I-B methods; however, she speaks about time pressures related to assessment in the excerpt that follows.

Julia (pre): Always assessment, because to me that is such a hard thing. I think that you really need to be assessing through observation and what not, but finding the time to log what you are observing while you are teaching has always been, I
think, and overly difficult thing. Maybe I should say an easier way to assess. It’s not just their written work that you take home and look at. I feel when I make my assessments I know they’re valid because I know I’ve seen it. But, it’s showing someone else what did I base that upon. Finding the time to put that into writing I suppose has always been my hardest, to be able to document my assessment. I feel very comfortable with where I have them within that assessment and the different tools I use. But again, it’s finding the time to document all of that. No time. It’s the time constraint; if I could just go around and log it. But as I am going around, I am usually interacting. So that part is the hard part to me.

Julia explains in her post PSI Professional Development Course interview session, “They only determine what I teach. I feel total freedom that they have the confidence that I will select the best approach.” Julia feels somewhat pressured by time constraints, however this only influences the amount of time she spends on a concept, not the method she chooses to teach the concept. Julia notes she decides to move from one concept to another through the following process, “I plot out the areas of study for the nine weeks. Unfortunately, there are time constraints and the calendar determines when I must move on. I try to select concepts that build upon one another.”

**Support.** Participants found that a strong support system was helpful as they went about the process of implementing I-B methods into their classrooms. Ariel, Liz, and Hailey noted that having materials available for I-B instruction was important. Ariel explains in her post PSI Professional Development Course interview that “time and materials being available” inhibit her from using I-B methods. In post PSI Professional Development Course interview excerpts, Liz also notes that “time and materials” might inhibit her from using more inquiry based learning in her science curriculum. Hailey also lists possible barriers to implementation of I-B methods into her classroom, “Time, like I said before, forgetting, and I guess sometimes a lack of materials.” Julia has found a way to overcome the barriers related to having a lack of science supplies.
Julia (pre): No, if the school can’t supply it you’d just go out and get it. The only thing might be lack of supplies, the kids, or the parents. There is really no reason. It is satisfying to watch these kids grow. I don’t know how people do it who don’t love kids. I use a lot of creative open-ended activities. We keep going with a million different ideas. There is almost too much to choose from.

Julia (pre): Parents are a big influence. It’s like training parents to know not to expect worksheets, that the classroom is hands-on. Parents come in to help with the hands-on activities. Parental participation is essential. They send in science supplies. It takes a village.

Julia utilizes parent volunteers in her science classroom for support and as a system for obtaining necessary supplies for implementing I-B methods.

Lucy brings up the topic of classroom space. She notes in her pre PSI Professional Development Course interview, “Probably the space, cause our rooms are teeny. So actually having enough space to put more projects out and things.” Space continued to serve as a factor. In post PSI Professional Development Course interview analysis Lucy noted that she “really couldn’t change much due to limited space, but I did put more scientific tools out in the open so students can get them when they feel they need them.”

Anna explains that the emphasis placed on reading by school administration inhibits her from using I-B methods. It is evident from post PSI Professional Development Course excerpts that this factor did serve as a barrier to the implementation of I-B science. Pre PSI Professional Development Course interview data suggests that Anna’s administrators have set reading is a priority so “…nothing is said or done about social studies or science.” Anna notes in the post PSI Professional Development Course that local, county, and state levels do influence her teaching. She explains, “Of course! They tell us what to teach and county level tells us when to teach it.”
Teacher knowledge. Ariel, Jo, Hailey, Robin and Anna all felt that teacher knowledge or a lack of knowledge related to science content or pedagogy, impacts their abilities to implement I-B methods into their classrooms. For example, Ariel explained in her pre PSI Professional Course interview, “Sometimes I feel I don’t know as much as I should, in depth knowledge.” When asked about barriers she faced, Jo stated in her pre PSI Professional Development course interview, “my own lack of knowledge. That would be a major one, just not prepared as well as I’d like to be.” Jo was also unhappy with her students’ test scores. She shares, “I was unhappy with the Benchmark scores so I knew that my methods are failing, so I need to do something to improve that.” Both teachers reported that content knowledge did not serve as a barrier to their implementation of I-B methods in the mini-units that they prepared in the PSI Professional Development Course.

Hailey, Robin, and Anna reported that their level of comfort with the lesson or subject knowledge might serve as a barrier to implementation of I-B methods in their classrooms. Hailey explained in her pre PSI Professional Development Course interview, “I think I really try to follow the objective, whatever it is I need to teach. Probably, I guess my downfall is that I am not as organized as I want to be.” Hailey explained further, “Time, like I said before, forgetting, and I guess sometimes a lack of materials.” Robin notes, “If I was not comfortable with the lesson or what I was doing then that would be the only drawback. If I hadn’t done the experiment before or I didn’t try it out myself, then I would be reluctant to bring it to the classroom.” Robin continues, “I think the subject matter certainly lends itself to how I’m going to approach it. Some things are much more geared toward the hands-on experiments than others. So, I guess, subject
matter will influence how I approach it.” Post PSI Professional Development Course interview data revealed information about Anna’s understanding of I-B methods. A lack of understanding of some portions of I-B methodology might have served as a barrier towards implementation. When asked to describe her own framework for understanding I-B methods after the PSI Professional Development Course, Anna explains, “I am still sketchy about it, but the more I implement it the better I’ll understand it.”

Teacher relationships with students. Ariel, Liz, Robin, Lucy, and Anna all decide what to teach based on the Virginia SOL and their student needs. For example, Ariel explains the influence the standards and her students have on the length of time she spends on a concept.

Ariel (post): They can express the concept in words that are meaningful to them. Again, the way it is, not necessarily the way I want it to be; they perform well on benchmarks, et cetera. I move to the next concept when I feel the kids have grasped that concept. Also, realistically, you have to move on to the next nine weeks to make sure you cover everything for the SOL test.

Robin, Liz, Lucy, and Anna relate examples that explain that the behavior of students might be a barrier to the implementation of I-B methods in their classrooms, especially considering the pressure from standards testing. This is illustrated in the following post PSI Professional Development Course interview excerpt, in which Robin discusses how she decides what to teach and what not to teach. “I go first by the curriculum map and then pick and choose from the materials that I feel will best suit my students’ needs.”

Robin, Liz, Lucy, and Anna explain further in the excerpts that follow.

Robin Pre: My teaching varies year to year, the students I have. Some need a lot of structure and can’t handle the freedom to explore on their own. They wouldn’t know how to go from there. They really need a lot of direction. So, I just kind of see or gauge from them how it is going to work. I could have a routine here and I could have two classes. One could be fine and [for] the other class, I might have
to tailor it more to what they need. The students have influenced me very much. The students themselves are going to determine, “Is this too much for them to handle?” “Are they going to need more structure?” “Do they need more time?” “How would I vary the lesson?”

Liz Pre: If I had a class that just had a lot of trouble getting along. Katrina’s class this year fought constantly, she was so glad to get rid of the kids. Most of the things that I did, because I taught her class science too, with my class, I did with hers. Because I just felt that is a better way to learn than just sitting in the classroom. But, every time I did it I had to talk to them. We’d come back in and we’d have to talk about it again. Like that activity where I took the kids through the Red Fox Trail, I could not have done that with her class. There would have been fights.

Anna also considers the maturity level of her students when deciding which methods to use to cover science concepts in her classroom.

Anna (pre): Well first of all, you have to teach what the SOL dictate that you have to teach. We go off on tangents because, “a”, I think the kids can deal with it. Or, “b”, they tend to go that way or ask questions that way. Like when you were here and somebody talked about that baby plant inside the seed, I was totally shocked when somebody said, “oh yeah, we get the food by the umbilical cord.” But, this year too, we kind of went into mom’s nurse babies. They didn’t, a lot of times they [the students] tee hee and giggle, so it really depends on how well they can take it. How far I go with things. This year everybody knew that mammals made mild for their babies. We didn’t go into necessarily where that milk comes from, but they [the students] seemed to deal with it without getting embarrassed or tee heeing. It really depends on what the class is made up of, what questions they ask, and where we can go. But, of course everything is based on the SOL. The content is there, you have to start with this and then you go from there.

Anna (pre): The things that they get the most out of are things dealing with animals and plants because that is something that they understand. They can comprehend that. I mean like matter, it doesn’t matter. The whole concept of, well all we have to teach is dissolving. But, it used to be gas, liquid, and solid. They don’t understand that. Plants and animals are something that they can reach out and touch. So I think that’s probably the most they get out of the whole science curriculum right now. I’m kind of impressed that one of my kids said, “the other day, yesterday I went home,” and for her little sister, Casey, she pulled up a little plant, an onion type thing, and she sat there and explained the different parts of the plant and what they did. And I’m like, “you know, something clicked, it worked.” Those are the kind of Ah ha moments that you get. But I would say plants and animals are maybe not the most beneficial, but the most remembered
things in first grade. So interesting, they know what a plant is. They know what an animal is.

Lucy explains that the behavior of the students in her class might serve as a barrier if she has “a very rowdy class that can’t control themselves. Obviously you can’t be doing experiments.” Although Lucy has threatened to do this, she “never had to ever just not do” an activity because her students always “got serious” when she had to discuss or correct their behavior.

_Triangulation Across Cases_

Triangulation across cases occurred throughout the cross-case analysis to make sure the picture is clear and meaningful. Cross case analysis began with an examination of the teacher’s written goal statements and pre and post interview data, which was useful in describing patterns found in the teachers’ frameworks for the mental models of the participants related to their Shared Identity (SI) to uncover patterns related to barriers faced by teachers as they go about the process of implementation of I-B methods in their science classrooms. The following was found useful in providing data for triangulation for Research Question 3: the (a) STEBI and (b) CLES instruments, (c) through direct observation of the participant’s teaching, and (d) the Partner Portfolio for Professional Development, which included lesson plans for the mini-unit and the Invitation to Practice: Mapping My Classroom activity, Exit Slips, Quick Writes, and journal entries. A framework for organization formed through reflection upon the teachers’ interview data and goals, beginning with their feelings of support from their teams and their administrators, followed by analysis of their desire to implement I-B methods, and
finished with an examination of possible barriers that teachers faced while attempting to implement I-B methods into their classrooms.

**Triangulation Related to Teachers’ Goal Statement Cross-Case Analysis**

Analysis of each teacher’s goal statement revealed that they all respond favorably and are interested in learning how to implement inquiry into their science teaching. Data analysis for points of triangulation continued with a look at the teachers’ beliefs related to their attitudes towards implementation of I-B methods. Pre PSI Professional Development Course and post PSI Professional Development Course interview data showed that all of the teachers had a desire to implement I-B methods into her classroom. Data from the participants Partner Portfolios for Professional Development support this finding related to the teacher’s goal statements. For example, an excerpt from Liz’s Invitation to Practice: Mapping My Classroom activity supports this idea. Liz wishes “to implement more Inquiry-Based instruction.” She notes in a journal entry, “I used my 5E lesson plan that I planned this summer.” As another example, Julia writes in an excerpt from an Exit Slip in her Partner Portfolio for Professional Development, “I’d like to read the [Douglas Llewellyn] book and better understand the inquiry process, more in depth.”

The Science Teaching Efficacy Belief Instrument (Appendix C) was designed by Riggs (1988) and Riggs and Enochs (1990) for elementary in-service teachers and is used to assess attitudes and beliefs toward science. All of the teachers’ scores fell into the average efficacy (T1-Ariel, T2-Jo, and T7-Anna) or high efficacy (T3-Liz, T4-Hailey, T5-Robin, T6-Lucy, and T8-Julia) range for the pre STEBI Personal Science Teaching Efficacy Scale. Scores for the post STEBI Personal Science Teaching Efficacy Scale all fell into the high efficacy category with the exception of one teacher (T7-Anna), her
score was in the average efficacy category. This is an indication that all of the participants were comfortable with their ability to teach science. All of the teachers’ scores fell into the average expectancy (T1-Ariel, T5-Robin, and T7-Anna) or high expectancy (T2-Jo, T3-Liz, T4-Hailey, T6-Lucy, and T8-Julia) range for the pre STEBI Outcome Expectancy scale. All of the teachers’ scores for the post STEBI Outcome Expectancy fell into the average (T1-Ariel, T3-Liz, T5-Robin, and T7-Anna) or high (T2-Jo, T4-Hailey, T6-Lucy, and T8-Julia) expectancy category. This is an indication that they had confidence in their teaching abilities to create desirable outcomes. In summary, all of the teachers were willing and felt confident to implement their I-B mini-units into their science classrooms.

*Shared Identity: Administrative and Team Support.* Interview data from the pre PSI Professional Development Course interview analysis showed that seven of the eight teachers are receiving the support from teammates and administrators while they are implementing the I-B process into their science classrooms. Anna feels pressure from her administrators to place more emphasis and time on reading instruction than on science instruction. While each of the teachers hold the desire to implement I-B methods, feel self-assurance in their teaching abilities, and think their critical friends, colleagues, and administrators (Anna being the exception) support their efforts; it is likely that each teacher might not be able to completely accomplish her science teaching dream. Appropriately, the researcher next looked at likely threats to fidelity or barriers to use of I-B instruction. Analysis of the pre PSI Professional Development Course interview questions revealed that the teachers faced numerous barriers as they went about the process of teaching science in their classrooms, including the following: time related to
time to teach, sharing science with other subjects, planning, and curriculum guidelines; support related to instructional assistance, space, and materials; and teacher knowledge.

**Barriers Faced by Teachers**

*Time Related to Time to Teach, Sharing Science with Other Subjects, and Curriculum Guidelines.* Time related to curriculum guidelines including the factors of pacing and standards emerged as a significant issue as it related to the implementation of I-B methods in teachers classrooms. All eight teachers gave multiple accounts of instances where curriculum guidelines served as a barrier to the implementation of I-B science methods in their classrooms. Ariel, Liz, Hailey and Anna all viewed the factor of time related to the amount of time available to teach science as a barrier to the implementation of I-B science methods in their classrooms. Data from the participants Partner Portfolios for Professional Development support this finding related to the teacher’s goal statements. For example, in one of her Exit Slip excerpts, Robin noted that time is a factor in implementation of I-B methods. She writes, “One thing I might have a hard time implementing is the investigable questions. I like the idea, but just wonder about time constraints.” In the excerpt that follows from another Exit Slip entry, Robin again expresses her concerns related to time.

> It seemed as we were working on the 5E [from the 5E Model of science teaching (Bybee, 1993, 2000; Carin et al., 2004)] lesson plans that we were doing a lot of activities. I am concerned about the time frame for each. I guess we will have to just see as we do each activity how much time we actually need.

Excerpts from *Liz’s Partner Portfolio for Professional Development* showed that time for instruction was a barrier for Liz. In an excerpt from one of Liz’s Exit Slips, she notes that
she would still like to learn more about “time management so that I can balance inquiry and directed teaching to get everything done in the time allotted.”

Liz and Robin both noted time for planning instruction served as a barrier towards implementation of I-B methods in their classrooms. Data from the participants Partner Portfolios for Professional Development support this finding related to the teacher’s goal statements. For example, this excerpt details barriers Robin encountered towards carrying out her plans.

I have not officially assigned roles to students. I keep forgetting to talk about the roles and when it comes time to do the investigation I don’t want to take the time to explain. Time is short!

In one of her journal entries Liz confirms that time for planning is indeed a barrier to implementation of I-B methods. She writes, “I have not consciously planned any other 5E lessons.” Further examination revealed that other teachers also experienced barriers related to planning. In her Invitation to Practice: Mapping My Classroom activity Hailey planned changes that would have to take place in her classroom in order for her to implement I-B science. The excerpt that follows outlines her plans.

On my map, I start with a question. I don’t generally start with a question that leads them to inquiry. I start with a review of the day before and often tell them what we are doing. I just haven’t taken the time to think of a way that starts with a question.

The factor of time, time for planning and time to teach was also confirmed in Anna’s Invitation to Practice: Mapping My Classroom activity. Anna notes, “Many of my plans are out the window because of my schedule this year. My classroom is smaller than it was last year, so it’s hard to find room to have “cozy” spots for literacy centers. Plus my daily schedule is not very helpful to doing anything!”
Ariel, Liz, Anna, noted that daily scheduling of science in relation to other subject areas served as a barrier to the implementation of I-B methods in their science classrooms. Data from the participants Partner Portfolios for Professional Development support this finding related to the teacher’s goal statements. For example, in an Exit Slip Jo wrote that she thought she might have difficulty with “time management.” She knows she “will want the kids to take all the time they need but that is not always possible with the schedule.” As another example, Anna notes in an October 15, 2007 journal entry, which is seven weeks into the new school year, that, “As of right now, I haven’t pulled anything out of my bucket because I haven’t taught a science unit yet.”

Support Related to Instructional Assistance, Space and Materials. Three participants, Ariel, Liz, and Robin, found that a strong support system was helpful as they went about the process of implementing I-B methods into their classrooms. Ariel, Liz, and Hailey noted that having materials available for I-B instruction was important. Data from the participants Partner Portfolios for Professional Development support this finding related to the teacher’s goal statements. For example, this statement was supported by Ariel’s Invitation to Practice: Collaboration activity. Ariel and her CF, Jo both agreed that they “…find it difficult to get all of the materials together for certain experiments.” In an Exit Slip Jo wrote that she might have a difficult time “organizing the classroom, finding and creating the space. Data from the pre PSI Professional Development Course interview revealed that classroom space and accessibility of science tools served as a barrier to Lucy’s implementation of I-B methods. Anna also found that classroom space served as a barrier, she notes, “…My classroom is smaller than it was last year, so it’s hard to find room to have “cozy” spots…”
The Invitation to Practice: Mapping My Classroom activity conveyed that Lucy made an attempt to remove some of the barriers that she faced to implementing I-B into her classroom. Lucy removed the barriers of a lack of classroom space and accessibility of science tools on her own. Lucy’s solution provided more opportunities for students to participate in I-B science activities. Lucy “made spots for supplies” so that she and her students “could find them” when they needed to use them. She put a “table in the middle of the classroom” so she can “perform demonstrations” so that all of her “students can see without having to move.” Lucy was not able to carry out one of the ideas she had to switch from desks to tables because tables were not available at her school. Although Lucy was able to make some adjustments related to providing space and opportunities for her students to participate in I-B science, she found that some factors like the furniture and the size of the room were beyond her control.

*Teacher knowledge.* Hailey, Robin, and Anna explained that their knowledge of science content material or comfort level with the science lesson activity might serve as a barrier. Data from all of the participants’ Partner Portfolios for Professional Development support this finding, which is related to the teacher’s goal statements. For example, the excerpt that follows from one of Hailey’s journal entries from her Partner Portfolio for Professional Development outlines her reflection upon what stayed in her bucket, or were not utilized by Hailey, because of factors that served as a barrier to implementing I-B methods. Hailey writes, “I am not writing every lesson plan by defining the 5E’s because of time limitations. I need to put the template on my computer.” In one of Robin’s journal entries from her Partner Portfolio for Professional Development she stated, “subject matter will influence how I approach it.” In her Invitation to Practice: Science Learning
Personal History activity, Robin also noted that when came across a topic that she “had little exposure with” she would “learn it before” she “could teach it.” She “needs to read about it as well as do something” to learn the science content before she can teach it. During the pre PSI Professional Development Course interview session, Ariel and Jo felt that lack of subject knowledge might prove to be a barrier. During the process of implementing their mini-units, they both learned that content knowledge was not a barrier for them.

*Students.* Robin, Liz, Lucy, and Anna explained that student behavior and teacher perceptions about their abilities to handle science concepts might have an effect on their use of I-B methods. Data from the participants Partner Portfolios for Professional Development support this finding related to the teacher’s PSI Professional Development Course goal statements. For example, during the PSI Professional Development Course, Lucy wrote in one of her Exit Slip entries, “I would love to have my kids planning their own experiments on a more regular basis.” The CLES Personal Relevance scale relates to students’ experience of the personal relevance of school science as perceived by teachers. The teachers’ CLES Personal Relevance scores support this finding. All of the teachers’ post CLES Personal Relevance scores fell into the high intermediate (T1-Ariel, T4-Hailey, and T7-Anna) agreement range or the high (T2-Jo, T3-Liz, T5-Robin, T6-Lucy, and T7-Anna) agreement range, which indicated that the teachers placed a high emphasis on linking school science with students’ everyday experiences (Suters, 2004; Taylor et al., 1997).
Summary

The professional development goals of each of the teachers who participated in this study revealed that they were all interested in learning how to implement inquiry into their science teaching. Analysis of each teacher’s goal statement revealed that they all respond favorably and are interested in learning how to implement inquiry into their science classrooms. During the PSI Professional Development Course session the teachers worked with each other to create and implement their own self-created I-B lesson plans into each of their science classrooms. During the pre PSI Professional Development Course interviews, the following similarities emerged across cases as possible barriers to implementing I-B science: time related to time to teach, sharing science with other subjects, planning, and curriculum guidelines; support related to instructional assistance, space, and materials; and teacher knowledge. Analysis of the data revealed that the teachers did indeed confront many of the barriers that they faced as they went about the process of implementing I-B science into their classrooms. For example, Hailey, Robin and Anna found that science subject knowledge served as a barrier towards implementation of I-B methods. In their pre PSI Professional Development Course interviews, Ariel and Jo explained that they thought a lack of knowledge of science subject matter might become a barrier to implementation of I-B methods but this proved not to be the case for their lesson on the topic of rocks and fossils.
Research Question 4 Cross-Case Analysis

What relationships exist between teachers’ perceptions and use of I-B methods?

Influences such as the teachers’ cultures, education-related life experiences, motivation, attitude, methodology, perceptions, expectations, organizational ritual, and style help mold their beliefs about I-B methods. John Dewey (1938, 1997) proposed that experience transpires as a result of the interrelationship of two principles, continuity and interaction. Continuity refers to how each experience a person has influences one’s future, for better or for worse. Interaction refers to the situational influence on one’s experience. The individual’s present experience is a function of the interaction between their past experiences and the present situation. No experience has a predestined value. Therefore, what might be a beneficial experience for one individual could be an unfavorable experience for another. In other words, "positive experiences" motivate, encourage, and enable students to go on to have more valuable learning experiences, whereas, "negative experiences" tend to lead towards a student closing off from potential positive experiences in the future. Dewey believed that learning experiences should be meaningful to each student and that teachers should step back and act as facilitators (Dewey, 1938, 1997).

Each teacher examined the methods and activities introduced at the PSI Professional Development Course and made a decision whether to use it or not in her classroom or based on her own system of values. When teachers perceived the activities were of considerable value they were motivated and determined to employ it. Teachers’ discovery of methods or activities that they perceived had little value had a negative
influence on their motivation, attitude, caring, determination and effort to employ it. This data findings were drawn upon in an effort to uncover patterns related to each teacher’s cognitive framework related to inquiry, her beliefs about inquiry teaching, and how this ties into the her daily teaching experiences. This information is vital to understanding teacher change related to inquiry (Keys & Bryan, 2000; Spillane et al., 2002).

*Teachers’ Cross-Case Interview Analysis: Pre and Post Professional Development Course*

A qualitative research design served as an appropriate methodology to utilize to examine patterns related to relationships that might exist between each teacher’s perceptions and use of I-B methods, since qualitative research is concerned with the perceptions of the participants and with process rather than outcomes or products (Bogdan & Biklen, 1992; Marshall & Rossman, 2006). This design serves as an appropriate methodology to utilize to define inquiry as it is perceived and used by each teacher. This cross-case analysis includes multiple data sources. It includes an integration of the (a) descriptions of each participant’s definition of inquiry as revealed in Research Question 2 cross-case analysis and (b) cross-case analysis of the teachers’ goal statements as revealed in Research Question 3 cross-case analysis. The data findings were analyzed for patterns related to teachers’ beliefs about inquiry teaching and to determine how each teacher’s cognitive framework related to inquiry and their beliefs about inquiry teaching tie into their daily teaching experiences. The researcher examined the teacher’s Conceptual Framework Relationship (CFR), the relationship between her Individual Identity (II), Subject Matter Knowledge (SMK) and her Shared Identity (SI). Other data sources included the teachers’ (c) post classroom observation analysis (see Appendix E
for the Classroom Observation Protocol), (d) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (e) Partner Portfolio for Professional Development were utilized to serve as sources for triangulation of multiple data sources and provided for multiple measures of the same phenomenon (Yin, 2003).

