TEACHING BEYOND THE WALLS: A MIXED METHOD STUDY OF
PROSPECTIVE ELEMENTARY TEACHER’S BELIEF SYSTEMS
ABOUT SCIENCE INSTRUCTION

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This mixed methods study investigated K-6 teacher candidates’ beliefs about informal science instruction prior to and after their experiences in a 15-week science methods course and in comparison to a non-intervention group. The study is predicated by literature that supports the extent to which teachers’ beliefs influence their instructional practices. The intervention integrated the six strands of learning science in informal science education (NRC, 2009) and exposed candidates to out-of-school-time environments (NRC, 2010). Participants included 17 candidates in the intervention and 75 in the comparison group. All were undergraduate K-6 teacher candidates at one university enrolled in different sections of a required science methods course. All participants completed the Beliefs about Science Teaching (BAT) survey. Reflective journals, drawings, interviews, and microteaching protocols were collected from participants in the intervention. There was no statistically significant difference in pre or post BAT scores of the two groups; however, there was a statistically significant interaction effect for the intervention group over time. Analysis of qualitative data revealed that the intervention candidates were more confident, driven by student prior experience, and committed to use of inquiry, real world contexts, and use of digital tools compared to their initial beliefs. In addition, the intervention candidates displayed awareness of each of the six strands of learning science in informal environments and commitment to out-of-school-time learning of science. This study supports current reform efforts favoring integration of informal science instructional strategies in science methods courses of elementary teacher education programs.
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by

Sumreen Asim
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I would like to begin by praising and thanking Allah (God) for His infinite Mercy upon me. Only through His assistance have I reached this goal, and only through placement of the following people in my life has completing this doctorate become possible.

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CHAPTER 1

INTRODUCTION

The STEM (Science, Technology, Engineering, and Mathematics) Education Coalition annual report to the Department of Education, proposes the need to create programs and curricula that complement classroom teaching and learning through the use of out-of-school experiences (“STEM Education Coalition Report”, 2014). In the same manner on a national scale, science education reform demands that science teacher educators draw upon guidelines such as the Next Generation Science Standards (NGSS) report, prepared by Achieve, Inc. (2013), as a valuable resource both for redesigning and improving course content, and also for supporting the vision of science education imparted to prospective K-12 teachers through quality instruction and meaningful experiences. Most importantly, there is a need to include informal science education a less researched area to science teacher education (National Research Council [NRC], 2009). Introducing future teachers to informal science education and helping them to envision its potential to advance learning of their future students is still in its infancy within science teacher education.

Prominent researchers in informal science education, Falk and Dierking (2000), Kisiel (2013), and Rahm (2014), have consistently referred to the lack of research about future teachers’ knowledge of informal science settings. This study investigated the nature of K-6 teacher candidates’ beliefs about informal science instruction prior to and after their experiences within a 15-week-semester elementary science methods course. Although the literature on the perspectives of K-12 students based on science learning experiences in informal settings is extensive (Briker, 2014; Birmingham & Calabrese Barton, 2014; Polman & Hope, 2014; Ramsey-Gassert, 1997; Tal & Dierking, 2014), the literature on perspectives of K-6 teacher
candidates and informal science instruction is limited, specifically, this literature lacks attention on the subject of how teacher candidates learn to teach in informal science settings. This lack of information is present despite the continued emphasis placed on learning in informal contexts as a key component in promoting science interest, increasing motivation, increasing dialogue, and deepening science content knowledge (Kisiel, 2010; Falk & Dierking, 2000). This study is aligned with the current goals of discovering “how teachers learn to engage in practices that successfully support student development and learning” (Bransford & Darling-Hammond, 2005, p. 25), and understanding teacher candidates’ beliefs and how they learn to teach science. In Chapter 1, I begin with discussing my personal rationale for the study. Next, I describe the theoretical framework that provided multiple lenses for interpreting this study. I then follow up the discussion with presenting the research questions and limitations of the study.

My Interest in the Study

My personal rationale for this study is drawn from my experiences as a graduate student at CUNY Brooklyn College which was memorable and shaped me as an elementary science educator. The faculty of this particular science teacher education program integrated several informal science experiences that included Project Learning Tree (Council for Environmental Education, 2000) and visits to the Brooklyn Botanical Gardens and the American Museum of Natural History (Miele & Powell, 2010) into their science teacher education program. These out-of-classroom experiences within the teacher education program heavily influenced my classroom practices as a science instructor.

Additionally, as a science cluster teacher in New York City, I had experience teaching both in and out of the classroom. I was fortunate to have an independent science lab classroom with a terrarium, a millipede, guinea pigs, and a plethora of resources such as materials and
books. As an educator, I incorporated informal science learning experiences to promote my students ability to make connections between the learning that occurred within the classroom and outside the classroom. By doing so, my students were given the proper scaffolding to enable them to recall science content from their regular classroom experiences and outside the classroom experiences. The students were then able to make connections between the science knowledge they gained from both the formal and informal settings they had experienced. I thought that the informal science experience of these students left them with extremely memorable impressions of science—impressions that might possibly lay a foundation for long-term interest in science content.

The design of the informal science education (ISE) model used in this study was influenced by a combination of personal experiences and my educational background, and the current trends in science education research. The ISE model adopted for this study provided for out-of-classroom science learning experiences to be incorporated into the formal classroom curriculum of a pre-service elementary science methods course. In this study, I examined the impact over time of the ISE model on the prospective science teachers’ belief systems about informal science instruction.

Problem Statement for the Present Study

The purpose of this study was to investigate the nature of K-6 teacher candidates’ belief systems about informal science instruction prior to and after their experiences within a 15-week semester elementary science methods course. To address the challenge of investigating K-6 teacher candidates’ beliefs about informal science instruction, the elementary science methods course was purposefully designed to integrate the Six Strands of Learning Science in Informal Science Education (NRC., 2009). Thus, the course included an ISE intervention based on the Six
Strands (referred to as the ISE model) which included the three types of informal learning environments the National Research Council (2010) describes as supporting science classroom content, the ISE model provided the framework for complementary out-of-classroom science learning experiences within the formal learning context of science methods course. (Hofstein & Rosenfeld, 1996). This redesigned science methods course using the ISE model provided the context within which K-6 teacher candidates’ belief systems were investigated. Although there have been several studies that address informal learning environments within teacher education, none have specifically concentrated on using an informal science education model as a framework for studying changes in K-6 teacher candidate belief systems within their teacher preparation programs.

Theoretical Framework

Unique learning environments have gained attention in recent reform efforts (Achieve, 2013). Learning experiences through partnerships of out-of-school programs, science institutions, and media are valuable contributors to society as a whole (National Science Teachers Association [NSTA], 2008). According to the NRC (2009), the community of education researchers, teacher educators, professional teacher development experts, educational funding officers, and education reformers are beginning to focus on informal environments because of its vast potential (NRC, 2009). Since this study focused on informal science learning, the theoretical rationale served to guide this study, and served as an analytical framework during data analysis. The framework of this derived from a fairly new and comprehensive report published by the NRC titled Learning Science in Informal Environments: People, Places, and Pursuits (2009). NRC (2009) work is an appropriate choice as a framework because it provides

The NRC (2009) report outlines a six-strand framework for science learning outcomes that articulate the science-specific capabilities, coherent principles, pedagogical practices, and goals supported by informal learning environments. The six strands/outcomes encompass “a broad, interrelated network of knowledge and capabilities that learners can develop in these environments” (NRC, 2009). Table 1 provides a list of the goals as provided by this report and provides an explanation of each strand. An elaboration of each strand as a theoretical guide follows the table.

Table 1

<table>
<thead>
<tr>
<th>Strands</th>
<th>Description</th>
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<tbody>
<tr>
<td>Strand 1: Developing Interest in Science</td>
<td>Experiencing excitement, interest, and motivation to learn about phenomenon in the natural and physical world.</td>
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<tr>
<td>Strand 2: Understanding Scientific Knowledge</td>
<td>Generating, understanding, remembering, and using concepts, explanations, arguments, models, and facts related to science.</td>
</tr>
<tr>
<td>Strand 3: Engaging in Scientific Reasoning</td>
<td>Manipulating, testing, exploring, predicting, questioning, observing, and making sense of the natural and physical world.</td>
</tr>
<tr>
<td>Strand 4: Reflecting on Science</td>
<td>Reflecting on science as a way of knowing, including the process, concepts, and institutions of science. It also involves reflection on the learner’s own process of understanding natural phenomena and scientific explanations for them.</td>
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Strand 5: Engaging in Scientific Practices
Participation in scientific activities and learning practices with others, using scientific languages and tools

Strand 6: Identifying with the Scientific Enterprise
Coming to think of oneself as a science learner and developing an identity as someone who knows about, uses, and sometimes contributes to science.


Strand 1: Developing Interest in Science

This goal focuses on the “motivation to learn science, emotional engagement, curiosity, and willingness to persevere” through complicated scientific ideas and procedures over time (NRC, 2009, p.43). Engagement can trigger motivation, which leads learners to seek out additional ways to learn more about a topic. One example of this is that learners in informal learning environments are more involved and excited to learn about a topic by asking their own questions.

Strand 2: Understanding Scientific Knowledge

The emphasis in this strand is on knowing, using, and interpreting scientific explanations of the natural world. Learners must understand interrelations among central scientific concepts and use them to build up scientific arguments. The learning in this strand encompasses content knowledge with a focus on concepts and the links between them, rather than on discrete facts. More importantly, it includes the ability to use this knowledge effortlessly in both formal and informal contexts.

Strand 3: Engaging in Scientific Reasoning

This strand incorporates using the scientific process as a way to evaluate theories and models based on new evidence. This strand encompasses the knowledge and skills needed to
build and refine models and explanations; design and analyze investigations; and construct and defend arguments with evidence. The strand also includes recognizing when there is insufficient evidence to draw a conclusion and determine what kind of additional data are needed. Therefore, there is an application of knowledge across multiple contexts: informal and formal contexts.

Strand 4: Reflecting on Science

Learning is a dynamic process, which is based on the continual evaluation of new evidence and the re-evaluation of old ideas (NRC, 2009, p.45). Similarly, scientists are constantly modifying their views of the world. This strand also focuses on learner’s understanding of science as a way of knowing in both formal and informal learning settings. This includes an appreciation for how the thinking of scientists and scientific communities changes over time, as well as the learner’s sense of how their own thinking changes. Informal learning environments are well suited to provide a chance for people to experience some of the excitement of participating in a process that is constantly open to revision.

Strand 5: Engaging in Scientific Enterprise

Science is a social process through which people with knowledge of the language, tools, and core values of the community can come together to achieve a greater understanding of a scientific problem. Through participation in informal environments, non-scientists can develop a greater appreciation of how gains are made in the scientific community. Individuals can also refine their own mastery of the language and tools of science.

Strand 6: Identifying with the Scientific Enterprise

Through experiences in informal environments, people may start to change the way they think about themselves and the nature of science. They may see themselves as scientists, too. This transformation occurs within many informal education programs when people realize that
they are smart because they can do science. Individuals want to become more knowledgeable
and they may seek out information in books or on the Internet, mapping the route to lifelong
learning.

Taken as a whole, the framework achieves a balanced synthesis that has the potential to
provide an innovative model for science methods courses within teacher preparation programs.
Including the learning goals set forth by NRC (2009) that these science education goals were
incorporated into the design of the intervention that formed the basis of this study.

Research Questions

An informal science education model was designed and implemented in a science
methods course. The following overarching question guided the study: “What are the teacher
candidate’s beliefs systems about science instruction and specifically, what is the effect of a
science methods course using an ISE model on prospective teachers’ science teaching beliefs?”

Quantitative Research Questions

1. In what ways did experience with the Informal Science Education (ISE) model affect
   prospective elementary teachers’ beliefs about teaching science?
   a. Were there differences in science teaching beliefs between the treatment and
      comparison groups?
   b. Did beliefs about participant abilities to teach science change over time?
   c. Did the effect of time (pretest and posttest) on science teaching beliefs depend on
      the ISE model or not?
   d. Was there an interaction effect of time (pretest and posttest) and did participation
      in the ISE model impact the science teaching beliefs?

Qualitative Research Questions
2. What was the status of prospective elementary teachers’ beliefs about pedagogical practices in science instruction before and after a science methods course using the Informal Science Education (ISE) model?

Mixed Methods Research Questions

3. In what ways did the qualitative data contribute to a more comprehensive understanding of the statistical results from the quantitative phase of the study?

Study Design

This study of K-6 teacher candidates’ beliefs about informal science instruction used a mixed methods research design (Creswell, 2013). The study was conducted in two phases. In the first phase, quantitative data were collected through a pretest/posttest design using a survey instrument that identified participants’ overall belief systems about science teaching. Descriptive and inferential statistics was used in analysis of this data. In the second phase, qualitative data that identified both beliefs about science instruction and specific belief systems about informal science teaching were collected through drawings, interviews, and observations of K-6 teacher candidates’ microteach sessions. Data analysis included a hybrid approach to inductive and deductive thematic analysis (Fereday & Muir-Cochrane, 2006; Yukhymenko, Brown, Lawless, Brodowinska, & Mullin, 2014). The quantitative and qualitative data were analyzed separately and then integrated to gain a holistic understanding of pre-service teacher candidate belief systems about informal science instruction.

Pilot Study

The design of the study was informed by a pilot study conducted in spring 2013 with a convenience sample of undergraduate students who were enrolled in a science methods course in the teacher education program at the University of North Texas (UNT). Prior reading had revealed that
most reform/intervention studies incorporating informal learning within science methods courses were qualitative in nature and used data sources such as drawings, open-ended questions, and interviews (Carrier, 2009; Katz et al., 2011). In the pilot study, I chose to use research tools and methods similar to those used in these types of research. The reasons for the pilot study were to

- permit preliminary testing of how to conduct research,
- provide the opportunity to test the proposed informal science education intervention,
- utilize the research method proposed for qualitative data collection,
- allow practice in inductive data analysis, and
- enable reflection on the usefulness of the methodological approach for answering the research question.

Through this process, some problems were identified. First, participants’ drawings and descriptions of themselves were not sufficient to understand their belief systems about science instruction. Second, the questions asked in the semi-structured interviews resulted in very broad and general answers. When conducting the interviews, I felt that I was a novice and needed more practice in questioning techniques. Another critique led me to see value in providing a list of questions for the participants to review in advance and refer back to during their interviews. I saw that the length and scheduling of the intervention within the methods course needed revision if it were to be an effective pedagogical practice. The pilot study led me to revisit the prior research studies and I discovered that a meaningful intervention should span more than one 3-hour class period. Despite the issues and obstacles, the experience of conducting pilot research in spring 2013 and conducting an improved study in the fall of 2013 allowed me to gain a better
understanding of the research process and guided me in development of the research design and questions.

Key Assumptions

In order to gain an understanding of the impact of the ISE model on K-6 teacher candidates’ belief systems, it is important to choose appropriate research methods. Quantitative methods lend themselves to a positivist paradigm (Tashakkorri & Teddlie, 2003), whereas the philosophical background of qualitative methods aligns with being interpretive (Lincoln & Guba, 1985). Thus, a mixed method approach more fully supports the research goal of broadly interpreting the experiences of the participants and providing understanding of their belief systems about informal science instruction.

The results of this study are only generalizable to the teacher education program, where the research was conducted. However, common characteristics of the K-6 teacher candidates and the context may be compared to aspects of other teacher preparation programs and suggest similar conclusions and findings that may be applicable.

Limitations

All research studies have potential weaknesses. The following are some of the limitations related to the internal validity of the present study:

- **Sampling:** By utilizing one teacher preparation program, the research conducted in this study depended on the number of participants enrolled in sections of an undergraduate science methods courses, which was a limitation on the sample size.

- **Demographics:** The participant pool in the treatment and comparison groups were not equally representative of one another.
• Survey: The study examined teacher candidates’ science teaching belief systems using self-report questions. The survey instrument was not specific to informal science teaching.

• Researcher: The author also served as the science methods instructor for the treatment group.

These issues were mitigated by the use of treatment and comparison groups for the first phase of the study in which data were collected using survey instrumentation. In the second phase of the study, both data and methods triangulation were used.

Scope and Delimitations

In this study, I focused on informal science education in a science methods course by means of an intervention. The delimitations of the study involve the threats to external validity. The following are the delimitations related to the present study:

• The study focused on K-6 teacher candidates in a single teacher preparation program.

• The study focused only on one subject—science.

Definitions of Key Terms

The following is a list of terms that were used in a particular way in this study. These terms was adopted and adapted from the literature referring to informal science education, teacher education, and science teacher education (Bybee, 2003; Bransford & Darling-Hammond, 2005; Hsieh et al., 2005; NRC, 2009; Khader, 2012; Newman et al., 2005; Riedinger, Marbach-Ad, McGinning, Hestness, & Pease, 2010).
Beliefs: Beliefs are personal constructs held in clusters within belief systems, which have the capacity to influence classroom practices, and are defined and shaped through experiences of an individual.

Context: The setting, surrounding, or circumstances. In this research, I use context and environment interchangeably.

Informal Science Education (ISE): Science learning that occurs outside the traditional, formal classroom.

Intervention: The informal science education (ISE) model in this study to bring about change.

Model: The educational model in this study is based on research and personal educational philosophy comprised of informal learning environments, designed learning environments, and programs.

Out-of-school-time (OST). According to the NRC (2009), out-of-school learning can be delivered through a formal afterschool program or informal exposure to science at a museum, on the Web, or via other non-formal learning settings.

Pedagogical Practice: A set of teaching strategies/methods of instruction used in a classroom. In this research paper, I use pedagogical practice and instructional practice interchangeably.

Project WILD: An interdisciplinary, supplemental environmental and conservation education program for educators of kindergarten through high school (Council for Environmental Education, 2005).

Science Methods Course: An undergraduate teacher education course that introduces the prospective teacher to strategies and techniques of science instruction.
**Teacher Candidate:** An undergraduate university student enrolled in a teacher preparation program. In this paper, I use prospective teacher, pre-service teacher, and teacher candidate interchangeably.

**Teacher Educator:** A faculty member, adjunct instructor, or doctoral teaching fellow, specific to UNT in the College of Education, who facilitates learning about teaching across teacher preparation coursework.

**5E Lesson Plan:** The lesson format based on the processes of learning concepts. The five phases in the lesson are known as Engage, Explore, Explain, Elaboration, and Evaluate, which are based on Bybee. (2003).

### Significance of the Study

The research study addressed the need both nationally and internationally for science education reform with reference to teaching within informal science education (Hofstein & Rosenfeld, 1996; Ramey-Gassert & Wahlberg, 1994). The significance of this study was three-fold. First, the study investigated the possible influence of K-6 teacher candidates’ belief systems on their instruction in informal science settings. Current trends in science education NRC, 2010; STEM Education Coalition Report, 2014) suggest that meaningful science learning that influences K-12 students’ future educational and career choices depends not only on instruction situated within formal science classroom settings but also on instruction situated within informal science settings. For example, the STEM Education Coalition report (2014) calls for targeted efforts to establish projects, programs, and curricula in education programs orchestrated by teachers to support students’ learning in classrooms and in out-of-school settings. So far, this concept of cross-contextual instruction has been investigated from the perspectives of (a) K-6 teacher candidates’ ideas about informal science instruction and how they relate to their
conceptualizations of informal science instruction (Avraamidou, 2014a; Katz, et al., 2011) and (b) K-6 teacher candidates’ development of a reform-minded science teaching identity for informal science environments (Avraamidou, 2014b).

Current research on K-6 teacher candidates’ belief systems about informal science instruction exists but lacks information on the study of the relationship between the candidates’ belief systems and their experiences with informal science instruction. This lack of information occurs despite an accumulated knowledge base about teachers’ belief systems about science instruction that claims belief systems about science instruction are key determinants of teachers’ decisions about teaching and learning (Ambusaidi & Al-Balshi, 2012; Koksal, 2011; Yilmaz-Tüzün, 2008). By focusing on how K-6 teacher candidates’ belief systems influence their instruction in informal science settings, this study contributed to the knowledge base on K-6 teacher candidates’ belief systems and how they may impact “the nature of the learning” that their future K-6 students experience “rather than necessarily where the learning happens” (Tal & Dierking, 2014, p. 252).

Second, this study was significant for science teacher educators because it provided a lens into K-6 teacher candidates’ beliefs and/or belief systems within their philosophies of science pedagogy. The study addressed the role that teacher candidate belief systems can play in science teacher educators’ design of coursework in order to better support teacher candidates’ professional readiness and pedagogical practice (Garrett, 2005). Support for this endeavor is evident in the literature. For example, Fletcher and Luft (2011), Parajes (1992), Poole (1995), and Yilmaz-Tüzün (2008) urge teacher educators to attend to belief systems because they are already entrenched within K-6 teacher candidates’ philosophies for learning how to teach science.
Third, the findings of this research are of interest to methods instructors, educational researchers, and professional development program developers for two reasons. An understanding of prospective K-6 teacher candidates’ beliefs about informal science instruction adds to the larger research about beliefs and beliefs systems and thus, how teachers who hold beliefs engage in informal science instruction that successfully and/or unsuccessfully impacts students’ learning of science. Also, insights into elementary teacher candidates’ beliefs are crucial to the design of teacher education programs to prepare science teachers who are responsive to their future students’ learning experiences in informal contexts. By taking into account the beliefs of teacher candidates’ belief systems, science teacher educators can configure programs that challenge and cultivate beliefs that are conducive to reform-based practices. But taking belief systems into account is difficult, as beliefs are impacted by different experiences throughout a pre-service program (Jones & Carter, 2007; Richardson, 1996). For those in teacher education, paying attention to the course work, field placement and informal learning experiences in a program is important in order to expand the belief systems of teachers during a pre-service program.