Interview data findings were drawn on to first illustrate each teacher’s cognitive framework related to inquiry. Review of descriptions of each participant’s definition of inquiry as revealed in Research Question 2 cross-case analysis reveals that seven of the eight teachers held some knowledge of inquiry science prior to the PSI Professional Development Course. Ariel, Jo, Liz, Hailey, Robin, Anna, and Julia used the following descriptors in their definitions of inquiry science: questioning, investigating, exploring, and making connections. In her interview prior to the PSI Professional Development Course Ariel defines inquiry science as “questioning, looking into something more thoroughly, and lots of questions, more observing.” After participating in the PSI Professional Development Course Ariel’s described inquiry as, “Questioning, investigating, figuring out answers, exploring.” In her interview prior to the PSI Professional Development Course, Jo’s definition of inquiry science includes, “Questioning, answers to puzzles.” After participating in the PSI Professional Development Course, Jo defines inquiry in the following manner, “Inquiry science is a combination of scientific method and further exploration to figure out the ‘How’s?’ It is a chance to wonder about life and ‘play,’ to make sense of it all.” Liz explains that she believes inquiry involves exploring and investigating in the excerpt that follows.

Liz (pre): “I take that [I-B methods] to mean you’re exploring, you’re investigating things. You are taking the unknown and learning a little more about what you don’t know or making connections to things that were not there before.”
In her post PSI Professional Development Course interview Liz elaborates further,

“Using investigative methods to learn science concepts,” to her definition of inquiry science. Robin and Anna, both include questioning and explaining in their definitions.

Robin (pre): “To define Inquiry science I would say questions…So inquiry is having the students, or whoever it is, exploring for that lab trying to understand the question that was asked and trying to explain further. They might ask, ‘what if we were to make these changes?’ and ‘why is it doing that?’ So it’s more exploring for themselves and trying to understand on their own, with guidance, how they arrived at the answers.”

Anna (pre): [I-B] “I think it’s basically a question, you ask, I tell. The kids ask what they want to know and the teacher spends time answering things that they want to know about a subject. It’s showing them the answers; again, it’s hands-on. It’s got to be able to get down to their level and explain things at their level. A lot of that is with show and tell type things.”

Anna’s definition is teacher more directed than student directed.

Julia (pre): “[Inquiry] For me I have a real positive feel because then you’re delving into it. You’re inquiring. Inquiring minds want to know. So when I think inquiry, I think you have something that you want to understand deeper and you are going to have to come to an understanding to acquire that knowledge. So, to me it’s a hands-on way to learn the end product. That’s what inquiry science means to me. You are inquiring and you are doing it through a variety of methods until you can come to a conclusion. Basically taking yourself through the scientific method.”

Julia shares in her post PSI Professional Development Course interview that she learned a systematic approach to inquiry. Julia says, “I knew what worked but did not have a systematic approach prior to the session.” She continues to explain, “I now have a systematic approach that organized my lessons and engages the students.” In the interview following the PSI Professional Development Course, Julia added to her definition of inquiry science, “The inquiry approach to science is a methodical plan which captivates the students. It incorporates the 5E’s [from the 5E Model of science
teaching (Bybee, 1993, 2000; Carin et al., 2004)] and is very much hands-on and exciting.” In her pre PSI Professional Development Course Hailey explains that she feels inquiry science includes, “providing exploration so that students will ask the questions and solve the problems through discovery.” Hailey explains in her post PSI Professional Development Course interview, “It [inquiry science] is a process. It can be achieved by writing a lesson using the 5E’s.” She further explains that she will use “engagement,” the “5E’s template to write lessons” and “try to pose a problem” in her lessons.

Prior to the PSI Professional Development Course Lucy was not familiar with inquiry science. Lucy explains that she “hadn’t even heard of it [I-B] before. It sounded like another buzz word for hands-on.” Lucy talks about what she learned in her post PSI Professional Development Course interview defining inquiry as, “A method of teaching that enables students to explore, manipulate, and experiment in order to truly build and lay the foundation of scientific understanding.”

Goal Statement Analysis

Participants set their own goals for I-B instruction during the professional development session (Hammerness et al., 2005). An analysis of these goals as demonstrated in cross-case data analysis for Research Question 2 and Research Question 3 revealed information about how the teachers’ cognitive frameworks related to inquiry and their beliefs about inquiry teaching tie into their daily experiences. Looking across the teachers’ goals allowed the researcher to study their attitudes towards implementation of I-B methods into their classrooms. The teachers’ goals revealed that they all responded favorably and were interested in learning how to implement inquiry into their science teaching. For example, analysis revealed that Ariel and Jo are interested in learning how
to implement experiments, the scientific process, and I-B methods into their classrooms. Liz is also interested in leaving “with some great ideas to use and improve” her science instruction and she is “open-minded” or willing to try some different things in her classroom. Julia expressed similar goals. Hailey and Robin are interested in integrating I-B science into their lesson plans. Anna is interested in becoming a “more interesting and exciting teacher”. Anna also wants to learn more about “hands-on ways,” gaining students’ interest, integration of other subject areas into science, and time management. Lucy would like to learn “some new ways to enhance my science teaching.” The teachers’ goal statements verify that their teaching styles, attitudes, level of interest, and points of view were not factors that served as barriers toward the implementation of I-B methods into the classroom. They are all interested in learning about and implementing I-B methods into their science classrooms.

Triangulation Across Cases

The teachers’ (a) post classroom observation analysis (see Appendix E for the Classroom Observation Protocol), (b) STEBI analysis (see Appendix C1 for instrument and C2 for scoring instructions), and (c) Partner Portfolio for Professional Development were utilized to serve as sources for triangulation of multiple data sources and provided multiple measures of the same phenomenon (Yin, 2003).

This analysis also allowed the researcher to determine how each teacher’s cognitive framework related to inquiry and their beliefs about inquiry teaching tie into their daily experiences. Classroom observations supported by lesson plan data from the teachers Partner Portfolio for Professional Development revealed that teachers were all working at different levels or stages of inquiry implementation. Llewellyn (2002) cautions that
teachers should not expect to become inquiry-based teachers immediately. In fact, he suggests that it takes 3 to 5 years to fully integrate inquiry-teaching techniques. Martin-Hansen (2002) illustrates four models of inquiry that are frequently utilized for instruction consisting of Structured Inquiry, Coupled Inquiry, Guided Inquiry, and Full or Open Inquiry. They range from student-centered to teacher-centered in that order. Each teacher moved at her own pace along continuum towards the implementation of full or open inquiry. Each teacher moved at her own pace along continuum towards the implementation of full or open inquiry. This finding supports Llewellyn’s (2002) assertion that fully integrating inquiry-teaching techniques takes time.

Classroom Observations

Data analysis for triangulation began with a look at each teacher’s progress related to the implementation of I-B methods. Data analysis revealed that all of the teachers were using some form of inquiry in their classrooms. The excerpts that follow, taken from Research Question 1 cross-case analysis, give examples of each teacher’s use of I-B methods in their classrooms. A continuum representing the use of I-B methods, as defined by Martin-Hansen (2002), in the teacher’s classrooms is located in Table 44. Through classroom observation and interview data analysis, the researcher learned that all of the teachers did not start at the same level of inquiry upon enrolling in the PSI Professional Development course. For example, Julia held more prior knowledge about inquiry than the other participants, while Lucy reported having almost no prior knowledge about the topic of I-B science methods.
Table 44.

*Use of I-B Methods by Participants*

<table>
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<tr>
<th>Teacher</th>
<th>Use of I-B Methods as defined by Martin-Hansen (2002)</th>
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<tr>
<td></td>
<td>Structured Inquiry</td>
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<td>1</td>
<td>Pre June 2007</td>
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<tr>
<td>2</td>
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<td>8</td>
<td>Pre June 2008</td>
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*Ariel’s classroom observation findings.* Ariel’s lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Structured Inquiry. In Ariel’s post PSI Professional Development Course lesson it was evident that she was in the process of implementing further use of I-B methods into her science classroom. Ariel used Coupled Inquiry, inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002). Ariel indicated that students would be given the opportunity to discover the answers to many of their questions on their own as they moved through the unit, thus showing that Ariel will slowly begin implementing the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002) into her science classroom.

*Jo’s classroom observation findings.* Data from Jo’s lesson plans and pre PSI Professional Development Course observation illustrated that she was successfully implementing Structured Inquiry into her classroom. In Jo’s post PSI Professional Development Course lesson it was evident that she was in the process of implementing further use of I-B methods into her classroom. Jo implemented Coupled Inquiry, inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002). Jo will slowly begin implementing the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), as she gradually allows students the opportunity to discover the answers to many of their questions on their own as they moved through the unit.
*Liz’s classroom observation findings.* Liz’s lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Structured Inquiry into her science classroom prior to the PSI Professional Development Course. Utilizing data from Liz’s post PSI Professional Development Course lesson, as noted in Research Question 2 analysis, it was evident that she was experiencing a degree of success while moving towards implementation of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002). Liz’s post PSI Professional Development Course lesson addressed the Virginia SOL related to the characteristics of the sun. The researcher observed evidence of Full or Open inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002), in the post PSI Professional Development Course observation as students created “What happens if?” questions throughout the design process while creating their solar cookers.

*Hailey’s classroom observation findings.* Hailey’s lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Structured Inquiry into her science classroom prior to the PSI Professional Development Course. In Hailey’s post PSI Professional Development Course lesson it was evident that she was in the process of implementing further use of I-B methods into her classroom. Hailey’s post PSI Professional Development Course lesson addressed Virginia SOL related to the classification of rocks. The researcher observed evidence of Guided Inquiry, inquiry in which the teacher develops the question and allows the students to co-construct the experimental design. Hailey was able to implement some elements of inquiry into her classroom lessons. In an Exit Slip in her
Partner Portfolio for Professional Development, Hailey explains, “I need to review investigable questions.” She explains, “It will take time to review what I’ve learned and feel comfortable creating I-B lessons. She indicated in one of her journal entries that she feels “less pressure with baby steps to do it all at once.”

Robin’s classroom observation findings. Robin’s lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Structured Inquiry into her science classroom prior to the PSI Professional Development Course. In Robin’s post PSI Professional Development Course lesson it was evident that she was in the process of implementing further use of I-B methods into her classroom. Robin’s post PSI Professional Development Course lesson addressed the Virginia SOL related to the layers of the Earth. During the lesson, the researcher observed evidence Guided Inquiry, through an activity titled “What’s in the bag?” Robin asked the students to guess, “What’s in the bag?” She told students that they were using scientific observation to develop a conceptual understanding. She led them to draw conclusions between the mystery object, a shovel, and concepts they would study about the Earth, for example: digging into the Earth, digging fossils, and searching for evidence related to Pangaea. The researcher also observed evidence of Coupled Inquiry, inquiry that starts as structured inquiry or teacher guided inquiry that is followed by an inquiry making use of a reduced amount of teacher control (Martin-Hansen, 2002) as she reduced teacher control and allowed students to work as individuals or pairs to investigate clues and to position together foam pieces of Pangaea.

Lucy’s classroom observation findings. Pre PSI Professional Development Course interview analysis revealed that Lucy used the following strategies in her classroom prior
to the PSI Professional Development Course: hand-on activities backed by practice, games, modeling strategies, technology, songs and fun. She uses reading as a follow-up activity to enhance instruction. As mentioned in Research Question 1 interview analysis, Lucy displayed evidence of the use of Guided Inquiry as defined by Martin-Hansen (2002). Lucy gained a great deal of knowledge related to the concept of I-B methods during the PSI Professional Development Course. After the course, Lucy reflected upon her science lesson from the mini unit that she created during the PSI Professional Development Course. Lucy revealed:

It was really hard for me to plan at first because I wanted every single lesson and thing that I was going to do with the students to be inquiry. It took me a while to decide on which activities I wanted to focus. I found that I was trying to put too much into the unit and had to really decide which activities would be the most effective and would get the most across in the shortest amount of time. Changing the activities to attach the inquiry method was not hard at all. It just took some different kind of thinking and deciding how to let go of some control.

Anna’s classroom observation findings. Anna’s lesson plans and pre PSI Professional Development Course observation data showed that she had already successfully implemented Structured Inquiry and Guided Inquiry into her classroom prior to the PSI Professional Development Course. Anna reported that she did not know much about I-B methods prior to the course, however classroom observation data showed that Anna was implementing I-B methods, perhaps without knowing the terminology to identify her teaching strategies. During the pre PSI Professional Development Course observation lesson the students followed Anna’s directions to investigate the parts of the seed, exhibiting evidence of the use of Structured Inquiry. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience (Martin-Hansen, 2002). Anna moved on to the next portion of the
experiment and allowed the students the opportunity to offer suggestions that would lead to the design their own class experiment with the carnation, this time exhibiting evidence of the use of Guided Inquiry. Guided Inquiry is inquiry in which the teacher develops a question and allows the student to co-construct the experimental design (Martin-Hansen, 2002). Data from the pre PSI Professional Development Course observation verifies data from the Pre PSI Professional Development Course interview that showed that Anna had already successfully implemented several forms of inquiry as described by Martin-Hansen (2002), Structured Inquiry and Guided Inquiry. In her post PSI Professional Development Course observation, the researcher observed Anna allowing students the opportunity to discover the answers to many of their questions during the sink or float activity and during the pumpkin observation and exploration activity. Both activities can be described as Structured Inquiry.

*Julia’s classroom observation findings.* Data from Julia’s lesson plans, pre PSI Professional Development Course observation, and post PSI Professional Development Course observation revealed that she has successfully implemented several forms of inquiry as described by Martin-Hansen (2002). Structured Inquiry, in which the teacher directs the methods of inquiry, was observed during the pre PSI Professional Development Course observation as students rotated through the frog themed centers exploring the concept of life cycles. Structured Inquiry is inquiry based on teacher directed methods and usually is not considered to be an authentic inquiry experience. Throughout her mini unit plan Julia gradually moved from Structured Inquiry to Guided Inquiry, inquiry in which the teacher develops a question and allows the students to co-construct the experimental design, to Coupled Inquiry, inquiry that starts as Structured
Inquiry or teacher Guided Inquiry that is followed by an inquiry making use of a reduced amount of teacher control. Julia gradually lessened teacher control as she allowed students to asked questions about pushes and pulls, designed their own mini experiments, and discussed the results with their classmates and teacher. Julia has gradually moved toward the implementation using the model of Full or Open Inquiry, inquiry in which students ask their own questions, design investigations, and convey results (Martin-Hansen, 2002).

Summary of classroom observation findings. Classroom observation data showed that each of the participants had successfully implemented some form of inquiry as defined by Martin-Hansen (2002). Analysis of the pre PSI Professional Development Course interview questions revealed that all of the teachers, except Julia, believed that they did face barriers as they went about the process of implementing I-B instruction. When asked if there was anything that inhibits her from using I-B methods in her science classroom, Julia responded with one word, “Nothing.” Data analysis for triangulation was conducted to examine the barriers faced by the other teachers, including the following: time related to time to teach, sharing science with other subjects, planning, and curriculum guidelines; support related to instructional assistance, space, and materials; and teacher knowledge.

STEBI Cross-Case Analysis

Details of the participants STEBI results were noted in Research Question 1 analysis. Ariel and Jo’s scores increased notably, moving from an average efficacy score to a high efficacy score indicating that they were comfortable with her ability to teach science. Lucy’s scores increased notably, both pre and post assessments were in the high
efficacy category. Anna’s scores increased notably, both scores were in the average efficacy range. Liz, Hailey, and Robin’s scores decreased slightly, but remained in the high efficacy category indicating that they all felt comfortable with their own abilities to teach science. Liz’s scores decreased notably, but remained in the high efficacy category (see Appendix C1 for instrument and C2 for scoring instructions) (Riggs, 1988; Riggs & Enochs, 1990). Although the scores ranged from average to high efficacy, all teachers felt comfortable with their own abilities to teach science.

Ariel and Robin’s STEBI Outcome Expectancy scores decreased notably, both scores fell within the average expectancy range indicating they had some confidence in their abilities to create desirable outcomes. Jo and Julia’s scores decreased slightly, both scores fell within the high expectancy range. Liz’s scores decreased notably, scores moved from the high expectancy to the average expectancy category. Hailey and Lucy’s scores increased notably, both post assessment scores were in the high expectancy category indicating that they had confidence in their teaching abilities to create desirable outcomes. Anna’s scores increased slightly, remaining in the average expectancy category. Table 19 displays the pre and post STEBI OE scores by participant (see Appendix C1 for instrument and C2 for scoring instructions). The scores fell among the average to the high expectancy range, indicating that they had a range of confidence levels; however all felt at least some confidence in their own abilities to create desirable outcomes and all were able to choose which methods they employed in their own classrooms (Suters, 2004; Taylor et al., 1997).
Partner Portfolio for Professional Development Cross Case Analysis

Throughout the professional development session, the teachers participated in exercises that led them to reflect upon and manage their thoughts and behaviors through strategic processing, reflection, and collaboration (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). The teachers’ portfolio data provided additional pieces that were used to solve the query, “What common relationships exist between their perceptions and use of I-B methods?” The researcher completed three steps in analyzing the partner portfolio. First, a review of the findings from the teachers’ interview analysis which includes the participants’ definition of inquiry was examined and compared with the definition of inquiry used during the professional development session to determine if the teachers’ methods allowed for the implementation of I-B methods. Second, Goal statement analysis, the PSI Post Professional Development Course lesson observations, which include the teachers’ level of I-B implementation or choice of teaching methods, and STEBI analysis, was conducted. Third, accounts were compared to excerpts from the participant’s lesson observations and numerous Journal Entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003).

First, the researcher examined the teachers’ definitions of inquiry from interview data. Review of descriptions of each participant’s definition of inquiry as revealed in Research Question 2 cross-case analysis reveals that seven of the eight teachers held some knowledge of inquiry science prior to the PSI Professional Development Course. Ariel, Jo, Liz, Hailey, Robin, Anna, and Julia used the following descriptors in their
definitions of inquiry science: questioning, investigating, exploring, and making connections.

Then, the definition of inquiry used during the PSI Professional Development Course was reviewed for comparison with the common descriptors used in the teachers’ definitions of inquiry. During the PSI Professional Development Course, inquiry instruction was defined as referring to any teaching method focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations and discover answers to their questions about the natural world. Students may plan systems to collect data and choose how to organize and represent the data (Carin et al., 2004). The National Research Council (1998) defines scientific inquiry as:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.” (p. 23)

The teachers’ used questioning, investigating, exploring, and making connections as common descriptors in their definitions of inquiry science. The common descriptors used in the teachers’ definitions of inquiry were similar to the definition of inquiry used during the PSI Professional Development Course.

Next, the researcher looked at the teachers’ choices of teaching methods. As revealed in Research Question 1 cross-case analysis, when asked to remember science
learning situations that influenced their teaching and learning all eight recalled multi-sensory, hands-on experiments or activities. All of the teachers experienced some difficulty when remembering science information when they were not actively engaged in their learning. Ariel, Hailey, Lucy, and Anna noted that they struggled with or felt uncomfortable with science in school. All eight teachers held unique beliefs related to science teaching methods the participants shared many common beliefs, including: use of a variety of teaching methods, flexibility when necessary, humor, and enthusiasm for the topic. Interview data analysis continued in an effort to reveal common factors related to teacher beliefs about how children learn and teaching methods. All eight teachers used positive emotions as descriptors of student learning. Hailey, Robin, Lucy, and Anna explained that novelty was a characteristic of their teaching. Ariel, Jo, Hailey, and Julia emphasized providing a comfortable learning atmosphere or comfort zone in their science classroom. All of the teachers believed that it is important for their students to be actively engaged in their learning. They encouraged investigation, exploration, and searching for answers. Each of the participants expressed their own teaching style; however they shared many similar characteristics. They spoke of structure or routine mixed with flexibility, humor, creativity, and fun. They all incorporated a variety of methods throughout each science lesson. All of the teachers’ choices of teaching methods allow for integration or use of I-B methods.

The researcher compared data from the teachers’ goal statements, classroom observations including methods of I-B implemented, and STEBI analysis. The teachers’ goals reveal that they all respond favorably and are interested in learning how to implement inquiry into their science teaching. Classroom observation data showed that
each of the participants had successfully implemented some form of inquiry as defined by Martin-Hansen (2002). STEBI analysis findings supported classroom observation analysis indicated that each of the teachers felt some confidence in their own abilities to create desirable outcomes and felt freedom to choose which methods they employed in their classrooms.

Last, in assembling the pieces of the puzzle to solve the query, “What common relationships exist between the teachers’ perceptions and use of I-B methods?” Accounts from the teachers’ interview analysis, Goal Statement analysis, and STEBI analysis were compared with excerpts from the teachers’ post PSI Professional Development Course lesson observations and numerous Journal Entries in order to provide additional triangulation of data sources for multiple measures of the same phenomenon (Yin, 2003). All of the teachers respond favorably to the idea of implementing I-B methods into their classrooms. STEBI analysis findings supported classroom observation analysis indicated that each of the teachers felt some confidence in their own abilities to create desirable outcomes and felt freedom to choose which methods they employed in their classrooms. In summary, the teachers felt a favorable response towards inquiry as well a feeling of self-confidence in their own teaching abilities. The perception that I-B methods hold large or great value had a positive influence on all of the teachers’ motivation, attitude, caring, determination, and effort during implementation of the methods in their classrooms.

Cross-case analysis continued with an examination of data related to teachers’ definitions or understanding of inquiry, each participant’s framework for understanding pedagogical science knowledge, and their use of inquiry in the classroom. Research
Question 2 cross-case analysis revealed that the teachers’ definitions of inquiry during the interview sessions matched their choice of methods for instruction. They are willing to use all methods that will help their students remember, particularly “hands-on” activities and active involvement. The teachers’ goal statements support this assertion. For example, the following excerpt from Hailey’s Goal Statement in her Partner Portfolio for Professional Development supported this idea. Hailey explains, “I would like to use inquiry in every science unit, particularly in those that currently seem like it would not lend itself to it.” Cross-case data analysis from Research Question 2 also included an examination of the descriptions of each participant’s framework for understanding pedagogical science knowledge. All eight of the teachers felt comfortable using a variety of different methods including hands-on, experimenting, or doing. The teachers try to reach all of their students through this use of a variety of activities. Jo, Liz, Hailey, Robin, Lucy and Julia discussed applying the science content information or making connections within the context of the science lesson through questioning or offering explanations. All eight teachers spoke of motivation either related to interest level (Ariel, Liz, Hailey, and Robin), curiosity (Jo and Julia), or helping students to remember (Lucy and Anna). Portfolio data analyses from Research Question 1 cross-case analysis showed that all eight teachers use some form of inquiry, investigation, questioning, hands-on, and activity-based methods their lessons. For example, in their Invitation to Practice: Collaboration activity, Jo and her CF, Ariel, both saw themselves as “very structured.” Although Jo sees herself as very structured, she will lead her children in investigations that allow them to stray from the routine to explore and discover on their own.
Although they were all veteran teachers and felt confident in their teaching abilities, the participants were willing to learn new things and improve their teaching practice. All of the teachers had a desire to implement I-B methods into their classrooms, were willing to learn more about the method, and practiced teaching methods that allowed for implementation of I-B methods. Teacher perceptions did serve as barriers to slow down the implementation process. For example, Anna explained in interview sessions that her administration has not influenced her choice of teaching methods, but class time allowed for science has been limited by the perception that reading instruction is a priority over science instruction. Analysis of the pre PSI Professional Development Course interview questions revealed that all of the teachers, except Julia, believed that they did face barriers as they went about the process of implementing I-B instruction. As noted in research Question 3 cross-case analysis, the teachers’ perceived the following factors as barriers to the implementation of I-B methods: time related to time to teach, sharing science with other subjects, planning, and curriculum guidelines; support related to instructional assistance, space, and materials; and teacher knowledge. Cross-case data analysis from Research Question 2 revealed that prior to the PSI Professional Development Course seven of the eight teachers held some limited knowledge of inquiry science (Lucy being the exception). Robin, Hailey, Ariel, Liz, Lucy, and Julia all felt limited by their pedagogical science knowledge and wished to learn more. Robin and Hailey explained in their interview sessions that they feel somewhat limited by their knowledge of pedagogical science knowledge and the amount of time available to apply science-teaching methods. These beliefs might explain why implementation of I-B methods into some of the teacher’s classrooms followed a slow gradual path.
Research Question 5 Cross-Case Analysis

How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Teacher Choice (TC) occurs when the teacher judges the merits of multiple options and selects a course of action founded on his or her own conceptual framework. When a teacher makes a choice she critically assesses the value of available options and chooses a course of action built on her own conceptual framework. Cross-case analysis of Research Question 5 was completed through a study across all of the teachers’ conceptual frameworks. Each teacher’s conceptual framework is composed of her:

1. Individual Identity (II), the portion of the their conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or personal constructs (Scribner et al., 2002);

2. Subject Matter Knowledge (SMK), her knowledge of content matter and pedagogy (the art and science of being a teacher) and curriculum knowledge (Shulman, 1986); and

3. Shared Identity (SI), the portion of her conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community.

Research Question 1 cross case analysis was utilized to reveal information related to Individual Identity (II), Research Question 2 cross case analysis was utilized to reveal information related to Subject Matter Knowledge (SMK), and Research Question 3 cross case analysis was utilized to reveal information related to Shared Identity (SI). An
examination of Teacher Choice (TC) was conducted in an attempt to disclose methods that encourage teachers to overcome resistance to implementing I-B teaching practices.

*Cross-Case Analysis of Individual Identity*

Teacher Choice (TC) is influenced by mental models, “the images, assumptions, and stories, which we carry in our minds of our selves, other people, institutions, and every aspect of the world” (Senge, 1990). In the Research Question 1 cross-case analysis, the information was utilized to examine the beliefs of the participants related to teaching science, how children learn science, and science teaching methods to uncover patterns that influence their teaching behavior as it relates to their autonomy or Individual Identity (II), giving the researcher a glimpse into the teachers’ Individual Identity (II). In the Research Question 1 cross-case analysis data from pre PSI Professional Development Course interview questions numbered 1, 2, and 3 was utilized to examine the beliefs of the participants related to teaching science, how children learn science, and science teaching methods to uncover patterns related to Teacher Choice (TC). Cross-case analysis started with an examination of the participants’ memories of their early science learning.

The constructivist approach to how people learn focuses on providing relevant experiences and opportunities that allow students to construct knowledge (Piaget, 1929; Vygotsky, 1978). Research Question 1 cross-case analysis revealed that all eight participants support the constructivist approach to learning; they all feel they learn science best through seeing and doing. They remember learning best when they were actively engaged or participated in hands-on activities throughout the learning process. All eight of the participants learn best through active engagement, observation and participation. They learned best doing hands-on activities. When asked to remember
science learning situations that influenced their teaching and learning all eight recalled multi-sensory, hands-on experiments or activities. All eight participants remembered lessons when they were active participants. They all had a difficult time remembering the science information taught to them when they were not actively engaged in their learning. Although the participants were actively engaged and active participants in their own learning, not all of their learning experiences were positive. Four of the participants (Ariel, Hailey, Lucy, and Anna) noted that they struggled with or felt uncomfortable with science in school.

Research Question 1 cross-case data analysis also contained an examination of teacher beliefs about how children learn and teaching methods. All eight teachers used positive emotions as descriptors of student learning. Hailey, Robin, Lucy, and Anna explained that novelty was a characteristic of their teaching. Ariel, Jo, Hailey, and Julia emphasized that they provided a comfortable learning atmosphere or comfort zone in their science classroom. All of the teachers emphasized that they believed it was important for the students to be actively engaged in their learning. They encouraged investigation, exploration, and searching for answers. Each of the participants expressed their own teaching style, however they shared many similar characteristics. They spoke of structure or routine mixed with flexibility, humor, creativity, and fun. They all incorporated a variety of methods throughout each science lesson. Seven out of the eight participants spoke about extending learning outside of the classroom in their interview sessions.

Triangulation across cases occurred throughout the cross-case analysis to make sure the picture is clear and meaningful. Excerpts from the Partner Portfolio for
Professional Development supported pre PSI Professional Development Course and post PSI Professional Development Course interview data. All of the teachers applied a constructivist approach to teaching and learning prior to and following the PSI Professional Development Course. They all felt or believed it was important for students to be actively engaged in their learning. The teachers’ beliefs did not change, this aspect of their conceptual framework remained consistent throughout the study; however, some of the teachers faced barriers that served to prevent the teacher from choosing teaching methods consistent with their beliefs that students should be actively engaged.

*Cross-Case Analysis of Subject Matter Knowledge*

Shulman (1986) proposed three categories of subject matter knowledge for teaching, (a) content knowledge, (b) pedagogical content knowledge, and (c) curriculum knowledge. *Content knowledge* entails the facts and concepts in a domain, information about why these facts are true, and information related to how knowledge is generated or structured within the discipline. The unique nature of the subject matter knowledge required by teachers for effective science teaching is referred to as *pedagogical content knowledge*. Pedagogical content knowledge includes familiarity with topics that learners find interesting or difficult, the representations most useful for teaching specific content topics, and learners’ typical errors and misconceptions. This clarification helped to inform the knowledge about qualities and resources needed for effective teaching. Shulman’s third category, *curriculum knowledge*, includes awareness ways of organizing programs of study, using curriculum resources, such as textbooks, of how topics are used over time and within a school year (Schulman, 1986; 1987).
As related directly to my topic of study, Shulman’s work is useful in understanding; (a) the portion of the teacher’s cognitive framework related to science content and knowledge of science and teaching methods and (b) a teacher’s beliefs about effective science teaching as they combine with (c) a teacher’s cognitive framework related to how children learn science to form the teacher’s vision of science teaching. In the Research Question 1 cross-case analysis, interview data findings were utilized to uncover patterns related to the participants’ knowledge of science subject matter and science pedagogical knowledge associated with their abilities to produce desired results according to their beliefs and self-efficacy and teachers’ abilities to produce desired or intended results in their science classrooms. Analysis of pre PSI Professional Development Course interview questions numbered 4, 5, 7, and 3 provided the researcher with data related to each teacher’s early Subject Matter Knowledge (SMK).

*Content knowledge.* Data from Research Question 1 cross-case analysis revealed that all eight participants noted that they had a difficult time remembering science in school for several reasons: (a) their science learning was not hands-on; (b) the method of instruction used by their teachers was limited to reading out of a book; and/or (c) science was not emphasized at their school. Science is usually conveyed as a group of specifics and sets of laws to be memorized, instead of as a way of knowing about the natural world in undergraduate science courses (NRC, 1998). The experiences of the teachers in this study support this assertion. For example, Ariel remembers taking only one course in each of the following subjects in college: chemistry, anatomy, and biology. Robin does not recall any specific directions that she learned for teaching science. She remembers her college science training as more of a broad teaching. Lucy’s early college science training
consisted of “doing a lot of reading out of the book.” Julia’s training experiences do not support this statement. Julia recalls a good training program while at a state university.

When I was training I thought we had a good program. We had to take a class in teaching science. This was in the state university of New York system and we had to do a methodology class in science but it was very much early childhood. I have a master’s degree in that. Everything in my masters program as well as that was very hands-on. It was not just theory. It was always emphasizing the importance of getting in there and having the kids participate in multi-sensory ways. So I feel very grateful because I know some preparation is not that way or are not that way now and I’m just glad that I got to see how well that did work. So I’m really happy that I had the opportunity to do that. That was good.

Julia’s classes in teaching science utilized early childhood concepts and science methodology. Classes in her masters program combined hands-on activities as well as theory.

Five of the participants explained in their pre PSI Professional Development Course interviews that they either disliked science or felt uncomfortable with science. Ariel, Hailey, Robin, Lucy, and Anna all felt negative emotions when thinking about science. The other three participants (Jo, Liz, and Julia) had positive experiences related to their early science learning.

Whether positive or negative, when placed in a learning experience that was hands-on or interactive, the teachers were able to remember the activity. The teachers remembered learning when they were “seeing” and “doing” or when their teachers used a constructivist approach. The constructivist approach to how people learn focuses on providing relevant experiences and opportunities that allow students to construct knowledge (Piaget, 1929; Vygotsky, 1978). When speaking about their understanding of science content information three of the teachers (Jo, Hailey, and Anna) brought up the topic of improving or making their teaching better. Julia feels it was important for her
students to “learn to remember, not for it to just be rote, not to just learn for the test.” Although they were all veteran teachers, the participants were willing to learn new things and improve their teaching practice.

*Pedagogical content knowledge.* Research Question 2 cross-case data analysis continued with an examination of the descriptions of each participant’s framework for understanding pedagogical science knowledge. All eight of the teachers used a variety of different methods including hands-on, experimenting, or doing. Lucy and Julia explain why they feel motivated to use a variety of activities in her teaching. Lucy explains in her pre PSI Professional Development Course interview, “I think because of the bad experience I had, I just always want to make the kids have a better experience.” Julia explains that her motivation is “what works best for the kids.” All eight teachers spoke of motivation either related to interest level (Ariel, Liz, Hailey, and Robin), curiosity (Jo and Julia), or helping students to remember (Lucy and Anna).

*Curriculum knowledge.* Last, Research Question 2 cross-case data analysis focused on the participants’ descriptions of their own frameworks for understanding I-B science methods as reported during their interviews. Seven of the eight teachers held some knowledge of inquiry science prior to the PSI Professional Development Course. The teachers (Ariel, Jo, Liz, Hailey, Robin, Anna, and Julia) included the following concepts in their definitions of inquiry science: questioning, investigating, exploring, and making connections. Lucy was not familiar with Inquiry science before the PSI Professional Development Course. Ariel, Hailey, Robin, Lucy, Anna, and Julia all discussed the point of view of the learner or student when defining inquiry science. Teachers associated emotions with science learning, both positive and negative.
In Research Question 2 cross-case analysis, interview data analysis was useful in uncovering patterns across the participants’ frameworks for understanding science related to each teacher’s ability to produce desired results according to their individual beliefs and self-efficacy. All eight of the teachers spoke of encouraging their students to question or investigate how science applies to their own lives. Ariel, Jo, Liz, Hailey, Robin, Lucy, and Julia all encourage their students to relate science to their own lives. They all mention discovery or investigation of the world around them when defining science.

*Additional themes.* When Partner Portfolio data analysis was conducted in Research Question 2 cross-case analysis multi-case themes were added to the themes created during interview data analysis (Stake, 2006). Classroom observations supported by lesson plan data from the teachers Partner Portfolio for Professional Development revealed that teachers were all working at different levels or stages of inquiry implementation. The teacher’s level of inquiry implementation emerged as a theme. Llewellyn (2002) cautions that teachers should not expect to become inquiry-based teachers overnight. In fact, he suggests that it takes 3 to 5 years to perfect inquiry-teaching techniques. Martin-Hansen (2002) illustrates four models of inquiry that are frequently utilized for instruction consisting of Structured Inquiry, Coupled Inquiry, Guided Inquiry, and Full or Open Inquiry. They range from student-centered to teacher-centered in that order. Each teacher moved at her own pace along continuum towards the implementation of full or open inquiry (see Table 44 for Use of I-B Methods by Participants).
Cross-Case Analysis of Shared Identity

Shared Identity (SI) is defined as the portion of the teacher’s conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents his or her shared identity or role as part of the professional community. Research supports that it is important that teammates and administrators are supportive of teachers while they are implementing the I-B science process and as they change to new or unfamiliar methods (Keller, 2004; Richardson & Placier, 2001). In the Research Question 1 cross-case analysis, data from pre PSI Professional Development Course interview questions numbered 7, 8, and 9 was utilized to uncover patterns related to each teacher’s Shared Identity (SI). Interview data from the pre PSI Professional Development Course interview analysis showed that seven of the eight teachers are receiving the support from teammates and administrators while they are implementing the I-B science process into their science classrooms. Anna feels pressure from her administrators to place more emphasis and time on reading instruction than on science instruction. Interview analysis also shows that in addition to the factor of administrative support, the factors that emerged as having an influence on a teacher’s choice of science teaching methods included the following: the teacher’s CF and teammates, their students, and the student’s parents. When examining possible barriers to the implementation of I-B science methods, the researcher learned that a teacher’s choice is also influenced by the following factors: time related to time to teach, sharing science with other subjects, planning, and curriculum guidelines; support related to instructional assistance, space, and materials; and teacher knowledge.
**Triangulation Across Cases**

Triangulation across cases occurred throughout the cross-case analysis to make sure the picture is clear and meaningful. At times multi-case themes were added to the themes created during interview data analysis (Stake, 2006). As noted in Research Question 1 cross-case analysis, the Partner Portfolio for Professional Development data supports the teachers’ interview data. Bandura (1997) states that knowledge of self-efficacy beliefs can have the ability to predict behavior. Based on Bandura’s (1977) theory of social learning, the researcher asserts that a teacher who possesses a high sense of self-efficacy is more likely to use student-centered, constructivist teaching practices than teachers who have a low sense of self-efficacy. Interview data analysis was also useful in uncovering patterns across the participants’ frameworks for understanding science related to each teacher’s ability to produce desired results according to their individual beliefs and self-efficacy. To provide further triangulation, the Science Teaching Efficacy Belief Instrument (Appendix C) designed by Riggs (1988) and Riggs and Enochs (1990) for elementary in-service teachers was used to assess attitudes and beliefs toward science. All of the teachers’ scores fell into the average efficacy (T1-Ariel, T2-Jo, and T7-Anna) or high efficacy (T3-Liz, T4-Hailey, T5-Robin, T6-Lucy, and T8-Julia) range for the pre STEBI Personal Science Teaching Efficacy Scale. Scores for the post STEBI Personal Science Teaching Efficacy Scale all fell into the high efficacy category with the exception of one teacher (T7-Anna), her score was in the average efficacy category. This is an indication that all of the participants were comfortable with their ability to teach science. All of the teachers’ scores fell into the average expectancy (T1-Ariel, T5-Robin, and T7-Anna) or high expectancy (T2-Jo, T3-Liz, T4-Hailey, T6-
Lucy, and T8-Julia) range for the pre STEBI Outcome Expectancy scale. All of the teachers’ scores for the post STEBI Outcome Expectancy fell into the average (T1-Ariel, T3-Liz, T5-Robin, and T7-Anna) or high (T2-Jo, T4-Hailey, T6-Lucy, and T8-Julia) expectancy category. This is an indication that they had confidence in their teaching abilities to create desirable outcomes (Riggs, 1988; Riggs & Enochs, 1990).

All of the teachers used a constructivist approach to teaching and learning. They all felt it was important for students to be actively engaged in their learning. They all incorporated multi-sensory and hands-on learning activities into their classrooms. Their teaching methods allowed for the implementation of I-B methods. Ariel, Hailey, Lucy, and Anna were able to overcome their uncomfortable feelings related to science subject matter. Barriers related to Shared Identity (SI) influenced Teacher Choice (TC) related to implementation of I-B methods in some of the teacher’s classrooms.

_Ariel’s case._ Ariel approached teaching using a constructivist approach. She uses a variety of methods to teach science. Ariel’s students are busy, “Investigating questions and finding answers that are important to them as far as making science something they can relate to in their lives.” Ariel’s Research Question 5 analysis revealed that Ariel acknowledged that her CF, her teammates, her students, and county and state curriculum standards influenced her choice of science teaching methods. Ariel believed support from her administration and grade level team was positive. Ariel’s Pre PSI Professional Development Course interview data showed that her CF and her teammates influence her. Ariel’s Research Question 3 data analyses revealed that Ariel confronted a number of barriers as she went about the process of implementing I-B science in her classroom, including: time to teach, this relates to sharing time teaching other subjects; time to
implement methods; time to gather materials; materials being available; and the amount of subject matter she is required to cover, this relates to curriculum guidelines including the curriculum framework, curriculum map, Virginia SOL, and county benchmark tests. Ariel thought a lack of knowledge of subject matter might become a barrier to implementation of I-B methods but this proved not to be the case. Prior to the PSI Professional Development Session, the researcher observed Ariel using Structured Inquiry. Ariel was able to move at a slow pace along continuum towards the implementation of Full Inquiry or Open Inquiry.

In summary, interview data revealed that Ariel makes choices about which methods to use to teach science based on the influences of her CF and her teammates, her students, and county and state curriculum standards influenced her choice of science teaching methods. She “enjoys” what she is doing. She wants “the kids to learn.” She exclaims that she does it all “for them!”

Jo’s case. Jo approached teaching using a constructivist approach. She uses a variety of methods to teach science. Jo’s students value the opportunity to engage in “hands-on and sharing out their thinking.” Jo’s Research Question 5 analysis revealed that her teammates, administration, her students, the curriculum map, the curriculum framework, benchmark tests and past SOL data influenced her choice of science teaching methods. Jo believed support from her administration and grade level team was positive. Jo’s Pre PSI Professional Development Course interview data showed that she is influenced by her teammates. Jo indicates that she feels that within her team “we share ideas. Ariel and I share a lot. We plan activities together.” Jo states that her administration “pretty much let us do and trust that we do what we feel will best help the
children learn.” Jo’s Research Question 3 analysis revealed that she faced a number of barriers as she went about the course of implementing I-B science in her classroom.

During the pre PSI Professional Development Course interview Jo viewed the following as possible barriers to implementing I-B science: content knowledge; time for instruction; curriculum guidelines, including the Virginia SOL, county curriculum maps, county benchmark tests, and the amount of content information to be covered. Analysis of the post PSI Professional Development Course interview questions confirmed pre PSI Professional Development Course interview data, which indicated that Jo viewed the amount of time available for instruction as a barrier to implementing I-B methods. Curriculum guidelines, including the amount of content information to be covered within the Standards and results of student test scores related to the Virginia SOL, county curriculum maps, and county benchmark tests also emerged as possible barriers to implementing I-B science. Jo did not mention the factor of content knowledge as a barrier in her post PSI Professional Development Course interview comments. Prior to the PSI Professional Development Session, the researcher observed Jo using Structured Inquiry. Jo was able to move at a slow pace along the continuum towards the implementation of Full Inquiry or Open Inquiry.

In summary, interview data revealed that Jo makes choices about which methods to use to teach science based on the influences teammates, administration, her students, the curriculum map, the curriculum framework, benchmark tests and past SOL data. She gets excited when her students become involved with their own learning.

*Liz’s case.* Liz approached teaching using a constructivist approach. She uses a variety of methods to teach science. Liz likes “…to extend their learning…I like doing
the higher level thinking activities with the kids and I think science gives you a real good way to use that.” Liz’s Research Question 5 analysis revealed that support from administrators influenced her choice of science teaching methods as well as other things she does at school. Liz believed support from her administration and grade level team was positive. Liz’s students also have an influence on her choice of teaching methods. Liz also feels influenced by her students’ reactions when learning about science. Liz also explained that the “SOL and benchmarks” influence both what she teachers and the way she teaches it. She feels she is “required to follow the county’s curriculum map and SOL.” Liz’s Research Question 3 analysis revealed that she confronted a number of barriers, including: time for planning and time for instruction, curriculum maps, benchmark testing, and materials. Prior to the PSI Professional Development Session, the researcher observed Liz using Structured Inquiry. Liz was able to move at a quick pace along the continuum towards the implementation of Full Inquiry or Open Inquiry.

In summary, interview data revealed that Liz makes choices about which methods to use to teach science based on the influences of her students, her teammates, her administration, state standards and county benchmark testing. Liz feels supported by her administration and she is positively influenced by her teammates. She loves to teach.

Hailey’s case. Hailey approached teaching using a constructivist approach. She uses a variety of methods to teach science. Hailey says, “I think I try to find different ways to teach subjects, like using the MI… I feel like I am fairly strict but the children know they can kid around with me. I try to maintain a sense of humor.” Hailey’s Research Question 5 analysis revealed that her CF, her teammates, her students, the Chesapeake Bay, and county curriculum map and the SOL influenced the way Hailey
teaches, her choice of science teaching methods. Hailey’s Research Question 3 analysis revealed that she confronted a number of barriers as she went about the process of implementing I-B science in her classroom, including: time, time related to the amount of material to cover in the curriculum map, organization, forgetting, and a lack of materials. Prior to the PSI Professional Development Session, the researcher observed Hailey using Structured Inquiry. Hailey was able to move at a slow pace along the inquiry continuum to utilize Guided Inquiry.

In summary, interview data revealed that Hailey makes choices about which methods to use to teach science based on the influences of her CF, her teammates, and her students. She is also influenced by county and state curriculum standards. Issues related to the care of the Earth and our environment, especially the Chesapeake Bay watershed, had an influence on her science teaching. She believes teaching science is fun and enjoyable.

Robin’s case. Robin approached teaching using a constructivist approach. She uses a variety of methods to teach science. Robin explains, “I give them a variety of ways to explore a concept. I give them meaningful and engaging activities. We have fun and learn at the same time.” Robin’s Research Question 5 analysis revealed that her administrators, teammates, students, and the curriculum map have influenced her choice of science teaching methods. Referring back to data from Robin’s Research Question 2 analysis, we learned that Robin believed support from her administration and grade level team was positive. Her administrators were very open to help when she needs them and supportive by allowing them to conduct experiments and try new things. Robin’s Research Question 3 analysis revealed that she confronted a number of barriers as she
went about the process of implementing I-B science in her classroom. Time is a factor that might serve as a barrier to the implementation of I-B methods, specifically, time related to curriculum guidelines, including the curriculum map and the Virginia SOL, and meeting the needs of her students. Robin felt uncomfortable allowing her students to choose their own investigable questions fearing that they would not have enough time for implementation. Robin thought a lack of experience with a lesson might become a barrier to implementation of I-B methods but this proved not to be the case. Robin was able to overcome the barrier of a lack of experience with the lesson or experiment. Prior to the PSI Professional Development Session, the researcher observed Robin using Structured Inquiry. Robin was able to move at a slow pace along the inquiry continuum to utilize Guided Inquiry and Coupled Inquiry.

In summary, interview data revealed that Robin makes choices about which methods to use to teach science based on the influences of administrators, teammates, students, and the curriculum map. She feels supported by her administration and teammates. She is also influenced by her students and feels it is important to meet their individual needs. When planning, Robin begins with the curriculum map and alters activities to meet the needs of her students. She wants her students to learn more and enjoy learning.

*Lucy’s case.* Lucy approached teaching using a constructivist approach. She uses a variety of methods to teach science. Lucy chooses hands-on inquiry methods because “when kids are active in their learning they remember and understand better.” Lucy believed support from her administration and grade level team was positive. Lucy’s administrators have “always been supportive of anything” she’s put into practice. Her
team has “given her ideas” and “helped her see and activity.” Her team does not influence her choice of science methods. Lucy saw curriculum guidelines, including the amount of content in the Virginia SOL, county requirements, and curriculum pacing; classroom space; the behavior of students; and time as possible barriers to implementing I-B methods. Lucy was able to manage student behavior. Although Lucy was able to make some adjustments related to providing space and opportunities for her students to participate in I-B science, she found that some factors like the furniture and the size of the room were beyond her ability to control. Prior to the PSI Professional Development Session, Lucy explained that she did not understand what inquiry was. Lucy was able to move at a slow pace along the inquiry continuum to utilize Guided Inquiry.