Organization of the Dissertation

This dissertation is organized into five chapters. Within this first chapter, the theoretical framework, the purpose and significance of the study, the research questions, and information about a pilot study, as well as the definition of terms, limitations and the delimitations are established. Chapter 2 considers the pertinent literature. Chapter 3 discusses the research methodology for the study outlining the research design, data collection, and analytical procedures. Chapter 4 reports the results and findings from both quantitative and qualitative perspectives and integrates the findings to address the mixed-methods research question. Chapter
5 summarizes the study, discusses the major findings and conclusions, and makes recommendations for future research.
CHAPTER 2

REVIEW OF LITERATURE

The intent of this study was to explore the impact of an intervention, the informal science education (ISE) model, on K-6 teacher candidates’ belief systems about teaching science while they were enrolled in an innovative undergraduate science methods course. The intervention was based on the NRC’s (2009) framework and was included in the course design of an undergraduate science methods course. This chapter reviews literature related to two major topics (a) belief systems in teacher education, and (b) informal science education. A number of studies have recognized the importance of teacher belief systems (Cronin-Jones, 1991; Nespor, 1987; Parajes, 1992), since it influences classroom decisions, pedagogy, and interactions. The review of literature on informal science education serves to situate the study within the larger research context of informal science education (Jung & Tonso, 2006; Olson, Cox-Petersen, & McComas, 2001; Tal & Morag, 2009; Yager, 2002).

Teacher Belief Systems

This study draws upon the literature about teacher belief systems from the field of science teacher education, and specifically, the literature on prospective teachers’ belief systems about science instruction, as well as the limited literature on prospective teachers’ belief systems about informal science instruction. Because of the messiness associated with the nature of belief systems (Aguirre & Speer, 2000; Parajes, 1992), the following definition of belief systems was used because it represented the “convergence of views” (Aguirre & Speer, 2000, p. 328) currently underpinning the literature on belief systems. In this study, teacher belief are defined as personal constructs held in clusters within belief systems gained from prior experiences and
these belief systems act as filters through which new phenomena are interpreted and subsequent behavior mediated.

I selected this definition of beliefs for the following reasons. First, the three major components of the aforementioned definition—personal constructs, experiences, and behavior—cohere with the overarching research purpose and question of the current study: “What are the teacher candidate’s beliefs systems about science instruction and specifically, what is the effect of a science methods course using an ISE model on prospective teachers’ science teaching beliefs?” In this case, the ISE model is the experience that impacts prior and new beliefs through which present and future behaviors, and pedagogical practices are determined. Secondly, this definition focuses on evaluative functions (Gess-Newsome, 1999; Nespor, 1987), experiences and behavior rather than attitudes, values and perceptions that are non-evidential (Richardson, 2003). Third, the definition focuses on logically structured components like personal constructs, experiences, and behaviors that guide actions—moving it away from issues that characterize debates about distinguishing beliefs from knowledge (Richardson, 2003). Three components of teacher beliefs (Bryan, 2012; Gess-Newsome, 1999; Nespor, 1987) that guided the framing of this study within the larger context of research about teacher beliefs are addressed in the next section.

Beliefs as Personal Constructs

As personal constructs, beliefs are part of belief systems (Bryan, 2012, Nespor, 1987; Rokeach, 1968), wherein beliefs are prioritized logically and/or illogically according to

- relationships with other beliefs forming hierarchies and complex systems,
- relationships with other cognitive and affective structures,
- the implicit and explicit nature of beliefs,
In view of this characterization of beliefs within belief systems, Bryan (2012) and others (Fletcher & Luft, 2011; Lotter, Harwood, & Bonner, 2007) contend that beliefs are predisposed to change and those beliefs that change profoundly impact the other beliefs within the belief system, which in turn logically and/or illogically prioritize in relation to other beliefs. Literature does contend that prospective teachers’ beliefs about instruction—gained and stabilized over their K-12 educational experiences—are impacted upon during teacher preparation programs (Fletcher & Luft, 2014; Parajes, 1992; Rokeach, 1968). For example, in defining characteristics of a good teacher, elementary education majors chose affective features over cognitive ones in a study conducted by Gunstone, Slattery, Baird, and Northfield (1993). In like manner, Miele (2014) assessed images of the scientist in a science methods course for early childhood teacher candidates and found that initial drawings displayed stereotypical images of scientists. By the end of the semester, candidates drew a “natural scientist”—a student, a child, or themselves—suggesting that beliefs about science and scientists can change through the impact of modified science teacher education methods courses.

According to Nespor (1987) and also Wallace and Kang (2004), teachers appear to depend on core belief systems rather than on knowledge to make decisions regarding instruction. Because beliefs are accepted indicators of behavior (Gess-Newsome, 1999; Mansour, 2008; Yero, 2002), it has been argued that teachers’ classroom behaviors have a strong relationship
with beliefs, and should be understood as a part of a complex of belief system (Wallace & Kang, 2004).

Hubbard and Abell (2005) looked at prospective elementary teachers’ beliefs about science instruction before, and after a month-long moon inquiry unit, in a science methods course. The participants were compared in regards to their previous or simultaneous enrollment in an inquiry-based physics course. The results from a beliefs questionnaire and students’ written artifacts indicated that those participants who did not experience the inquiry physics course showed the least change in their beliefs. These candidates not enrolled in an inquiry course also tended to hold onto their more limited view of science teaching as a task in which the teacher acts by disseminating information in a way that is fun for the students. Participants who had previously enrolled in the inquiry physics course appeared better able to recognize and learn from inquiry-based situations and were more capable in applying an inquiry approach to their lesson planning.

Not addressed in the literature of science teacher education are the piecing together of possible connections between specific beliefs and the instructional practices favored by teachers. If these connections were uncovered, researchers could better examine the particular practices and teacher educators could best utilize information that might contribute to change in beliefs. Brownlee, Boulton-Lewis and Purdie (2001) addressed this issue in part by collecting data that suggested that reflective practice in teacher preparation could provide key evidence for dealing with how beliefs change over time.

Interestingly, So and Watkins (2005) found that pre-service teachers’ in Hong Kong changed to a more constructivist approach by their first year of teaching providing evidence that
teaching, planning, and reflections having a relationship in the early years of a teaching career and develop over time.

Beliefs and Experiences

The review of literature indicated that beliefs as personal constructs about instruction that are situated within belief systems result from teachers’ experiences and enculturation as K-12 students, as teacher candidates (Nespor, 1987; Özgün-Koca & Şen, 2006; van Driel, Bulte, & Verloop, 2007), as novice teachers (Kang, 2008; So & Watkins, 2005), and as in-service teachers (Sanders, Borko, & Lockard, 1993). Therefore, it appears that experiences act as forerunners to the development of beliefs and that teachers are dependent on their experiences and personal understanding of similar contexts in order to deal with classroom instructional situations.

Additionally, the literature on the relationship between beliefs and experiences included the findings that teachers’ prior beliefs (despite a resistance to change), are, nonetheless, prone to change during early career teaching (Gess-Newsome, 1999; Özgün-Koca & Şen, 2006), and that experiences within teacher education programs impact the developing conceptual coherency of connections between beliefs about instruction and research-based knowledge about instruction (Gess-Newsome, 1999; Özgün-Koca & Şen, 2006; Skamp, 2001; van Driel et al., 2007). Support for the aforementioned perspectives and the relationship between beliefs and experiences is also evident within empirical studies. For example, the review of the literature on K-12 teacher candidates’, so far, claims that (a) teacher beliefs shape the learning experiences provided by teachers to students in science classrooms (Hubbard & Abell, 2005; Ogan-Bekiroglu & Akkoc, 2009), (b) teachers’ negative beliefs about science content impacted their perceptions of science content, learning, and instruction (Kelly, 2000), and (c) teachers’ beliefs, though persistent, are capable of changing but are affected by the experiences gained in teacher preparation programs
(Bryan, 2003; Hubbard & Abell, 2005; Skamp, 1989; Roehrig & Luft, 2006). Together, the interplay of experiences and prior beliefs influences teachers’ ideas about reform-based instructional strategies and/or current trends in instruction such that instruction is modified to cohere with existing beliefs about teaching (Speer, 2008).

Teacher education programs, therefore, should assist prospective teachers in recognizing their beliefs about science, and science teaching and learning, confronting evidence that may be inconsistent with those beliefs, and modifying their beliefs in view of the evidence. Researchers have also demonstrated that pre-service teachers filter their learning in the pre-service program through these preexisting beliefs (whether that filtering takes place outside their conscious thought or through conscious experiences) with guidance from instructors and other mentors, or through self-directed growth (Conkling, 2003; Dolloff, 1999; Haston & Leon-Guerrero, 2008; Schmidt, 1998).

Beliefs and Behavior

Beliefs as personal constructs derived from experiences are seen as important factors and predictors of a teacher's present and future practice. Bryan (2012) states that beliefs

- guide instructional decisions (lesson planning and assessment strategies),
- influence classroom management,
- impact the representation of the content,
- influence how teachers perceive their students and students’ learning,
- influence how they see themselves as teachers,
- provide a lens through which to understand classroom events.

This list of teacher classroom behaviors represents the consensus among researchers that beliefs are espoused theories of action used by teachers to frame and organize classroom tasks.
and problems, instead of academic knowledge gained from teacher education programs and professional development (Bryan, 2012). Thus, as determinants of teacher’s practice, beliefs are valid predictors of subsequent and future practices and also indicators of changes in practice only if they are enacted as theories in use or beliefs in use are evident in teacher classroom practice. Although past researchers, such as Nespor (1987) and Parajes (1992, 1996), pinpointed the tenant of teacher beliefs as dependent on the often ill-structured nature of authentic classrooms, current researchers claim otherwise. Results of more recent studies claim that teacher behavior is also dependent on the complex interaction between teacher beliefs and teacher actions (Bryan, 2012), and researchers further assert that teacher actions are not dependent on separate entities of teacher’s beliefs but collectively represent the belief system as a whole (Nespor, 1987). For example, Bryan’s (2003) work addressed the relationships between belief and practice. It was found that an elementary-level pre-service teacher’s beliefs about teaching science had a high level of complexity. The teacher’s belief system was characterized as containing rudimentary beliefs intertwined with the dualistic beliefs that are embedded in one another. The dualistic beliefs existed in opposition/contradiction to each other and Bryan (2003) concluded that the pre-service teacher’s future practices were dependent upon her ability to change her fundamental beliefs.

In the same way, Lester (2002) argued that beliefs explain practice because they reference an individual’s beliefs. To put it simply, beliefs impact classroom practice. In another instance, Ogan-Bekiroglu and Akkoc (2009) examined the belief-to-practice relationship. Through examination of interview and observational data, and other written artifacts, they found that the instructional beliefs of pre-service physics teachers were consistent with their pedagogical practice as displayed both in methods courses and in classroom settings.
Thus, according to research literature, beliefs play an important role in teacher preparation. The nature of teacher candidates’ beliefs about science teaching and learning, and the factors that influence those beliefs should shape the experiences provided by teacher education programs.

Synthesis

The literature reviewed led me to the following conclusions: (a) Beliefs are interconnected within a belief system. The beliefs of individuals are complex and pre-service teachers’ entering beliefs play a key role in assisting how beliefs are explored and developed. (b) Reflective practice may facilitate changes in belief. The integration of new beliefs into belief systems depends upon prior knowledge and experience. Teacher education programs play a role in the development of teachers’ beliefs about teaching and learning. (c) Beliefs are expressed in behavior. The strong relationship between beliefs can be seen in the implementation of a lesson plan.

Thus, the purpose of this study—the investigation of teacher candidates’ beliefs in relation to informal science instruction—coheres with the current focus on how K-6 teacher candidates’ beliefs influence their instruction in informal science settings and how their beliefs impact “the nature of the learning” that their future K-6 students “engage in, rather than necessarily where the learning happens” (Tal & Dierking, 2014, p. 252).

Informal Science Education

According to the National Association for Research in Science Teaching (NARST), some of the most important skills in science teaching and learning are the science process skills. These skills include observing, inferring, measuring, communicating, classifying, and experimenting (2015, NARST). Learning is an active process no matter whether the context is a formal learning
environment (such as a lecture hall), or an informal learning environment (like a playground) (NRC, 2004). A description of informal science education contexts taken from the National Science Teachers Association (NSTA) website, defines informal science learning environments as places encompassing aquariums, universities, museums, nature clubs, zoos, parks, playgrounds, libraries, websites, a student's home (NSTA, 2012). To further explain and categorize informal learning environments, one can turn to the NRC (2010), which discusses the science learning that occurs out of school time (OST). The OST environments have been categorized into three broad groups:

- informal environments (e.g., TV programs, newspapers, kitchens, conversations, and outdoors),
- designed environments (e.g., museums, planetariums, science centers, libraries, and zoos), and
- programs (e.g., science clubs, citizen science, science clubs, after-school activities, and 4-H programs).

The experiences that occur in OST environments are viewed as nonthreatening (Falk & Storksdieck, 2009; Melber & Cox-Peterson, 2005). Therefore, several stakeholders such as the National Science Foundation (NSF) and the Center for Advancement of Informal Science Education (CAISE), have drawn attention to these supplemental learning environments. Although informal learning environments cover a broad spectrum of informal spaces, some basic qualities have been agreed upon by researchers. These informal spaces are “engaging participants in multiple ways…encouraging participants to have direct interaction…providing multi-faceted portrayals of science…building on prior knowledge…and allowing participants considerable choice or control over their learning” (NRC, 2010, p.5). Learning in informal
contexts has been repeatedly seen as a key component in promoting science interest, increasing motivation, increasing dialogue, and deepening content knowledge (Kisiel, 2010; Falk & Dierking, 2000). Research on Informal Science Education

Over three decades ago, the American Association of the Advancement of Science responded to the need for science education reform through the creation of the National Science Education Standards (NSES; NRC, 1996) The NSES (NRC, 1996) called for professional development experiences for teachers of science to combine “all pertinent aspects of science and science education.” (NRC, 1996, p.59) Similarly, over the last ten years, professional education associations such as the American Educational Research Association (AERA), NSTA, and NARST have recognized the importance of making the connection between formal and informal environments and have created special interest groups (SIG) devoted to the informal context.

This section of the literature review is a synthesis of the research pertaining to informal science education within teacher preparation programs. The review of relevant literature indicated that informal science education experiences within teacher preparation programs give prospective educators experiences that are nonthreatening and comfortable, and provide for inquiry-based science teaching and learning across various contexts deserving an in-depth examination.

Informal Environments

All learning environments contribute to the cognitive, affective, social, and behavioral aspects of learning (NRC, 2009). Investigations of authentic places, such as an individuals’ own local environment provide for hands-on learning opportunities (Tal & Morag, 2009; Yager, 2002), which is a key factor in recognizing the use of spaces beyond the classroom walls as
effective contexts for science teaching and learning. The studies highlighted in this section emphasize the advantages of utilizing outdoor education.

Teacher education researchers have tried to understand self-efficacy. According to Bandura (1977), self-efficacy is a person’s attitude and belief in his or her ability to produce specified attainments. Parajes (1996) claimed that self-efficacy was part of “self-beliefs,” expectancy, and self-competence (p.545). Therefore, in teacher education programs, the study of self-efficacy provides a lens to see the effectiveness and preparedness of pre-service educators. Moseley, Reinke, & Bookout (2002) used outdoor environmental education, an informal learning environment, as a part of their science methods course at a state university. The study involved a quantitative pretest/posttest data collection design. The results of a $t$-test showed a lack of change in self-efficacy of the participants over a seven-week program. The researchers in this study suggested a need for longitudinal study. One of the foundational issues in the design of this study was the size of the sample population. The initial sample size was 63 participants, with the control group of 25 and the experimental group of 38. By the end of the study, a few participants had dropped out. When using a convenience sample, a low number of participants in a study creates a problem in running statistical analysis. Thus, future quantitative researchers need to run a power analysis prior to conducting a study but getting an ideal number of participants is difficult.

Similarly, Carrier (2009) explored elementary pre-service teachers’ self-efficacy in regards to teaching science through the collection of reflections and field notes. The qualitative research design allowed the researcher to gain a clearer understanding of authentic settings and their impact. The participants in this study were asked to teach a Project WILD lesson in an outdoor setting. The researcher discovered that initially some of the participants were nervous
and uncomfortable with teaching in an outdoor context. But within a couple of weeks in the outdoor field experience, participants’ reflections indicated that the outdoor experience created a memorable experience for the developing educators. Some of the accounts in the field notes of the participants mentioned that the interactions in this setting showed enthusiasm and excitement. The findings indicated experiential learning in an authentic setting provided for effective experience for pre-service educators. Both Moseley et al. (2002) and Carrier (2009) in their studies identified experiences that occurred in the natural environment as productive pedagogy that provided both engaging and enduring learning and was viewed by participants as a valuable part of their teacher educator programs.

Designed Environments

Descriptions of “learning by doing” and interacting with material are commonly seen in authentic environments. Designed learning environments provide learners with a variety of planned learning opportunities rich in authentic learning experiences (Orion & Hofstein, 1994). The studies in this section focus on two broad types of designed learning environments (a) museum and nature centers and (b) web-based environments.

According to Olson et al. (2001), the traditional use of museums and nature centers as venues for field trips is a widely accepted practice in K-12 systems for supplementing classroom instruction. Field trips to designed learning environments, such as science museums, have been a traditional resource for K-12 students (Chin, 2004). The adoption of field trips in teacher preparation programs has slowly gained support, as well.

In an ethnographic study, Jung and Tonso (2006) used both a museum and a nature center context as parts of an elementary science methods course. Their findings revealed that elementary pre-service teachers had positive experiences when visiting these designed learning
environments. Both of the sites allowed innovative opportunities for the participants to gain knowledge about teaching science. One advantage of this cultural anthropological design was that it allowed the elementary pre-service teacher participants to develop professional science teaching identities over time. Despite the robust design, using qualitative data such as observations and interviews that enabled data triangulation over time, the researchers stated that a pitfall in their design was its reliance on participants’ own “sense of science learning” (p.28). A recommendation made to teacher educators was to have a balance between formal and informal contexts in science methods course design.

Riedinger et al. (2011) devoted a class session in their science methods class to a field trip and another to a virtual field trip to the Marian Koshland Science Museum of the National Academies of Science. This type of use of digital media is complementary to the use of designed learning environments and can benefit science learning across multiple content areas (Hung, Lee, & Lim, 2012; Lai, Khaddage, & Knezek, 2013; Perkins, Hazelton, Erickson, & Allan, 2010). The NSTA position statement encourages the use of e-Learning and its potential to “…provide access to certain science concepts and pedagogy when appropriate tools are incorporated;…give science educators opportunities to experience firsthand the appropriate use of technology;…meet needs of students; and…reduce the isolation of science educators…by providing access to colleagues and experts” (NSTA, 2008, p.1).

Riedinger et al. (2011) used a survey instrument along with qualitative data collection methods to explore the relationship between beliefs of teacher candidates and their participation in informal science education. These researchers integrated informal science experiences into undergraduate science methods courses by means of a virtual field trip and activities such as guest speakers and live animal demonstrations. This study made connections between formal and
informal science education by providing innovative experiences. However, the findings were inconclusive. In spite of recognition of the value of informal science experiences, this study could not provide justification for the adoption of particular informal science education experiences.

Bouck, Courtad, Okolo, Englert and Heutsche, (2009) used a virtual history museum (VHM) in a universal design for learning, promoting accessible environments, and curricula. Bouck et al. (2009) suggested that VHM is a useful resource “to introduce, supplement, enhance, or review curriculum (Bouck et al., 2009, p.19). Furthermore, it is a teaching tool that helps create a more inclusive environment and equity among users. In the same way, other educational researchers have found the use of informal spaces an avenue for discussing culturally responsive pedagogy (Eshach, 2006; Blair, 2009).

Programs

Authentic learning opportunities are also provided through programs such as science clubs, Girl Scouts, 4-H, and science fairs. According to NSTA (2008), *Exemplary Science in Informal Education Settings*, these types of programs promote not only inquiry skills (observing, comparing, communicating, and researching), but life skills (self-confidence, communication, problem solving, critical thinking) as well. Research studies involving internship experiences for teacher candidates have reported the positive impact of involvement in family nights, summer camps, and science clubs. For example, Katz et al., (2011) focused on prospective teachers’ beliefs in science teaching and learning in relation to their pedagogical practices in an after-school internship. The researchers in this study were concerned with understanding the developing professional identities of prospective educators. The group of participants in this study became more confident and comfortable with teaching science as a result of their
involvement in an informal science education internship. One recommendation made from this study was to include researchers’ observations of participants while teaching to enrich the data.

Similarly, Harlow (2012) incorporated teaching experience for prospective teachers in informal contexts through teacher candidate participation in a “family science night.” In this qualitative study, the data sources included photos, reflections, class discussions, and observations. The results emphasized the need for multiple learning contexts in teacher education because they allowed the pre-service educators to experience different types of learning. Harlow (2012) stated that informal science education is not used to its fullest potential and suggested that partnerships should be created between scientists, universities, and students. Additionally, Harlow (2012) suggested measuring self-efficacy with an instrument such as the Science Teaching Efficacy Belief Instrument (STEBI-B) at the beginning and the end of the course. Use of a quantitative instrumentation, in addition to the qualitative data, was needed to gain further insight.

Next, Wallace (2013) investigated the influence of an informal learning process of action research on pre-service teachers’ thinking about teaching and learning through a qualitative interpretive case study utilizing pre- and posttest questionnaires, reflective journals, and interviews. Her study was shaped by her own prior educational experience. She found that the participants developed a deeper understanding of teaching and learning by involving pre-service educators in action research projects. The implications for teacher educators stated by Wallace (2013) were to allow for smaller, focused practice of pedagogical skills and to allow for more dialogue and reflection by prospective educators. Although this study did investigate pre-service educators’ thoughts about science teaching, learning, and action research through interviews, the questions were judged as not sufficiently content-specific; however, they did provide a
foundation on which future researchers might build. Other limitations of this study were a small number of participants and lack of sufficient explanation of pedagogical practices employed by the teacher educators.

Synthesis of Informal Science Education

The literature reviewed led me to the following conclusions: (a) informal learning environments bridge science methods course content to authentic settings; (b) the integration of informal science education increased interest and enjoyment in science teaching and learning; (c) informal contexts increase understanding of science content; and (d) outdoor field experiences increased the capabilities of future science teachers in science teaching. As research has revealed, teacher educators should not be restricted to formal classrooms. The encouraging and positive influence of informal science learning supports breaking free from classroom walls and integrating informal science education in methods coursework on a continuum from formal to informal (Carrier, 2009; Harlow, 2012; Jung & Tonso, 2006; Katz et al., 2011; Riedinger et al., 2011). Methods courses in teacher education programs have an important role in addressing needs of conceptual understanding, content knowledge, pedagogical practices, and student attitudes and beliefs; hence, ISE should be a critical component of NGSS (2013) reform efforts.