In summary, interview data revealed that Lucy carried around the images, or assumption in her mind that she did not like science when she was a child. Lucy had a difficult time understanding science concepts. A hands-on science class in college allowed Lucy to enjoy and understand science. Lucy chooses to use inquiry science in her classroom because she does not want her students to suffer bad experiences like those she had to endure. Lucy believed support from her administration and grade level team was positive. Lucy’s administrators have “always been supportive of anything” she’s put into practice. Her team has “given her ideas” and “helped her see and activity.” Her team does not influence her choice of science methods.

Anna’s case. Anna approached teaching using a constructivist approach. She uses a variety of methods to teach science. Anna explains, “…if I can get it into a game then I can create that type of an atmosphere or a learning experience they’re going to remember it more. In my class I don’t believe in just sitting there…” Anna’s Research Question 5
analysis revealed that her teammates, her students, and curriculum guidelines, including county and state curriculum standards influenced her choice of science teaching methods. Interview data also showed that time allotted for teaching science, related to an emphasis by administrators on teaching the subject of reading, influenced Anna’s science teaching. Anna believed support from her grade level team was positive. Anna’s pre PSI Professional Development Course interview data showed that her teammates influence her. Anna’s team influences her more than any other factor. Anna is willing to try new ideas in her classroom and shares ideas with others, she “creatively steal[s] everything” she can. Anna’s Research Question 3 analysis revealed that she confronted a number of barriers as she went about the process of implementing I-B science in her classroom, including the following barriers: time for planning science instruction and time for teaching science, classroom space, sharing time with other subjects, lack of administrative support, curriculum guidelines, including the Virginia SOL and county curriculum maps, and a lack of understanding of I-B methods. Post PSI Professional Development Course interview data revealed that Anna is “…still sketchy about…” I-B methods. She is confident that she will be able to implement inquiry in the future. She explains, “but the more I implement it the better I’ll understand it.” She admits she is not using I-B methods in her classroom, “I’m not really using a lot of it for science because of time and a lack there of.” Prior to the PSI Professional Development Session, the researcher observed Robin using Structured Inquiry. Lucy was able to move at a slow pace along the inquiry continuum to utilize Guided Inquiry.

In summary, Anna’s interview data revealed that she sometimes makes choices about which methods to use to teach science based on the influences of her CF and her
teammates; her students; and curriculum guidelines, specifically the Virginia SOL; and time for science teaching. Anna explains that her administration has not directly influenced her choice of teaching methods, but indirectly the amount of class time allowed for science has been limited by the perception that reading instruction is a priority over science instruction.

*Julia’s case.* Julia approached teaching using a constructivist approach. Julia uses a variety of methods that all relate to the inquiry approach. Julia is enthusiastic and excited about teaching science. Julia’s Research Question 5 analysis revealed that her CF, her teammates, her administrators, her students, and the student’s parents influenced her choice of science teaching methods. Research Question 3 analysis revealed that when asked if there was anything that inhibits her from using I-B methods in her science classroom, Julia responded with one word, “Nothing.” Julia was able to easily move along the inquiry continuum to utilize Full Inquiry or Open Inquiry.

In summary, Julia’s interview data revealed that she makes choices about which methods to use to teach science based on the influences of her CF and her teammates, her students, and her students’ parents. Julia is motivated to keep going because she wants finds it exciting when students are learning. Post PSI Professional Development Course interview data revealed that county and state curriculum standards only influence what she teaches, not how she teaches.

*Similarities across cases.* This study leads to a more meaningful understanding of teacher’s perceptions as they connect to Teacher Choice (TC) framed by her mental models, conceptions of science subject matter, and barriers related to teaching and learning. Throughout the course of this study teachers made use of their own education
and teaching experiences, analyzed what they learned during the staff development training and made decisions whether or not to adopt and implement the ideas based on their own system of values. An excerpt from Julia’s interview outlines her view how she makes choices, “Because over the years you learn what works best for kids and that’s your ultimate goal.”

Data findings were used to examine Teacher Choice (TC) in an effort to reveal methods that encourage teachers to overcome resistance to implementing I-B teaching practices. Each teacher made decisions about her choice of teaching methods by assessing the value of the options available to her and deciding upon a course of action based on her own conceptual framework. Data analysis for Research Question 5, “How do teachers choose to use I-B methods as opposed to teacher-centered activities?” consisted of an examination of Research Question 1 cross-case analysis, Research Question 2 cross-case analysis and Research Question 3 cross-case analysis, which examined the participants conceptual framework made up of her Individual Identity (II), Subject Matter Knowledge (SMK) Shared Identity (SI). Partner Portfolio analysis supported previous findings related to each teacher’s Individual Identity (II).

All eight participants noted that they had a difficult time remembering science in school either because their science learning was not hands-on, the method of instruction used by their teachers was limited to reading out of a book, or science was not emphasized at their school. The teachers used many of the teaching methods that helped them learn in their own teaching. All eight of the teachers used a variety of different methods including hands-on, experimenting, or doing. Each of the participants expressed their own teaching style, however they shared many similar characteristics. They spoke
of structure or routine mixed with flexibility, humor, creativity, and fun. They all incorporated a variety of methods throughout each science lesson. Seven out of the eight participants spoke about extending learning outside of the classroom in their interview sessions.

In each case the teacher approached teaching using a constructivist approach. Each of the teachers uses a variety of methods to teach science and possessed a desire to implement I-B science. All eight teachers explained that their students affected their choice of teaching methods. All of the teachers except Lucy felt that their teammates, school colleagues and grade level teams have an influence on their teaching methods. Ariel, Jo, Liz, Robin, and Anna are influenced by curriculum guidelines like the Virginia SOL and curriculum maps. Julia noted that the parents of her students influence decisions in her classroom. Lucy is motivated to create an experience for the students in her class that is different from the one that she experienced as a child.

Julia’s case is of particular interest because she felt that that she is able to overcome the barriers she might have encountered while implementing I-B methods. Julia explains the influence that positive administrative support has on her science teaching. Julia believed support from her administration and grade level team was positive. Julia explains, “They want to see the kids engaged. We are fortunate to have administrators who want kids moving around the classroom. This impacts your freedom to design the classroom the way you best know how.” All of the teachers with the exception of Anna felt that their administrators encouraged and supported the use of I-B instruction. Anna’s administrators placed emphasis on reading, not science or social studies. This might serve as a barrier slowing her progress along the inquiry continuum.
Julia’s students and their parents also have an influence on her choice of science teaching methods. This excerpt from Julia’s pre PSI Professional Development Course interview session explains why Julia is motivated by the excitement of her students.

Seeing the excitement of the students and knowing that’s what works. I wouldn’t do it any other way. The inquiry approach works for kids with special needs. A few examples are the frog activities that you observed, providing frog words at the center, the kids are mobile and able to move around, they have opportunities to display knowledge, think outside the box. It is exciting to have them display knowledge in a unique way. Inquiry allows that.

Julia is motivated to continue using constructivist science teaching methods because she wants finds it exciting when her students are learning. The researcher observed parent helpers working with Liz, Anna, and Julia. Julia explains the importance of the parents of her students and the influence they have on Julia’s use of I-B methods in the excerpt that follows.

Parents are a big influence. It’s like training parents to know not to expect worksheets, that the classroom is hands-on. Parents come in to help with the hands-on activities. Parental participation is essential. They send in science supplies. It takes a village.

Julia depends on parental support to facilitate a hands-on inquiry approach in her classroom. She feels it important to take time to educate the parents so they understand her method of instruction. Julia’s example shows the importance of not trying to tackle hands-on inquiry science tasks alone. It’s acceptable to ask for and accept assistance. The idea of working together to help the students achieve learning goals is important to integration of I-B instruction into the classroom.

All of the teachers in the study felt pressures of local or state curriculum guidelines. Julia’s approach might prove helpful to other teachers who feel pressured when making choices related to choice of teaching methods. Julia explained in her pre
PSI Professional Development Course interview that local, school, or state regulations do not influence the way she teaches. She explains in her post PSI Professional Development Course interview session, “They only determine what I teach. I feel total freedom that they have the confidence that I will select the best approach.”

Role of the Researcher as a Science Leader

What are the roles played by science leaders and other educational leaders in implementing standards based reform? In order to improve student learning through the implementation of standards-based reform a leader should be skilled in leading change, networking, and problem solving (Lambert, 1998). The leader needs to hold a firm understanding of self, including personal strengths and weaknesses. The leader uses this knowledge to build a professional development agenda, serve as a mentor, and act as a role model. The leader must possess the skills and knowledge to foster learning at all levels within a school and school division. The leader should listen to participants, examine their work, and use this data to help teachers plan lessons and guide instructional decisions, while keeping in mind differences related to self-esteem, maturity, and social development as well as diversities such as race, gender, and socioeconomic status (Lambert, 1998; Spillane, Halverson & Diamond, 2001). Teachers are more apt to change their practices if they feel they have been offered: a respectful invitation, empowerment, authentic modeling, connections to the classroom and ideas grounded in content (Galloway, 1999). Researchers can play an important role in adding to the knowledge base of effective science leadership. I next present an outline of the role played by the researcher and other educational leaders. I have included the researcher’s reflections on
experiences as they relate to current literature on science reform and implementation of change.

Through participation in coursework as part of the fulfillment of the requirements for the degree of Doctor of Philosophy in Education, the researcher acquired new science content knowledge, and concepts related to effective classroom learning and teaching, including scientific inquiry, the nature of science, problem solving, applications of knowledge, and methods to challenge and measure student learning. The researcher was able to network with other science leaders, teachers, and professionals by presenting at and participating in sessions on current education and science topics at local, state, and national conferences. The researcher facilitated a number of professional development sessions and presentation to teachers, principals, and administrators in Milton County modeling hands-on inquiry approach to science learning and teaching. The researcher was able to form a better understanding of the process of implementation of standards based reform though observation and discussion with others.

In order to improve student learning through the implementation of standards-based reform the leader needs to hold a firm understanding of self, including personal strengths and weaknesses (Lambert, 1998; Spillane et al., 2001). Qualitative research requires that researchers examine their own biases, the context, and the phenomenon questioned prior to beginning the process of investigation (Bogdan & Bilken, 1992). The researcher in this study is the instructor of the PSI Professional Development Course in which the participants participated. The researcher wanted to find an answer to the question, “In light of science standards based reform, what is required to implement inquiry-based methods in elementary science classrooms?” To generate a picture of the
experience of the researcher, an account of the researcher’s background and experience will follow. The researcher felt she needed to hold a firm understanding of self, including personal strengths and weaknesses related to implementing I-B methods, before she could help others learn about and implement I-B methods. As part of the preparation process, the researcher read about and conducted research on the phenomenon, implementing I-B methods into the classroom. The researcher then conducted her own self-study to uncover her own bias towards using I-B methods and to reflect upon the context and the phenomenon of the implementation of I-B methods into the science classroom.

At the onset of this study, the researcher spent months reading and reflecting on the topics of science education reform, teacher professional development, and implementation of I-B methods. The researcher was looking for a way to frame or focus a series of questions or puzzlements she had related to teacher beliefs, choices, methods of science instruction, and science education reform. The researcher signed up to take a self-study qualitative research methodology course offered by Anastasia Samaras. As a student in the course, the researcher was introduced to the notion of Learning Zones (Samaras, 2004), adapted from Vygotsky’s (1978) conception of the zone of proximal development. Learning zones represent multiple spheres of collaborative work, which invite students with various skills to explore and inquire about the questions they have and want to better understand through collective activity. Learning Zones are fluid, diverse, and culturally situated. When operating within Learning Zones, the participant experiences a community of expertise where learners’ move through spheres of ongoing construction, social mediation, problem solving, negotiation, intersubjectivity, and shared understanding. As they journey through the learning process, participants learn from each
other while offering each other their perspectives as critical friends. A non-competitive atmosphere of support, welcoming, and valuing each other was encouraged throughout the course.

The self-study course included a comprehensive review and synthesis of the self-study literature including guidelines and Invitations to Practice (Samaras & Freese, 2006). As the researcher completed the exercises and participated in the Invitations to Practice activities, she thought about ways that she could use the methods in her role as a professional development leader. The research and self-study exercises allowed the researcher to explore biases stemming from previous research. As a result of this experience, the researcher realized that a self-study action research approach to her dissertation study was the most appropriate approach. The research investigation explored how and why elementary teachers make certain decisions and take specific actions as they engage in planning and implementation for I-B instruction in science. The emergent design for this qualitative study utilized action research methodology and collective case study applications. An action research approach allowed the participants themselves to control the research and act as researchers in its design and methodology. The action research design allowed the researcher to reflect on the research process as well as the findings (Herr & Anderson, 2005). As part of the researchers self-study, the researcher examined her views towards bias, context, and the phenomenon of implementing I-B methodology.

Through the projects completed in the self-study course, the researcher was able to examine and problematize her teaching by reflecting on her practice and by becoming a reflective practitioner (Samaras & Freese, 2006; Schön, 1987; Zeichner & Liston,
The researcher was able to think through her methodology and create a systematic approach towards investigating the implementation process. Through self-study the researcher was also able understand the experiences that contributed to an appreciation and importance of knowing about nature and natural processes through exploration and discovery. The reflections about their worldview made sense and encouraged her to help others gain a like appreciation. This journey gave the researcher a renewed sense of self-confidence and a direction to conduct the research. The researcher was able to see connections between the self-study research methods course, its theoretical framework and creation of a science professional development course designed to help teachers implement I-B methods into their classrooms.

The leader used this knowledge to design the PSI Professional Development Course, serve as a mentor, and role model (Lambert, 1998; Spillane et al., 2001). From a methodological perspective, the researcher felt prepared to begin a study that would meld the reflective aspects of self-study with the systematic nature of action research to create a research approach that would allow the researcher to help participants to study their own teaching practices as they move through the process of implementing I-B methods in their classrooms. The researchers goal is to help others gain the kind of knowledge that has helped her in understanding a broad range of science topics and the natural world. More importantly, the researcher created a template that would allow other teachers to more quickly grasp the importance of scientific concepts from a well rounded, well framed scientific context. The template would provide other science leaders with a program that offers teachers: a respectful invitation, empowerment, authentic modeling, connections to the classroom, and ideas grounded in content (Galloway, 1999).
The template would provide a manageable and effective delivery of professional development across a school division. The science supervisor of Milton County Schools supports and encourages the implementation of I-B science into all classrooms. Through the course of this study the researcher has learned that although principals support implementation of I-B methods in their schools, however there are a handful of schools that have established reading and mathematics as the school’s learning priorities. This means that on a school division level science instruction is often overlooked. Milton County Schools must work towards increasing the level of support for science instruction within all schools in the division.

Teachers can and should be agents of reform or change in their own classrooms. The methods teachers use to engage students in the active search for knowledge varies considerably (Haury, 1993). The researcher should listen to students, examine their work and use this data to help teachers plan lessons and guide instructional decisions (Lambert, 1998; Spillane et al., 2001). The researcher operated from a constructivist paradigm (Dewey, 1938, 1997; Lincoln & Guba, 1985), assuming interaction would occur between the researcher and the participants. From a constructivist perspective, prolonged engagement is necessary to build trust and rapport with participants.

The teachers meaning making of their own experiences through reflection is the source of understanding their development and the multiple realities within it. A teacher’s principles or attitude, her tendency to respond favorably or unfavorably toward a topic, students or other objects, determines what students will see, hear, think, and do (Souza Barros & Elia, 1998). A relational connection is essential to bringing their stories to the forefront, understanding them, and interpreting them in a way that resonates with the
participants. Attention should be given to teachers’ self-esteem, maturity, and social
development along with diversities such as race, gender, and socioeconomic status
(Lambert, 1998; Spillane et al., 2001). Encounters with nurturing the researcher-
participant relationship while maintaining the quality of the research serves as an
illustration of these connections.

Implementing standards-based reform is a daunting task. Individuals need
different kinds of support and assistance at different stages in the change process. Change
is a process that takes time and persistence (Loucks-Horsley et al., 2003). Knowing that
the teachers are often resistant of changing practice, an exploration, using the action
research methodology enabled the researcher to both study the process of their change
and her practice as an educational leader facilitating a group of teachers as they attempted
to implement inquiry-based methods. The researcher was careful to proffer the inclusion
of a respectful invitation, empowerment, authentic modeling, connections to the
classroom, and ideas grounded in content. Teachers are more inclined to revise their
practices if attention to these elements is offered (Galloway, 1999).

The conviction in science reform efforts is that all students are able to learn
science and consequently must be given the crucial opportunities in the right environment
that permits optimal science learning in our nation’s schools. Following this group of
teachers as they proceeded along their journey revealed examples of what is required and
what supports are needed for implementation of standards based reform efforts including
inquiry-based teaching methods in the elementary science classroom.
Reflections

When reflecting upon the events surrounding the PSI Professional Development Course, the researcher followed the Systems Thinking approach to science leadership. In his book *the Fifth Discipline*, Peter Senge (1990) details five core disciplines that will help leaders and organizations reach their highest aspirations. The five disciplines are: personal mastery, mental models, shared vision, team learning, and systems thinking. These disciplines can be refined to create and effective science leadership program in science teaching.

Senge (1990) describes the first discipline, personal mastery, as personal vision, holding creative tension and commitment to truth. The leader must create and commit to a personal vision for the science program. The leader can encourage personal mastery in principals, teachers, parents, and students by encouraging them to work together in action research teams and study groups (Lambert, 1998; Spillane et al., 2001). The vision of the PSI Professional Development Course was to provide teachers with the tools and resources needed to successfully implement science reform, specifically I-B methods into their classrooms. Like the researcher, participants were given the opportunity to acquire new science content and concepts related to effective classroom learning and teaching, including scientific inquiry, the nature of science, problem solving, applications of knowledge, and methods to challenge and measure student learning. The PSI Professional Development Course allowed teachers the opportunity to participate in activities and experience lessons modeled using authentic I-B learning experiences. This allowed the participants the opportunity to build pedagogical and content knowledge skills. Participants were also given the opportunity to examine their own learning approach.
through reflection and in-depth investigation into their beliefs and teaching methods (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006).

Senge’s (1990) second discipline, mental models, permits us to appreciate our deeply held images of how the world operates. The vision and actions of the team must be consistent with the cultural conditions of the school or system, and the philosophy of the members of the community. The science leader should create opportunities for listening that will allow for constant monitoring of school wide and community feedback (Galloway, 1999). In Milton County Schools, the vision is that all students will achieve scientific literacy. The curriculum follows the Science Standards of Learning for Virginia’s Public Schools, which identifies academic content at different grade levels. The vision of the school system is consistent with the vision of the National Science Standards, that all students should experience quality science instruction rooted in authentic, inquiry-based experiences (NRC, 1996).

The third discipline, shared vision, promotes personal visions and repositions individuals together to construct a shared vision. The enlistment and actions of every constituent of the team, even minute ones are vital. This shared vision will result in program coherence (Senge, 1990). For this reason, the researcher designed the PSI Professional Development Course to provide participants with opportunities to collaborate with colleagues and other experts in the school setting (Loucks-Horsley et al., 2003). The researcher found evidence that the component of choosing a critical friend was an asset to implementation of I-B methods. Ariel writes in one of her Exit Slips, “I found it very helpful to work with my critical friend and plan a lesson.” Hailey writes that she found her “critical friend and your [the researcher’s] guidance” helpful. An example
to support the assertion that collaboration results in program coherence comes from Julia’s pre PSI Professional Development Course interview. The excerpt that follows shows the benefits of team collaboration.

I have a buddy in the loop, Mrs. Z. She and I collaborate. We say just like with the children. They can work together. I think it takes the stress out of the work for them. Not to say there aren’t times when they have to do it independently. But I try to do a lot of collaborative learning because I think they are able to pull from each other’s strengths. We do the same thing. We work together as a team for planning, for implementation, even our parent volunteers work together for the greater cause. So that has been the best, the very best, for me. That’s what comes to mind, definitely, having a teacher that you agree with in theory as well, you can work together collaboratively and brainstorm. It just works awesome. We can feed off of each other’s ideas.

Principals, teachers, and parents working together as a team can reflect on their core values and weave those values into the education system in order to craft a vision to which each and every team member feels comfortable enough to commit himself or herself. As they examine each instructional practice they can ask themselves, “How does this relate to our vision (Lambert, 1998; Spillane et al., 2001)?

The fourth discipline is team learning. The focus is on dialogue and discussion (Senge, 1990). The roles and actions of the participants reflect broad involvement and team members share collective responsibility. The science team can engage in planning, questioning, reflection, dialogue, and inquiry in collaborative work settings across grade levels. This creates a sense of shared responsibility and becomes the energy force of the school (Lambert, 1998; Spillane et al., 2001). The PSI Professional Development Course offered the opportunity for participants to collaborate across grade levels and across schools. The participants explained that they found that the time to design and plan inquiry units allotted during the PSI Professional Development Course was helpful. Julia
wrote in one of her exit slips, “We designed two units of study that we will use.” Ariel wrote in a journal entry, “I used the lesson plan Jo and I made up this summer. I think it went pretty well, kids seemed to be interested!” The researcher learned that incorporation of the notion of Leaning Zones (Samaras, 2004), allowing the participants to collaborate in pairs or teams was beneficial to the process of implementing I-B methods. Through many years of staff development training, the researcher notes a pattern that teachers follow when signing summer professional development courses. Many sign up in groups or clusters based on grade level or school. All stakeholders would benefit if professional development planners took advantage of this pattern and encouraged collaboration throughout the professional development course.

In order to be successful the leader should come to an understanding of the fifth discipline, systems thinking. An organization or school system arrives at this station through reflection. The members realize that there seldom is a single cause and effect chain or relationship in life. Countless sources may lead to the occurrence of a single incident. The organizations members learn to recognize “structures” or events that reoccur again and again. Systems thinking simplifies life by permitting us to see the deeper patterns lying behind the events as well as the details, new ways of doing things often emerge in the course of analysis and reflection (Senge, 1990). This way of thinking is consistent with the researchers conceptual framework of teachers’ professional development where teachers are tidal pool explorers on the beach gathering treasure in their buckets. As a teacher trainer, the researcher strives to create positive experiences that give the participants the opportunity to see more than one point of view. Learning activities are designed to create a global view of events that metaphorically make up the
beach and a local view of details that make up the treasures, the pebbles and the shells in the teachers bucket. The goal is for the teacher to see both the broadness of the beach and its hidden and small treasures.

Teachers who have first-hand experiences with inquiry will be more likely to implement the strategy in their own classrooms. The professional development course provides opportunities for teachers to add to their bucket of treasures. The researcher learned that simple, easy to implement strategies work best. The “What’s in the Bag?” activity is an example of this. Students try to guess what is in the bag using science process skills, through observation using the senses. The teacher can modify the activity for any content topic simply by changing the object in the bag. Robin used this activity in her post PSI Professional Development Course lesson. Robin engaged the students by having them guess, “What’s in the bag?” She told students that they were using scientific observation to develop a conceptual understanding. She led them to draw conclusions between the mystery object, a shovel, and concepts they would study about the Earth, for example: digging into the Earth, digging fossils, and searching for evidence related to Pangaea.

The leader should interact with the organization’s members to create shared instructional leadership that includes skillful participation, shared vision, inquiry, collaboration, reflection, and student achievement. These features are vital for school improvement (Lambert, 1998; Spillane et al., 2001). As the science leader, the researcher believes, it is her job to expose the participants to a wide range of experiences. She takes the time to assess the needs of the participants. She gathers books, pictures, songs, games, lesson plans, resources, and other objects that relate to the topic. She collaborates with
colleagues to learn additional activities that might fit with the topic of instruction. She presents the activities with enthusiasm. When finished, she asks for feedback and seeks to meet the needs of all participants. The researcher learned that the factor of time for planning instruction is valuable. Allowing teachers the opportunity to gather knowledge about inquiry, to learn through demonstration or modeling, and allowing time to collaborate and plan together during the professional development course is very important.
Chapter V: Discussion

Organization of the Chapter

This chapter provides a discussion and final reflection on the research outcomes of this study and indicates potential directions for science education and educational research. The discussion consists of four sections: (a) a summary consisting of the purpose of the research study, thesis statement, research questions, and a description of the participants and methodology; (b) conclusion and discussion; (c) implications for practice implications of findings; and (d) suggestions for future research.

Summary

*Purpose of the Research Study*

The purpose of this research study was to describe and document elementary teachers’ beliefs or perceptions of effective science instruction and to determine how these teachers interpret and implement a model for Inquiry-based (I-B) science in their classrooms. The study chronicles a group of teachers working in a large public school division and documents how these teachers interpret and implement reform-based science methods after participating in a professional development course on I-B science methods administered by the researcher. Throughout this investigation, the researcher’s goal was to gain a deeper understanding of teacher perceptions as mental models frame them, conceptions of science subject matter, and barriers related to teaching and learning. This research also included a thick description of the process of enacting change as teachers attempt to implement I-B methods into their classrooms as opposed to teacher-centered
activities. There are three stories to document through this action research study, (a) explaining or describing the professional development course and exploring what role the professional development course played in each teacher’s attempts to implement I-B methods into her own classrooms, (b) presentation of the accounts of the teacher’s individual “portraits” or case studies, and (c) outlining the role played by myself and other educational leaders and reflecting on the research as it relates to the current literature on science reform and implementation of change.

*Thesis Statement: Real World Implications*

Implementing I-B methods is essential because it is supported by research and established professional standards, promoted by professional associations, and espoused by scientists who work with both the content and the process of how the knowledge base of science can be extended. Knowing that the teachers are often resistant of changing their practice, an exploration, using the action research methodology enabled the researcher to both study the process of their change and study her own practice as an educational leader facilitating a group of teachers as they attempted to implement inquiry-based methods. This study is useful to understanding what supports or hinders teachers’ adoption of applying standards based reform measures in their classroom.

*Research Questions*

One wide-ranging question provided the momentum for the research: In light of science standards based reform, what is required for elementary teachers to effectively implement inquiry-based methods in their elementary science classrooms? Several sublevel questions were asked to discover the answer to this broad question. The sublevel questions included:
1. What do elementary teachers believe about teaching science? More specifically, what are teachers’ beliefs about how children learn science? What are teachers’ beliefs about science teaching methods?
2. How do teachers describe their abilities to produce desired or intended results in their science classrooms? What do teachers believe about their science content knowledge and their pedagogical science knowledge? What do teachers understand about I-B methods?
3. What barriers to implementing I-B methods exist?
4. What relationships exist between teachers’ perceptions and use of I-B methods?
5. How do teachers choose to use I-B methods as opposed to teacher-centered activities?

Participants and Methodology

*Procedures and Strategies*

The teachers that participated in this study were purposefully selected (Maxwell, 1996) to provide information because they are all teachers of elementary science. The participants were involved in a standards-based curriculum project, Project Science Inquiry, designed to promote inquiry as presented in science reform initiatives. This research endeavored to determine how, and to what extent, the elementary teachers attending the PSI Professional Development Course designed to introduce science reform initiatives, subsequently interpret and use I-B science in their classrooms. A qualitative research design served as an appropriate methodology to utilize to define inquiry as it is perceived and used by elementary science teachers. Qualitative research relates to the perceptions of the participants and deals with process rather than outcomes or products.
Maxwell lists five purposes for doing qualitative research: (a) understanding the meaning, i.e., cognition, affect and intentions, (b) understanding the context in which participants act and the influence this has on their actions, (c) identifying unanticipated phenomena and influences and generating new theories, (d) understanding the process by which events and actions take place, and (e) developing causal explanations, i.e., how x plays a role causing y (Maxwell, 1996). Data collection strategies were used to discover the natural flow of process events, as well as how participants interpret them (McMillan & Schumacher, 1993).

Along with action research methodology, collective or multiple case study methodology was utilized for this study. The study consisted of an exploration of multiple cases over a period of time involving specific in-depth data collection of context rich information sources (Creswell, 1998; Merriam, 1998). The investigator must uncover examples of authentic experiences for science instruction to completely understand the decisions teachers make with regard to science instruction. If findings in a case study are based on a number of different sources of information and abide by a corroborative format, the conclusion is expected to be a great deal more accurate and convincing (Yin, 2003). Triangulation of multiple data sources provides for multiple measures of the same phenomenon and addresses any potential problems with construct validity. Data from interviews, observations, and field notes was obtained through a number of onsite visits over a period of seven months. The data findings were analyzed using a pattern matching technique where a link between themes and concepts was discovered (Yin, 2003). This exploration brought about the assemblage of a register of methods or choices available to
the elementary science teacher. The purpose of this investigation was to explore what encourages or inhibits a teacher to make use of certain methods of science instruction.

Conclusion and Discussion

Teachers are agents of change or reform at the classroom level. This study outlines examples and increases understanding related to what supports or hinders teachers’ adoption of applying standards based reform measures in their classrooms. Results can assist teacher trainers and professional development instructors as they endeavor to persuade teachers to utilize best practices, which will in turn increase teachers’ ability to teach science, founded on evidence that students are learning.

*PSI Professional Development Course*

Through the PSI Professional Development Course, teachers were given the chance to acquire new science content and concepts related to effective classroom learning and teaching, including scientific inquiry, the nature of science, problem solving, applications of knowledge, and methods to challenge and measure student learning. The PSI Professional Development Course was designed to present teachers with opportunities to collaborate with colleagues and other experts within the elementary school setting (Loucks-Horsley et al., 2003). The PSI Professional Development Course also presented teachers with the opportunity to participate in authentic inquiry based learning experiences, which gave the teachers the chance to build pedagogical and content knowledge and skills. Teachers were able to examine their own learning approach through reflection and in-depth investigation into their beliefs and teaching methods (Hawley & Valli, 1999; Keller, 2004; Samaras & Freese, 2006). Through
participation in this project, teachers gained important skills that they can share with their colleagues within their own schools.

*Teacher Portraits*

Teachers come from a wide range of backgrounds and carry with them a variety of beliefs, knowledge, and abilities or mental models that influence their day-to-day decisions. The beliefs, knowledge, and abilities that drive and guide the actions of teachers can be inferred through observation of their actions as individuals acting as agents for their schools. Although beliefs and behaviors are interdependent, a straightforward connection between beliefs and actions does not exist. Following this group of teachers as they attempted to deliver I-B science teaching revealed many of the challenges elementary science teachers face and the professional supports necessary for them to effectively meet science standards. This investigation lead to a deeper understanding of teachers’ perceptions related to teaching and learning according to research-based national science standards as mental models, conceptions of science subject matter, and barriers, frame them. A conclusion and discussion of each research question follows next.

*Research Question 1 Conclusion and Discussion*

*Research Question 1 Conclusion*

Research Question 1 data analysis yielded information related to teachers’ beliefs about how children learn science and science teaching methods. The PSI Professional Development Course was designed to encourage reflection or looking back upon early science related schooling experiences of the teachers. The purpose of this component was to allow teachers to see themselves as learners, feeling comfortable in knowing one’s
self, so that each teacher could understand and explain how they apply their own knowledge and experience as they make choices related to their elementary science teaching instruction. Data analysis of stories about early science related schooling experiences revealed that all eight teachers believe that they learn best when they are actively engaged in the learning experiences, by seeing and doing. When asked to remember science learning situations that influenced their teaching and learning, all eight recalled multi-sensory, hands-on experiments or activities. All of the teachers experienced difficulty remembering the science information taught to them when they were not actively engaged in their learning. Half of the teachers reported that that they struggled with or felt uncomfortable with science in school.

Further data analysis revealed more information related to teacher beliefs about how children learn and teaching methods. All eight of the teachers emphasized that they believed it was important for the students to be actively engaged in their learning. They all incorporated a variety of methods throughout each science lesson. All eight teachers use some form of inquiry, investigation, questioning, hands-on, and activity-based methods their lessons. They also encouraged investigation, exploration, and searching for answers. Each of the participants expressed their own teaching style, however they shared many similar characteristics. They spoke of structure or routine mixed with flexibility, humor, creativity, and fun. All eight teachers felt that positive emotions were essential descriptors that encouraged student learning in science. Half of the teachers explained that novelty was a characteristic of their teaching. Half of the teachers emphasized that providing a comfortable learning atmosphere or comfort zone was important in their
science classroom. Seven out of the eight participants spoke about extending learning outside of the classroom in their interview sessions.

Research Question 1 Discussion

Research Question 1 data analysis yielded information related to teachers’ beliefs about how children learn science and science teaching methods. As the teachers learned and understood more about themselves as learners, they became more comfortable explaining how they apply their own knowledge and experience as they made choices related to their own elementary science teaching instruction. In light of science standards based reform, examining teacher beliefs related to what is required for elementary teachers to effectively implement I-B is important because teachers are often resistant to change. The data analyzed to answer this question helped the researcher to better understand what the researcher has categorized as the teacher’s Individual Identity (II). This is important because what the teacher knows and believes about science teaching will have an impact on how she presents science information to her students.

For professional development training to be effective, the trainer must purposefully get to know the teachers, their backgrounds, and their needs in order to help them along the process towards standards based reform, which includes implementation of I-B methods. The teacher trainer should keep two key points in mind while planning professional development sessions or courses. First, many elementary science teachers have limited science training and background experience. Second, teacher’s beliefs are not always put into practice. Although teachers exhibit their own unique teaching styles, similarities in the types of beliefs emerged. Most teachers believe that active engagement and hands-on inquiry methods are important. Teachers encourage structure or routine
mixed with flexibility, humor, creativity, and fun; however, they do not always implement the lesson methodology that they believe is best for helping students learn.

Research Question 2 Conclusion and Discussion

Research Question 2 Conclusion

Research Question 2 data analysis yielded information related to teachers’ descriptions of their abilities to produce desired or intended results in their science classrooms, beliefs about their science content knowledge and their pedagogical science knowledge, and their understanding about I-B methods. All eight participants noted that they had a difficult time remembering science during their early schooling experiences either because their science learning was not hands-on, the method of instruction used by their teachers was limited to reading out of a book, or science was not emphasized at their school. Interview data revealed that five of the participants explained in their pre PSI Professional Development Course interviews that they either disliked science or felt uncomfortable with science.

Efficacy. Individuals are motivated to carry out an action if they believe the action will have a positive outcome (outcome expectation), and they feel confident that they can execute that action successfully (self-efficacy expectation). Knowledge of self-efficacy beliefs can have the ability to predict behavior (Bandura, 1997). Bandura (1986) advocated strategies such as modeling, verbal persuasion, and provision of successful experiences in the improvement of efficacy beliefs. Based on Bandura’s (1977) theory of social learning, the researcher asserts that a teacher who holds a high sense of self-efficacy is more likely to utilize student-centered, constructivist teaching practices than teachers who possess a low sense of self-efficacy. Data analysis revealed that all of the
teachers participating in this research study feel comfortable with their abilities to teach science and possess confidence in their teaching abilities to create desirable outcomes. All of the teachers also feel comfortable utilizing a variety of methods to teach science. Although the teachers were not always confident with the subject of science, after being exposed to a number of visual, hands-on, lessons or events throughout the course of the PSI Professional Development Course their confidence level increased.

*Pedagogical Science Knowledge.* When describing their own framework for understanding science content and teaching methods teachers reported both positive and negative memories from their science educational experiences. Whether positive or negative, when placed in a learning experience that was visual, hands-on or interactive, all of the teachers reported that they were able to remember the activity. All eight of the teachers used a variety of different methods throughout each science lesson including hands-on, experimenting, or doing teachers encouraged motivation, making connections, and helping students remember science concepts. Several teachers explained that they use humor and novelty to encourage students to remember science content information. Six of the teachers felt limited in some way by their pedagogical science knowledge and wished to learn more. All felt limited by the amount of time available to apply science teaching methods. Although they were all veteran teachers and felt confident in their teaching abilities, the participants were willing to learn new things and improve their teaching practice.

*Framework for Understanding I-B Science Methods.* Teachers are at different phases in the process of implementing models for I-B science instruction, and should not expect to become inquiry-based teachers overnight. It takes 3 to 5 years to perfect
inquiry-teaching techniques (Llewellyn, 2002). Martin-Hansen (2002) illustrates four models of inquiry that are frequently utilized for instruction consisting of Structured Inquiry, Coupled Inquiry, Guided Inquiry, and Full or Open Inquiry. They range from student-centered to teacher-centered in that order. Observations of the teachers participating in this research study supported the assertion that teachers operate in different phases as they utilize different models of inquiry. Each teacher moved at her own pace along continuum towards the implementation of Full or Open Inquiry.

*Research Question 2 Discussion*

In light of standards based reform, examining teachers’ descriptions of their abilities to produce desired or intended results in their science classrooms, beliefs about their science content knowledge and their pedagogical science knowledge, and their understanding about I-B methods is important to help teachers overcome their resistance to change. Although the teachers participating in this study were all veteran teachers and felt confident in their teaching abilities, the participants were willing to learn new things and improve their teaching practice, thus showing that you can teach an old dog new tricks. When providing training for teachers, it is important to remember that all teachers do not learn at the same rate. Teachers may hold preconceived notions as to which methods of science teaching are effective or not effective. It is important to provide teachers with the opportunity to recognize their previous beliefs and science training and then allow them to decide what is applicable for implementing science education reform efforts like I-B methods or deciding what they might need to change in their classrooms. The level or phase of inquiry at which a teacher is operating may not be consistent with the number of years of teaching experience he or she has acquired. When teachers are not
confident with the subject of science, exposing them to visual, hands-on, lessons or events will increase their confidence. Offering assistance and support as teachers try new teaching methods is essential. Teachers are more willing to try new things when they see or actively participate in an activity, for example, teachers might take part in a sample lesson or follow a model to create their own new lesson.

Research Question 3 Conclusion and Discussion

Research Question 3 Conclusion

Research Question 3 data analysis provided information about barriers that exist related to implementing I-B methods. The researcher first examined teachers’ goal statements and beliefs related to support towards implementation of I-B to determine if these factors served as barriers as the teachers went about the process of implementing I-B science methods into their elementary classrooms. The teachers’ goals reveal that they all respond favorably and are interested in learning how to implement inquiry into their science teaching. During the PSI Professional Development Course session the teachers worked with each other to create and implement I-B lesson plans into each of their classrooms. Seven of the eight teachers are receiving the support from teammates and administrators while they are implementing the I-B process into their science classrooms. One of the teachers feels pressure from her administrators to spend most of her day teaching reading, leaving less time for science instruction. While each of the teachers hold the desire to implement I-B methods, feels self-assurance in their teaching abilities, and thinks their critical friends, colleagues, and administrators (Anna being the exception) support their efforts; it is likely that each teacher might not be able to
completely accomplish her science teaching dream of implementing I-B science methods into her classroom.

Data analysis revealed that there were similarities among things that served as barriers to teachers as they worked to implement I-B science methods into their classrooms, examples of barriers faced by teachers are: time related to time to teach, sharing science with other subjects, planning, and curriculum guidelines; support related to instructional assistance, space, and materials; and teacher knowledge. Analysis of the data revealed that the teachers did indeed confront these barriers as they went about the process of implementing I-B science into their classrooms. Some of the teachers found that a lack of subject knowledge served as a barrier towards implementation of I-B methods. In their pre PSI Professional Development Course interviews, teachers explained that they feared that a lack of knowledge of subject matter might become a barrier to implementation of I-B methods but as they proceeded to implement their I-B lessons this proved not to be the case.

Research Question 3 Discussion

In light of science standards based reform, examining barriers that exist related to what is required for elementary teachers to effectively implement I-B is important because teachers may use the barriers as excuses to remain resistant to change. This examination also allows teacher trainers to anticipate barriers and make plans to help teachers overcome the barriers as they arise. Valuable information was gathered through examination of teachers as they struggled to overcome barriers. Teachers were able to overcome some barriers while others proved more difficult to conquer. The largest barrier faced by teachers was that of time. Time related to curriculum guidelines including the
factors of pacing and standards emerged as a significant issue as it related to the implementation of I-B methods in teachers’ classrooms. Teachers were not able to remove this barrier. The issue of time related to pacing and standards emerged as a great point of stress for most teachers. Continuing with the factor of time, time for planning instruction time to teach and daily scheduling of science in relation to other subject areas emerged as another barrier to the implementation of I-B methods in teachers’ classrooms. Some teachers were able to work around this barrier by integrating science into other subject areas or borrowing time from other subject areas to increase instructional time, and by working late hours into the evening planning and preparing lessons. Other teachers were not able to rearrange their schedules or put in extra hours to remove this barrier.

While going about the process of implementing I-B methods into the science classroom, teachers found the following helpful towards the removal of barriers: support related to instructional assistance, space, and materials. When teachers believed that they had a strong support system, they were able to easily overcome any barriers they encountered. For example, a lack of materials emerged as a barrier for many teachers. Teachers with a strong or helpful support system felt comfortable locating materials through creative means, like asking parents, administrators, or their parent teacher organizations. Content knowledge emerged as a factor that many teachers felt could serve as a barrier to I-B science instruction. Teachers noted that given time and information they could read or study to eliminate this factor as a possible barrier. In summary, teachers can overcome barriers such as classroom space, accessibility of science tools, and content knowledge. As additional barriers arise, the teacher makes choices related to
the barrier. For example, if the barrier of teacher relationship with students or student behavior surfaces, then the teacher can overcome the barrier if a support network is in place. If there is no support network in place, the teacher might choose not to implement I-B methods and have the misbehaving students answer questions out of a textbook. Teachers can overcome many barriers if they feel supported while dealing with the issue at hand.

Research Question 4 Conclusion and Discussion

Research Question 4 Conclusion

Research Question 4 data analysis provided information about the relationships that exist between teachers’ perceptions and use of I-B science methods. The component of teacher perception is a key factor in the success of I-B science implementation. When teachers understand the methodology behind inquiry instruction and hold the confidence to implement the strategies in their classrooms they are better able to overcome barriers as they emerge. The perception that I-B science methods is of paramount value had a positive influence on the teachers’ motivation, attitude, caring, determination, and effort of all of the teachers during implementation of the methods in their classrooms. The perception that I-B science methods is of little or no value will certainly translate to failure upon attempting to implement I-B science methods into the classroom.

During the PSI Professional Development Course, inquiry instruction was defined as referring to any teaching method focused on developing science understanding and inquiry abilities. Inquiry can be promoted from an extensive array of activities usually initiated through the posing of a question. Students work individually or in small groups to explore materials, make observations and discover answers to their questions about the
natural world. Students may plan systems to collect data and choose how to organize and represent the data (Carin et al., 2004). The National Research Council (1998) defines scientific inquiry as:

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.” (p. 23)

The teachers’ used questioning, investigating, exploring, and making connections as common descriptors in their definitions of inquiry science. The common descriptors used in the teachers’ definitions of inquiry were similar to the definition of inquiry used during the PSI Professional Development Course.

When asked to remember science learning situations that influenced their teaching and learning, all eight recalled multi-sensory, hands-on experiments or activities. All of the teachers had a hard time remembering science information presented to them when they were not actively engaged in their learning. Half of the teachers noted that they struggled with or felt uncomfortable with science in school. Despite any early struggles they might have encountered, teachers felt a favorable response towards inquiry as well a feeling of self-confidence in their own teaching abilities after participating in the PSI Professional Development Course. Each of the teachers felt some confidence in their own abilities to create desirable outcomes and felt freedom to choose which methods they employed in their classrooms. This is an important finding as it allowed the researcher to steer attention away from issues of self-esteem and place a greater focus on how teachers
perceive barriers related to implementation of I-B methods stemming from outside influences or sources that might affect Teacher Choice (TC).

The researcher examined teachers’ choice related to science teaching methods. All eight teachers held unique beliefs related to science teaching methods. However, the participants shared many common beliefs, including: use of a variety of teaching methods, flexibility when necessary, humor, and enthusiasm for the topic. Interview data analysis revealed common factors related to teachers’ beliefs about how children learn and teaching methods. All of the teachers believed that it is important for their students to be actively engaged in their learning. They encouraged investigation, exploration, and searching for answers. Each of the participants expressed their own teaching style; however they shared many similar characteristics. They spoke of structure or routine mixed with flexibility, humor, creativity, and fun. They all incorporated a variety of methods throughout each science lesson. All of the teachers’ choices of teaching methods allowed for integration or use of I-B methods. All eight teachers used positive emotions as descriptors of student learning. Half of the teachers explained that novelty was a characteristic of their teaching. Many also emphasized providing a comfortable learning atmosphere or comfort zone in their science classroom.

The perception that implementing I-B science methods takes time and that using “baby steps” was acceptable provided comfort and encouragement to the teachers that participated in the research study. Llewellyn (2002) cautions that teachers should not expect to become inquiry-based teachers immediately. In fact, he suggests that it takes 3 to 5 years to fully integrate inquiry-teaching techniques. Martin-Hansen (2002) illustrates four models of inquiry that are frequently utilized for instruction consisting of Structured
Inquiry, Coupled Inquiry, Guided Inquiry, and Full or Open Inquiry. They range from student-centered to teacher-centered in that order. Classroom observations, supported by lesson plan data from the teachers’ Partner Portfolio for Professional Development revealed that teachers were all working at different levels or stages of inquiry implementation. Each teacher moved at her own pace along continuum towards the implementation of full or open inquiry.

**Research Question 4 Discussion**

In light of science standards based reform, examining the relationships that exist between teachers’ perceptions and use of I-B methods related to what is required for elementary teachers to effectively implement I-B may help researchers and teacher trainers to understand what factors influence a teacher’s resistance to change. Although they were all veteran teachers and felt confident in their teaching abilities, the participants were willing to learn new things and improve their teaching practice. The teachers in this research study felt a favorable response towards inquiry as well a feeling of self-confidence in their own teaching abilities. All of the teachers had a desire to implement I-B methods into their classrooms, were willing to learn more about the method, and practiced teaching methods that allowed for implementation of I-B methods. The perception that I-B methods hold large or great value had a positive influence on all of the teachers’ motivation, attitude, caring, determination, and effort during implementation of the methods in their classrooms.

Even those teachers willing and ready to implement I-B science methods faced barriers as they attempted to implement I-B methods into their classrooms. Teacher perceptions did serve as barriers to slow down the implementation process. For example,
Anna felt in interview sessions that her administration has not influenced her choice of teaching methods, but later revealed that class time allowed for science by her administration has been limited by the perception that reading instruction is a priority over science instruction at her school. Analysis of the pre PSI Professional Development Course interview questions revealed that all but one of the teachers believed that they did face barriers that slowed the process of implementing I-B instruction. Most of the teachers felt limited in some way by their pedagogical science knowledge and wished to learn more, other barriers included: time related to time to teach, sharing science with other subjects, planning, and curriculum guidelines; support related to instructional assistance, space, and materials. These perceptions played a role in explaining why implementation of I-B methods into some of the teacher’s classrooms followed a slow gradual path.