In Summary of Chapter 2

Collectively, the reviewed studies provided insights into the importance of studying prospective teachers’ beliefs as an indicator of instructional practices related to science. Pertinent research in science teacher education related to informal science education was examined indicating its positive impact on teacher candidates. These bodies of literature together lay the foundation for this dissertation study.
CHAPTER 3

METHODOLOGY

This chapter describes the research paradigm, participants, context, data sources, and data collection procedure, as well as the analysis techniques, for this mixed methods study to determine the effect of an intervention using the ISE model on K-6 teacher candidates’ belief systems about informal science teaching. Changes in K-6 teacher candidates’ belief systems were viewed as indicators of the impact of the ISE model. A sequential explanatory mixed methods design was used, and both quantitative data and qualitative data were collected (Creswell, 2013). Quantitative and qualitative data were collected to explain the significance or nonsignificance of the statistical results. The qualitative data explored the belief systems of K-6 teacher candidates and further expanded the quantitative results. Data were first analyzed separately and then merged.

The overarching question guiding the study was, “What are the teacher candidate’s beliefs systems about science instruction and specifically, what is the effect of a science methods course using an ISE model on prospective teachers’ science teaching beliefs?”

Quantitative Research Questions

1. In what ways did experience with the Informal Science Education (ISE) model affect prospective elementary teachers’ beliefs about teaching science?
   a. Were there differences in science teaching beliefs between the treatment and comparison groups?
   b. Did beliefs about participant abilities to teach science change over time?
   c. Did the effect of time (pretest and posttest) on science teaching beliefs depend on the ISE model or not?
d. Was there an interaction effect of time (pretest and posttest) and did participation in the ISE model impact the science teaching beliefs?

Qualitative Research Questions

2. What was the status of prospective elementary teachers’ beliefs about pedagogical practices in science instruction before and after a science methods course using the Informal Science Education (ISE) model?

Mixed Methods Research Questions

3. In what ways did the qualitative data contribute to a more comprehensive understanding of the statistical results from the quantitative phase of the study?

Intervention: ISE Model Design and Development

Calling attention to national reform efforts to improve science education that were proposed in the NGSS report (2013), one must recognize that there are no easy solutions to address the multitude of needs inherent in science education. Curriculum efforts and change require thought, hard work, and resources to develop effective plans and support desired results. Resources to support change extend not only to classrooms but also beyond the walls of the school, where sustainable partnerships must be built between institutions and community (Bouck et al., 2009; Jung & Tonso, 2006). Historically, science methods courses have been a vehicle for change since science teacher educators influence what is learned by the future science teachers (Howitt, 2007; Irez, 2006).

Teacher educators may wonder what parts of ISE should be integrated into a science methods course. For this study, I depended on the ISE model described in Chapter 1. This model is not fragmented. Rather, it is focused and ties together all aspects of informal science
education. Table 2 describes the desired goals and outcomes of the ISE model as I conceptualized them for pre-service elementary teachers.

Table 2

Goals of Informal Science Education Model for Pre-Service Elementary Teachers

<table>
<thead>
<tr>
<th>Goals</th>
<th>Description</th>
<th>Evidence of outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal 1 Developing Interest in Science</td>
<td>Provide a wide-range of experiences to facilitate excitement and interest to learn to teach science beyond the classroom through hands-on learning in various learning environments</td>
<td>Documented change through reflections Lesson plans using 5E</td>
</tr>
<tr>
<td>Goal 2 Understanding Scientific Knowledge</td>
<td>Modeling 5E and providing understanding of science content and concepts as well as pertinent to grade level TEKS</td>
<td>Written lesson plans</td>
</tr>
<tr>
<td>Goal 3 Engaging in Scientific Reasoning</td>
<td>Provide opportunity to test, explore, and making sense of science education in outdoor context</td>
<td>Outdoor peer-teaching microteach lessons using informal learning environments</td>
</tr>
<tr>
<td>Goal 4 Reflecting on Science</td>
<td>Require self-reflections on science teaching process as a way of knowing and processing new concepts</td>
<td>Reflections Educational Philosophy</td>
</tr>
<tr>
<td>Goal 5 Engaging in Scientific Practices</td>
<td>Enhance participation in activities through questioning and promoting engagement through teaching tools such as cooperative learning and inquiry</td>
<td>Informal Assessments of experience at Elm Fork Education Center, Project WILD and Virtual Museums</td>
</tr>
<tr>
<td>Goal 6 Identifying with the Scientific Enterprise</td>
<td>Supporting and mentoring individuals through providing a safe environment to develop professional identity as teacher and align to course objectives</td>
<td>Microteach Lesson</td>
</tr>
</tbody>
</table>

All parts of the ISE model are interrelated and capture all three OST environments (NRC, 2010): informal environments (outdoor microteach lesson), designed environments (virtual museums and nature center), and programs (Project WILD). The ISE model was purposefully designed to give attention to the sequence and clustering of concepts and interrelated processes. The purpose of the packaging of the model was to enable its easy adaptation.

Details of the Intervention Based on the ISE Model

As a researcher and facilitator for the learning of prospective elementary teachers, I considered the logistics of the intervention arising from the ISE design based on the literature (NRC 2009; NRC 2010). First, the amount of instructional time for my study was one semester, with the methods course meeting once each week for three hours. Equal amounts of time were to be allocated to both formal and informal science learning environments. The first seven weeks of the semester would be in the classroom context and the remaining seven weeks of instructional time would be devoted to informal experiences to broaden the prospective elementary teachers’ exposure to cross-contextual pedagogy for science instruction. The ISE experiences included a field trip to Elm Fork Education Center (Elm Fork) at UNT, the use of Project WILD activities, a virtual museum exploration, and outdoor space microteach sessions. Figure 1 presents the four segments of the ISE model. Each of these segments is described in more detail in Table 3, which lists details on the use of the ISE model in the design of the intervention.
Figure 1. Subcategories of Informal Science Education

Table 3
Strategies of Informal Science Education (ISE) Intervention Model

<table>
<thead>
<tr>
<th>Part of model intervention</th>
<th>Time spent</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elm Fork Education Center</td>
<td>1 class session</td>
<td>The instructor guided the prospective elementary teachers in a field trip to the Elm Fork Education Center at the University of North Texas in Denton, Texas. The prospective elementary teachers were guided through a model lesson for the “dig” and the “aquatic” experience that students from local schools experience when visiting the nature center. A visit to the Planetarium was also part of the experience.</td>
</tr>
</tbody>
</table>
Virtual museum  1 class session

The instructor guided the teacher candidates in a choice of online virtual field trips to the following websites:

- www.exploratorium.edu (The Exploratorium)
- http://www.si.edu/ (Franklin Institute Science Museum)
- http://www.mos.org/museum-online (Museum of Science)
- https://www.koshland-science-museum.org/ (Marian Koshland Science Museum ex. Earth Lab, Life Lab)

These websites were chosen based on content and ease of navigation, as well being an age-appropriate resource for the educators to be used in their own classrooms.

Outdoor microteach lesson  4 class sessions

All the participants in the treatment group utilized outdoor space as a part of their microteach lesson.

Designed Learning Environment: Elm Fork Education Center

According to Olson et al. (2001), the traditional use of museums and nature centers as venues for field trips is a widely accepted practice in Grades K-12 to supplement classroom instruction. Several studies have explored the impact of museums (Bevan & Dillon, 2010; Bybee, 2002; Kisiel, 2010; Rennie, 2007; Weiland & Akerson, 2013). This part of the ISE model has inspired a call for deeper understanding of formal and informal science educational practice (Bevan & Dillon, 2010; Melber & Cox-Peterson, 2005; Gupta, Adams, Kisiel, & DeWitt, 2010; Orion & Hofstein, 1994). Positive impacts of integrating designed learning environments, such as museums, into the science classroom have been reported by several research studies (Duran, Ballone-Duran, Haney & Beltyukova, 2009; Kisiel, 2010; Weiland & Akerson, 2013). It is crucial to point out that Jung & Tonso (2006) found the experiences of prospective educators at museums and nature centers provided experiential learning that had a positive impact on the prospective educators.

As a part of this study, the participants took a field trip to the Elm Fork Education Center, located in the Environmental Science Center, at the University of North Texas, Denton Campus. As stated on their website, “Elm Fork Education Center is the public education branch of the
University of North Texas’s Environmental Programs, which include Environmental Science, Environmental Ethics, Environmental and Community Journalism, Astronomy, Environmental Education, and the Department of Geography” ([https://efec.unt.edu/](https://efec.unt.edu/)). Elm Fork has four distinct areas—an outdoor environmental learning area, an exhibit hall, Crow Creek, and the Sky Theatre—each bringing its own unique contribution to the learning environment. This OST site acted as a vehicle for the conceptualization of the content for the methods course, offering the prospective teachers in this science methods course a chance to experience a practical, inquiry-based, real-world application of their coursework. Additionally, it allowed for the K-6 teacher candidates to not only to explore the facility as visitors but also provided a lens for prospective teachers as future teachers planning field trips.

First, the prospective teachers were presented with a lecture outlining the experiences that the center provides for a school field trip. Once the prospective teachers were given an overview of the experience, they learned how the center used the 5E lesson plan model (Bybee, 2003) in the design of their activities. Then, the participants got a chance to experience both a fossil dig and an aquatic science hands-on activity guided by the facilitator at Elm Fork. Next, the pre-service educators were asked to observe elementary school students on a field trip at the site. After this, the science methods students saw a show in the planetarium. Last, the participants were asked to design pre- and posttest activities for elementary students as an assignment for their science methods course.

Informal Learning Environment: Project WILD

Project WILD environmental education curriculum is one of the most common in-service training resources presented to science educators (Council for Environmental Education, 2005). The activities within Project WILD are socially geared for the use of outdoor spaces (Nelson,
Moseley et al. (2002) conducted a quantitative study with a three-day outdoor education program using Project WILD and they suggested more extensive research was needed to understand the impact of outdoor education and science instruction. Weiland and Morrison (2013) incorporated Project Learning Tree and Project WILD as a part of environmental education in science methods courses and found that after having the experience, pre-service educators could “envision” the use of the context and curricula. Carrier, Tugurian, and Thomson (2013) found that many participants failed to label “outdoor experience,” such as those from Project WILD and Project Learning Tree as science. Carrier et al. (2013) also suggested that the outdoor experiences helped participants make connections between the learning of science and their own comfort with school science.

The traditional six-hour Project WILD workshop engages educators by having the participants actually “doing the activities as if they were the students.” I modified the workshop time and dedicated one class session to Project WILD activities that included an informal learning context in an outdoor setting, according to the ISE model. I selected the following three activities from the Project WILD manual: *Oh Deer, How Many Bears Can Live in the Forest?*, and *Quick Frozen Critters*. The three activities are provided in Appendix A, in a Bybee (2003) 5E learning cycle format.

**Designed Learning Environment: Virtual Science Museum**

Tremendous growth in Internet technology has brought an abundance of information sources to both school and home. Technology applications have been slowly been creeping into the teaching of STEM content areas. The NSTA position statement, as referenced in Chapter 2, encourages the use of e-Learning. Similarly, Katz et al. (2011) devoted a class session in their science methods class to a virtual field trip to the Marian Koshland Science Museum of the
National Academies of Science, using this as a resource to integrate informal science education experiences into the course.

The choice of a virtual science museum in this study was an attempt to use content-specific technology, as well as to complement the Elm Fork experiences by providing another designed learning environment similar experience using educational technology. The course instructor modeled a virtual museum tour in class to the whole group. The teacher candidates were then asked to choose a virtual museum from a list and explore it on their own in order to understand the process of using such a tool. The science methods students were also assigned a written assignment about their experience. The websites were chosen based on quality of content and ease of navigation. The list of virtual museum choices in Table 4 was given to the participants.

Table 4

<table>
<thead>
<tr>
<th>Virtual Museum Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name of Website</strong></td>
</tr>
<tr>
<td>The Exploratorium</td>
</tr>
<tr>
<td>Franklin Institute Science Museum</td>
</tr>
<tr>
<td>Museum of Science</td>
</tr>
<tr>
<td>Koshland Science Museum</td>
</tr>
</tbody>
</table>

Informal Learning Environment: Outside the Classroom

Teaching is a complex task and pre-service educators moving through a teacher preparation program need as much “clinical practice” as possible (Bransford & Darling-Hammond, 2005). Moseley et al. (2002), Ballantyne and Packer (2009), and Carrier (2009)
identified experiences that occurred in the natural environment as productive pedagogy that provided both engaging and enduring learning. Important aspects of such pedagogy were hands-on investigations of authentic places and tasks in the student’s own local environment (Tal & Morag, 2009; Yager, 2002). The opportunity to participate in an outdoor learning experience is a type of experiential learning and gives science context in the real world (Blair, 2009; Sobel, 2004). Ball and Forzani (2009), Coyle (2005), Subramaniam (2013), and others call for authentic outdoor experiences as support for teaching and learning. This study asked the participants to conduct microteach sessions outside the classroom to show how they would provide authentic science-learning experiences in their future careers as science educators.

ISE Intervention Model Implementation

The science methods course schedule allocated equal numbers of class sessions for the formal classroom context and the informal education component. The review of literature provides support for use of the ISE model, which assumed many purposes in the development of the science methods course. The field trip to the Elm Fork Education Center provided an alternative context for the use of the 5E model for science lesson plans. The addition of virtual museums allowed for an innovative educational technology teaching tool that was content-specific.

Table 5 presents a timeline of the 15-week semester and the schedule of the topics for the science methods course by week.
Table 5

Topics by Week for the Semester for Treatment Group

<table>
<thead>
<tr>
<th>Week</th>
<th>Context</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Formal</td>
<td>Inquiring minds in the classroom</td>
</tr>
<tr>
<td>2</td>
<td>Formal</td>
<td>Discovering science through inquiry Science notebooks</td>
</tr>
<tr>
<td>3</td>
<td>Formal</td>
<td>Planning for inquiry</td>
</tr>
<tr>
<td>4</td>
<td>Formal</td>
<td>Inquiry and assessment</td>
</tr>
<tr>
<td>5</td>
<td>Formal</td>
<td>Inquiry and science as practice</td>
</tr>
<tr>
<td>6</td>
<td>Formal</td>
<td>Effective practices of science vocabulary instruction</td>
</tr>
<tr>
<td>7</td>
<td>Formal</td>
<td>Inquiry experiences for all children</td>
</tr>
<tr>
<td>8</td>
<td>Midterm</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Informal</td>
<td>Inquiry learning opportunities: Elm Fork Education Center</td>
</tr>
<tr>
<td>10</td>
<td>Informal</td>
<td>Professional development in support of inquiry: Project WILD</td>
</tr>
<tr>
<td>11</td>
<td>Informal</td>
<td>Inquiry support through technology: movies, virtual museums and Web 2.0</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Microteach lessons that occur outside the classroom</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Microteach lessons that occur outside the classroom</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Microteach lessons that occur outside the classroom</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Microteach lessons that occur outside the classroom</td>
</tr>
</tbody>
</table>

Selection of Mixed Methods Research Paradigm

Mixed methods studies include both qualitative and quantitative research and, therefore, contain elements of positivist (quantitative) and interpretive-constructivist (qualitative) philosophies. Greene states “the main value of mixed-method research…[is] creating a dialogue between different ways of seeing, interpreting, and knowing, not simply in combining different methods or types of data” (as cited in Maxwell, 2010, p. 478). As a result, I used both quantitative and qualitative methods in a manner that opens up the opportunity to obtain and
develop answers to research questions situated in a postpositivist research paradigm. This research design aligns with pragmatism, which utilizes transferability, allowing researchers to investigate factors that affect whether the knowledge gained can be transferred to other settings.

An additional purpose for mixed methods research is to aid in examining what others can do with the knowledge provided in the findings. Mixed methods study blends data collection and analysis methods consistent with the philosophical underpinnings of sequential mixed methods designs (Onwuegbuzie & Leech, 2006).

Since the 1980s, the field of mixed method study has gained popularity within the research community. There are a plethora of books and articles on the topic of mixed method research that help develop effective research designs. The six typologies of mixed methods research branch into two major categories, sequential and concurrent (Heyvaert, Maes, & Onghena, 2013; Leech & Onwuegbuzie, 2007). Once a sequential or concurrent mixed-method is established, the researcher can choose either a fully or partially mixed method study, which is highly dependent on the research questions raised. (Hanson, W. E., Creswell, J. W., Plano Clark, V. L., Petska, K. P., & Creswell, J. D., 2005; Heyvaert et al., 2013. Ivanovo, Creswell, and Stick (2006) and Creswell, Shope, Plano Clark, and Green (2006) suggest that when doing mixed methods research, some of the following ideas need to be taken into consideration, especially for intervention studies:

- Before Intervention
  - Have a clear understanding of the participants and context.
  - Understand the need for an intervention.

- During Intervention - Understand the impact of the intervention.
After Intervention

- Validate quantitative outcomes with qualitative voices.
- Determine the sustained effect of the intervention.

Paradigms have a high priority in the field of science. The research community has acknowledged that the ways in which researchers design and participate in the process of inquiry shapes their interpretation of findings and influences research outcomes and implications (Lincoln & Guba, 1985; Tillema, Barak, & Marcos, 2008). Thus, when starting my study, I formulated working constructs, guiding principles, and a theoretical and methodological framework to support the research questions and the design of the project.

As suggested in the literature, I would like to present my stance as a researcher. I identify with the postpositivist philosophical worldview, similar to the lens used by Gasiewski, Eagan, Garcia, Hurtado, and Chang (2012) when they designed a sequential mixed methods research design. In their study, Gasiewski et al. (2012) explored the relationship between students’ academic engagement and the instructional styles used in introductory science, technology, engineering, and mathematics (STEM) courses, utilizing both quantitative and qualitative research tools. The quantitative data included results of a survey instrument that evaluated academic engagement of students \( N = 2,873 \) in introductory STEM courses using multivariate statistical analysis to gain a general understanding of the relationship between student engagement and course instructor pedagogical style. In their hierarchal linear regression model, they found only one out of four variables to be statistically significant. In order to gain more detail and insight, the researchers collected semi-structured interview data from 41 focus groups. Gasiewski et al. (2012) found that faculty utilizing active learning strategies, as well as higher-order thinking activities in class enhanced student learning and engagement.
Since each individual experiences the world in different ways, realities are different for each individual person and context is important (Denzin & Lincoln, 2003). The constructivist paradigm assumes a subjectivist epistemology—that the knower and the responder co-create understanding (Denzin & Lincoln, 2003; Teddlie & Tashakkori, 2009). Therefore, my dissertation “effectiveness” study relies on both researcher and participants who collectively construct the meaning of a phenomenon (Day, Sammons, & Gu, 2008; Teddlie & Tashakkori, 2009). Similar to Scott (2005), I believe that knowledge must be derived from contextualized ways of knowing. As explained by Basit (2010), the epistemological assumptions underlying my dissertation research rely on the foundation of observing, participating, experiencing, and interacting. Furthermore, both ontology and epistemology underpin my axiology, which values the process more than the product of research Guba & Lincoln as cited in Morrow (2005).

Research on a Mixed-Method Continuum

Researchers who choose to conduct a mixed methods study have to consider certain procedural, implementation, methodological, and integration issues (Creswell et al., 2006; Ivankova, Creswell, & Stick, 2006). Such issues include: (a) the priority or weight given to the quantitative and qualitative data collection and analysis in the study, (b) the sequence of the data collection and analysis, and (c) the stage(s) in the research process in which the quantitative and qualitative phases are connected and how results are integrated (Morgan, 1998; Creswell, 2013).

According to Tashakkori and Teddlie (2009), a sequential mixed method design begins with a quantitative method and follows with a qualitative method. The quantitative part of my study captured beliefs about science teaching for all participants in treatment and comparison groups, through both pretesting and posttesting. The work of Kunz (1990) served as a precedent for designating a portion of the elementary pre-service educators as a comparison group for the
rest of the participants. The independent variable (IV) was the ISE intervention and the
dependent variable (DV) was participant beliefs about their abilities to teach science. The
qualitative part of the research was applied to the treatment group only and was given more
weight in data analysis. My goal was to further explain the belief systems of the participants
involved in the ISE experiences. Table 6 shows the sequence of the data collection specific to the
participants involved in the treatment group. The purpose of the integration of the data at the
conclusion of the study was to further understand the change in prospective elementary
educators' informal science teaching beliefs over the course of the semester within their belief
systems for science instruction.

Table 6
Research Design for Treatment Group

<table>
<thead>
<tr>
<th>Data Sources</th>
<th>Pre-Intervention Beliefs</th>
<th>Post-Intervention Beliefs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantitative</td>
<td>Quantitative</td>
</tr>
<tr>
<td></td>
<td>1. Survey</td>
<td>1. Survey</td>
</tr>
<tr>
<td></td>
<td>Qualitative</td>
<td>Qualitative</td>
</tr>
<tr>
<td></td>
<td>1. Drawings</td>
<td>2. Microteaching</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Lesson Plans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Observations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Semi-Structured Interviews</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Drawings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Educational Philosophy/Wordle</td>
</tr>
</tbody>
</table>

Reflections throughout the semester

Methods

Context

This study was conducted with prospective elementary teachers enrolled in seven
sections of an elementary science methods course, EDEE 4330, Science in Grades for EC-6,
taught by three different science teacher educators during the time of quantitative data collection spring 2014, fall 2014, and spring 2015 semesters at the University of North Texas (UNT). The qualitative data collection occurred during the spring 2014 semester.

The UNT College of Education had 144 full-time faculty and over 3,200 students in the undergraduate teacher education program (UNT College of Education brochure, 2015) at the time of the study. The science methods course was taken by the participants the semester before student teaching and while participants were concurrently enrolled in mathematics, English language arts, and social studies methods courses and an early field experience class, professional development school (PDS 1). Refer to Appendix B for the science methods course schedule. Upon completion of the program, the participants would be certified to teach all grades of elementary school, defined by Texas as grades K-6. Prospective participants were given consent forms approved by the university’s Institutional Review Board that explained the purpose of the study and that participation in the study was voluntary.

Selection and Description of Participants

A non-probability sampling technique was used. The participants were a convenience sample. The participants in this study were undergraduate students at UNT. They were enrolled in the teacher education program.