We can not always control what barriers teachers will face; however, teachers can be trained to control their response to the barriers they face. The teacher trainer must take to time to learn about and understand the teachers’ perceptions of barriers, whether they are based inferences related to prior experience or current observations. Reflection, incorporating self-study methodologies, are appropriate techniques to assist both the teacher and the teacher trainer as they endeavor to learn more about teacher beliefs and perceptions. The trainer can then implement steps to reprogram any perceptions that teachers might hold that would prevent them from overcoming certain barriers by: encouraging the teacher to think positively, boosting their confidence, showing them examples, and giving the teachers an opportunity to actively participate in sample lessons. For example, acknowledging the fact that implementing I-B science methods
takes time and that using “baby steps” is appropriate, as it provided comfort and
encouragement to the teachers that participated in the research study. Another suggestion
for teachers facing barriers related to the implementation of I-B science methods would
be to take a step back from the barrier, to look at the barrier from all angles. Teachers can
ask themselves, “What can I do to overcome this barrier?” Teachers can also be trained
to: look for positive aspects related to the barrier, determine what other might have done
to overcome the barriers, and investigate ways to prevent the barrier from getting in the
way next time.

Research Question 5 Conclusion and Discussion

Research Question 5 Conclusion

Research Question 5 data analysis provided information about how teachers
choose to use I-B methods as opposed to teacher-centered activities. This analysis ties
together all of the elements discovered in previous research questions. Teacher Choice
(TC) occurs when the teacher judges the merits of multiple options and selects a course
of action founded on his or her own conceptual framework. Based upon Schoenfeld’s
knowledge, and Scribner, Hager, and Warne’s work related to autonomy and professional
community; the researcher formed three categories of study to identify a teacher’s
Relationship (CFR) is composed of his or her:

1. Individual Identity (II), the portion of the their conceptual or cognitive framework
   (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents autonomy or
   personal constructs (Scribner et al., 2002);
2. Subject Matter Knowledge (SMK), her knowledge of content matter and pedagogy (the art and science of being a teacher) and curriculum knowledge (Shulman, 1986); and
3. Shared Identity (SI), the portion of her conceptual or cognitive framework (knowledge, goals, and beliefs) (Schoenfeld, 1998) that represents her shared identity or role as part of the professional community.

The teacher judges the merits of multiple options and selects a course of action founded on his or her own Conceptual Framework Relationship (CFR) made up of her Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI). The researcher has labeled this term Teacher Choice (TC).

*Individual Identity (II).* All eight teachers participating in this research study support the constructivist approach to learning; they all feel they learn science best through seeing and doing. They all remember learning science best when they were participated in hands-on activities or actively engaged throughout the learning process. All eight of the participants felt they learn best through active engagement, observation, participation, and doing hands-on activities. When asked to remember science learning situations from their early science learning experiences that influenced their teaching and learning, all eight recalled multi-sensory, hands-on experiments or activities. They all had a difficult time remembering the science information taught to them when they were not actively engaged in their learning. All eight participants noted that they had a difficult time remembering science in school either because their science learning was not hands-on, the method of instruction used by their teachers was limited to reading out of a book, or science was not emphasized at their school. Although the participants were actively
engaged and active participants in their own learning, not all of their learning experiences were positive. Half of the teachers noted that they struggled with or felt uncomfortable with science in school.

The researcher focused the investigation on the choice of teaching methods used by the teachers participating in the research study. The teachers used many of the teaching methods that helped them learn in their own teaching. All of the teachers applied a constructivist approach to teaching and learning prior to and following the PSI Professional Development Course. All eight of the teachers used a variety of different methods including hands-on, experimenting, or doing. Each of the participants expressed their own teaching style, however they shared many similar characteristics. They spoke of structure or routine mixed with flexibility, humor, creativity, and fun. Seven out of the eight participants spoke about extending learning outside of the classroom in their interview sessions. Throughout the duration of the study, all of the teachers felt or believed it was important for students to be actively engaged in their learning. The beliefs of the teachers did not change, this aspect of their conceptual framework remained consistent throughout the study; however, some of the teachers reported that they faced barriers that served to discourage them from choosing teaching methods consistent with the belief that their students should be actively engaged.

Subject Matter Knowledge (SMK). Shulman (1986) proposed three categories of subject matter knowledge for teaching, (a) content knowledge, (b) pedagogical content knowledge, and (c) curriculum knowledge. Content knowledge involves the facts and concepts within a domain, information about why these facts are true, and information related to how knowledge is generated or structured within the discipline, in this case the
discipline of science. The unique nature of the subject matter knowledge required by teachers for effective science teaching is referred to as *pedagogical content knowledge*. Pedagogical content knowledge includes familiarity with topics that learners find interesting or difficult, the representations most useful for teaching specific content topics, and learners’ typical errors and misconceptions. This clarification helps to inform the knowledge about qualities and resources needed for effective teaching. Shulman’s third category, *curriculum knowledge*, includes awareness of modes of organizing programs of study, using curriculum resources, such as textbooks, and of methods in which topics are used over time and within a school year (Schulman, 1986; 1987). As related directly to the researcher’s topic of study, the implementation of I-B science methods, Shulman’s work is useful in understanding; (a) the portion of the teacher’s cognitive framework related to science content and knowledge of science and teaching methods and (b) a teacher’s beliefs about effective science teaching as they combine with (c) a teacher’s cognitive framework related to how children learn science to form the teacher’s vision of science teaching.

The researcher examined each teacher’s framework for understanding content knowledge related to Teacher Choice (TC) to use I-B as opposed to teacher-centered science activities. Data revealed that all eight participants noted that they had a difficult time remembering science in school for several reasons: (a) their science learning was not hands-on; (b) the method of instruction used by their teachers was limited to reading out of a book; and/or (c) science was not emphasized at their school. Science is usually conveyed as a group of specifics and sets of laws to be memorized, instead of as a way of
knowing about the natural world in undergraduate science courses (NRC, 1998). The experiences of the teachers in this study support this assertion.

The researcher also examined each teacher’s framework for understanding pedagogical science knowledge related to Teacher Choice (TC) to use I-B as opposed to teacher-centered science activities. All eight of the teachers used a variety of different methods including hands-on, experimenting, or doing. They all felt it was important for students to be actively engaged in their learning. They all incorporated multi-sensory and hands-on learning activities into their classrooms. All eight of the teachers spoke of encouraging their students to question or investigate how science applies to their own lives. Their choices of teaching methods allowed for the implementation of I-B methods.

Research data analysis also focused on the participants’ descriptions of their own frameworks for understanding I-B science methods as reported during their interview sessions. Data analysis revealed that even of the eight teachers held some knowledge of inquiry science prior to the PSI Professional Development Course. When defining inquiry science, teachers included the following concepts: questioning, investigating, exploring, and making connections. During the cross-case analysis the teacher’s level of inquiry implementation emerged as a theme. The researcher observed that each teacher moved at her own pace along continuum towards the implementation of full or open inquiry. The teachers implemented methods of inquiry ranging from student-centered to teacher-centered activities. In fact, six of the teachers discussed the point of view of the learner or student when defining inquiry science.

The researcher also examined each teacher’s framework for understanding curriculum knowledge related to Teacher Choice (TC) to use I-B as opposed to teacher-
centered science activities. Most of the teachers were familiar with knowledge related to the curriculum and felt that they were influenced by curriculum guidelines, including the Virginia SOL, the curriculum framework, and curriculum maps. Teachers utilized curriculum guidelines to plan instruction. Time related to curriculum guidelines including the factors of pacing and standards emerged as a significant issue as it related to the implementation of I-B methods in teachers classrooms. Curriculum guidelines also had an influence on the shared identity of the teachers participating in the research study.

*Shared Identity (SI).* Interview data from the pre PSI Professional Development Course interview analysis showed that seven of the eight teachers are receiving the support from teammates and administrators while they are implementing the I-B process into their science classrooms. One of the teachers feels pressure from her administrators to place more emphasis and time on reading instruction than on science instruction, this pressure did serve an a negative an impact on the rate of implementation of I-B science methods into her classroom. Interview analysis also shows that in addition to the factor of administrative support, the teacher’s CF and teammates, their students, and the student’s parents are all factors that emerged as having an influence on a teacher’s choice of science teaching methods. When examining possible barriers to the implementation of I-B methods, the researcher learned that a teacher’s choice is also influenced by the teacher’s perception of her role as part of the professional community.

*Research Question 5 Discussion*

In light of science standards based reform, examining how teachers choose to use I-B science methods as opposed to teacher-centered activities is important to help teachers make appropriate changes related to what is required for elementary teachers to
effectively implement I-B science methods into their classrooms. When examining possible barriers to the implementation of I-B methods, the researcher learned that a teacher’s choice is also influenced by: time related to time to teach, sharing science with other subjects, planning, and curriculum guidelines; support related to instructional assistance, space, and materials; and teacher knowledge. All of the three components of a teacher’s conceptual framework, Individual Identity (II), Subject Matter Knowledge (SMK), and Shared Identity (SI), work together to influence Teacher Choice (TC).

The connections between the three components of a teacher’s conceptual framework should be considered when planning professional development instruction for teachers. Not all teachers were exposed to positive experiences related to science learning. Five of the teachers participating in this research study explained that they either disliked science or felt uncomfortable with science. This negative example related to a teacher’s Individual Identity (II) is a barrier that can be overcome. Teachers operated at varied levels of experience with all aspects of Subject Matter Knowledge (SMK). Many teachers have been exposed to a limited amount of Subject Matter Knowledge (SMK). In fact, science is usually conveyed as a group of specifics and sets of laws to be memorized, instead of as a way of knowing about the natural world in undergraduate science courses (NRC, 1998). The experiences of the teachers in this study support this assertion. Implications for professional development training emerge from these ideas. You may recall that the teachers reported that they remembered learning when they were “seeing” and “doing” or when their teachers used a constructivist approach. Teachers also reported that they benefited from participating in or observing others teaching science activities. Teachers are always asking for ideas or methods that they can take back to
their classrooms and put into use immediately. We can take advantage of this; allow teachers to “copy” science teaching techniques and lessons by immersing them in carefully planned science activities. This will strengthen both the teachers Individual Identity (II) and Subject Matter Knowledge (SMK). Model I-B science methods for teachers and they will “copy” the technique in their own classrooms.

Negative experiences related to a teacher’s Individual Identity (II) or Shared Identity (SI) can be turned around and used as a motivation. For example, one of the teachers explains in her pre PSI Professional Development Course interview, “I think because of the bad experience I had, I just always want to make the kids have a better experience.” This teacher is motivated to create an experience for the students in her class that is different from the one that she experienced as a child. She turned her own negative experience into a positive experience for her students. Motivating students emerged as an important factor in successful student learning. Teachers spoke of motivation either related to interest level, curiosity, or helping students to remember.

The teachers own motivation is also a critical factor. All of the teachers, except one felt that their teammates, school colleagues and grade level teams have an influence on their teaching methods. Teachers are feeling increasing pressure related to curriculum guidelines like the Virginia SOL and curriculum maps. Keeping a positive outlook and encouraging a support system will help teachers as they go about the process of implementing I-B methods into their classrooms. Teachers are more apt to change their practices if they feel they have been offered: a respectful invitation, empowerment, authentic modeling, connections to the classroom and ideas grounded in content (Galloway, 1999).
Role of the Researcher

It takes time to successfully implement systemic change, such as science reform efforts like the implementation of I-B methods. The teachers who have participated in the PSI Professional Development Course will continue to build upon their knowledge of inquiry over time. As the science teacher professional development leader, the researcher served as a facilitator to engage the participants in a wide range of experiences. She took the time to assess the needs of the participants and offered opportunities for the participants to participate in self-study exercises and reflective activities. She encouraged teachers to gather books, pictures, songs, games, lesson plans, resources, and other objects that related to the topic of their mini-units. She collaborated with colleagues to learn additional activities that might fit with the teachers’ topics of instruction. She explained and very importantly modeled I-B science activities and lessons. She presented the activities with enthusiasm. When finished, she asked for feedback and worked to meet the needs of all participants. The researcher learned that the factor of time for planning instruction is valuable to teachers. The teachers explained that they benefited from the opportunity to gather knowledge about inquiry, to learn through demonstration or modeling, and having time to collaborate and plan together during the professional development course. They expressed enthusiasm in continuing the work they began in the PSI project.

Implications for Practice

Prior to this study, this is what we know about science teacher education. A new vision of science learner-centered instruction and inquiry teaching is being developed. Responses to national and international standards should focus on practicing teachers and
their professional development, as this will reach a larger population of teachers within the system (Hewson, 2007). Most teachers are not implementing I-B science as called for by the standards (Mondale & Patton, 2001). Many teachers face issues related to a limited amount of instructional time dedicated to science in most elementary schools (Appleton, 2007), limited subject matter knowledge and pedagogical content knowledge, and low self efficacy (Anderson & Mitchener, 1994; Cochran & Jones, 1998).

This study adds to the literature on I-B science teaching and its implementation as an example of one potential method to address the current call for national education reform. Efforts to implement science education reform focus on meeting the increasing needs of all students to achieve scientific literacy and the role of teachers in that effort. The conviction of science education leaders engaged in science reform efforts is that all students are able to learn science and consequently must be given the crucial opportunities in the right environment that permits optimal science learning in our nation’s schools. Unfortunately, teachers are feeling increased pressure as they struggle to meet curriculum guidelines and assure that all students achieve. An example of the stress and pressure felt by teachers related to curriculum knowledge is outlined next.

This study supports Appleton’s (2007) assertion that teachers face issues related to a limited amount of instructional time dedicated to science in most elementary schools. For instance, Anna finds that the factor of time is a concern she feels when planning to teach science in her classroom. This excerpt from the pre PSI Professional Development Course interview illustrates Anna’s beliefs.

We try to feel, touch, and actively do things in the classroom, but unfortunately, our time is so limited. Our science and social studies time is the last half hour of the day. So, we did do some hands-on type things, but not that many. Not that
many, because we didn’t have a whole lot of time and we were rushing so much at the end of the year. I usually do an animal thing where we touch, it’s not even animals stuff, but it’s feeling like scaly skin, which is an onion bag. We didn’t even get to that because, oh my gosh, we have to hurry up and get to the next unit, and the next. So, this year has not been very good, or conducive for teaching any hands-on type things, unfortunately.

This excerpt revealed that the barrier of time in relation to science instruction included time to teach and sharing time with other subjects, like social studies. Anna explains why science and social studies are not a priority in her school, “Unfortunately with the thrust of the SOL with us, is to teach them to read more than even math, science, social studies, any of those subjects. So we base most of our day on reading.” From this excerpt we also see curriculum guidelines like the Virginia SOL emerging as a barrier to all science instruction, especially hands-on, interactive, and I-B methods. Anna emphasizes the fact that time and curriculum guidelines, such as curriculum maps, influence her science teaching. Anna explains that she decides to move from one concept to another based upon, “unfortunately curriculum maps, just time allotted in a day. I know things I have got to get done, so unfortunately I push on. It’s terrible.” In essence, teachers don’t feel and can’t feel it’s worth it or even doable.

Teachers, like Anna, feel they must cover all of the content or curriculum material in a restricted amount of time. To some teachers this means that they feel that they must talk about all of the content material, with teacher acting as a lecturer not a facilitator. Because of this pressure, teachers’ beliefs that children should learn by “seeing” and “doing” are not always put into practice.

Many teachers face issues related to limited subject matter knowledge and pedagogical content knowledge, and low self-efficacy (Anderson & Mitchener, 1994;
Cochran & Jones, 1998). If standards-based reform is to be achieved, professional development activities need to include practices that engage potential and practicing teachers in active learning that fosters their comprehension, knowledge and ability (NRC, 1998). The teachers participating in this study were able to overcome barriers related to their knowledge and confidence and were able to do that with the support of colleagues and the support of the professional development trainer. Their work was transferable and immediately applicable to their classrooms and unit planning. The accounts of their resolutions add to the current knowledge base as implications for practice came into view throughout the discussion section. This study revealed numerous factors and considerations valuable to professional development trainers who are designing reform efforts and science teacher education programs, which I present next.

*Wilcox’s Model for Science Teacher Professional Trainers.*

- Active Involvement to Application. Teachers frequently ask for ideas and methods that they can take back and immediately use in their classrooms. When teachers are not confident with the subject of science, exposing them to visual, hands-on, lessons or events will increase their confidence. Offering assistance and support as teachers try new teaching methods is essential. Teachers are more willing to try new things when they see or actively participate in an activity, for example, teachers might take part in a sample lesson or follow a model to create their own new lesson.

- Exploring Teachers’ Personal Education-related Histories of Science. The teachers participating were willing to learn new things and improve their teaching practice, although they were all veteran teachers and felt confident in their
teaching abilities. Teachers may hold preconceived notions as to which methods of science teaching are effective or not effective. It is important for teacher trainers to provide teachers with the opportunity to uncover and acknowledge their previous beliefs and science training and then decide what is applicable for implementing science education reform effort like I-B methods and to also deciding what might need to be changed. In PSI, teachers participating in self-study of teaching exercises and reflection to get at the core of their beliefs and the reframing of their teaching practices. As the teachers learned and understood more about themselves as learners, they became more comfortable explaining how they apply their own knowledge and experience as they make choices related to their own elementary science teaching instruction.

- Differentiated Teacher Learning. The level or phase of inquiry at which a teacher is operating may not be consistent with the number of years of teaching experience he or she has acquired. Teachers need different kinds of support and assistance at different stages in the process of implementing I-B science methods into their classrooms. No two teachers are alike despite their years of experience; therefore, the trainer shouldn’t make the assumption that older is better. Some veteran teachers could be at an earlier stage of development in using I-B science that a younger one. In the same way that national standards call for reform efforts to meet all students, professional development training should include measures to both recognize and accommodate for all levels of teacher learning related to using science inquiry.
• Curriculum Guidelines as Contributing rather than as Competing. Some teachers were able to overcome many of the barriers faced while going about the process of implementing I-B science methods while others proved more difficult to conquer. The largest barrier faced by teachers was that of time. Time related to curriculum guidelines including the factors of pacing and standards emerged as a significant issue as it related to the implementation of I-B methods in teachers’ classrooms. Teachers were not able to remove this barrier. The issue of time related to pacing and standards emerged as a great point of stress for most teachers.

• Support Over Time. Time for planning instruction, time to teach, and daily scheduling of science in relation to other subject areas emerged as barriers. The PSI Professional Development Course gave teachers the opportunity to plan lessons and a mini unit over a duration of seven months. One of the teachers reported that she uses inquiry when teaching science, however she has not planned any other lessons or mini units because of time constraints. Some teachers were able to overcome this barrier by integrating science into other subject areas or by utilizing time from other subject areas to increase instructional time for science. The teachers also worked late hours after school planning and preparing lessons. Unfortunately, some teachers were not able to rearrange their schedules or put in extra hours to remove the time barrier.

• Local Support Services to Overcome Barriers. Teachers found support related to instructional assistance, space, and materials helpful towards the removal of barriers while going about the process of implementing I-B methods into the
science classroom. When teachers believed that they had a strong support system, they were able to easily overcome any barriers they encountered. For example, when a lack of materials emerged as a barrier for many teachers, those with a strong or helpful support system felt comfortable locating materials through creative means, like asking parents, administrators, or their parent teacher organizations.

- Support for Science Background Knowledge. Many elementary science teachers have limited science background knowledge or experience. This lack of content knowledge emerged as a factor that served as a barrier to I-B science instruction. Teachers noted that they could read or study to eliminate this factor as a possible barrier if they were given time and information to help them understand the concept.

- Relational and Sociocultural-based Training. The barriers that teachers face can’t always be controlled; however, teachers can be trained to control their response to them. Teacher trainers must take to time to learn about and understand the teachers’ perceptions of barriers. Self-study methodologies and reflective exercises can assist both the teacher and the teacher trainer as they make an effort to learn more about teacher beliefs and perceptions. Trainers can then implement steps to reprogram any perceptions that teachers might hold that would prevent them from overcoming certain barriers. They can accomplish this by encouraging the teacher to think positively, boosting their confidence, showing them examples, and giving the teachers an opportunity to actively participate in sample lessons. For example, explaining to teachers that implementing I-B science methods takes
time and that using “baby steps” was comforting to the teachers that participated in the research study.

- Professional Collaboration. The success of collaboration or working with a critical friend revealed through this study is an important contribution to the current knowledge base related to science education reform. Teachers participating in the research study felt that their critical friend played an important role as they offered support and encouragement throughout the process of implementing I-B science into their classrooms. The critical friend also proved to be helpful by providing the scaffolding necessary to differentiate and reach all of the teachers as learners at their own level or phase of I-B implementation. The researcher participated in critical friend work in the development of her model and modeling the very practice she asked teachers to do. Professional trainers would also benefit from critical friend work in their continued efforts in scaffolding teachers’ usage and appreciation of science inquiry. The most effective teachers are life-long learners.

Future Research Suggestions

Improving the Research Design

In his research study, teachers completed two surveys, were interviewed before (April/May) and after (October) they participated in the PSI Professional Development Course, and were observed over a week of instruction during a class specified by the participant. The participants completed a portfolio of their professional development with feedback from their Critical Friend (CF), which began with their work in the PSI Professional Development Course. Teachers took part in activities that provided practice
in exploring one’s teaching and learning using reflection as a critical dimension (e.g.,
journaling, personal history papers, and goal statements) and included those activities in a
portfolio. The timeline for the course was such that the researcher observed the teacher
instructing two different classes over two different school years. In some cases, the
maturity of the students entering a grade level at the beginning of the school year caused
the teachers to adjust their teaching practices allowing less student freedom. This was
evident as teachers answered questions on the STEBI and CLES surveys.

To improve the research design of this study, the researcher could implement a
timeline where the pre PSI Professional Development interview and observation data is
collected during the beginning of a new school year, then the PSI Professional
Development Course would be implemented, followed by post interview and observation
data collection as the school year progressed. This would allow the researcher to observe
both the growth of the teacher and of one group of students throughout a single school for
a longer period of time over a year.

Another way to improve the research design of this study would be to carry out a
two-year study. In this case the researcher would implement a timeline where the pre PSI
Professional Development interview and observation data is collected over the course of
an entire school year, then the PSI Professional Development Course would be
implemented as a summer staff development course, followed by post interview and
observation data collection over the course of the following school year. This would
allow the researcher to observe changes in specific curriculum based lessons prior to and
following the PSI Professional Development Course.
Future Research

Perfecting inquiry-teaching techniques takes time (Llewellyn, 2002). A follow-up study with the same teachers would provide more data about the process of implementing I-B science methods. If the researcher was able to observe the teacher teaching the topic that was the focus of the pre PSI Professional Development Course observation the following year, this would allow the researcher to observe changes in specific curriculum based lessons to learn if the teacher incorporated more I-B activities into the lesson following the PSI Professional Development Course.

Teachers were all working at different levels or stages of inquiry implementation. A researcher could devise and implement a test to measure the level of inquiry at which a teacher is operating. Then the researcher could provide tiered or leveled professional development sessions based on Martin-Hansen’s (2002) four models of inquiry, Structured Inquiry, Coupled Inquiry, Guided Inquiry, and Full or Open Inquiry. This study could chart the growth or progress made by the participants and examine the barriers that exist at different levels of inquiry instruction.

Change takes place most readily in collaborative work contexts, and hinges upon changes in values and beliefs. Research is needed to understand more fully the collaboration that must be developed, especially in the day-to-day work context, but also through professional development, conferences and networks. More understanding is needed of learning organizations—in terms of both teachers and students—and how it is related to values and beliefs, both individually and collectively (Anderson, 1996). Following the teachers at one school as they go about the process of implementing I-B methods would allow the researcher to focus on relationships and collaboration within the
context of one school setting. Including school principals in future studies would also provide data related to relationships and collaboration within the school context. For example, learning how they see their role in supporting teachers in and across schools with other principals by sharing their ideas would create a network of support for both teachers and administrators and ultimately for students.
Appendix A

Informed Consent Form for Project Science Inquiry
George Mason University—Fairfax, Virginia

RESEARCH PROCEDURES
You are invited to participate in a research study. This research is being conducted to describe and document elementary teachers’ beliefs or perceptions of effective science instruction and to determine how these teachers interpret and implement a model for inquiry science in their classrooms.