Participants in the Quantitative Phase

The quantitative portion of the study included participants enrolled in all sections of the science methods course. The intervention section was taught by the author and by other qualified science teacher educators. The participants were identified as the intervention (treatment group) and the group that did not receive the intervention (comparison group). Students enrolled in the comparison and treatments groups used the same textbooks and followed similar syllabi.
Appropriate Numbers of Participants

A large sample size was needed for use of an ANOVA analysis. A power analysis (Faul, Erdfelder, Buchner, & Lang, 2009) was used to determine the minimum number of participants required. The power analysis indicated a minimum effect size ($D$) of .26 and a significance criterion of $\alpha = 0.05$ (level of significance) with a power meaning of .80. Therefore, an appropriate sample size was 120 participants. Table 7 presents the actual number of completing participants in each group by ethnicity. Missing data were handled and explained in the quantitative data analysis section later in this chapter.

The 92 participants ranged in age from 21 to 47, a total of four males and 88 females. The treatment group had 17 and the comparison group had 75 participants. The unequal sizes of the groups were not viewed as a problem because the treatment group was a subset of the population being studied.

Table 7

Demographic Information for All Participants

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Comparison</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percentage</td>
</tr>
<tr>
<td>Caucasian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>5</td>
<td>7%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>22</td>
<td>30%</td>
</tr>
<tr>
<td>Asian</td>
<td>3</td>
<td>4%</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>3%</td>
</tr>
<tr>
<td>Total ($N = 92$)</td>
<td>75</td>
<td>101%</td>
</tr>
</tbody>
</table>
Participants in the Qualitative Phase

Table 8 presents information on the participants in the qualitative portion of the study. These 17 participants were enrolled in the science methods course that had been designated to receive the intervention program. The demographic information was gathered from the survey instrumentation and pseudonyms were assigned randomly. The treatment group had a higher portion of males and Asians in comparison to the sample population of the comparison group.

Table 8
Demographic Information of Participants in the Qualitative Study

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Gender</th>
<th>Ethnicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td>27</td>
<td>Female</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Mary</td>
<td>23</td>
<td>Female</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Jen</td>
<td>21</td>
<td>Female</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Dave</td>
<td>22</td>
<td>Male</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Pam</td>
<td>42</td>
<td>Female</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Jasmin</td>
<td>22</td>
<td>Female</td>
<td>Hispanic</td>
</tr>
<tr>
<td>Ann</td>
<td>21</td>
<td>Female</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Emma</td>
<td>21</td>
<td>Female</td>
<td>Hispanic</td>
</tr>
<tr>
<td>Sonya</td>
<td>22</td>
<td>Female</td>
<td>Asian</td>
</tr>
<tr>
<td>Taylor</td>
<td>24</td>
<td>Female</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Sara</td>
<td>23</td>
<td>Female</td>
<td>Asian</td>
</tr>
<tr>
<td>Dora</td>
<td>21</td>
<td>Female</td>
<td>Hispanic</td>
</tr>
<tr>
<td>Nancy</td>
<td>23</td>
<td>Female</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Hannah</td>
<td>25</td>
<td>Female</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Mia</td>
<td>22</td>
<td>Female</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Kim</td>
<td>25</td>
<td>Female</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Jason</td>
<td>32</td>
<td>Male</td>
<td>Caucasian</td>
</tr>
</tbody>
</table>
Data Sources and Collection

There were several sets of data collected as a part of this study. This section reports on the data sources for each phase of the study and the sequence of the data collection for the treatment group.

Quantitative Phase

Participants in both the treatment and comparison groups were administered the Beliefs about Teaching (BAT) survey instrument, which was developed by Yilmaz-Tüzün (2008). The BAT instrumentation was used after consultation of an expert in the science education field. Special attention was given to both the its face and content validity. The survey was administered at the beginning and also at the end of the semester. The survey was used to collect information regarding the participants’ belief systems about science teaching. The instruments also included demographic questions about gender, age, ethnicity, student ID, and instructor. The BAT uses a 5-point Likert scale response system, with five possible responses: strongly agree, agree, uncertain, disagree, and strongly disagree. The BAT also has four subscales: instructional methodologies, elementary school science, assessment, and classroom management.

Table 9 displays the Cronbach’s alpha values for each subscale provided in Yilmaz-Tüzün (2008). These values were double-checked prior to analysis using SPSS. The only part of the survey that was used in this research was the subscale on instructional methodologies. The instructional methodologies section has 19 items with a high level of internal consistency.

Table 9

Cronbach’s Alpha Statistics for Each Section of the BAT

<table>
<thead>
<tr>
<th>Section of the Instrument</th>
<th>Number of Items</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional Methodologies</td>
<td>19</td>
<td>0.91</td>
</tr>
<tr>
<td>Elementary School Science</td>
<td>20</td>
<td>0.95</td>
</tr>
<tr>
<td>Classroom Management</td>
<td>27</td>
<td>0.96</td>
</tr>
<tr>
<td>Assessment</td>
<td>13</td>
<td>0.89</td>
</tr>
</tbody>
</table>
The collection protocol for quantitative data called for the instructional methodologies subscale of the BAT to be administered at the beginning and end of the spring 2014 semester to both treatment and comparison groups. When the survey was administered during the study in spring 2014, 41 participants completed either the pretest or the posttest but only 36 completed both. To get a large enough sample size, the survey was administered again in fall 2014. This time, it was administered through Qualtrics. Again, not enough participants completed the survey in a timely manner or completed both the pretest and a posttest. The survey was administered again in the spring 2015 and 69 participants completed either the pretest or the posttest, with 56 completing both. Thus, the number of participants who completed both the pretest and the posttest was 36 (from the spring 2014 semester) and 56 (from the spring 2015 semester), which resulted in 92 total participants—an adequate sample for the study.

Although comparison group data for this study were collected over several semesters, this was not viewed as a problem for the study. During the period in question, the same master syllabus, textbook selection, and standards were in use, and all instructors met the qualifications for employment by the university department.

Qualitative Phase

Qualitative data were collected for the treatment group only. In this study, a descriptive-interpretive approach was adopted through the use of drawings, interviews, and an array of artifacts. The data sources chosen to help answer the qualitative research questions are described in the sections that follow. The drawings were placed first since they were collected prior to and after the intervention; coinciding to the quantitative data collection times. The subsequent data sources were used for rich description and to triangulate findings.
Drawings

Drawings have been used by researchers to assess response to interventions (Barman, 1997; Flick, 1990; Katz et al., 2011), and to gain insight into participant belief systems (Thomas, Pederson, & Finson, 2001) and understandings of experiences (Subramaniam, 2013; White & Gunstone, 2000). The advantages of using drawings are that they are not seen as a test by participants (Carnes, 2009) and they can supplement individuals’ lack of words to properly express themselves (Rennie & Jarvis, 1995). For this study, drawings were collected at the beginning and end of the same semester. Participants created drawings on 5”x 8” index cards. The prompt given to the participants was, “Draw a picture of yourself teaching science, and write three to five sentences describing your drawing.” The participant drawings were all scanned into a computer and saved as individual PDF files.

Observation from Microteach Lessons

Observations from participant microteach sessions enabled the researcher to use a protocol to construct a holistic picture of each participants’ pedagogical practices in relation to other data resources. The microteach observation protocol appears in Appendix C. These protocols were developed by the researcher using ideas and guidelines from the research work of Park and Ertmer (2008); Stearns, Morgan, Capraro, M., and Capraro, R. M., (2012); and Persellin and Goodrick (2010) to facilitate documentation (Patton, 2002; Yin, 2009). The protocol notes allowed for construction of a lens of completeness—beliefs in action paradigm—for each individual participant (Tobin & McRobbie, 1996). The microteach observation protocols were also scanned into a computer and saved as individual PDF files.
Interviews

Interviews were meant to assist in uncovering the understandings and belief systems of the participants about ISE. Seidman (1998) explains that at the foundation of interviewing is “understanding the experience of other people and the meaning they make out of that experience” (p. 3). In this study, it was important to understand how the participants constructed meaning and how they were influenced by the ISE experiences that might affect participants’ belief systems. Additionally, interviews were a data collection method complementary to drawings (Katz et al., 2011; Subramanian, 2013). In this study, one-on-one 30-minute participant interviews were conducted in a room adjacent to the classroom during microteach sessions. The single interview included responses to 19 questions posed to address three areas: (a) the teacher candidates’ science teaching belief systems, (b) the candidates’ perceptions of the importance of ISE throughout the methods course, and (c) the candidates’ description of science teaching. The interviews were digitally recorded using an iPad and then transcribed into a Microsoft Word document. The list of the interview questions is available in Appendix D.

Written Artifacts

Written artifacts were also collected as a part of the science methods course. The scope of the collection spanned the entire length of the course. These artifacts included reflective journals (post-microteach lesson reflections), education philosophy statements with Wordles, and lesson plans.

One of the purposes of reflective journaling is for participants to see their growth over time. The reflections also provided the prospective teachers time to grapple with new ideas, activities, and content and classroom pedagogy (Akerson & Abd-El-Khalick, 2005). However, the quality and depth of the reflections can vary from simply restating what happened, to reasons
for events, to how to use learnings in the future (Anderson & Matkins, 2011). In this study, reflective journals were used on various topics throughout the semester. On the first day of class, the teacher candidates were asked questions about themselves through a “Getting to Know You” assignment, which allowed me, as the instructor and researcher, to understand the background experiences and initial thoughts of each individual. Table 10 provides the list of reflection topics the participants were asked to complete as homework assignments in their reflective journals.

Table 10
List of Reflection Topics Used During the Semester

<table>
<thead>
<tr>
<th>Week</th>
<th>Reflection Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interactive Notebook Golden Lines</td>
</tr>
<tr>
<td>2</td>
<td>Objectives and Science Safety Websites</td>
</tr>
<tr>
<td>3</td>
<td>Effective Science Lesson</td>
</tr>
<tr>
<td>4</td>
<td>Assessment</td>
</tr>
<tr>
<td>5</td>
<td>Objective and Assessment for Water Cycle Activity</td>
</tr>
<tr>
<td>6</td>
<td>Measuring and Tools</td>
</tr>
<tr>
<td>7</td>
<td>Diversity in a Classroom</td>
</tr>
<tr>
<td>8</td>
<td>Extending beyond the classroom</td>
</tr>
<tr>
<td>9</td>
<td>Project WILD</td>
</tr>
<tr>
<td>**</td>
<td>Final Exam: Educational Philosophy and Wordles</td>
</tr>
</tbody>
</table>
Post-Microteach Lesson Reflections

Microteach lesson reflections were collected after the microteach lesson for each participant. The microteach reflections allowed the teacher candidates to share any metacognitive understanding of science teaching they experienced and also, how they perceived their development as novice practitioners. The following prompt was given to the participants as a guide:

1. List three of your major strengths of microteach lesson.
2. List three of your major weaknesses of microteach lesson.
3. What did you gain from the outdoor microteach teaching?
4. Do you think you utilized the outdoor space effectively during your microteach?
5. Do you now feel more confident about your potential as an elementary classroom science teacher? What has helped you feel this way?
6. What else might help you to improve your teaching of science?
7. Did you really enjoy a lesson your peer presented? How would you incorporate their ideas in the future?

Educational Philosophy

The students created their educational philosophies of teaching science by following these steps. First, they considered their reflections from the entire semester. Then, they created a Wordle by using important words found in their reflections that represented themselves as a science teacher. The prospective science teachers were also asked to write an one-page Word document describing their philosophy of teaching science. The Wordle they produced and their written educational philosophy were collected as part 1 of their final exam.
Lesson Plans

All participants designed and submitted three lessons plans. The Biological Sciences Curriculum Study 5E Instructional Model was used as a guideline for lesson plans (Bybee, 2003). A physical science lesson plan, a life science lesson plan, and an earth and space science lesson plan were the three broad categories of lessons assigned. Since the Earth and Space lessons were to be discussed in the microteach section, the Physical Science and the Life Science Plans were considered as the lesson plan data set for the current study. In this data set, I looked only for examples of ISE. Unlike the microteach lesson, there were no stated instructions for participants to include ISEs as part of their lesson plans.

Timeline for Data Collection

This section describes the data collection procedures for the study. Table 11 shows the schedule for the types of data that were collected for the treatment group.

Table 11

Data Collection Timeline

<table>
<thead>
<tr>
<th>Week</th>
<th>Pre/Post Intervention</th>
<th>Data Collection/ Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prior</td>
<td>Survey/ Getting to Know You</td>
</tr>
<tr>
<td>2</td>
<td>Prior</td>
<td>Drawings/Reflective Journal</td>
</tr>
<tr>
<td>3-10</td>
<td>Prior</td>
<td>Reflective Journal</td>
</tr>
<tr>
<td>11</td>
<td>Post</td>
<td>Survey/Drawings/Lesson Plans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Observation of Microteach/ Interview/Post Microteach</td>
</tr>
<tr>
<td>12-14</td>
<td>Post</td>
<td>Reflections/Lesson Plans</td>
</tr>
<tr>
<td>15</td>
<td>Post</td>
<td>Observation of Microteach/ Interview/Educational Philosophy</td>
</tr>
</tbody>
</table>
Data Analysis Overview

This section reports the data analysis procedures for the quantitative and qualitative phases of this study. The sequential explanatory mixed method study combined both quantitative and qualitative data and their associated analysis methods (Creswell, 2013). The next section presents the quantitative analysis process, including data cleaning and missing values considerations. Then, qualitative analysis methods are presented, including inductive and deductive coding. Finally, the methods used in the integration of quantitative and qualitative data are discussed.

Quantitative Analysis

All data from the survey were entered into the Statistical Package for the Social Sciences (SPSS), version 22, organized by participant ID for the treatment and the comparison groups. The four subscales of the BAT were checked for internal consistency using Cronbach’s alpha. According to Cronbach and Meehl (1955), a coefficient alpha score equal to or exceeding 0.70 indicates a strong reliability statistic on a scale of 0 to 1. The reliability of the questionnaire was measured by calculating a Cronbach’s alpha score for each of its subscales; the Cronbach’s alpha values for each sub-scale matched Table 9. The only part of the survey that used in the ANOVA analysis in this research was the subscore on instructional methodologies. The reliability of the scales exceeded the minimum and was considered adequate (DeVellis, 1991; Nunnally, 1967) for the exploratory purpose of the current study.

Data Cleaning

All statistics were tested using SPSS with an alpha level of .05, and where appropriate, effect sizes were calculated, including Cohen’s d (1988) for mean differences for ANOVA. As
reported in Table 12, the data were reviewed by running descriptive statistics, examining missing
data, and checking frequencies prior to the ANOVA analysis for Research Question 1.

Table 12
List of Quantitative Data Cleaning Procedures

<table>
<thead>
<tr>
<th>Data cleaning</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data screening</td>
<td>Conducted descriptive statistics and frequencies</td>
</tr>
<tr>
<td>Cronbach’s α</td>
<td>Calculated estimate of the reliability</td>
</tr>
</tbody>
</table>

Summary of Deleted Cases

Any participant data for which there was a missing pretest or posttest score was deleted before the analysis of data (See Table 13). The table shows the number of complete cases that were used in the analysis (N = 92); it also shows the collection of quantitative data attempts over three semesters. The fall 2014 data was not used because (a) participants either had incomplete data (missing a pretest or posttest), or (b) the data was not collected in a timely fashion. The results in Chapter 4 report the results including mean, variance, standard deviation, frequency, and descriptive statistics.

Table 13
Summary of Deleted Cases

<table>
<thead>
<tr>
<th>Semester</th>
<th>Total</th>
<th>Incomplete</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring 2014</td>
<td>41</td>
<td>5</td>
<td>36</td>
</tr>
<tr>
<td>Spring 2015</td>
<td>69</td>
<td>13</td>
<td>56</td>
</tr>
<tr>
<td>Amount of Total Cases Used</td>
<td>92</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

60
Note. Fall 2014 was not included in the data analysis

Missing Values

The problem of missing values in a data set can have serious implications for statistical analysis. Of the 92 participants using the Likert scale in the BAT, there were six missing values. Thus, there was a need to replace missing values prior to data analysis. The following formula was used to determine the percentage of missing values. Since .002% of the values were missing, in order to correct the missing values for individual participants, values were imputed by SPSS.

\[ \frac{6}{3496} = .0017 = .002\% \]

The BAT data were examined to identify teacher candidates with low scores (pretest) and those with greatest change in scores (pretest to posttest) for the mixed method data integration.

Qualitative Analysis

Analysis of the multiple types of qualitative data in this study followed recommendations for rich description of each of the participants. Redundancies in the data helped to uncover convergence of information, which allowed for triangulation and support for the findings (Stake, 2005). Figure 2 represents the importance of understanding belief systems through multifaceted data.
Figure 2. Data Triangulation Diagram

All qualitative data for each participant were organized in files under pseudonyms that were used throughout the results and findings of the study. The data for each individual was analyzed independently in order to generate thick and rich descriptions for each case. Each case profile chronicled prior and post belief systems, and possible changes in informal science instructional beliefs. A hybrid approach of deductive and inductive coding was used in this study (Fereday & Muir-Cochrane, 2006). The deductive data analysis included “arranging things in a systematic order” using the theoretical framework to develop understanding of phenomena. Whereas, the inductive approach was “intended to aid an understanding of meaning in complex data through the development of summary themes” (Thomas, 2006, p.3). The explanation of the data analysis method follows by data source.

Drawings
The drawings were identified as pre-intervention or post-intervention (Saldana, 2009 p. 8). Next, the data were deductively coded based on the scoring rubric developed by Katz et al. (2011) and shown in Appendix E: Deductive Analysis Framework. Special attention to information relating to informal science education was documented under the notes section of this rubric.

**Observations from Microteach Sessions**

The observation protocol notes were inductively coded. The protocol notes allowed for construction of a lens of completeness (beliefs in action paradigm) for each individual participant.

**Interviews**

The interview transcriptions involved several iterations of analysis that consisted of reading and coding. I read through the interview transcriptions and created codes. The codes were then combined into themes that emerged from the data.

**Written Artifacts**

All course artifacts were analyzed in the same manner. The process of analyzing textual data involved several iterations of analysis, e.g. reading and coding reflection pieces. The deductive codebook began with the six themes from the theoretical framework: (a) science interest; (b) understanding of science learning; (c) science process (d) reflecting on knowledge; (e) engaging with tools; (f) and self-scientific identity. Appendix F presents the teacher candidates’ belief systems codebook with deductive codes by the themes listed here.

During the next step, I applied inductive coding to the textual data. In this study, codes were used to capture key elements of what was described. This analytic technique as outlined in Fereday and Muir-Cochrane (2006) is iterative and during the process codes are identifying
themes, inductive codes that described a new theme not specified in the established deductive codebook were uncovered. Subsequently, these codes were clustered into broad themes. See Appendix G.

As a result, new categories discovered with regards to teacher candidates’ science instructional belief systems included: (a) affective; (b) pedagogical practice; and (c) environment. These three themes were further clustered into two broad themes, teacher candidates’ science teaching belief systems: (a) formal and (b) informal. Likewise, additional themes were discovered with regards to informal science teaching, such as (a) interactive; (b) student-driven learning; (c) expanded digital tools; (d) informal learning environments; and (e) designed learning environments. Because this study employed the hybrid approach of inductive and deductive analyses, the inductive codes extracted were not merged into the themes outlined by the deductive codes in order to gain a holistic understanding of the belief systems. An example of the coding process is given Table 14.
Table 14

Sample Inductive Coding

<table>
<thead>
<tr>
<th>Participant (Pre-Intervention)</th>
<th>Codes</th>
<th>Major Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>When I think of science, I think of experimenting, hypothesizing, learning about different systems (water cycle, body system, and learning about the different parts of the plants or body, etc...), and all the other subjects that make up science. Science has plays a huge role in education, it helps students build and improve their problem solving skills. In addition, by students receiving a good science education, then that could benefit the world in the future. I believe I have a personal and social relationship with science. Without science, I would not have a phone, computer, or be able to take medicine when I have a headache. Several positive experiences with learning science, but I learned the most when teachers used hands-on activities or incorporated interesting materials. I am not entirely worried about teaching science, so far I have enjoyed making science lessons for my classes (Kim, Getting to Know You, week 1).</td>
<td>Science process</td>
<td>Beliefs about teaching science</td>
</tr>
<tr>
<td></td>
<td>Role of science</td>
<td>importance of experimenting</td>
</tr>
<tr>
<td></td>
<td>Science benefit to world</td>
<td>problem-solving</td>
</tr>
<tr>
<td></td>
<td>Positive experience</td>
<td>hands-on</td>
</tr>
<tr>
<td></td>
<td>Approach to teaching</td>
<td>interesting</td>
</tr>
<tr>
<td></td>
<td>Teaching tool</td>
<td></td>
</tr>
</tbody>
</table>

In summary of the data analysis, Table 15 displays a visual representation of the data analysis by research question. The purpose of the table is to present the multiple sources of data and various data analysis associated with each research question.
Table 15

Data Collection and Analysis Approach

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Source</th>
<th>Data Analysis Method</th>
<th>Data Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>In what ways does the experience of ISE model affect prospective elementary teachers’ beliefs about teaching science?</td>
<td>Instrumentation</td>
<td>Descriptive</td>
<td>Data Representation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Statistics</td>
<td>Means</td>
</tr>
<tr>
<td>What is the status of prospective elementary teachers’ beliefs about pedagogical practices in science instruction before and after a science methods course using the Informal Science Education (ISE) model?</td>
<td>Drawings</td>
<td>Inferential</td>
<td>Comparison</td>
</tr>
<tr>
<td></td>
<td>Written Artifacts</td>
<td>Statistics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Observations</td>
<td>Hybrid Approach:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Semi-Structured Interviews</td>
<td>Deductive/Inductive</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Analysis</td>
<td></td>
</tr>
<tr>
<td>In what ways does the qualitative data contribute to a more comprehensive understanding of the statistical results from the quantitative phase of the study?</td>
<td>Results from Research Questions 1</td>
<td>Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and 2</td>
<td>Triangulation</td>
<td>Integration</td>
</tr>
</tbody>
</table>

Legitimation Procedures

Using the typology compiled by Onwuegbuzie and Leech (2006), I used several methods to legitimate the qualitative data. A listing of each method used and a description of how it helped legitimate the data follows.

Triangulation

The qualitative data sources provided data triangulation, as well as methodological triangulation by use of drawings, reflections, interview sessions, and observations of microteach sessions. The diverse data sources were used in order to enhance validity (Bryman, 2008; Creswell, 2013). Each data set was intended to complement the others, with the belief questionnaire providing a larger picture not possible from the qualitative data sources. The
drawings, observations, and interviews provided the depth not possible with the close-ended questionnaire. Both types of date filled in gaps and provided additional support for the analysis.

Audit Trail

Tables and figures provided extensive documentation for all parts of the study from the proposal stage, through data collection and analysis, to the integration of data sets.

Inter-Rater Reliability

This process was implemented to enhance the accuracy of the study (Bryman, 2008). A peer—a doctoral candidate in education with extensive experience with qualitative methodologies participated in a inter-rater reliability process. The peer reviewed the study and findings, asked questions about the study, and interpreted the results from the perspective of someone who was not involved in the research process. The degree of congruence was 70%.

Contrasts and Comparisons

In this study, the treatment group was a subset of the comparison group. This allowed differences to be highlighted between the groups and also improved the descriptive value of the data presented.

Referential Adequacy

Each of the interviews was recorded using an iPad and some photographs were taken during the microteach lessons (Lincoln & Guba, 1985).

Accuracy

Each interview recording was transcribed into a Microsoft Word document, as were field notes from the microteach lessons.
Negative Case Analysis

As described by Creswell and Plano Clark (2011), in order to reduce threats to internal validity by reporting this data, I identified and tried to interpret inconsistencies.

In Summary of Chapter 3: Methodology

Chapter 3 discussed the research methods used to accomplish the research objectives of this study. The chapter included discussion about

- the reasoning and description of the ISE model,
- the rationale for utilizing mixed method research design,
- the participants and context,
- the data collection procedures,
- the data analysis, and
- the legitimation issues.

I also presented the procedural issues in the sequential mixed method research with a discussion of priority, implementation, and integration issues.
CHAPTER 4
RESULTS AND FINDINGS

The main objectives of this study were to examine the impact related to an ISE intervention in an undergraduate science methods course and how use of the ISE model influenced the belief systems of prospective elementary teachers’ pedagogical practices in science teaching. Chapter 4 reports the results and findings for the study and is organized as follows: (a) answering Research Question 1 quantitatively through the ANOVA analysis, (b) answering Research Question 2 through the qualitative phase, and (c) integrating results of both the quantitative and qualitative analyses to answer Research Question 3.

Research Questions

The research questions for this study are repeated below.

Quantitative Research Questions

1. In what ways did experience with the Informal Science Education (ISE) model affect prospective elementary teachers’ beliefs about teaching science?
   a. Were there differences in science teaching beliefs between the treatment and comparison groups?
   b. Did beliefs about participant abilities to teach science change over time?
   c. Did the effect of time (pretest and posttest) on science teaching beliefs depend on the ISE model or not?
   d. Was there an interaction effect of time (pretest and posttest) and did participation in the ISE model impact the science teaching beliefs?
Qualitative Research Questions

2. What was the status of prospective elementary teachers’ beliefs about pedagogical practices in science instruction before and after a science methods course using the Informal Science Education (ISE) model?

Mixed Methods Research Questions

3. In what ways did the qualitative data contribute to a more comprehensive understanding of the statistical results from the quantitative phase of the study?

Results from the Quantitative Phase

Ninety-two participants completed both pre-and posttests of the Yilmaz-Tüzün (2008) Beliefs about Teaching (BAT) survey. The independent variable (IV) was the ISE intervention and the dependent variable (DV) was participant beliefs about their abilities to teach science.

Summary of Statistical Conditions for Quantitative Data

A close-ended Likert-scale survey was administered to participants on the first day of class and a posttest survey on the last day of class preceding the final exam. Participants completed both pre-and posttests, which measured their belief systems on four subscales. Descriptive statistics from only the instructional methodologies subscale were used in this study. The lowest score possible on the 19 questions for instructional methodology was 19 and the highest score possible was 95. Individual scores ranged from 61 to 95. Table 16 displays the participants’ scores for instructional methodologies beliefs.
Table 16

Pretest and Posttest Descriptive Statistics for Instructional Methodologies Belief Systems

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>17</td>
<td>72.71</td>
<td>7.08</td>
<td>.518</td>
<td>-.915</td>
</tr>
<tr>
<td>Posttest</td>
<td>17</td>
<td>84.47</td>
<td>7.04</td>
<td>-.634</td>
<td>-.512</td>
</tr>
<tr>
<td>Comparison Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>75</td>
<td>75.58</td>
<td>8.22</td>
<td>.451</td>
<td>-.588</td>
</tr>
<tr>
<td>Posttest</td>
<td>75</td>
<td>80.57</td>
<td>8.52</td>
<td>-.070</td>
<td>-1.024</td>
</tr>
</tbody>
</table>

The data distributions for both pretest and posttest scores are illustrated in the histograms in Figure 3 and Figure 4.

*Figure 3. Distribution of Data Treatment Group*
Test of Normality

Before the data were analyzed, basic assumptions were evaluated. For the dependent variable (Beliefs about Teaching Science), assumptions of normality and homogeneity of variance were tested for the entire instrument. In Table 16, the evaluation of the skewness and kurtosis coefficients are displayed; no distributions exceeded the critical values for skewness or kurtosis statistics of participants’ belief systems about science teaching. Thus, the data were assumed to be normally distributed. The Mauchly’s test, assumption of sphericity, was violated at the $p > .05$ level. Violations of sphericity can result in an increased Type 1 error rate. Therefore, using SPSS, the degrees of freedom were corrected using the estimates of sphericity arising from the Greenhouse-Geisser adjustments to the $F$-statistics in a one-way analysis of variance (ANOVA). All inferences made from the ANOVA analysis were performed using the adjusted Greenhouse-Geisser ($\varepsilon = 0.00$) for time and Greenhouse-Geisser ($\varepsilon = 0.06$) for time x group. I also performed a check of boxplots, shown in Figure 5, to visually inspect outliers; no outliers were indicated.
Test of Variance/Covariance

Box’s Test of Equality of Covariance was used to determine the homogeneity of variance (i.e., equal covariance matrices) across groups. Results indicated Box’s $M$ homogeneity of variance was not statistically significant. Thus I accepted that the data met the assumption that Box’s $M = 1.51$, $F (3, 11119.77) = 480$, $p = .697$, which is greater than $p > .05$.

![Boxplots for Treatment and Comparison Groups](image)

*Figure 5. Boxplots for Treatment and Comparison Groups*

Answering Research Question 1

Although results indicated that there was no statistically significant difference between the change in scores on the instructional methodologies subscale of the BAT for the treatment and comparison groups, any differences between groups and their differences over time were also explored through the qualitative analysis.
Research Question 1a

Differences between science teaching belief systems for the treatment and comparison groups were evaluated by using a 2 (time) X 2 (group) mixed factorial ANOVA analysis at $\alpha = .05$ (See Table 17).

Null Hypothesis

The participants in the treatment and comparison group will have no difference in change in their science teaching beliefs ($H_0 : \mu_1 = \mu_2$)

Alternative Hypothesis

The participants in the treatment group will have a statistically significant difference in change in belief systems about science teaching compared to the comparison group ($H_a : \mu_1 \geq \mu_2$)

A one-way ANOVA, administered through a 19-question survey, was conducted to determine differences between two groups of participants’ belief systems about teaching science. The participants were divided into two groups: treatment ($n = 17$) and comparison ($n = 75$). The treatment group pretest scores ($M = 72.71$, $SD = 7.08$) and posttest score scores ($M = 84.47$, $SD = 7.04$); and the comparison group pretest scores ($M = 75.58$, $SD = 8.22$) and posttest scores ($M = 80.57$, $SD = 8.52$) indicated that there was a difference between the treatment and comparison group participants. However, being in the treatment or comparison group only accounted for a small variance in beliefs about science teaching. Thus, the null hypothesis for Research Question 1a was not rejected because the results did not indicate statistical significance. However, the participants in the ISE model treatment group showed greater change in their beliefs about science teaching than participants in the comparison group.
Research Question 1b

A repeated measures ANOVA analysis was used to determine whether there were any significant differences in participants’ belief systems about science teaching from pretest to posttest.

Null Hypothesis

The participants’ science teaching belief systems will not change over time (H0: µ1=µ2).

Alternative Hypothesis

The participants’ science teaching belief systems will change over time (Ha: µ1≠µ2).

Results indicate there were changes in participants’ belief systems from the time that the pretest was administered to the time of collection of the posttest data for both the treatment group and the comparison group. The results of the repeated-measures ANOVA revealed a change in the participants’ belief systems about science teaching; there was a statistically significant difference over time from pretest to posttest, \( F(1,90) = 51.966, \ p < .001, \ \eta^2 = .347. \)

Table 17

Mixed Factorial ANOVA Table

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig (p)</th>
<th>Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within Subjects Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time: Pre/Post</td>
<td>1988.15</td>
<td>1</td>
<td>1988.150</td>
<td>51.966</td>
<td>.000</td>
<td>.347</td>
</tr>
<tr>
<td>Interaction:</td>
<td>301</td>
<td>1</td>
<td>301.00</td>
<td>7.872</td>
<td>.006</td>
<td>.053</td>
</tr>
<tr>
<td>Time*Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>3441.325</td>
<td>90</td>
<td>38.237</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
An effect size metric is measured by the multivariate based on eta-squared. By
convention, effect sizes of 0.01, 0.06, and 0.14 are termed small, medium, and large, respectively
(Cohen, 1988). The results indicated that a statistically significant difference did exist for time
$F(1,90) = 1.996$, $p < .001$: Wilk’s lambda = .634, $\eta^2 = .347$. Therefore, 34.7% of the variability in
the dependent variable can be explained by time. In this study, there was a large effect size in the
strength of the relationship between belief systems about science teaching and time. These results
indicate that the overall belief systems for both groups improved across time ($p < .05$).

Research Question 1c

Is there an interaction effect of time (pretest and posttest) and participation in the ISE
intervention on the participants’ science teaching beliefs? In order to answer the question,
ANOVA analysis at $\alpha = .05$ was used to compare differences between the treatment and
comparison groups across time.

Null Hypothesis

There is no interaction effect ($H_0: \mu_1=\mu_2$).

Alternative Hypothesis

There is an interaction effect on science teaching beliefs ($H_a: \mu_1 \geq \mu_2$).
The ANOVA analysis indicated there was no statistical significance for overall differences in belief systems between the groups, as shown in Table 18. In spite of this lack of significance, participants in the treatment group did have a slightly larger increase in scores compared to those in the comparison group.

Table 17 and Figure 6 show that a statistically significant interaction effect of time and group existed for the treatment group, $F(1, 90) = 7.8772, p < .01, \eta^2 = .053$; therefore, the null hypothesis was rejected in favor of the alternative hypothesis. The scores representing participants’ belief about science teaching improved upon completion of the science methods course for both groups. The findings suggest that the methods course, regardless of the treatment or the comparison group, was associated with increases in science teaching belief scores. However, the treatment group’s slope is steeper than the slope of the comparison group.

Overall, participants in the treatment group showed a greater change in scores than participants in the comparison group in their beliefs about science teaching instructional methodologies, although this difference was not statistically significant. Furthermore, the effect of time was statically significant; however, the effect group was not statistically significant.
Findings from the Qualitative Phase

This section addresses the qualitative research question: What was the status of participants’ belief systems about pedagogical practices in science instruction before and after a science methods course using the ISE model?

Belief Systems

Participants’ pedagogical beliefs about science teaching prior to the implementation of the ISE model were derived from the analysis of three data sets: drawings, journal entries from “The Getting to Know You” assignment given as homework to participants in the first week of the science methods course, and participants written reflections. Participants’ pedagogical beliefs about science teaching after the implementation of the ISE model were derived from the analysis.
of the following data sets: drawings, written reflections, instructor observations of participants’ microteaching sessions, participants’ self-reviews of their self-microteaching sessions, semi-structured interviews, and participants’ written philosophy papers with Wordles about science teaching. Table 18 summarizes the participants’ belief system according to the data prior to and after the implementation of the ISE model. Since the purpose of this study was to investigate participants’ overall pedagogical beliefs and to highlight beliefs related to informal science instruction. The sets of beliefs prior to and after the ISE intervention are described in the sections that follow to indicate that participants’ beliefs were embedded within their belief systems for science teaching.

The participants’ beliefs specific to ISE were not separated from other data because they are inseparable from their belief systems. This section is unique in its presentation of ISE as a part of a larger belief system that varies from individual to individual. Glimpses of ISE are interwoven throughout this phase of the data analysis.
Table 18

Participants’ Beliefs

<table>
<thead>
<tr>
<th>Common Features of Participants’ Belief Systems for Science Teaching</th>
<th>Participants’ Beliefs Prior to ISE Model Implementation</th>
<th>Participants’ Beliefs After the ISE Model Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Affective: Uncomfortable and Apprehensive</strong></td>
<td>A. Affective: Confident and Comfortable</td>
<td>1a. Hands-on and Science Process skills</td>
</tr>
<tr>
<td><strong>B. Pedagogical Practice</strong></td>
<td>1b. Science process skills</td>
<td>1. Approach</td>
</tr>
<tr>
<td>1. Approach</td>
<td>1c. Real-World</td>
<td>2. Tools</td>
</tr>
<tr>
<td>2a. Classic Tools</td>
<td>2b. Digital Tools</td>
<td></td>
</tr>
<tr>
<td>2c. Learning Environment as a Tool</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. Environment</strong></td>
<td>1. Supportive</td>
<td>1. Supportive and Inclusive</td>
</tr>
<tr>
<td>2. Inclusive</td>
<td></td>
<td>2. Collaborative Groups</td>
</tr>
<tr>
<td><strong>Participants’ Beliefs Specific to Informal Science Teaching</strong></td>
<td></td>
<td>3. Variety of Learning Environment</td>
</tr>
<tr>
<td><strong>A. Affective (Confidence)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. Instructional Practice (Interactive Hands-on, Free-Choice Student-Driven Approach, Expanded Digital Tools –Media, Virtual Museums, iPads for documenting–)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. Environment (Outdoor Informal Learning Environment, Museum and Zoo Designed Learning Environment)</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

80
Beliefs about Teaching Science Prior to Intervention

Uncomfortable and Apprehensive

Participants’ belief systems about teaching science prior to the implementation of the ISE intervention were predominantly centered on their uneasiness about teaching science. Their hesitation was related primarily to concerns about their limited science content knowledge. The quotes below indicate participants’ hesitancy as related to their limited science content knowledge.

- As of right now, I would not be comfortable teaching science because of my limited knowledge on a majority of science related topics. (Sara, *Getting to Know You*, Week 1)
- I feel a little nervous that I will not have the knowledge to teach science. (Pam, *Getting to Know You*, Week 1)
- I am a little apprehensive about teaching science. I don’t feel that I have enough experience or knowledge about the topics that I will have to teach. (Jen, *Getting to Know You*, Week 1)
- I personally feel a little nervous, because I feel unknowledgeable about the topics. (Mia, *Getting to Know You*, Week 1).
- My confidence is building but it is my weakest subject. (Nancy, *Getting to Know You*, Week 1)

I noted these issues as a researcher but more importantly as the instructor of the science methods course. Seven of the participants enrolled in the treatment group did not feel comfortable or were not confident in teaching science. These comments allowed me to be aware of the emotional support that the participants needed.

Initial Beliefs about Pedagogical Practices
All participants believed that a student-centered approach to teaching involving “doing” science. For instance, Dave wrote, “My belief is that science in elementary [grades] is learned through doing, as you get to create your own inquiries and ideas…through experimentation.” (Dave, Week 3 Reflection) Several participants described “doing” science through hands-on science and others indicated words explicit to science process skills. My analysis of the themes of “teaching approach” and “process” is included in the sub-themes, (a) hands-on, (b) science process skills and (c) real-world connections. The sections that follow consider participants understandings of the three subthemes.

Hands-on

Several of the participants emphasized beliefs that student learning involved performing hands-on activities. For example, Kim reported, “Several positive experiences with learning science, [I] learned the most when teachers used hands-on activities or incorporated interesting materials.” (Kim, Getting to Know You, Week 1). In one of her first reflections Emma wrote:

I believe the way to plan an effective lesson is by first, deciding what you want the students to take away from the lesson…Having the students participate in an experiment really helps make the information more meaningful and memorable. This means for me that I need to plan carefully when developing science lessons. I need to be sure to know my students well enough to understand their zones of proximal development. (Emma, Week 3 Reflection)

Emma’s idea about experimentation was illustrated in her drawing at the beginning of the semester (See Figure 7). Her drawing depicted herself with a long ponytail and wearing a lab coat
Science Process Skills

Some participant responses used terms that identified science process skills. Hannah said,
Science encompasses many things; plants to animals, rocks, and minerals, bodies of water to the atmosphere, etc. Science is the study of the earth to how things work. It is all around us and ever-changing. Science is ever changing. There are always things to discover, learn, explore, and identify. I am excited and nervous about teaching science. I feel that science can be fun and interesting, but at the same time it is intimidating to teach. I like the fact that there is so much to learn and many opportunities to discover and access information. (Hannah, Getting to Know You, Week 1)
In another example, Dora commented,

I have to be really aware of what I want my students to learn in the classroom. I have to be familiar with the science TEKS and the concepts…different methods of assessments…use ‘hands on activities’ to provide my students ‘the best experience while learning science.’” (Dora, Week 3 Reflection)

Real-World Connections

Several participants declared the need to connect science topics to applications of information to the real world. Mia voiced her beliefs about making connections to the real world when she identified with science as a big part of education. Mia claimed that

[s]cience can be categorized into four subjects: biology, physics, chemistry, and earth science, and sciences teaches [sic] how the world works. In education, science is how the students know things work and connect.” (Mia, Getting to Know You, Week 1).

Mary’s pre-intervention illustration showed learning about phenomena in the natural world (See Figure 8).
Figure 8. Mary’s Pre-ISE Drawing
Another example of real-world connection to science teaching beliefs was expressed by Kim,

I believe that exemplary science teaching in PK-6 and even up to higher grades
would have differentiated instruction….One of the most important things as an
educator is to respect all learners and accommodate as much as possible so you
can set the student up to succeed…Another example of exemplary science
teaching is incorporating many hands-on activities and using topics that their
students are interested in. (Kim, Week 6 Reflection)

Engaging Student Interest

A sense of enjoyment, fun, value, creativity, curiosity, excitement, and student interest
was mentioned several times by a majority of the participants. The concept of fun was first seen
in the Getting to Know You assignment from Week 1 of the course. For example, Amy stated,

I have always enjoyed science….I remember playing a game where we used a
coin to determine our genes….I always enjoy hands-on activities, such as
analyzing soil…I like science and feel it’s absolutely necessary….” (Amy,

Getting to Know You, Week 1)

Jasmin’s pre-intervention drawing narrative was unique since she identified with reflecting and
the continuum of life-long learning. She wrote,

I believe in on-going learning and growing. I love the fact that science changes so
often, and I believe that making sure we keep our minds keen is extremely
important. I want my students to love science and science learning. (Jasmin, Pre-
ISE Narrative)

Another participant, Emma, wrote:
I believe the way to plan an effective lesson is by first, deciding what you want the students to take away from the lesson…Having the students participate in an experiment really helps make the information more meaningful and memorable.” (Emma, Week 3 Reflection).

Jason identified with the sentiment that we should make learning interesting for students. In one of his reflections he said,

[S]tudents will be required to reflect on the lessons that were presented and connect them to other concepts with which they are already familiar. This will help the lesson connect to their interests and reality and allow them to determine if they have truly grasped the concepts. (Jason, Week 5 Reflection)

Sonya also focused on students’ interests as part of her lesson planning, stating

[W]hen planning a science lesson, my question to myself is what I want students to take away from the lesson. A big part of designing a science lesson plan is to make it so that it sparks interest in the students and initiates a greater desire in discovering more about it. (Sonya, Week 3 Reflection)

Science Teaching Tools

Based on some responses of participants about their beliefs, tools for science teaching were categorized into three themes: classic teaching tools, digital tools, or learning environment as a tool. It is important to note that not all participants mentioned tools as part of their belief systems at the beginning of the semester. Table 19 contains a summary of science teaching tools.
Table 19

Summary of Science Teaching Tools Identified in Data Sources

<table>
<thead>
<tr>
<th>Classic</th>
<th>Digital</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple</td>
<td>Simple</td>
<td>Traditional</td>
</tr>
<tr>
<td>Complex</td>
<td>Complex</td>
<td>Non-Traditional</td>
</tr>
<tr>
<td>Books</td>
<td>MythBusters</td>
<td>Classroom</td>
</tr>
<tr>
<td>Fossil &amp; rocks</td>
<td>NASA</td>
<td>Outdoors/Park</td>
</tr>
<tr>
<td>Notebooks</td>
<td>Telescope/Flask</td>
<td>Bill Nye</td>
</tr>
<tr>
<td>Worksheets</td>
<td>BrainPop</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Museum/Zoo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Learning games</td>
</tr>
</tbody>
</table>

Responses that featured laboratory settings with notebooks for documenting and lab equipment were classified as using classic tools for science teaching. Responses in which tools used educational technology such as websites, iPads, videos or games were included in the digital tools. Responses in which the learning environment was used as a tool were classified as “environment.”

Participants’ beliefs about use of tools for learning fell into two distinct themes. Tools for learning were categorized as simple or complex. Where the focus was on students’ finding predetermined or right answers or outcomes for experiments or questions, responses were categorized as simple. Educational technology can be a complex vehicle for student motivation and learning. Examples of complex digital technology tools include seeing a YouTube video, watching a shoe, or visiting a website, but these are vague in showing value for the use of the tool. More genuinely complex examples were tools students could use to make connections between science content knowledge, apply scientific information, and/or transfer science content knowledge to new contexts. Using an out-of-classroom context for a change of scenery is not using a resource to its potential. Examples were pulled from participant drawings and quotations and from narratives to reflect their beliefs about the use of each kind of tool.
Classic Tools

At the beginning of the methods course, four participants expressed beliefs about use of classic tools in science teaching. They recognized that tools fell on a spectrum of simple to complex. During one of the first assignments in class Amy told me,

I have always enjoyed science, with the exception of chemistry; my 7th grade teacher brought tangible objects, such as fossils and rocks. I remember playing a game where we used a coin to determine our genes… I always enjoy hands-on activities, such as analyzing soil… I like science and feel it’s absolutely necessary.” (Amy, Getting to Know You, Week 1)

Later, in one of her reflections, Amy identified the use of notebooks as a classic tool to help students monitor their own learning by having them “look back and reflect” and using “portfolios” to monitor students’ growth and progress over time (Amy, Week 4 Reflection).