If you agree to participate, your participation in this study may include the following:

1. Individual Teacher Interviews - The teachers will be interviewed before (April/May) and after (October) they participate in the course. The interviews will be audio taped and transcribed. The interview will be held at the participant’s school site. The amount of time for each interview will consist of 45 minutes in duration.
2. Observations of Teaching – Each participant will be observed as he/she teaches class before (April/May) and after (October) they participate in the course. Observations will occur over a week of instruction during a class specified by the participant (during science instruction for elementary teachers).
3. Completion of the following surveys/questionnaires on the first and last day of the course.
   a. Science Teaching Efficacy Belief Instrument (20 minutes x 2)
   b. Constructivist Learning Environment Survey (30 minutes x 2)
4. Participate in informal Self-Study – The participants will participate in activities that provide practice in exploring one’s teaching and learning using reflection as a critical dimension (e.g., journaling, personal history papers, goal statements). (Time requirement: variable)
5. Keep a Reflective Journal – The teachers should complete at least six journal entries over the duration of the course. Each entry should be one and a half to two pages of double-spaced type. (Time requirement: variable)

RISKS
There is minimal risk involved in participating in this study. Pseudonyms will be used in the transcriptions of the audiotapes of the individual interviews and the audiotapes will be erased after transcription.

BENEFITS
There are no direct benefits to you for participating in the research.
CONFIDENTIALITY
The data in this study will be confidential and be stored securely. Pseudonyms will be used when referring to your individual survey and questionnaire results in written reports, (1) your name will not be included on the surveys and other collected data; (2) a code or pseudonym will be placed on the survey and other collected data; (3) through the use of an identification key, the researcher will be able to link your survey to your identity; and (4) only the researcher will have access to the identification key.

PARTICIPATION
Your participation is voluntary, and you may withdraw from the study at any time and for any reason. If you decide not to participate or if you withdraw from the study, there is no penalty or loss of benefits to which you are otherwise entitled. There are no costs to you or any other party. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed upon your request.

CONTACT
This research is being conducted Dawn Renee Wilcox under the direction of Dr. Anastasia Samaras, Associate Professor, Secondary Education Program at George Mason University. The researcher, Dawn Renee Wilcox may be reached at 540-582-6457 for questions or to report a research-related problem. Dr. Anastasia Samaras may be reached at 703-913-8154 for questions or to report a research-related problem. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

CONSENT
I have read this form and agree to participate in this study.

________________________________________
Name

________________________________________
Date of Signature

Version date: 2/11/07
Appendix B: Interview Questions for Science Teachers

1. Tell me an example of yourself as a science student…I’d like to hear an example of a science lesson/activity that helped you learn a science concept. Tell me how you best learned science.
   • Do you try to model that teaching/learning situation in your classroom?
   • Why or why not?
2. Tell me about how you were trained to teach science.
   • Can you tell me about your teacher training/preparation?
   • Can you tell me about specific content training/instruction? (In the past and most recent.)
   • Tell me about a teacher or mentor that had an influence on your training.
3. Tell me about yourself as a teacher. (Number of years teaching, grade levels)
   • How would you describe yourself as a classroom teacher?
   • What do you believe are your main strengths as a teacher?
   • In what areas would you like to improve as a teacher?
   • In what ways do you manipulate the educational environment (classroom, school, etc.) to maximize student understanding?
4. Tell me about science content and curriculum.
   • How do you decide what to teach and what not to teach?
   • What science concepts do you believe are the most important for your students to understand by the end of the school year?
   • Are there any things at the local/school/state levels that influence the way you teach? Please give some examples.
5. What do you think of when someone says “science?” What do you think of when someone says “inquiry science?”
6. Tell me about your idea of student learning.
   • When you picture a good learner in your mind, what characteristics of that person lead you to believe that they are a good learner?
   • How do you know when your students understand a concept?
   • How do you decide when to move from one concept to another?
   • How do you accommodate students with special needs in your classroom?
   • What are some of the things that you believe your students value most about their educational experience in your classroom? When they leave they say, “I really liked class because ________.”
7. Tell me about the methods which you generally use to teach science?
   • What motivates you to use the above-mentioned methods (Motivations)
   • What inhibits you from using the above-methods? (Barriers)
   • What motivates you to keep going in the face of ________?
8. Are there methods that you do not use to teach science? Tell me about them.
   • Why do you choose not to use them? (Barriers)
9. In what ways has your team **influenced your choice** of science teaching methods?
   - In what ways do you feel your administrators have influenced your choice of science teaching methods?
   - In what ways have your students influenced your choice of teaching methods?
   - Have there been any other influences on your choice of science teaching method?

10. Is there anything else you’d like to tell me that I haven’t already covered?
Appendix C1 Science Teaching Efficacy Belief Instrument*

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

<table>
<thead>
<tr>
<th>Statement</th>
<th>SA</th>
<th>A</th>
<th>UN</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.</td>
<td></td>
<td></td>
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<tr>
<td>2. I am continually finding better ways to teach science.</td>
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<tr>
<td>3. Even when I try very hard, I don’t teach science as well as I do most subjects.</td>
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<tr>
<td>4. When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.</td>
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<tr>
<td>5. I know the steps necessary to teach science concepts effectively.</td>
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<tr>
<td>6. I am not very efficient in monitoring science experiments.</td>
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<tr>
<td>7. If students are underachieving in science, it is most likely due to ineffective science teaching.</td>
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<tr>
<td>8. I generally teach science ineffectively.</td>
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<tr>
<td>9. The inadequacy of a student’s science background can be overcome by good teaching.</td>
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<tr>
<td>10. The low science achievement of some students cannot generally be blamed on the teachers.</td>
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<tr>
<td>11. When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.</td>
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<tr>
<td>12. I understand science concepts well enough to be effective in teaching elementary science.</td>
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<tr>
<td>13. Increased effort in science teaching produces little change in some students’ science achievement.</td>
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<tr>
<td>14. The teacher is generally responsible for the achievement of students in science.</td>
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<tr>
<td>15. Students’ achievement in science is directly related to their teacher’s effectiveness in science teaching.</td>
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</tr>
<tr>
<td>16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child’s teacher.</td>
<td></td>
<td></td>
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<tr>
<td>17. I find it difficult to explain to students why science experiments work.</td>
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<tr>
<td>18. I am typically able to answer students’ science questions.</td>
<td></td>
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<tr>
<td>19. I wonder if I have the necessary skills to teach science.</td>
<td></td>
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</tr>
<tr>
<td>20. Effectiveness in science teaching has little influence on the achievement of students with low motivation.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>21. Given a chance, I would not invite the principal to evaluate my science teaching.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>23. When teaching science, I usually welcome science questions.</td>
<td></td>
<td></td>
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<tr>
<td>24. I don’t know what to do to turn students on to science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>25. Even teachers with good science teaching abilities cannot help some kids learn science.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Appendix C2  Scoring the Science Teaching Efficacy Belief Instrument*

Based on Bandura’s two-component model, the STEBI is composed of two scales. The first scale, PSTE, contains 13 items and measures self-efficacy. The second scale, STOE, contains 12 items and measures outcome expectancy. The instrument is scored on a 5 point Likert scale according to the favorability of the response. A choice of strongly agree is rated as 5 points, agree as 4, and continues down until strongly disagree is rated as 1. Neutral answers are assigned three points regardless of the question wording. Items 3, 6, 8, 10, 13, 17, 19, 20, 21, 24, and 25 are reversed scored. The two scales are independent constructs; they are not combined for a total score. To score the test, total the individual scores from the PSTE and STOE scores and employ this data with an analysis of associations with background variables which include: gender, ethnicity, age, teaching experience, science courses, and school science learning experiences.

Personal Science Teaching Efficacy Belief Scale scores range from high efficacy (65-49), through average efficacy (48-31), to low efficacy (30-13).

Science Teaching Outcome Expectancy Scores range from high efficacy (60-45), through average efficacy (44-29), to low efficacy (28-12).

Appendix D1

Salish I Research Project
Constructivist Learning Environment Survey*

**Directions:** For each statement, fill in the circle that best describes your feelings about the class that was observed. Please consider each item carefully and answer every item.

<table>
<thead>
<tr>
<th>In this class …</th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Students learn about the world outside of school.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2. Students learn that scientific theories are human inventions.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3. It’s OK for students to ask “Why do we have to learn this?”</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4. Students help me plan what they are going to learn.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5. Students get the chance to talk to each other.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6. Students look forward to the learning activities.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7. New learning starts with problems about the world outside of school.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8. Students learn that science is influenced by people’s values and opinions.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9. Students feel free to question the way they are being taught.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10. Students help the teacher decide how well their learning is going.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11. Students talk with each other about how to solve problems.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12. The activities are among the most interesting at this school.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13. Students learn how science can be a part of their out-of-school life.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14. Students learn that the views of science have changed over time.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15. It’s OK for students to complain about activities that are confusing.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16. Students have a say in deciding the rules for classroom discussion.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17. Students try to make sense of each other’s ideas.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>18. The activities make students interested in science.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>19. Students get a better understanding of the world outside of school.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>0</td>
<td>0</td>
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<tr>
<td>---</td>
<td>------------------------------------------------------------------------------</td>
<td>---</td>
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</tr>
<tr>
<td>20</td>
<td>Students learn that different sciences are used by people in other cultures.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>It’s OK for students to complain about anything that stops them from learning.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>22</td>
<td>Students have a say on deciding how much time they spend on an activity.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Students ask each other to explain their ideas.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>24</td>
<td>Students enjoy the learning activities.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>25</td>
<td>Students learn interesting things about the world outside of school.</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>26</td>
<td>Students learn that scientific knowledge can be questioned.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Students are free to express their opinions.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>28</td>
<td>Students offer to explain their ideas to one another.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Students feel confused.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>30</td>
<td>What students learn has nothing to do with their out-of-school life.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>31</td>
<td>Students learn that science reveals the secrets of nature.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>32</td>
<td>It’s OK for students to speak up for each other’s rights.</td>
<td></td>
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</tr>
<tr>
<td>33</td>
<td>Students have a say in deciding what will be on the test.</td>
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<tr>
<td>34</td>
<td>Students explain their ideas to each other.</td>
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<td></td>
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<tr>
<td>35</td>
<td>The learning activities are a waste of time.</td>
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</tr>
<tr>
<td>36</td>
<td>Students have a say in deciding what activities they do.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>What students learn has nothing to do with the world outside of school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Students learn that scientific knowledge is beyond doubt.</td>
<td></td>
<td></td>
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<tr>
<td>39</td>
<td>Students feel unable to complain about anything.</td>
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<tr>
<td>40</td>
<td>Students have a say in deciding how their learning is assessed.</td>
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<tr>
<td>41</td>
<td>Students pay attention to each other’s ideas.</td>
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<tr>
<td>42</td>
<td>Students feel tense.</td>
<td></td>
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</tbody>
</table>

Appendix D2  CLES Scoring Instructions

Salish Research Project
Constructivist Learning Environment Survey

This instrument consists of both positive and negative statements that teachers must answer on a scale that ranges from “Almost Always” to “Almost Never.” For positive item statements, the “Almost Always” choice would receive a 5 moving on down to the “Almost Never” choice that would receive a 1. For negative item statements, the numbering procedure is reversed.

Example:

In this class…

<table>
<thead>
<tr>
<th>(+) 1. students learn about the world outside of school.</th>
<th>Almost Never</th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>X</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(-) 2. What students learn has nothing to do with the world outside of school.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>X</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Sample item one would be scored as a 4 while sample item two would be scored as a 2. The total score would be 4 + 2 = 6, in this example.

1. PERSONAL RELEVANCE SCALE (PR)

This scale is concerned with students’ experience of the personal relevance of school science as perceived by teachers. The scale has been designed to measure the extent to which teachers feel that their students perceive the relevance of school science to their out-of-school lives. From a constructivist perspective, the classroom environment should not promote a discontinuity between school science and students’ out-of-school lives by evoking an abstract and decontextualized image of science. Rather, the classroom environment should engage students in opportunities:

(1) to experience the relevance of school science to their everyday interests and activities;
(2) to use their everyday experiences as a meaningful context for the development of their formal scientific knowledge.

Items:

1. (+) 30. (-)
7. (+) 37. (-)
13. (+)
19. (+)
25 (+)
II. SCIENTIFIC UNCERTAINTY SCALE (SU)

This scale is concerned with students’ perceptions of science as a fallible human activity as perceived by teachers. The scale has been designed to measure the extent to which teachers feel that their students perceive science to be an uncertain and evolving activity embedded in a cultural context and embodying human values and interests. From a constructivist perspective, the classroom environment should not promote: (1) a scientistic view of science as a supreme universal monocultural activity that is independent of human interests and values; or (2) the objectivist myth that science provides an accurate and certain representation of objective reality (i.e., a correspondence theory of truth). Rather, the classroom environment should be concerned with engaging students in opportunities to learn to be skeptical and critical about the nature and value of science. In particular, to learn:

(1) that scientific knowledge is evolving and provisional;
(2) that scientific knowledge is shaped by social and cultural influences;
(3) that scientific knowledge arises from human interests and values.

Items:

2. (+) 31. (-)
8. (+) 38. (-)
14. (+)
20. (+)
26. (+)

III. CRITICAL VOICE SCALE (CV)

This scale is concerned with students’ development as autonomous learners. In particular, the scale has been designed to measure teachers’ assessment of students’ perceptions of the extent to which they are able to exercise legitimately a critical voice about the quality of their learning activities. From a constructivist perspective, the classroom environment should not favor technical curriculum interests (e.g., covering the curriculum content) to an extent that accountability for classroom activities is directed largely towards an external authority. Rather, the teacher should be willing to demonstrate his/her accountability to the class by fostering students’ critical attitudes towards the teaching and learning activities. This can be achieved by creating a social climate in which students feel that it is legitimate and beneficial:

(1) to question the teacher’s pedagogical plans and methods;
(2) to express concerns about any impediments to their learning.

Items:

3. (+) 39. (-)
9. (+)
15. (+)
21. (+)
27. (+)
32. (+)
IV. SHARED CONTROL SCALE (SC)

This scale is concerned with another important aspect of the development of student autonomy, namely students sharing with their teacher’s control of the classroom-learning environment. In particular, the scale has been designed to measure the extent to which the teacher involves students in the management of the classroom learning environment. From a constructivist perspective, students should not be required to adopt the traditional role of complaint recipients of a predetermined pedagogy that is controlled entirely by the teacher. Rather, the teacher should invite students to share control of important aspects of their learning by providing opportunities for them to participate in the processes of: (1) designing and managing their own learning activities; (2) determining and applying assessment criteria, (3) negotiating the social norms of the classroom.

Items:

4. (+)  
10. (+)  
16. (+)  
22. (+)  
33. (+)  
36. (+)  
40. (+)  

V. STUDENT NEGOTIATION SCALE (SN)

This scale is concerned with negotiation amongst students as perceived by teachers. The scale has been designed to measure teachers’ beliefs concerning students’ perceptions of the extent to which they interact verbally with other students for the purpose of building their scientific knowledge within the consensual domain of the classroom. From a constructivist perspective, the classroom environment should not require students to learn in social isolation from other students to regard the teacher or textbook as the main arbiter of what counts as viable scientific knowledge. Rather, the classroom environment should be concerned with engaging students in opportunities: (1) to explain and justify their newly developing ideas to other students; (2) to make sense of other students’ ideas and reflect on the viability of their ideas; (3) to reflect critically on the viability of their own ideas.

Items:

5. (+)  
11. (+)  
17. (+)  
23. (+)  
28. (+)  
34. (+)  
41. (+)
VI. ATTITUDE SCALE (AT)

This scale has been included to provide a measure of the concurrent validity of the CLES. The attitude scale has been used extensively in research on science laboratory classes, and has an established reliability. The scale measures teachers’ interpretations of student attitudes to important aspects of the classroom environment, including:
(1) their anticipation to the activities;
(2) their sense of worthwhileness of the activities;
(3) the impact of the activities on student interest, enjoyment and understanding.

Items:

6. (+) 29. (-)
12. (+) 35. (-)
18. (+) 42. (-)
24. (+)

For the purposes of this study, subscale scores were divided into categories for analysis.

Scores:
7-13 = Low agreement with scale
14-20 = Low intermediate agreement with scale
21-27 = High intermediate agreement with scale
28-35 = High agreement with scale

Appendix E: Classroom Observation Protocol

Date of Observation ________________________________

1. Classroom setting
   - Describe the classroom resources.
   - Describe the classroom space.
   - Describe and sketch of the classroom arrangement.
2. Observation of a Lesson

- In a paragraph or two, describe the lesson. How does it fit into the overall unit of study? What was the structure of activities (whole group, small groups, pairs, individuals)? How were students engaged?

- What was the topic or major content area(s) of this lesson or activity?

- Teaching and learning activities (check those that apply and explain)
  - Presentation (By whom? ____________________)
  - Discussion
    - Whole group
    - Pairs or small group
  - Students engaged in problem solving or investigation
    - Used manipulatives
    - Played a game to build knowledge or skills
    - Followed instructions in an investigation
    - Designed an investigation
    - Recorded, represented, and/or analyzed data
    - Recognized patterns, cycles or trends
    - Evaluated the validity of claims or arguments
    - Provided formal proof or informal justification
  - Students engaged in communication
    - Read about science and/or mathematics
    - Answered worksheet or textbook questions
    - Reflected on activities, problems or readings (individually or in pairs)
    - Prepared a written report
    - Wrote a description of a plan, procedure, or problem solving process
    - Wrote reflections in a notebook or journal
  - Teacher or students used technology or audio-visual resources
    - To develop conceptual understanding
    - To learn or practice a skill
    - To collect data (e.g., probe ware)
    - As an analytic tool (e.g., spreadsheets or data analysis)
    - As a presentation tool
    - For word processing or as a communications tool
  - Other activities
    - Arts and crafts activity
    - Listened to a story
    - Wrote a poem or story
    - Other (Please specify.) ____________________

*Adapted from a classroom observation protocol used by Johnson, Carla Cunnagin, (2003). Barriers influencing implementation of the National Science Education Standards by middle school teachers engaged in collaborative professional development. University of Cincinnati.
Appendix F: Interview Questions for Science Teachers

**Exit Interview Questions for Science Teachers**

1. How would you define science?
2. How would you define inquiry science?
3. Tell me about your learning during the professional development session.
   - What was helpful to you?
   - What was not?
   - Did the session help you in the areas would you like to improve as a teacher?
   - In what ways did you use the information learned to change or manipulate the educational environment (classroom, school, etc.) to maximize student understanding?
4. Tell me about **science content and curriculum**.
   - How do you decide what to teach and what not to teach?
   - What science concepts do you believe are the most important for your students to understand by the end of the school year?
   - Are there any things at the local/school/state levels that influence the way you teach? Please give some examples.
5. Tell me about **student learning**.
   - When you picture a good learner in your mind, what characteristics of that person lead you to believe that they are a good learner?
   - How do you know when your students understand a concept?
   - How do you decide when to move from one concept to another?
   - How do you accommodate students with special needs in your classroom?
   - What are some of the things that you believe your students value most about their educational experience in your classroom? When they leave they say, “I really liked class because ________ .”
6. Tell me about the **methods** you use to teach science?
   - Do you use any of the methods outlined in the professional development session? (Fidelity)
   - What motivates you to use the above-mentioned methods (Motivations)
   - What inhibits you from using the above-methods? (Barriers)
   - What motivates you to keep going in the face of _________?
7. Are there **methods** (from the professional development session) that you do not use to teach science? Tell me about them.
   - Why do you choose not to use them? (Barriers)
8. In what ways has the professional development session **influenced your choice** of science teaching methods?
   - In what ways do you feel your administrators have influenced your choice of science teaching methods?
   - In what ways have your students influenced your choice of teaching methods?
   - Have there been any other influences on your choice of science teaching method?
9. Is there anything else you’d like to tell me that I haven’t already covered?
Appendix G: Invitation to Practice-Science Learning Personal History

Invitation to Practice Science Learning Personal History

Everybody has a Story

Purpose

Although we can explore our teacher identity numerous ways, this education-related life history is one way to explore how our professional learning experiences shape our professional practice.

Context

(You add your own personal context.)

Wonderings/questions

- How have social and cultural influences shaped my development and that of my students?
- How can inquiry into my education-related life history inform my current practice?
- How can conducting personal history self-study assist me in understanding how my students’ experiences have impacted and shaped their learning?

Process and Data Collection

1) Find a place to work alone.
2) Reflect back on a compelling science related experience where you tried to learn something that was difficult for you. Visualize yourself as a novice learning a difficult science concept such as learning to ride a bicycle, learning to swim, learning to drive. It can be a learning experience that occurred some time ago or more recently. It might be an experience from a science class or from a situation outside of a school setting.
3) Write a narrative about that experience. The key is to write and describe your experience as a learner as specifically and fully as you can.
   - What was involved for you as you learned something new? As teachers, we have all also been learners. Think about what it means to you to be a learner.
   - Try to focus on an example of an experience, which a stand out in its vividness, or as it was when it occurred.

Collaboration

4) Pair Share Session
Appendix H: Invitation to Practice-Mapping My Classroom

Invitation to Practice: Arts-Based Self-Study Method—Visual Representation

Mapping My Classroom
(Adapted from the work of Samaras & Freese, 2006)

Purpose

Arts-based self-study method promotes and provokes self-reflection, critical analysis, and dialogue about improving one’s teaching through the arts. The arts are a conduit for dialectical unity or our capacity to relate to ourselves and others (see Holzman, 1997). Arts-based self-study teachers use a wide range of art forms to represent and reinterpret, construct and deconstruct meaning, and communicate their study of teaching as they make it public. It can take many forms including visual/image based arts, (e.g., portraits, performance, photography, video documentary, art installations, multi-media representations, films, drawings, cartoons, graffiti, signs, cyber graphics, diagrams, and concept maps (see Weber & Mitchell, 2002).

Concept maps are visual representations of what you know and what you want to know more about (see Novak & Gowin, 1984). They are ways of representing and thinking about your theories and practice (Samaras, 2002). Concepts are ideas derived from your conscious perception and classification of facts and events based on their common characteristics. Concept maps are artistic and cognitive tools that allow you to discover and demonstrate conceptual connections between and within concepts in a self-study. How you design your concept map is up to you. You can create your map using circles, boxes, pictures, or symbols of big ideas; use text alone; text within boxes; hand-drawn or computer drawn; black and white or color-coded, etc. There are no predetermined categories or concepts. The self-study teacher draws on his/her understandings based on the connections noted in the concept map.

Context

(You add your own personal context.)

Wonderings/questions

• What can I learn about my teaching by mapping my classroom environment?
• What type of learning culture do I want to create with my students?
• If someone else “read” my classroom and observed my teaching, what might they conclude about my teaching beliefs?