Emma in her pre-intervention narrative said,

You will notice a variety of equipment to use to better study different aspects of science. You will also notice a book shelf with lots of books as a reference, as a resource, and a quote of inquiry on the wall for encouragement.

She further displayed these ideas in one of her first reflections, writing,

I believe the way to plan an effective lesson is by first deciding what you want the students to take away from the lesson… Having the students participate in an experiment really helps make the information more meaningful and memorable.

(Emma, Week 3 Reflection)

From this statement, I can infer that this participant is referring to classic tools.
Examples from Dora and Ann (See Figure 9) showed the use of a telescope, a classic tool for scientists exploring the night sky. In Dora’s drawing, she depicted herself as a scientist wearing a lab coat using a telescope. In her narrative she stated the use of science equipment as a means of “studying the universe…the stars and the planets.” (Dora, Pre-ISE Drawing Narrative) In the same fashion, Ann’s illustration showed the use of a telescope. She wrote, “looking through the telescope” about to “make the next big discovery in space” (Ann, Pre-ISE Drawing Narrative). These examples claim a classic use of a telescope as tool and the incorporation of an outdoor space as a learning environment tool.
Figure 9. Pre-ISE Drawings for Dora and Ann
Digital Tools

Two participants expressed beliefs about using digital tools in science teaching at the beginning of the methods courses. Sonya acknowledged the use of videos as a means of solidifying the learning of scientific concepts,

When the students are studying a particular science concept, this site can be useful in a way where it provides various activities and videos the students can explore to help them grasp the concepts being learned. They will be able to make real-life connections with what they are learning in the classroom and explore them.

(Sonya, Week 3 Reflection)

Jason showed his awareness of the use of media, such as “MythBusters” to engage students’ interest. He also recognized the classic worksheet as a part of a teacher’s toolbox that can be “not as fun.” Amy agreed with the use of additional resources, saying,

I would suggest useful articles and science books for them to look at with their children and explain why they are useful. I would also refer them to the NTSA site as well as some others such as NASA and National Geographic that have educational science games for kids. (Amy, Week 5 Reflection)

Learning Environment as a Tool

Amy mentioned digital tools that were part of designed learning environments in Week 5, noting, “I would also refer them [students to websites]…that have educational science games for kids. I would also encourage inquiry in everyday situations, as well as trips to zoos, museums, nature centers, etc.” (Amy, Week 5 Reflection).

On the first day of class, Jen told me that she aspired to make learning fun as an important belief about teaching and how past experiences had shaped her learning. Jen’s
illustration (See Figure 10) showed her knowledge of using the outdoor context as part of her teaching tools.

Dave’s thoughts were later expressed in his reflection, which emphasized the diversity in a society. After the Inquiry for All session, he wrote,

Diversity in the classroom is on the rise! I suppose that means you have to increase your “teacher effectiveness scope” to keep up…communication is the
first step I would focus on when trying to improve on my teaching methods with diverse learners. This includes your direct communication with your learners …consciously designing and altering your [science] centers you give your students, especially English Language Learners, an opportunity to build on…strategies that help students intake language, also absorbing the present content. We have GLAD (Guided Language Acquisition Design)….Multimedia allows students to follow-up on their own relevant inquiries…(Dave, Week 7 Reflection)

According to Dave, expressed in his Week 7 reflection, society today was more diverse than ever, and therefore, it was important that people from diverse background were able to communicate and work together. Similarly, Jason shed light on his beliefs about instructional tools to support the needs of learners. In his reflection Jason commented,

[D]ifferences have begun to be acknowledged, and it is expected that teachers teach in a differentiated way and are more sensitive to all students’ needs… This may be a daunting task but in actuality turns out to produce well rounded thinkers that understand the intricacies and core elements of a concept. This can be no more true [for] ELLs [English Language Learners]. It is imperative to emphasize language… [and] breaking down concepts….Another technique for a diversified classroom is using lots of media whether this is a pictures or videos….One last technique that can be utilize[d] for ELLs is to use a Word Wall which lists all of the academic vocabulary (Jason, Week 7 Reflection)

Jason, like Dave, anticipated the use of digital tools to support English Language Learners (ELL).
Last, Sara in her drawing and narrative, provided evidence of her beliefs about science teaching (See Figure 12). She valued engaging discussion when it came to science teaching and learning. She represented the sharing of ideas through bubble representations in her drawing. In her narrative she stated, ”everyone has something to share…I would like to work in a setting where everyone is welcoming and supportive with each other.” (Sara, *Pre-ISE Drawing Narrative*)
Figure 111. Sara’s Pre-ISE Drawing
Summary of Initial Beliefs of Prospective Elementary Teachers

After examining the participants’ beliefs at the beginning of the semester through drawings, narratives, and written artifacts, it was evident to me that the participants were limited in scope in regards to teaching science content, instructional tools, and learning environments. Several participants shared their anxiety about teaching science content. Despite participants’ use of key phrases such as hands-on and real-world, their pedagogical toolbox was limited to classic tools of scientists such as test tubes and telescopes. The participants did not share information regarding ISE despite having shared this information as part of the meet and greet discussion on the first day of class, when I had asked them to introduce themselves by the school to which they were assigned to observe for PDS1, by saying what inspired them to choose teaching as a profession, and by telling the places they had visited as an extension of their school educational experiences. The informal environments mentioned were Perot Museum, Dallas World Aquarium, Dallas Arboretum, Dallas Zoo, Fort Worth Zoo, Fort Worth Science Museum, U.S. Bureau of Engraving and Printing in Fort Worth, Children’s Museum, and waste water treatment plant.

Prospective Elementary Teachers’ Profiles After ISE Intervention

At the end of the semester, participants’ beliefs about science teaching were analyzed through drawings, lesson plans, educational philosophy, Wordles, and reflections. Examples of ISE are integrated into the discussion of science teaching beliefs that follows.

By the end of the semester, participants expressed a more in-depth view of teaching. Data indicated participants’ beliefs were not only part of their articulated belief systems but were demonstrated in their microteach lessons. Jason had one of the most verbose of the Wordles collected for this study. His teaching beliefs aligned with progressivism. He wrote:
I believe that what we learn in school should reflect the real world... I like hands-on, inquiry based learning which teaches children how to think for themselves so that they may function in society in a productive way, not as a drone that is only able to recall information.” (Jason, *Teaching Philosophy*)

The complexity of his beliefs can be seen in Jason’s Wordle (see Figure 13).

![Figure 12. Jason’s Wordle](image)

Confident and Comfortable

By the end of the semester, participants showed increased comfort with and positive dispositions towards science teaching. This change was clearly identified in participants’ microteach reflections, educational philosophies, and interviews. For example, during her
interview, Nancy mentioned that the Elm Fork experience was the one she enjoyed the most, and her advice to future science methods instructors was that Elm Fork “should be part of the course.” Nancy said she felt “more confident” in teaching science through encouragement, lesson planning, and microteaching (Nancy, Interview Data). Her evolution occurred through more experience in teaching science, initially with a physical science short demonstration, and later by developing and modifying her microteach lesson, teaching it, getting feedback from peers, and writing a final microteach reflection. All participants created other lesson plans and an engineering unit as part of the course requirements.

Pam in her microteach reflection was able to identify one of her strengths in instructional practice. In Pam’s microteach, she took the students outdoors to “find things” they could recycle, reduce, reuse or upcycle (Pam, Microteach Field Notes). She facilitated this task by providing a scavenger hunt worksheet. In Pam’s reflection she wrote,

I believe that one of the strengths of my lessons were the examples I provided to the class. The upcycled bottle as well as the visuals in the power point seemed to get their attention. They were fun but also creative, so I think it makes people look at items we throw away differently. I think the reusable lunch items I shared were good, as well, because that shows students a direct way that they can help.

(Pam, Microteach Reflection)

Pam’s lesson kept the students attentive because she shared the relevance in everyday life of the concept, “recycle, reduce, reuse or upcycle” and showed examples. Pam provided a worksheet to document objects that students found during the outdoor exploration and walked around to question groups of participants about what they had discovered and to explore possibilities for recycling or upcycling. Finally, in Jasmin’s interview, she commented, “I love teaching younger
kids about science because there’s so many more hands-on activities you can do with them!” (Jasmin, Interview Data).

Pedagogical Practice

Participants’ descriptions of classroom science were consistently identified with the process of hands-on learning. Although this concept was seen at the beginning of the semester in multiple data sets, participant growth in the spectrum of how to use hands-on conveyed more complex ideas of the quality of effective instructional practice. A picture of the participants at the Elm Fork archeological dig site involved in the Explore part of the field trip, showing participants interaction with science tools as a part of their experiential learning (see Figure 14).

Figure 13. Archeological Dig Site at Elm Fork Education Center

Hands-On and Science Process Skills
The outdoor context was used in Ann’s post-intervention drawing. Her narrative provided details about her beliefs about teaching and learning. She wrote:

When I see myself as a teacher of science, I imagine being outside in nature. I want to teach my students about how food grows, the water cycle, and weather. I believe that students learn hands-on and I want to provide my students with that opportunity. Even if there are no funds to buy anything. I am still going to have them observe the world around them and make it meaningful to them. (Ann, Post-Drawing Narrative)

Ann’s Wordle (see Figure 15) did not explicitly use the word hands-on but displayed words such as “analyzing,” “explore,” and “research” alluding to her beliefs about teaching science and the incorporation of hands-on instructional practice across learning contexts.

Figure 14. Ann’s Wordle
After engaging in the ISE intervention, Dora depicted science teaching in a classroom setting with different science centers. Her post-narrative stated:

In my drawing I am teaching my students science by having them experiment. They are working together, experimenting, writing, and gathering their own data and doing research. It’s important for students to take part in their education by participating in inquiry-based lesson and collaborating with others. (Dora, Post-Drawing Narrative)

Dora’s drawing lacked evidence of interaction between students by words or bubbles despite her claim of collaboration in the narrative. It also lacked evidence of students’ manipulating scientific tools, but the drawing did display three science centers: 1) science equipment, 2) computers, and 3) a book/notebook with writing on it (see Figure 16). Dora’s narrative further explained her intention of including science process skills in her teaching approach and incorporating hands-on and student self-exploration in science centers.
Fun and Messy

A sense of enjoyment, fun, value, creativity, curiosity, excitement building of personal confidence was evident in the statements of several participants throughout the semester that science should be fun. For example, Jason mentioned,

In my experience, everyone, including adults, loves a fun game. Often times I feel that instructors forget this. I don't care what the age level is, if you make something fun, people will learn it organically. When people learn things organically, they remember those things. I have learned so many things through studying and cramming, and guess what? I may remember them for the test, but I forget after that. However, when I learn in a fun way, I naturally remember.

(Jason, Interview Data)
Dora had a firm belief that science teaching and learning required active participation as seen in her pre-intervention drawing where she is using a telescope to observe the night sky. After the Project WILD activities, she commented that she had remembered an activity from her elementary school experience, stating, “…[the] games we played were fun and engaging; I would love to incorporate these games in my class in the future….Doing things as simple as these games is a great way to help” students learn. She also recalled when she “actually played the deer game (Oh Deer) in elementary school” and

I still remember what a great experience it was. Kids will have a great time playing these games … I want to use these games in my own classroom. They are very engaging and get the kids moving, and it’s educational. (Dora, Week 11 Reflection)

Kate also said she recalled students on a field trip playing Mixed Freeze Critters,

I enjoyed going outside to play games we could use with our students. Just like elementary students, we also like to go outside and play. It is a nice change to the normal class day. The first game we played was the deer game. The deer could choose shelter, water or food. I think this is a fun game to help students understand scarcity and over population. The second game was one where students could pretend to be bears and had to gather food. There was a wounded bear and a mama bear with cubs. This was a fun game and teaches students ideas similar to the deer game…. Mixed Critters Freeze was one that I had seen played on a second grade field trip. The students played the game in an area where there
was prey that would needed to hide. The kids loved it, and I think we had just as much fun. (Kate, Interview Data)

Sonya added:

I think having students role-play in the two different games is a good way to help them develop understanding of basic essentials needed for all different types of animals. Even one of the TEKS addresses the basic needs of animals, such as food, water, and shelter. These activities are the perfect way to introduce or reinforce what animals need to survive. (Sonya, Week 11 Reflection)

Dora identified her own strengths while teaching her peers during her microteach lesson and revisited her confidence in her reflective piece. She wrote, “[m]y activity allowed my students to play the roles of the Lorax and the Oncler and replay the effects of cutting so many trees.” However, she also recognized that the activity might have been smoother if she had “model[ed] what I expect[ed]” during the activity. (Dora, Educational Philosophy)

Student-Driven and Real-World

All participants believed that using inquiry-based activities helped create a classroom where students constructed their own understandings. Participants believed that active student learning was facilitated by involvement in experiments, centers, observation, and research.

Sonya explained,

In all of my lesson planning, I try to make them as engaging and interactive as possibly I can. I believe students learn better by actually doing. I think it is important in letting have students control over their learning by giving them choices within different topics. I believe in allowing students to do more hands-on activities, such as trial and error activities. This way they can see how certain
concepts relate to the real-world. I would implement group work, because I know
child learn a lot from one another…We as teachers should continue to encourage
students to pursue the topics that they are interested in knowing more about.

Students will be learning these different concepts through exploration and
research, and from there, they will begin to discover how much they can learn
from each other….” (Sonya, Teaching Philosophy)

Sonya described the teacher’s role as starting with “lesson planning” and then moving to
student-driven learning where her role was to encourage and facilitate learning. The depth of her
understanding of science teaching processes was shown in her word choices in the Wordle she
created (see Figure 17).

Figure 16. Sonya’s Wordle
In the following excerpt from Kim’s educational philosophy, she wrote,

Classroom lesson and teaching instructions are inspired by one’s philosophy…

The student centered philosophy, progressivism, is the main philosophy that considers the three styles of learning. The types of learning include auditory, visual and kinesthetic learners. As an educator, I believe that a teacher should incorporate all the three learning styles as much as possible. .. I believe that every child is different, and they have a special gift that makes them unique … (Kim, Educational Philosophy)

She continued,

Dewey, believed that teachers should educate students more about real world problems and social interaction in school. I believe that teachers should develop meaningful lessons by using real life situations so the students have a greater opportunity to master the lesson…. As a teacher, I want to provoke curiosity, connect content to my lessons that are relevant and interesting to my students.

(Kim, Educational Philosophy)

As seen before in the findings section under Hands-on and Science Process Skills, Ann’s beliefs included, “I want to provide my students with the opportunity…to have them observe the world around them…” (Ann, Post-Narrative) indicating her desire to make the connection between classroom-based learning to the real world situations and circumstances surrounding the student.
5E and Questioning

Embedded within the science methods course was the use of the Bybee (2003) 5E lesson. Nancy said that she “would send home the **Elaborate** component of the lesson so that parents have the options to explore the lesson at home with their learner.” Hannah stated,

As teachers, we can also include an **Extension** portion to our science lessons for students to do at home. For example, if we’re doing mass of different stones, ask them to go home and find two stones to bring with them that they could incorporate to the experiment. Another way is by making sure parents know what we’ve been doing in class and to ask their children to share what they did in class. (Hannah, Week 8 Reflection)

Dora’s Wordle includes the word 5E, indicate that the learning cycle holds importance in her belief system (see Figure 18).

![Figure 17. Dora's Wordle](image)
The importance of communication with partners, groups, and teachers as a means of learning science was evident in the data sets. According to the participants, questions were an effective tool in science instruction. The purposes for the use of questions varied from promoting curiosity, to facilitating and guiding students during inquiry or informal assessments. For example, Amy mentioned, “I believe that facilitating a learning experience through providing tools, technology, cooperative learning, and questions that evoke critical learning is key to molding successful students.” (Amy, Educational Philosophy). Amy also emphasized the importance of her role as a facilitator to foster higher order thinking: “[I would walk] around and continue asking higher-order thinking questions to scaffold their inquiry.” (Amy, Interview Data)

Reflective Practice

At the completion of the course, several participants identified reflections as a part of the process of becoming better science teachers. Kim is an exemplary model of how she believed in growth and change through reflections. This could be seen in her pre- and post-ISE drawings, Wordle, and educational philosophy.

A philosophy of education is the most important thing to develop during one’s teaching career and will continue to grow as the teacher develops professionally…My philosophy is inspired by my beliefs [in]the student centered philosophy, progressivism … One of the ways I will demonstrate this [is by letting] my students choose topics for their projects... As I continue to grow professionally through school and experiences, my philosophy [will] continue to evolve with me, which I believe will only improve my classroom as the years progress.
In Kim’s Wordle, words and phrases such as “continue” and “benefit of reflect” added value and strength to what Kim identified with in her educational philosophy (see Figure 19). She stated her desire to “grow” as a professional through “school and experiences” that would help her develop as a practitioner.

![Figure 18. Kim's Wordle](image)

Mary wrote that she enjoyed the activities that were done outdoors and they reminded her of the experiences she had in middle school, Doing activities like this because they tend to stick in my head better. I can, to this day, remember going to the gym in 8th grade with my life science class. We were learning about the food chain. My teacher taught us this game that we played where each person was something different in the food chain. We played a game that was similar to tag. Being tagged symbolized getting eaten. Everyone loved this game so much we actually got to play it the next day, too! (Mary, Week 11 Reflection).
Sonya, in one of her journal reflections wrote,

Student data is a good way to help guide teacher instruction because it lets the teacher know which concepts the students do not understand, thereby, helping the teacher know what part of the instruction needs to be improved. Reflecting on what went right and what went wrong with a lesson can also help the teacher see what might need improvement, and feedback from colleagues gives the teacher a good idea on what area he/she needs to work on as well.

Like Kim, Sonya placed the word “reflect” in her Wordle, showing her valuing of reflecting as an educator.

Science Teaching Tools

The responses of participants about their beliefs about tools for science instruction were categorized in the same manner as were initial findings about participant beliefs. I identified three themes, *classic* teaching tools, *digital* tools, and *learning environment* as a tool. Not all participants mentioned tools as part of their beliefs system at the beginning of the semester, but all participants referred to tools at the end of the semester.

Classic Science Teaching Tools

Drawings of science classrooms at the end of the semester were more complex than the pre-ISE drawings. For example, the drawings illustrated by Amy, Sara, and Mia retained students working on tables in teams (see Figure 20). The drawings also depicted: a) teachers as part of the classroom environment, b) tables with students around them working in groups, c) each table having different materials, equipment, or manipulatives, and d) indicators of written language.
Figure 19. Examples of Post-ISE Drawings from Three Participants
Classic tools, such as science equipment, clipboard, and a whiteboard, were key components in the classrooms. Amy’s thoughts at the end of the semester displayed her belief in being a constructivist teacher, guiding students through learning by questioning. She said,

In this picture the students are conducting a student-led experiment on melting ice. They are at different stations using different methods to melt ice and timing it. I, as a teacher, am walking around and asking higher-order thinking questions to scaffold their inquiry.

Emma concurred with Amy’s approach and wrote:

In this drawing of my science classroom you will notice the instruction is student led. I think guiding students to discover things on their own interest is essential when teaching science. You will also notice all the students are wearing gloves and googles; this is to show how safety will be priority in my class. Lastly, I am holding a clipboard, this is to show that the teacher is taking constant informal assessments.” (Emma, *Post-ISE Drawing Narrative*)

The focus on student-led science learning and identifying hands-on learning exhibited more complex ideas of the use of classic tools. Safety, science process skills, and understanding were evidences of students’ active engagement in the investigate process. Mia’s post-intervention drawing narrative stated,

In my science classroom, my students will be creating, discovering, explaining, manipulating, and researching different concepts. There is a window with students holding magnifying glasses to represent informal environments and discovery outside. The teacher will be walking around the classroom helping to facilitate the students’ thinking. (Mia, *Post-ISE Drawing Narrative*)
Expanded Digital Science Teaching Tools

In Amy’s Physical Science lesson, she used both a classic tool and a digital tool. Assessment based on science journals and Wordles showed how classic and digital tools might be used for the same purpose. In the Engage part of Amy’s lesson she incorporated a simple digital tool, “watching Bill Nye video: http://www.teachertube.com/viewVideo.php?video_id=186099;” and then, at the end of the lesson, as part of her Evaluate, she mentioned that “students will be evaluated on their journals and their Wordle list/explanations” (Amy, Physical Science Lesson). Similarly, in her Life Science lesson plan, Mary used a virtual field trip as a digital tool. The virtual field trip to The Bronx Zoo included a 50-minute videoconference with a representative of the zoo. The students would talk about the sizes and shapes of animals. (Mary, Life Science Lesson).

Similarly, Emma, in one of her entries related to Elm Fork wrote, “I think I would have adjusted the pre-visit activity to be paired with BrainPop, PebbleGo, or some sort of entertaining educational video or song;” (Emma, Week 10 Reflection) indicating the desire to integrate learning technology to an out-of-classroom experience such as a field trip.

Pam’s teaching philosophy mentioned, showing that she valued the use of digital tools. My microteach lesson on recycling is an example of how I can bring real-life experiences to the classroom. This lesson and a WebQuest that I created on building a compost are two experiences that I would like to bring to my class so my students can learn how they can contribute to the world. (Pam, Teaching Philosophy),
In Kim’s educational philosophy she stated: “One of the ways I will demonstrate this [is by letting] my student choose topics for their projects… [Another] activity, having my class learn as a whole by partaking in educational games, will help them study for quizzes.”

Combination of Classic and Informal Learning Environments as Tools

This drawing by Jason showed the use of science equipment, a classic tool, on a table (see Figure 21).

Figure 20. Jason's Post-ISE Drawing

Featuring the use of a Bunsen burner for a whole class demonstration, Jason elaborated about his role in the narrative,

I am preforming a demonstration for the students. I am planning on dazzling my students with fascinating displays, similar to David Copperfield that will create
wonder and excitement before they discover the concepts on their own. I want my classroom to be a very exciting place. (Jason, *Post-ISE Drawing Narrative*)

Jason believed that science should be approached with the teacher demonstrating and followed by students doing a teacher-led exploration. His style of teaching and choice of tools were part of his instructional practice. In Jason’s microteach lesson, his peers were entirely dazzled by his demonstration since he captured their attention with mysterious white smoke emitted from dry ice (see Figure 22).

![Figure 21. Jason's Dry Ice](image)

Jason continued to keep his peers involved in the *outdoor space as a tool* for exploration, showing the sophistication of his understanding of the use of ISE as a tool for science teaching. During the **Explore**, students went outside and explored the feeling of the wind moving through their clothes and hair. Each student was given a streamer so they might see the wind moving, making use of the outdoors (See Figure 23), where Jason asked,
Which way is the wind blowing? Can anyone make a connection between the wind we are feeling and the demonstration that we just watched? Where does the cold air come from? Where does warm air come from?” (Jason, Microteach Field Notes).

Jason said in his reflection about the microteach,

[T]he main strength that I believe I had was that my lesson was engaging. Students seemed interested in what was being presented, and I think that started with a strong Engage portion of the lesson. Once you grab the students’ attention it is easier to keep it rather than starting slow. I have spoken with some teachers in My PDS1 School, and they feel like they are performing when they teach. It is as if it is a show and the kids are their audience. This is the main thing that I like about science, is that it can be thrilling.” (Jason, Microteach Reflection)

Figure 22. Picture of Participants Exploring the Moving Wind with Streamers in Jason’s Lesson
In another lesson, Mary utilized the outdoor space in her lesson as a part of the Explore. She mapped out the distance of planets in the solar system using a mapping tool; this tool was categorized as a classic tool (See Figure 24). Mary’s simple use of the outdoor environment in her microteach lesson was more for space than development of content (see Figure 25). In her reflection she wrote, A major strength that I saw was that… [when they] were outside, they were all interested in how the measuring tape tool was going to be used. Once we started placing students in places where a planet would be, related to the Sun, all students were engaged and eager to 1) answer questions about which planet I was describing, 2) be picked to play the role of that planet, and 3) hear how far apart the planets are in actual miles.” (Mary, Microteach Reflection)


*Figure 24. Picture of Mapping the Planets in Mary’s Microteach Lesson*
Contrastingly, in Sonya’s microteach lesson, the students were asked to use a paint chip card as a tool to identify the gradient of the color of the sky (See Figure 26). The picture encapsulates how each individual was actively engaged in this lesson and exploring the learning environment. Sonya, like Jason, used the ISE as a tool in a complex manner to investigate the outdoor space.

![Figure 25. Sonya’s Microteach Lesson](image)

Informal Learning Environment as a Tool

Some of the participants’ post-ISE drawings identified informal learning contexts as a tool. For example, Ann used the outdoor context and discussed the use of the outdoors,

I imagine being outside in nature. I want to teach my students about how food grows, the water cycle, and weather…. I am still going to have them observe the world around them and make it meaningful to them” (Ann, *Post-ISE Drawing Narrative*)

Kim’s post-ISE (see Figure 27) drawing mirrored her teaching beliefs when she mentioned incorporating student-centered authentic experiences in an outdoor space.
According to Dave in explanations of his drawings (see Figure 28), his preference for the ISE changed from simple to complex. In his first iteration, the use of this tool was for a change of scenery, whereas in his next drawing, use of the ISE was more complex because it involved the informal context as well as displays of animals.

Figure 26. Kim’s Post-ISE Drawing

Figure 27. Dave's Pre- and Post-ISE Drawings
Some participants, like Sonya, depicted in concept webs limited scopes of science teaching tools and expanding their toolboxes to incorporate more informal science teaching tools (See Figure 29).

*Figure 28. Sonya’s Concept Web from Flap book*
Emma’s flap book (see Figure 30) is another example of how her pedagogical tools expanded due to the ISE model. All the writing in the lighter black pen showed her tools to include written assessments, one size fits all for formal and differentiation, trial and error, and more freedom for informal. Later she revisited her flap book as a post-assessment and added ideas of fun, engaging, natural learning, and student-centered. Although, under her tools, Emma listed manipulatives, technology, supplies, SMART boards, and iPads, I was unable to decipher whether these items were listed prior to or after the session on ISE and Project WILD activities.

![Image of Emma's Concept Map from Flap Book]

Figure 29. Emma’s Concept Map from Flap Book

All participants were asked to revisit their flap books, and with a different writing utensil make any additions to what they had written at the beginning of the class session. These flap
books were part of the participants’ notebooks and were created as a part of the end of the class session assessment. In Table 20, some participant concepts webs are shown. Through the review of the concept map, I have identified Google Hangout and virtual field trips as most common used word. However, items such as the outdoors, iPads, other teachers, and gaming were also seen on many of the post-assessments. These findings support the inclusion of first-hand experiences, content-specific educational technology, and outdoor education.
Table 20

<table>
<thead>
<tr>
<th>Name</th>
<th>Pre-ISE Concepts</th>
<th>Concept Web from Flap Book</th>
<th>Post-ISE Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td>Actual field trips</td>
<td>Environment</td>
<td>SMART board</td>
</tr>
<tr>
<td></td>
<td>Environment</td>
<td>Hands-on</td>
<td>Virtual field trips</td>
</tr>
<tr>
<td></td>
<td>Hands-on</td>
<td>Demos</td>
<td>iPod</td>
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<tr>
<td></td>
<td>Checklist</td>
<td>Anectodal</td>
<td>iPad</td>
</tr>
<tr>
<td></td>
<td>SMART boards</td>
<td>records</td>
<td>videos</td>
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<tr>
<td></td>
<td>State assessment</td>
<td></td>
<td>Skype</td>
</tr>
<tr>
<td>Jen</td>
<td>Classroom library</td>
<td>SMARTboards</td>
<td>Google Hangout</td>
</tr>
<tr>
<td></td>
<td>Computers</td>
<td>Manipulatives</td>
<td>Other teachers</td>
</tr>
<tr>
<td></td>
<td>iPads</td>
<td></td>
<td>Professional development</td>
</tr>
<tr>
<td>Mary</td>
<td>Classroom library</td>
<td>SMARTboards</td>
<td>Field trips</td>
</tr>
<tr>
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<td>library</td>
<td>computers</td>
<td>Environment</td>
</tr>
<tr>
<td></td>
<td>SMARTboards</td>
<td>manipulatives</td>
<td>Everyday experiences</td>
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<td></td>
<td>Computers</td>
<td>iPads</td>
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<tr>
<td></td>
<td>Manipulatives</td>
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<td>Google Hangout</td>
</tr>
<tr>
<td></td>
<td>iPads</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Overall Analysis of Formal and Informal Concept Web of Participants in Treatment Group
Learning Environment

The data in this theme were placed in two major subthemes: a) traditional and b) non-traditional. The traditional learning environment was the classroom and nontraditional was any other context. Emma, in her teaching philosophy, wrote about both environments in relation to her Professional Development School (PDS1) experience as follows,

Being in the classroom over this past semester has acquainted me with what my teaching philosophy really is. Before being in the classroom, it was easy to declare a certain belief without having actual experience… I also believe that what I have learned in the classroom and in the “real world” should not be two separate domains. The knowledge that students are building in the classroom should be recent and relatable to what is going on in the ever-changing society outside of the classroom….When I write a lesson, I make sure to take great consideration how the lesson relates to the students in and outside of the classroom. I also am sure to design a lesson that will be exciting and genuinely fun. (Emma, Teaching Philosophy)

Traditional

For example Jasmin mentions having a “challenging environment” allowing for students to be engaged in learning in her classroom. She stated

I am in the middle of experimenting and using students’ feedback to create a web on inquiry. I believe that as teachers we should create opportunities for our students to have engaging lessons and to get messy and have fun! We should create challenging environments for students to get to know their strengths.”

(Jasmin, Post-narrative)
In the same vein, Jasmin’s Wordle (see Figure 31) includes words such as: engage, hands-on and inquiry. These ideas related to her classroom are further understood by her teaching philosophy statement. She wrote:

As modern-day teachers it is essential that we transform our teaching habits from ordinary to extraordinary. Today’s presence of technology within the classroom creates the opportunity to accommodate students with all different learning styles.…Overall, establishing meaningful, long-lasting student to student and teacher to student connections among all in the classroom is a goal outlined in my personal teaching philosophy that I hope to accomplish each and every years as a teacher (Jasmin, *Teaching Philosophy*).

*Figure 30. Jason's Wordle*
Similarly, Sonya’s philosophy of education statement showed that digital tools were part of her science teaching beliefs system. Another participant, Sara, mentioned in her teaching philosophy:

In order to grasp the full content, it must be connected to students in ways more than between the four walls of the classroom. It should be drawn from the students’ personal experiences, real world experiences, anything that is meaningful…My main goal as an educator is to create learning experience that is enriching for my students. (Sara, Educational Philosophy)

Explaining the need for educators to teach science content in a traditional classroom makes connections for the application of knowledge learned across learning environments.

Non-Traditional

Once again, digital tools were mentioned by participants. Some identified digital tools, and others focused on the non-traditional learning environment. In this case, the emphasis was placed on the non-traditional learning environment such as a designed learning environment. For instance:

With virtual field trips certain students can benefit in a way where if they do not have the opportunity to go on a real field trip due to financial situations, they can take a tour on a virtual field trip. They will have the opportunity to virtually explore places around the world and see that what they are learning in the classroom applies to the outside world as well. (Sonya, Week Reflection)

Other examples of the emphasis on non-traditional learning environments pertained to informal contexts. According to Sara, there are three key elements of science lessons: “questions,” “engaging students,” and “TEKS (Texas Essential Knowledge Standards).” She believed
teachers need to challenge and “push” students to go a bit further to learn. Her most memorable experience was “role-playing” during Project WILD. (Sara, Interview Data). Later, she mentioned that “we shouldn’t always be in the classroom…use informal learning environments: Elm Fork and outdoors.” She said that these methods courses helped teacher candidates how to teach, so “everything should be more applicable” and “I can see myself using the Project WILD activities.” In the interview, she continued to aspire to challenging students, which she thought would allow them the opportunity to push for learning and achieving more. (Sara, Interview Data)

On a similar note, Mary wrote:

the teacher (me) is having the students investigating outside. The students are working together. Instead of (me) running the show, the students have task cards that need to be completed. It is up to the students to work together. I am here to facilitate and help students if they get stuck….” (Mary, Post-ISE Drawing Narrative).

She shared, “…I don’t understand why they don’t do enough science [in school] but I definitely want to do more science.” (Mary, Interview Data). Mary was a big advocate for making science an enjoyable and memorable part of the school experience. In her interview, she went on to identify her use of a non-traditional space for learning. As an assignment in her Life Science lesson, she created “a virtual field trip to the Bronx Zoo…it would be a 50-minute field trip.” (Mary, Interview Data). Mary also shared that [Teachers should] “not do the bare minimum, like worksheets…[rather we] need more experiments, go outdoors like our microteach [lesson.] Her advice for future science methods instructors was, “I like going to Elm Fork,” real-life experiences, and more content-specific “examples and model lessons.” (Mary, Interview Data).
Microteaching helped the participant to practice teaching and was seen as one of the most valuable experiences during the science methods course (see Figure 32).

![Figure 31. Mary’s Post-ISE Drawing](image)

Dora also concurs with Mary saying informal science education experiences allowed for “more student engagement” and exploration. According to Dora, the most memorable experiences were the microteach lessons where she got to see others teach. Dora was impressed by her peers, “whether we had the same TEKS [Texas Essential Knowledge Standards],” she told me that she “enjoy[ed] the learning process. Teacher training should include “engaging activities.” (Dora, Interview Data) The voices of the participants under the nontraditional subthemes brought added-value evidence, which unanimously supported the ISE model experiences.
Supportive and Inclusive Classrooms

Most participants felt the need for learning environments to be “inviting” and comfortable for all learners. In Kim’s educational philosophy, she clearly states,

I believe that every child is different and they have a special gift that makes them unique. People should learn from one another instead of judging just because they view them as different. In the classroom as teacher, I would have the students learn and understand about diversity. (Kim, Educational Philosophy)

Like Kim, in the following excerpt from Pam’s teaching philosophy, she believed that a classroom environment must be a place that provides nurturing.

Students enter the classroom as individuals and this should be embraced. We are not factory workers and the goal is not to create the same product. Students are unique and our goal is to reach their potential. I want to create lifelong learners who will question “What can I do to contribute in this world?” We need to help students develop critical thinking skills that will continue outside the walls of the school. (Pam, Educational Philosophy). Hannah discussed the need to extend learning beyond the classroom and

[k]eep the parents up to date with the science topics and experiments done in the classroom or lab. If students are able to continue their learning and exploration of certain topics at home that were introduced at school, then they are more likely to make real-life connections. When these connections are made, the students are more likely to gain a deep understanding of the topics and concepts being learned. (Hannah, Week 10 Reflection)
In another reflection about diversity Ann wrote:

One strategy to help include diversity in the classroom is making sure that there is enough room for all students to access the science center. The center can be used to help students understand different backgrounds, culture, and other languages based on the materials provided in the center at a given time. (Ann, Week 10 Reflection)

Collaborative Group Experiences

Experiences involving collaboration amongst peers facilitate learning. Although it was not clear that the participants distinguished amongst different types of group work, such as collaborative work or cooperative learning.

Collaboration groups

Participants’ drawings, reflections, comments in interviews, and educational philosophy writings demonstrated their understanding of the need for dialog. The need for dialog was also seen in the microteach instructions evidenced by the inclusion of cooperative learning strategies, such as think-pair-share or simply assigning roles. However, the depth of the essence of cooperative learning groups was not clear. For example, the illustrations drawn by Amy, Sara, Emma, and Mia depicted group work within a formal classroom setting; however, Kim’s drawings depicted students working together outdoors. Although the drawings illustrated collaboration, the narratives did not use words or phrases that explicitly stated positive interdependence—a key component of cooperative learning.

Another perspective of collaboration was mentioned by highlighting partnerships between the classroom and the home. For instance, in Dora’s post-ISE drawing narrative, she commented about student collaboration in the classroom, “[students] are working together,
experimenting, writing and gathering their own data, and doing research…collaborating with other[s].” Whereas, Mia extended students’ learning through involvement of parents:

I will support my students' families by giving them the tools to help their children succeed. The tools can range from websites to examples of household items that they can use. The students can explore science through any item in or out of the house. For example, they can explore their house for light or heat energies, living and nonliving things. There are many tools that parents can use to help their students explore beyond the classroom. (Mia, Week 10 Reflection)

In general, the participants considered collaboration as a means to promote learning through dialogue and active participation where students are engaged in learning.

Variety of Learning Environment

This statement from Mary in her weekly reflection summarizes the main reason for including variety in the learning environment, “Learning doesn’t stop when students exit your classroom for the day. Learning happens everywhere!” Another participant, Jenn, reflected on her OST experiences:

I have learned that there is a lot of work that goes into a field trip. It needs to have a relevant purpose so that the students are able to make connections and gain from the experience. Field trips are informal environments for students to learn in. (Jenn’s Week 11 Reflection).

In her interview, Jenn mentioned in regards to Project WILD,

I really liked how we were able to go outside and move around. I feel that this would be intriguing for students to begin the lesson. I even forgot that I was
learning during the games, so I think this was an effective way to grab students’ interests. (Jenn, *Interview Data*)

In the same way, Sonya expressed a desire to get their children to inquire about various things related to natural and man-made resources. Have them ask questions like “why.” Why does something work this way? How does it work? What does it do and what is it for? If no one can figure out the answer to the questions presented, then they both can research it together to try to find the answer. (Sonya, Week 10 Reflection)

Several of the participants mentioned that they enjoyed the informal learning context. The following are examples from three participants:

- Mary said in one of her reflections, “I really enjoyed the activities that we were able to do outside.”
- Kim resonated the same idea, “I personally really enjoyed the activities that we partook in while outside.”
- Jason, “I thought the activities outside were really fun.”

Emma in one of her reflections wrote:

I think this lesson could be modified to fit any grade. It is a great idea to go outside anytime the opportunity presents itself, especially on nice days. It helps refocus the students and makes the content in the lesson more meaningful to the students. The most important part of the lesson is that it was fun. It helped me better understand content in the TEKS, dare I say it, while having FUN! It also gave the opportunity for students to question each other and the teacher.
Hannah brought attention to using the students’ homes. For example, she wrote,

As teachers, we can also include an “extension” portion to our science lessons for students to do at home. For example, if we’re doing mass of different stones, ask them to go home and find 2 stones to bring with them that they could incorporate to the experiment… Above all else, I believe that exploration shouldn’t stop at 3:00 when the bell rings. Even if it means extra work, we must ensure that students are receiving proper help to feed their sense of wonder and curiosity.

(Hannah, *Week 10 Reflection*)

Summary of Beliefs of Prospective Elementary Teachers after Intervention

Although the semester began with some participants expressing a lack of confidence in their science teaching, the evidence through several data sources illustrated that, by the end of the semester, participants developed increased confidence and comfort in their ability to teach science. Both the content of the science methods course and the experiences provided through the demonstrations and microteach sessions allowed participants opportunities to “try out” science teaching in a supportive environment. Interviews revealed that the most memorable experiences in the science methods course were the “peer demos,” “hands-on” activities, and “microteaching.” Although there were not statistically significant differences in changes in belief systems between the control and intervention groups, findings from the qualitative phase of the study indicated growth in science teaching beliefs for the treatment group. The changes in these participants’ belief systems were shaped by the various experiences within the course, their previous experiences with science education, their feelings about their ability to teach science, and the simultaneous PDS 1 experience within school classrooms.
Answering Research Question 3: Mixed Method Phase: Data Integration

This section addresses the ways the qualitative data contributed to a more comprehensive understanding of the results from the quantitative phase of the study. This study implemented a sequential explanatory mixed method design (Creswell & Plano Clark, 2011; Crewswell, 2013; Hesse-Biber, 2010). Both quantitative and qualitative data were analyzed through the lens of perceived beliefs about the teaching of science. Findings from the analysis of both the quantitative results and qualitative data indicated positive growth of participants’ beliefs about teaching science although quantitative differences between groups were not statistically significant. Table 17 presents statistics for participants in the treatment and comparison groups based on use of the BAT instructional methodologies scale (Yilmaz-Tüzün, 2008). These data were insufficient to draw inferences regarding changes in belief as they might pertain to ISE. The qualitative follow-up helped to promote understanding of change in beliefs as influenced the ISE model.

Participants in the treatment group began the semester with lower pretest scores ($M = 72.71, SD=7.08$) compared to the comparison group ($M = 84.47, SD =7.04$). The descriptive statistics indicated that the participants in the treatment group model had a larger increase ($\Delta M = 11.76, SD = -.76$) in scores than the non-treatment group ($M = 4.99, SD = .30$). Further quantitative analysis revealed that there was not a statistically significant main effect between the groups. However, the combination of variables of time and group had a statistically significant interaction effect.

The qualitative phase of the study enabled an in-depth understanding of the change in beliefs about science teaching of the treatment, or ISE, group over the semester. The qualitative
data were analyzed using a hybrid approach. The themes emerged from the data are displayed in Table 19; these themes helped explain results in more detail.

The participants in the treatment group made connections between the ISE experiences and their beliefs about informal science teaching. Participants beliefs about science teaching expanded to include a broader sense of teaching science. Looking at the participants in the ISE group, the interaction effects display a steeper increase in participant scores from pretest to posttest. Although, as a treatment group, the majority of the participants did display an increase in their beliefs about science teaching as captured by the BAT instrumentation. The purpose of the data integration was to further understand the type of change for participants.

Examples of Participants with Average Mean Scores for Participants in Treatment Group

Table 21 displays data for two participants in the ISE group whose BAT instructional methodologies scores showed average gain across the semester.

Table 21
Beliefs about Science Teaching Post-Test Scores for Pam and Dave

<table>
<thead>
<tr>
<th>Beliefs About Science Teaching, Instructional Methodologies</th>
<th>Average Score for Treatment Group</th>
<th>Participant Names</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>Pam</td>
</tr>
<tr>
<td>Pretest Scores</td>
<td>72.71</td>
<td>63</td>
</tr>
<tr>
<td>Posttest Scores</td>
<td>75.58</td>
<td>71</td>
</tr>
</tbody>
</table>

**Pam.** Despite the fact that Pam’s BAT results scores indicated an average amount of growth from pretest to posttest; at the end of the semester, she was the participant with the lowest
BAT score in the treatment group. Pam was a nontraditional student who was the oldest participant in the treatment group. Her score on the posttest was 71, which was even lower than the mean pretest scores ($M = 72.71$, $SD = 7.08$) for her class at the beginning of the semester. Further insight about her scores on the BAT can be expanded on by looking at her individual qualitative data.

Beyond looking at her BAT score, Pam had a lack of confidence which was unveiled on the first homework assignment. She shared her feelings of apprehensiveness, “I feel a little nervous that I will not have the knowledge to teach science.” (Pam, *Getting to Know You*, Week 1). She also wrote that her “worst experience [in highschool] was in chemistry” and further explained, “I really do not feel like I had a great experience with science until college.” Like Pam, 40% of her peers shared their uneasiness in the beginning of the semester in their first homework assignment.

Despite her apprehension at the beginning of the semester, Pam showed growth over the course of the semester. For example, her microteach lesson plan was student-centered and covered the topic “upcycle,” which drew upon peer interest. Her post-ISE drawings and narratives further illuminated her beliefs about teaching.

In her drawing, she draws herself at the front of the classroom. The drawing also has equipment on two separate tables near her. She stated her science class…will be student-centered. I want the room to be open for class discussion. I also want to prepare as many demonstrations as possible. I believe students will learn more by seeing examples of what objective I want them to meet. (Pam, *Post-ISE Drawing Narrative*).
Her drawing in Figure 33, displays her standing in front of the classroom and in her narrative for the drawing, she states that her science classroom will include discussion—indicating that dialogue is needed for science learning to occur.