Process and Data Collection

1. Be a participant and an observer of your own classroom. Reflect on what you see. Seeing is more than observing. Be open and suspend your assumptions. Look at your
students from different vantage points, on different days of the week, and at different
times of day. Notice students interacting with peers, when they are alone, and during
various classroom activities.
2. Draw a pre-action concept map of your classroom’s groups, sub-groups, and the
placement of you within that grouping before attempting any changes in your
classroom. Here are some ideas to get you started:
- Map the social theater of your classroom including seating arrangements, room
layout, where things are located, and resources available.
- What are the relationships and interactions between you and your students?
- What are the power relationships between you and your students, and among
students themselves?
- Are there differentiated rules for individual students?
- Are there subcultures or groups in your classroom?
- What are the positions of participants? Are there leaders and followers? Do those
positions change? When? Why?
- Consider the interactions and social events between students.
- What are the rights and responsibilities of students and the teacher?
- Describe the interactions between yourself and students including the norms and
sanctions.
- Are students responsible for their own behavior?
- Is there a shared culture of monitoring behavior?
- Who decides when activities are begun and how long they last?
- Map what the classroom looks like when you are teaching and when you are not
 teaching.
- What does this mapping and reflection tell you about your classroom?

3. Remapping: Decide what you want to know and/or change (for next year) and think
about how you might implement those changes. Develop strategies for that change.
4. As the new school year progresses, keep a record of your strategies and actions for
change and keep notes on the consequences of your actions over time.
5. Collect data on this process as you come to better understand the dynamics of your
classroom.
6. Next, draw a post-action concept map after implementing your strategies. Pre-action
and post-action concept maps are useful for formative and summative assessment to
see the differences before and after you take action. You may also find metaphors
useful to capture significant changes and enter those words into and around your post-
action concept map frame.
7. Place your pre-action and post-action concept maps side-by-side. Analyze them for
differences. Prepare to share any shifts and differences you can identify with a
colleague.

Collaboration
8. Pair Share Session
- Take time to examine each other’s concept maps. On a visual plane, what is most
obvious to you?
- Have a discussion about what you each notice.
- Actively listen to your colleague.
Appendix I: Invitation to Practice: Developmental Portfolio Self-Study Method

Partner Portfolio for Professional Development
(Adapted from the work of Samaras & Freese, 2006)

Purpose

There are various ways we can explore our professional development. One way is the developmental portfolio self-study that enables us to uncover new and not always apparent dimensions of our teaching. Effective teaching involves continuous learning. Partner portfolios provide us with opportunities to inquire into our practice with critical friends/collaborators who help us reframe our thinking about teaching and learning. Critical friends provide support as well as a feedback loop to improve our practice and our students’ learning.

Context

(You add your own personal context.)

Wonderings/questions

- What aspects of inquiry science instruction would I like to be the focus or the foci of this growth document?
- What components of my science teaching would I like to improve? What are my personal and professional goals?
- What span of time am I interested in studying?

Process

1. Choose your developmental self-study focus. A developmental self-study portfolio typically spans a considerable period of time so you can examine the longitudinal nature of your professional development either broadly or with a specific focus. It can assist you in identifying the dilemmas encountered and changes over time. It may address a broad professional goal such as how to best and equitably integrate inquiry in your classroom or a specific concern such as dealing with “difficult behavior” during science lessons or experiments.
2. Once you have selected your focus, decide on a timeline for data collection and what kinds of data you will collect, e.g., Goal Statement, Personal History Invitation to Practice, Reflections, QW (Quick Writes), Mapping My Classroom Invitation to Practice, Lesson Plans for the mini-unit, and classroom observation notes. Your portfolio can also include photographs of your classroom, student feedback, notes from phone conversations, journals, projects, and mentor feedback. You might write about an experience, and/or an interaction that led you to a new way of seeing your teaching world. Multiple data sources serve to validate your findings.
3. Use a binder that allows you to insert and remove materials. Organize according to your focus. Add pockets for non-written sources such as CD’s, videos, student projects, etc.

Data Collection

4. Collect and date all data.
5. Read and re-read your data. Pay particular attention to any repeated statements, behaviors, and actions across your data set. Reflect on your work and learning. Read back through the items you have decided to collect in your developmental portfolio. Give yourself time and permission to reflect honestly and to study yourself as a learner and teacher. It is all right to change your philosophy and actions without incurring guilt over past practices and beliefs.
6. Analyze and write about your professional growth. Below are suggested questions to guide your data analysis:
   • Look through your journals. Which entries stand out for you and why?
   • What categories or common themes are evident in your looking back?
   • Read back to your earlier viewpoints, beliefs, and attitudes. Has anything changes? Remained the same? What factors and experiences do you believe contributed to the changes? What new insights have you gained about yourself?
   • Is there evidence of reflective thinking about your new understandings regarding teaching and students' learning?
   • What are your dilemmas?
   • What metaphor best captures who you are as a teacher?
   • Are there paradoxes that capture the essence of your work? These might include: disharmony/harmony; despair/hope; status quo/change; struggle/success; or consistency/possibilities.
   • What was your greatest ah-ha or discovery?
   • How do you see yourself as a teacher at this stage of your professional development?
   • Do you think your colleagues would describe you differently form when they first started working with you? What might they say?
   • How would you assess your participation with students, parents, colleagues?
   • What do you want to continue doing?
   • What are you still struggling with to understand about yourself and/or others?
   • What are your professional wishes and hopes yet unfulfilled?

Collaboration

7. Next, using your notations from your data analysis, write a letter to a trusted colleague about your professional journey to date.
8. Pair Share Session
   • Engage in several planned conversations with your colleague about your professional development.
   • Use active listening, i.e., listening for each other without judgment and without personal agendas.
   • Share personal stories you might have included in your portfolio.
   • Take turns listening and hearing each other’s perspectives.
Appendix J: Seven Steps for Organizing Wonder

Project Science Inquiry

Integrating IB Activities: The Seven Steps for Organizing Wonder
(Adapted from Callahan, Hall, O’Brien & Kitchell, 1998; Peters, 2006; Wiggins & McTigh, 1998)

Read over your lesson and put a check in the box that indicates you have included this step in your lesson or mini-unit plan.

☐ 1. Does the topic lend itself readily to investigation?
   ▪ A “big idea” of enduring understanding
   ▪ An idea or topic that resides at the heart of the discipline
   ▪ An idea or topic, or process that requires “uncovering”
   ▪ An ideas, topic, or process that engages the students
   ▪ An idea that integrates well with other subjects

☐ 2. Do the activities have potential for investigation?

☐ 3. Did you change COOKBOOK procedures into inquiry investigations? Here are a dozen ideas:
   ▪ Students take on roles
   ▪ Scramble the steps
   ▪ Students write the data table
   ▪ Students get data table only
   ▪ Give the results in a paragraph
   ▪ Interpret a concept map
   ▪ Give only the first few steps
   ▪ Teacher writes a step, student writes a step
   ▪ Round Robin 1: Class takes turns
   ▪ Round Robin 2: Students take turns in their groups
   ▪ Give only the problem
   ▪ Give the IV an DV

☐ 4. Did you introduce and idea or series of ideas for exploration or investigation?

☐ 5. Did you provide opportunities for children to transform ideas and questions into questions for investigation?

☐ 6. Did you provide an opportunity for students to determine if the investigation includes a fair test? (What is being measured or compared?)

☐ 7. Did you ask children to plan, carry out, and/or interpret an investigation?
Appendix K: Inquiry Professional Development Template
Prior to the PD

<table>
<thead>
<tr>
<th>Time</th>
<th>Action Required</th>
<th>Activity Description</th>
<th>Justification</th>
<th>Data Collection Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>April/May</td>
<td>Post as DWPD in My Learning Plan</td>
<td>Post description so that participants can sign up for DWPD</td>
<td>HSRB Gathering subjects</td>
<td>Class Roster</td>
</tr>
<tr>
<td>May</td>
<td>Contact and meet with principals of the participants</td>
<td>Contact and meet with principals or others involved with the leadership of the school of the participant</td>
<td>School principals should be supportive of the process and encouraging of the change (Richardson &amp; Placier, 2001; Keller, 2004) also sets the researcher up to collaborate with others (Davis, 2002)</td>
<td>Anecdotal notes</td>
</tr>
<tr>
<td>May/June</td>
<td>Contact the teachers and arrange an on-site visit</td>
<td>Seek agreement to participate in the study Fill out forms Set up interview and observation dates</td>
<td>HSRB Knowledge and practice at start (Davis, 2002) STEBI (Riggs &amp; Enochs, 1990) CLES (Taylor et al., 1997)</td>
<td>STEBI (beliefs), CLES (constructivist learning)</td>
</tr>
<tr>
<td>May/June</td>
<td>On-site visit to the teacher’s school</td>
<td>Interview the teacher Knowledge, beliefs, practice at start, experience, training (Davis, 2002)</td>
<td></td>
<td>Interview tape and transcription</td>
</tr>
<tr>
<td>May/June</td>
<td>On-site visit to the teacher’s school</td>
<td>Observe a science lesson taught by the teacher Observe classroom</td>
<td>Gather data of knowledge and practice at start (Davis, 2002)</td>
<td>Anecdotal notes</td>
</tr>
<tr>
<td>June</td>
<td>Email or personal contact Set Goal-which SOL bullet??</td>
<td>As preparation for the DWPD have participants bring a copy of a lesson they currently use in science Resources they use for one unit in the first nine weeks</td>
<td>Participants will change the lesson into a more inquiry based lesson Participants will create a mini unit to implement into their classroom in September</td>
<td>Mapping Classroom &amp; Artifact Idea/topic for mini-unit Lesson Plan Modified Lesson Plan</td>
</tr>
</tbody>
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### Day 1: Using Inquiry to Teach Inquiry

<table>
<thead>
<tr>
<th>Time</th>
<th>Action Required</th>
<th>Activity Description</th>
<th>Justification</th>
<th>Data Collection Document</th>
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<tbody>
<tr>
<td>June 25</td>
<td></td>
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<tr>
<td>8:00</td>
<td>Get to know you activity</td>
<td>Introduction Artifact</td>
<td>Collaborate with others (Davis, 2002)</td>
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</tr>
<tr>
<td></td>
<td>Choose a critical friend</td>
<td></td>
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<tr>
<td>8:20</td>
<td>Invitation to Practice--Follow steps in the</td>
<td>Personal History Self-Study Method--Everybody has a Story page 66</td>
<td>Own personal knowledge-beliefs and practices at start (Davis, 2002) Experience (Davis, 2002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Samaras Freese book page 66</td>
<td></td>
<td></td>
<td>Personal History</td>
</tr>
<tr>
<td>8:50</td>
<td>What is science? What is scientist? What is Inquiry?</td>
<td>NOS</td>
<td>Gather data on knowledge and practice at start (Davis, 2002) Vision (Hammerness et al, 2005) Inquire Within-Inquiry (Llewellyn, 2002) #1</td>
<td></td>
</tr>
</tbody>
</table>
|            | Create KWL and Goal statement (Vision)               | Set the personal goal for the DWPD and the following school year         |                                                                              | What is science? What is Inquiry? KWHL Goal statement |}
<p>| 9:20       | Simulation                                            | Engage                                                                  | Create cognitive dissonance or disequilibrium or discrepant events (Llewellyn, 2002) | Notes                   |
|            |                                                       | Participants complete worksheet mimic special needs                     |                                                                              |                          |
|            | Model a sample 5E Inquiry lesson                      | Model Inquiry (Learning cycles) Lesson (5E lesson)                      |                                                                              |                          |
|            |                                                       |                                                                         | Reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley &amp; Valli, 1999: Keller, 2004; Samaras &amp; Freese, 2006) |                          |
|            | Participants will read, gather books and examine      | centers with samples of inquiry lessons, books, the Internet—They will gather information and ideas and add to portfolio |                                                                              |                          |
|            | Internet sites                                       |                                                                         | Reflect &amp; manage thoughts &amp; behaviors through strategic processing, reflection &amp; collaboration (Hawley &amp; Valli, 1999: Keller, 2004; Samaras &amp; Freese, 2006) |                          |</p>
<table>
<thead>
<tr>
<th>Time</th>
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<th>Activity Description</th>
<th>Justification</th>
<th>Data Collection Document</th>
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</thead>
<tbody>
<tr>
<td>11:00</td>
<td>Use presentation modified through pilot studies</td>
<td>Explain through Inquiry Presentation Match concepts to those in the model lesson</td>
<td>Inquiry, 5E. (Bybee, 1997) Meeting special needs (Melber, 2004) Children learn (Llewellyn, 2002)</td>
<td>QW Reflections</td>
</tr>
<tr>
<td></td>
<td>• Inquiry</td>
<td>T-QW-P-S</td>
<td>Reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley &amp; Valli, 1999: Keller, 2004; Samaras &amp; Freese, 2006)</td>
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<tr>
<td></td>
<td>• How children learn</td>
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<td></td>
<td>• Science for ALL</td>
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<td></td>
<td>• 5E model</td>
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<tr>
<td>12:00</td>
<td>Designing Inquiry Based Classrooms Invitation to Practice: Mapping my Classroom</td>
<td>Elaboration—make the connection to the teachers own classroom, an arts based self-study</td>
<td>Knowledge of practice at start, reflection, concept maps, create structure or framework (Darling-Hammond et al., 2005; Davis, 2002; Samaras &amp; Freese, 2005) Reflect and manage their thoughts and behaviors through strategic processing (Hawley &amp; Valli, 1999: Keller, 2004) Design Class (Llewellyn, 2002) #4</td>
<td>Mapping my Classroom</td>
</tr>
<tr>
<td>1:30</td>
<td>Integrating IB activities</td>
<td>Explain Seven Blind Mice-Seeing the BIG picture Model for planning and carrying out inquiry science in the classroom.</td>
<td>Learning how to direct student activity without dampening their curiosity (Callahan, Hall, O’Brien, &amp; Kitchell, 1998) Integrating activities (Llewellyn, 2002) #5</td>
<td></td>
</tr>
<tr>
<td>2:00</td>
<td>Cookbook to Inquiry Practical use of the Scientific Method</td>
<td>Elaboration—make the connection to the teachers own classroom</td>
<td>Knowledge of practice at start, reflection, concept maps, create structure or framework (Darling-Hammond et al., 2005; Davis, 2002; Samaras &amp; Freese, 2005) Scientific Method (Llewellyn, 2002)</td>
<td>QW Reflections</td>
</tr>
<tr>
<td></td>
<td>T-QW-P-S</td>
<td>Reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley &amp; Valli, 1999: Keller, 2004; Samaras &amp; Freese, 2006)</td>
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<td></td>
</tr>
<tr>
<td>3:00</td>
<td>Summary and Questions</td>
<td>Further Exploration and modeling to obtain more content knowledge</td>
<td>Ask questions</td>
<td>Exit slip for questions</td>
</tr>
<tr>
<td></td>
<td>• What makes a good question?</td>
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<tr>
<td></td>
<td>• Misconceptions</td>
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<tr>
<td></td>
<td>• Safety</td>
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</tbody>
</table>

Next Day--bring resources for mini unit

851
## Day 2: Design and Plan to Implement your own Inquiry-Based Mini Unit

<table>
<thead>
<tr>
<th>Time</th>
<th>Action Required</th>
<th>Activity Description</th>
<th>Justification</th>
<th>Data Collection Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00</td>
<td>Copy of Curriculum map/ Curriculum framework</td>
<td>Teachers will create a goal or set of questions for the mini-unit, vocabulary list, etc</td>
<td></td>
<td>Goal Statement</td>
</tr>
<tr>
<td></td>
<td>Worksheet to create list with elements of the 5E model</td>
<td>ENGAGE! Brainstorm a list of ideas that apply to each of the elements in the 5E model that match the participants BIG IDEA for their mini-unit. Begin to create a concept map of the unit</td>
<td>5E (Bybee, 1997) Inquiry, concept map (Llewellyn, 2002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Critical Friend</td>
<td>Meet with their <strong>critical friend</strong> to share and add to the list</td>
<td>Collaborate with others (Davis, 2002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need to provide items to explore (books, sample lessons, Internet access, objects)</td>
<td><strong>EXPLORATION</strong> time for teachers to see what ideas and resources are available for their mini unit</td>
<td>5E model (Bybee, 1997)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>T-QW-P-S</td>
<td>Reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley &amp; Valli, 1999: Keller, 2004; Samaras &amp; Freese, 2006)</td>
<td>QW Reflections</td>
</tr>
<tr>
<td>9:00</td>
<td>Integrating IB activities Chart for the seven steps of organizing wonder</td>
<td>Teachers will use the 5E model and the check list that follows the steps to help organize the first lesson in their unit</td>
<td>Applying what they have learned about directing student activity without dampening their curiosity (Hall, 1998)</td>
<td>Lesson Plan</td>
</tr>
<tr>
<td></td>
<td>Lesson template for 5E model</td>
<td>Write the introductory lesson for the unit</td>
<td>5E model (Bybee, 1997)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“checklist” worksheet</td>
<td>“checklist” for Inquiry</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Critical Friend</td>
<td><strong>EXPLAIN</strong> Meet with their <strong>critical friend</strong> to share and polish the lesson</td>
<td>Collaborate with others (Davis, 2002)</td>
<td></td>
</tr>
<tr>
<td>10:00</td>
<td>Discussion</td>
<td><strong>Check on progress Ask questions</strong></td>
<td>Reflect &amp; manage thoughts through collaboration (Hawley &amp; Valli, 1999: Keller, 2004; Samaras &amp; Freese, 2006)</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Action Required</td>
<td>Activity Description</td>
<td>Justification</td>
<td>Data Collection Document</td>
</tr>
<tr>
<td>------------</td>
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<td>--------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>June 26</td>
<td>Chart for the seven steps of organizing wonder</td>
<td>Teachers will follow the steps to help organize the future lesson in their unit</td>
<td>Applying what they have learned about directing student activity without dampening their curiosity (Hall, 1998)</td>
<td></td>
</tr>
<tr>
<td>10:15</td>
<td>Chart for the seven steps of organizing wonder</td>
<td>Teachers will follow the steps to help organize the future lesson in their unit</td>
<td>Applying what they have learned about directing student activity without dampening their curiosity (Hall, 1998)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lesson template for 5E</td>
<td>Write the remaining lessons for the unit</td>
<td>5E (Bybee, 1997)</td>
<td>Lesson Plan</td>
</tr>
<tr>
<td></td>
<td>“test” worksheet</td>
<td>EVALUATE “test” for Inquiry</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Critical Friend</td>
<td>Meet with their critical friend to share and polish the lesson</td>
<td>Collaborate with others (Davis, 2002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reflection</td>
<td>T-QW-P-S</td>
<td>Reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley &amp; Valli, 1999; Keller, 2004; Samaras &amp; Freese, 2006)</td>
<td>QW Reflections</td>
</tr>
<tr>
<td>Lunch</td>
<td>“appointment”</td>
<td>Meet with the facilitator</td>
<td>Offer feedback</td>
<td>Sets the researcher up to collaborate with others (Davis, 2002) Access to experienced professional or mentor guide (Davis, 2002)</td>
</tr>
<tr>
<td>1:00</td>
<td>Organization tips</td>
<td>Making it work in my classroom! Classroom set up</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supplies (paper, scissors, glue, manipulatives, etc.)</td>
<td>Vocabulary, Manipulatives, Foldables, Books</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reflection</td>
<td>T-QW-P-S</td>
<td>Reflect and manage their thoughts and behaviors through strategic processing, reflection and collaboration (Hawley &amp; Valli, 1999; Keller, 2004; Samaras &amp; Freese, 2006)</td>
<td>QW Reflections</td>
</tr>
<tr>
<td>3:00</td>
<td>What’s Next?? Portfolio</td>
<td>Implementing the Unit</td>
<td></td>
<td>Begin Partner Portfolio</td>
</tr>
</tbody>
</table>
## Implement Unit

<table>
<thead>
<tr>
<th>Time</th>
<th>Action Required</th>
<th>Activity Description</th>
<th>Justification</th>
<th>Data Collection Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>September/October</td>
<td>Classroom Observation with feedback</td>
<td>Teacher implements unit</td>
<td>Access to experienced professional or mentor guide (Davis, 2002)</td>
<td>Notes</td>
</tr>
<tr>
<td>September/October</td>
<td>Portfolio with final reflective entry</td>
<td>Portfolio is put together</td>
<td>Reflect and manage their thoughts and behaviors through strategic processing, reflection (Hawley &amp; Valli, 1999; Keller, 2004; Samaras &amp; Freese, 2006)</td>
<td>Reflection</td>
</tr>
<tr>
<td>September</td>
<td>Set up time schedule</td>
<td>When will the teacher implement the unit?</td>
<td></td>
<td>Notes</td>
</tr>
<tr>
<td>September/October</td>
<td>Visit and Observe</td>
<td>Implementation of Unit</td>
<td></td>
<td>mini-unit Observations</td>
</tr>
</tbody>
</table>

### Day 3 (Two hour session)

<table>
<thead>
<tr>
<th>Time October</th>
<th>Action Required</th>
<th>Activity Description</th>
<th>Justification</th>
<th>Data Collection Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:15</td>
<td>Pair Session for Invitation to Practice Partner Portfolios for Professional Development Mapping My Classroom</td>
<td>Invitation to practice discussion of portfolio with critical friend</td>
<td>Reflect and manage their thoughts and behaviors through strategic processing, reflection (Hawley &amp; Valli, 1999; Keller, 2004; Samaras &amp; Freese, 2006)</td>
<td>Written Feedback Partner Portfolio Mapping My Classroom</td>
</tr>
<tr>
<td>4:45</td>
<td>Final reflections</td>
<td>Write and/or share</td>
<td></td>
<td>Notes</td>
</tr>
</tbody>
</table>

### Day 4 (Two hour session)

<table>
<thead>
<tr>
<th>Time October</th>
<th>Action Required</th>
<th>Activity Description</th>
<th>Justification</th>
<th>Data Collection Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:15</td>
<td>Share with group</td>
<td>Share</td>
<td>Collaborate with others (Davis, 2002)</td>
<td>Written Feedback</td>
</tr>
<tr>
<td>4:45</td>
<td>Implications for the Future</td>
<td>Discussion</td>
<td>Collaborate with others (Davis, 2002)</td>
<td>Notes</td>
</tr>
</tbody>
</table>

### Follow-UP

<table>
<thead>
<tr>
<th>Time</th>
<th>Action Required</th>
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<th>Data Collection Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>By appointment</td>
<td>Portfolio</td>
<td>Follow-up sessions to wrap up instruction</td>
<td>Reflect/manage thoughts and behaviors through strategic processing, reflection (Hawley &amp; Valli, 1999; Keller, 2004; Samaras &amp; Freese, 2006)</td>
<td>Portfolio</td>
</tr>
<tr>
<td></td>
<td>Exit Interview</td>
<td>Interview</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
REFERENCES
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Hoban, G.F. (2005). The missing links in teacher education design: Developing a multi-
linked conceptual framework. The Netherlands: Springer.


CURRICULUM VITAE

Dawn Renee Wilcox was born on November 19, 1964 in Trenton, New Jersey, and is an American citizen. She graduated from Pennsbury High School, Fairless Hills, Pennsylvania, in 1982. She received her Bachelor of Science from the University of Maryland in 1989. She was employed as a teacher in Prince Georges County, Maryland County for three years and Spotsylvania County Schools, Virginia for thirteen years. She received her Master of Education in Curriculum and Instruction from George Mason University in 2001.

Dawn Renee was honored with the 2001 Presidential Award for Excellence in Mathematics and Science Teaching. She is currently the Division Science Coordinator at Spotsylvania County Schools in Spotsylvania, Virginia. She works with administrators, teachers, parents, students, and community members to encourage life long learning that allows Spotsylvania County Schools to bridge the gap between knowledge and practice. She helps to build and support a community of learners that engages in research and shares ideas and findings with colleagues. She encourages achievement of standards based reform, which includes inquiry-based instruction and integration of technology.

Dawn Renee has published in referred and teacher journals as well as in edited books. Dawn Renee has presented her research at international and national professional conferences. Her research interests include hands-on inquiry-based science instruction, brain research, how people learn, self-study, communities of teaching and learning, team or collaborative teaching, and staff development.

She is also known as the Zoo Lady. She once saved someone’s life by wrestling a crocodile to the ground in Australia!