![Figure 32. Pam's Post-ISE Drawing](image)

**Dave.** Dave’s case drew attention because, towards the end of the course, he mentioned that he would consider teaching in an informal environment, such as a zoo rather than a traditional classroom. His scores on the BAT went from 72 at the beginning of the semester to 80 at the end of the semester, showing an average gain of scores between pretest and posttest. His pretest and posttest BAT scores were close to the mean scores for the entire treatment group; however, the deductive analysis for the pre-ISE drawing and post-ISE drawings indicated that his scores for **Strand 1** and **Strand 5** remained the same across time (See Appendix E: Deductive Analysis). The stagnancy in Strand 1 meant that his motivation, interest, and excitement stayed the same over time and the lack of change in Strand 5 meant that he did not display a change in the use of scientific language or science tools.
The quantitative results and the deductive analysis of his drawings did not truly illuminate this participant’s change in beliefs about informal science teaching over the semester. Therefore, further investigation of data sources helped expand on his BAT scores. Dave’s narrative clarified his beliefs about science teaching. In his pre-ISE drawing narrative, Dave wrote, “in this picture students are outside holding blue and red balls. They represent positive and negative charges. The students are attempting to emulate magnetic forces, opposite charges attracting and similar charges repelling (See Figure 11, Dave’s Pre-Intervention Drawing).” Later, in his post-ISE drawing narrative, he stated, “I think it could be fun to have my career centered around animals instead of children. Perhaps as a zoologist of some sort or more likely with my personality, a park ranger,” which indicates his preference to be in an informal context. Although the scoring rubric did not change, his narrative provides evidence of the influence of the ISE experience. Although, the intention of the ISE model was not to lead candidates away from classroom teaching, Dave’s post-ISE drawing (see Figure 28) illustrates himself in an animal caretaker uniform with a snake wrapped around him body. This change in Dave’s science teaching beliefs may have been influenced by the ISE experience in the science methods (See 28).

Pam and Dave are examples of participants with an average amount of change on the BAT instrument. They were selected since their individual BAT scores were close to the mean scores for the treatment group. The integration of the quantitative and qualitative data gives a more holistic picture of the changes in the belief systems of these particular participants.

Although the change for both Pam and Dave reported average change in participant belief systems, there were additional cases in the treatment group that benefited from further investigation. Table 22 offers more examples of the scores of selected participants who are
discussed in the next section. These individual cases were chosen based on the fact that their scores demonstrated the most amount of change on the BAT, the least amount of change on the BAT, and a negative directional change on the BAT.

Table 22

Table: BAT Scores for Participants with Most, Least, and Negative Amount of Change

<table>
<thead>
<tr>
<th>BATS Instructional Methodology Scores</th>
<th>Average Score for Treatment Group</th>
<th>Greatest Change in Score</th>
<th>Least Change in Scores</th>
<th>Negative Directional Change in Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Hannah</td>
<td>Sara</td>
<td>Emma</td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>72.71</td>
<td>66</td>
<td>77</td>
<td>83</td>
</tr>
<tr>
<td>Post</td>
<td>75.58</td>
<td>89</td>
<td>78</td>
<td>73</td>
</tr>
</tbody>
</table>

Least Amount of Change

**Sara.** Sara’s BATS scores drew attention by displaying the least amount of change, going from a 77 on the pretest to a 78 on her posttest. Sara, like some of her peers, mentioned that she was a bit uncomfortable with teaching science at the beginning of the semester.

According to Sara, one of the most memorable activities of the science methods course was the Project WILD activities. This is part of her reflection

My favorite activity was the Bears activity. You can talk about how animals struggle in the wild just as how we do in our everyday lives and what their struggles are. But like how you can talk about a lot of things, it clicks better when the students are able to actually see/experience what you’re talking about. It makes you think about how certain animals survive when they face the struggles
we role-played in this game. This game also does a great example demonstrating
‘survival of the fittest’ (Sara, *Reflection Week 11*).

Sara’s teaching philosophy mentioned “

In order to grasp the full content, it must be connected to students in ways more
than between the four walls of the classroom. It should be drawn from the
students’ personal experiences, real world experiences, anything that is
meaningful…My main goal as an educator is to create learning experience that is
enriching for my students (Sara, *Educational Philosophy*).” Her BATS score does
not adequately present her shift in beliefs.

Most Amount of Change

**Hannah.** Hannah’s pre-posttest scores showed the greatest amount of change in belief
systems about science teaching when compared to her peers. Her BAT scores went from a 66 to
an 89. Her scores increased on 16 out of the 19 BAT items. This jump in her survey scores
invited further investigating and understanding of her growth over the semester.

Hannah’s pre-ISE drawing (see Figure 34) displayed her knowledge of teaching science
in a playground, which is an informal learning environment. The words “push” and “pull” are
indicative of physics concepts. By the end of the course, Hannah displayed considerable change
in her course artifacts, such as her lesson plans. In comparison to her peers, her lessons plans
contained more in-depth science content and questions.
Another example was in the reflection Hannah wrote for Week 10:

If students are able to continue their learning and exploration of certain topics at home that were introduced at school, then they are more likely to make real-life connections. When these connections are made, the students are more likely to gain a deep understanding of the topics and concepts being learned.

In order to support the parents with extending learning outside of the classroom, I would try to provide them with not only the topics and experiments being done at school, but other sources as well (Hannah, Week 10 Reflection)

Reverse Directional Change

**Emma.** Emma’s BAT scores decreased from an 83 to a 73; none of the other participants in the ISE group followed this trend. However, 21.13% of the participants in the comparison group showed the same pattern. The overall set of BAT scores showed a negative change that ranged from as small as -1 to as large as a -14 difference, with Emma’s score difference at -10.

A review of Emma’s qualitative data did not align with her BAT scores. Several of her artifacts displayed evidence of growth. Her initial drawing depicted herself wearing a lab coat in a classroom setting with traditional tools: a book, a chart on the wall, flasks, test tubes, and a
microscope. In the post-intervention drawing, she drew herself in a classroom with students in groups at round tables and charts on the wall. In her narrative she said,

In this drawing of my science classroom, you will notice the instruction is student led. I think guiding students to discover things on their own interest is essential when teaching science. You will also notice all the students are wearing gloves and goggles. This is to show how safety will be priority in my class. Lastly, I am holding a clipboard; this is to show that the teacher is taking constant informal assessments. (Emma, Post-ISE Narrative)

Her narrative indicated that she has expanded her beliefs in regards to teaching science. She depicts a science learning experience where students are engaged, interest of the students is driving learning, and she is using informal assessments to document student learning. In her educational philosophy, she reflected upon the experiences in professional development school (PDS 1) and bridging classroom content to “real-world” contexts. Emma’s case demonstrates that the reliance on purely quantitative data (such as the BAT score) is limited in scope and that the integration of the qualitative data with the quantitative helps provide a better understanding of changes that occur in participant’s believe system.

Summary of Data Integration of Prospective Elementary Teachers

The participant cases in the previous section strengthened the results and findings of the study. The merging of the data helped me understand that, by looking at the totality of the data gathered for an individual participant, a picture of holistic change emerged. The information learned here was most noteworthy because of the detail regarding changes that occurred for individual participants in the treatment group. This mixed-method question was worth sharing
because it provided a more complete picture and description about the change in participant beliefs.

Negative Case Analysis

Creswell and Plano Clark (2011) suggest that in order to reduce threats to internal validity, one should report negative case data analysis identifying inconsistencies and that negative case data is a part of legitimization for a study. The following participant case shows that Taylor may not have been influenced by the ISE model and stayed strong to her initial beliefs prior to intervention.

**Taylor.** Taylor’s profile suggested a belief in the traditional role of teaching as the “sage on stage.” Although her BAT scores did move from a 65 to 85, she did not exhibit growth over time in her qualitative data set. Taylor consistently provided evidence of her desire to have a very controlled and teacher-centered classroom. Her post-ISE drawing aligned with Taylor’s beliefs at the end of the semester, continuing to support a teacher-centered classroom.

Taylor described science as a “study of living things.” She stated that science education “interlocks with other subjects, as well as gives students the opportunity to do experiment[s] with few limitations.” She readily admitted, “science has never really been a friend of mine… I don’t understand it easily.” Recalling, her most positive experience in science learning, she said “when I learned Punnet Squares [in biology], that’s like the ONLY thing I ever understood right off the bat.” She also explained that all her other science experiences were negative. In her Getting to Know You assignment, Taylor claimed that she was “okay with” teaching science but clearly uncomfortable with her preparedness, stating, “I would be forced to learn something and fully understand it in order to teach it. I’m not nervous.” She reflected on her elementary school experience saying that “all we did was read books and answer questions; we never really did any
experiments.” In junior high, her experiences were teacher-centered, based on “a lot of book work and [we] watched A LOT of Bill Nye the Science Guy.” Taylor’s post-ISE drawing (see Figure 35) indicated that she has remained with the teacher-centered idea.
Figure 34. Taylor's Post-ISE Drawing
Despite the fact that Taylor’s illustration showed the use of a SMART board, displaying her knowledge of technology as a tool in teaching practice, her narrative stated:

This is me teaching science to my second graders! I am using a SMART board to introduce food chains to them before we begin our project. A benefit to the SMART board is that I can incorporate learning and educational games in lessons…to build students’ knowledge and connect concepts.

The narrative indicated that Taylor was in control of what was being taught in the classroom and her role was to “transfer” knowledge rather than engage her students in learning science content through student-driven lessons. Her choice of using “educational games” seemed indicative of her using educational technology to “solidify concepts” more than facilitate student interest and self-exploration.

Additionally, in Taylor’s teaching philosophy, she identified herself with essentialism—an approach in which traditional methods of teaching and learning guide mastery of predetermined content. She maintained the idea of a highly disciplined, authoritative, structured classroom throughout the course. Figure 36 is Taylor’s Wordle, which includes words such as “reflect,” “classroom,” “reteach,” and “assessment.”

Despite the fact that her BAT scores indicated a positive change, her drawings and other written artifacts created substantial evidence for a lack of change in her beliefs about science teaching. Additionally, there was no evidence of influence of the ISE model in any data set.
Summary of Chapter 4

After a single semester of experiences and learning in a science methods course designed for elementary pre-service educators, most participants showed an increase in their science teaching belief scores using the BAT. According to the quantitative analysis, pre-service teachers’ beliefs about instructional practices did not differ significantly between the comparison and the treatment groups, where the treatment was application of the ISE model. However, treatment group scores went from $M = 72.71, SD = 7.08$ pre-ISE intervention to $M = 84.47, SD = 7.04$ post-ISE, indicating a greater positive shift over time for the ISE group than was attained by the comparison group. Qualitative findings also showed an expansion of science teaching beliefs for participants who experienced the ISE intervention. The findings of this study demonstrated a positive effect on participants’ beliefs about science teaching specific to student-centered learning and utilization of informal learning contexts. Additionally, the participants who experienced the ISE model indicated growth in instructional pedagogy with the incorporation of

Figure 35. Taylor's Wordle

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educational technology, such as virtual museums, iPads, and gaming. The integration of quantitative and qualitative data gave a further understanding of specific changes in beliefs.
CHAPTER 5
DISCUSSION, CONCLUSIONS, AND IMPLICATIONS

This mixed method study investigated the nature of K-6 teacher candidates’ beliefs about ISE prior to and after their experiences in a 15-week elementary science methods course. A treatment experienced by some of the teacher candidates was based on an ISE model developed from the work of the NRC (2009), which formed the theoretical framework for the study. The Beliefs about Teaching Science (BAT) survey was administered to participants in both the treatment and comparison groups (Yilmaz-Tüzün, 2008). The surveys assessed K-6 teacher candidates’ self-reported beliefs about science teaching. Only the Instructional Methodologies subscale of the survey was analyzed for this study. The quantitative analysis attended to analysis of variance between groups. Scores on the selected subscale items showed improvement (not statistically significant) in the beliefs about science teaching for the treatment group compared to comparison students. The nature of the changes in the beliefs of the treatment group participants were further explicated through the analysis of qualitative data. The qualitative phase of the study showed that participants in the ISE intervention had a deeper understanding of inquiry-based learning, expanded views of the use of digital tools, and a vision of providing students opportunities to continue learning across multiple contexts including informal environments. This chapter provides a discussion of the findings through the use of the theoretical framework and literature. Finally, the implications of the study and recommendations for future research are presented.

Discussion

In my study, a majority of the participants transformed their understanding of science teaching from classroom and lab-based learning to viewing science as a part of everyday life that
was connected to school, home, and informal and designed learning environments. The findings of this study suggest that participants’ beliefs and beliefs systems about science teaching change in science methods courses. Methods courses in teacher education programs have an important role in addressing needs of conceptual understanding, content knowledge, pedagogical practices, and the beliefs and belief systems of prospective teachers. The findings in my study indicate that participants’ belief systems in science teaching change across time while they are participating in science methods courses. The findings also suggest that prospective teachers’ beliefs and belief systems could be influenced in a positive direction with the integration of the ISE experiences. The ISE model provided participants in this study “meaningful and equitable opportunities for science learning” and how to teach science across a variety of learning contexts (NRC, 2009, p.79).

Using the quantitative and qualitative data collected through a mixed-method approach, participants’ beliefs and belief systems about science teaching were presented in Chapter Four. Participants’ science teaching beliefs and belief systems are known to be predictors of future teaching practices and are related to teacher effectiveness and student learning (Gess-Newsone, 1999; Mansour, 2008; Yero; 2002). Science teaching belief systems are especially important in elementary teacher preparation because prospective teachers are not content savvy and are traditionally less confident in science (Bulunuz & Jarrett, 2009; Jeanpierre, 2007; Skamp, 1989). This study drew attention to how the ISE model could provide experiences that developed participants’ overall science teaching belief systems, and more specifically, beliefs about informal science teaching.

Learning the art of teaching is not a static; rather it is a dynamic process. In the profession of teaching, educators are perpetually developing and changing their beliefs. This
study reviewed participants’ belief systems at the beginning and end of a science methods course and the differences were noted both quantitatively and qualitatively. Such queries help the field to gain a holistic understanding of participants’ beliefs about science instruction. Information about the three research questions used in this dissertation are presented in this section.

Research Question 1

In what ways did experience with the Informal Science Education (ISE) model affect prospective elementary teachers’ beliefs about teaching science?

Teachers make decisions about teaching practices based on underlying beliefs (Bryan, 2012; Kelly, 2000). This research attempted to explore the impact of the ISE model on participants—future elementary teachers. Therefore, participants’ overall beliefs about science teaching were gathered quantitatively through use of the survey instrument BAT. Additionally, the drawings and narratives prepared by the participants throughout the semester were essential in understanding the complexity of their prior belief systems. Participants began the science methods course with a variety of beliefs about science teaching. These belief systems were based upon prior knowledge and experiences.

As seen in Table 16, there was virtually no difference, statistically speaking, between the beliefs of participants in the treatment group and the comparison group. However, the treatment group participants’ beliefs about science instruction revealed a greater rate of change, as indicated by the quantitative analysis. These results are consistent with previous research on the positive impacts of informal experiences on teacher candidates’ beliefs about science (Carrier, 2009; Harlow, 2012; Jung & Tonso, 2006; Katz et al., 2011; Wallace, 2013). In the present study, all participants in the treatment group voiced their valuing of at least one of the parts of the ISE model—the microteaching, the Elm Fork Education Center visit, or the virtual museum tour—
from which I infer that participants’ beliefs were heavily influenced by the experiences provided in the ISE model science methods course only by the qualitative data analysis.

Research Question 2

What was the status of prospective elementary teachers’ beliefs about pedagogical practices in science instruction before and after a science methods course using the Informal Science Education (ISE) model?

The quantitative data analysis provided evidence that participants’ beliefs about science instruction did change; however, this was better understood by the emerging themes uncovered through the qualitative data analysis than through quantitative analysis. As suggested by prior research, teacher educators can invite teacher candidates to articulate models, metaphors, and images of teaching (Mensah, 2011; Subramaniam, 2013; Riedinger et al., 2010; Harlow, 2012) to document ideas about their own teaching. Katz et al. (2011) asked teacher candidates to draw pictures of “students learning” and “themselves teaching” and found that many of them held mental models of “inquiry-based science teaching.” These conceptions provided evidence of change in teacher candidates’ emergence as teachers of science. In the Katz et al. (2011) study, the involvement in a program (an informal afterschool internship), provided for confidence building and an enthusiasm to teach science. In the current study, the microteach assignment allowed for an outdoor experience, a similar type of role as was provided in the Katz et al. (2011) study, which allowed the participants to “practice” teaching in an informal learning environment.

Participants’ drawings and written artifacts in this study demonstrated that they had a superficial understanding of what science instruction truly requires. Initial beliefs about science teaching prior to the implementation of the ISE intervention were general and unpracticed. Therefore, it can be inferred that participants did not have a well-developed understanding of
concepts related to science teaching: the learning cycle as an inquiry-based teaching approach, the use of educational technology as a means of student-driven lessons, and designed learning environments as an extension of the classroom. It was clear from their responses in their written reflections for the course that they wanted science teaching to include hands-on activities and experimentation, but at the same time they voiced a concern about their lack of preparation. This type of characterization of under-preparedness was noted by Cronin-Jones (1991) when studying middle school teachers.

Through the qualitative analysis, this study uncovered that several new ideas were added to participants’ belief systems through the use of the ISE model. Tal and Dierking (2014) called attention to “the nature of the learning” in relation to learning environments (p. 252). This study demonstrated that the prospective elementary teachers’ beliefs as reported in their reflections, interviews, and Wordles, and their learning-to-teach philosophies, may have changed through the influences of the science methods course and the ISE model. Participants’ use of peer questioning techniques and multiple outdoor spaces gave evidence that their belief systems now incorporated ideas related to a cross-context focus on teaching science. Lesson plans for these microteach sessions included informal science experiences that were clearly influenced by the ISE model—indicating that the participants perceived themselves as users of ISE. The beliefs of were enacted in the outdoor microteaching sessions and were expressed in their reflections throughout the semester. Supporting evidence from prior researchers gives credence to the relationship between belief and practice (Bryan, 2003; Lester, 2002; Ogan-Bekiroglu & Akkoc, 2009).
The intervention presented the participants with digital tools that fit well with the ISE model, such as Google Hangout and virtual museums (built on prior personal constructs related to the use of technology in the classroom). Prior to the ISE experiences, the participants’ concepts of technology use in the classroom were very limited in scope and related to PowerPoint, Google searches, or playing a video clip. By the end of the study, many exhibited integrating educational technology in science instruction that was now purposeful, used to engage with science content, and facilitating for extending the context beyond the classroom. Use of environments as tools for teaching were observed in their microteaching opportunities when participants conveyed experiences of science learning from a student’s viewpoint, which showed their understanding of the need to engage learners and tailor content and teaching methods to student interest.

At the end of the course, during the interview discussions participants indicated their increased confidence in teaching science content and instructional practices. Participants’ beliefs about science teaching included a wide-range knowledge related to science teaching. The belief systems for these participants included a variety of learning environments specific to informal science teaching, authentic learning experiences, reflective practice, and expanded digital tools. These participants also embraced nontraditional environments that used the Bybee (2003) 5E learning cycle and questioning to create a student-centered learning environment.

First of all, participants in the treatment group with the ISE model seemed to benefit from the science methods course. In their drawings, reflections, and interviews they mentioned new ideas about pedagogical approaches, instructional tools, and learning environments in science teaching and learning. Once they had experienced the ISE model, they began to recognize how to teach science by the use of variety of tools, inquiry-based lessons, student-centered processes,
and multiple contexts. The teacher candidates commented that teaching science lessons involves the use of student-driven, real-world connections, and interactive hands-on approaches that are fun and messy.

Second, the prospective candidates felt the inquiry-based learning through the use of the 5E learning cycle and questioning was appropriate for science instruction no matter what the context of learning would be. Finally, by the end of the semester, belief systems of treatment group teacher candidates had expanded, indicating their ideas about the use of tools (including digital tools) and approaches including messiness, and they were now open to the use of non-traditional environments (such as virtual spaces and collaborative learning). The participants in the treatment group shifted from limited belief systems towards belief systems that integrated the use of tools and processes in science instruction. The peer teaching experience that was integrated in the ISE model through the use of outdoor microteach sessions, virtual museum tours, and the Elm Fork Education Center expanded the idea of teaching beyond the classroom walls for the treatment participants. Similarly, Carrier (2009) found that when elementary preservice teachers taught outdoors in their science methods course and with students in day camps, it set the stage for their acquisition of positive models of teaching practice that bolstered enthusiasm from students and provided a meaningful teaching experience from which candidates could gain a sense of inquiry-based instructional practice in an authentic setting. The findings of this study cohere with Carrier (2009) were participants used the outdoor spaces to make connections between science content and relating it to real-world context making learning meaningful.

Research Question 3
In what ways did the qualitative data contribute to a more comprehensive understanding of the statistical results from the quantitative phase of the study?
The nature of the teacher candidates' beliefs systems were examined through several data sources. The most revealing results and findings were showcased in the selected cases presented in Chapter Four. Regardless of their prior knowledge and experience, the participants in the treatment group claimed that the ISE model had a positive impact on their ideas about teaching science. Aspects of participants’ initial apprehension to teach science changed over the course of the semester. All the participant cases in this section make connections to ISE indicating the experiences as memorable and influential.

Conclusions

Summary of Results for Question 1

In what ways did the experience of the Informal Science Education (ISE) model affect prospective elementary teachers’ beliefs about teaching science? The participants in this study were administered a survey instrumentation (BAT) to understand their overall beliefs about science teaching. The participants’ beliefs in both the treatment and comparison group changed over the course of the semester from pretest to posttest. That is, mean scores of the beliefs about the ability to teach science grew during the science methods course. However, there was no statistically significant difference between the groups. The results of the BAT instrumentation for the treatment group were not statically significant over time, but the effect of group and time interaction effect was statically significant when the participants in the treatment group were involved in the ISE model (See Figure 4.4).

Summary of Findings for Question 2

What was the status of prospective elementary teachers’ beliefs about pedagogical practices in science instruction before and after a science methods course using the ISE model? The beliefs of the treatment group participants about science instruction as expressed in BAT
scores increased from the beginning to the end of the semester. The quantitative data analysis provided evidence that participants’ beliefs about science instruction did change as expressed through emerging themes revealed in the qualitative data analysis. Treatment candidate initial beliefs about science teaching prior to the implementation of the ISE intervention were general and unpracticed. Additionally, the participants voiced a concern about their lack of preparation.

Through qualitative analysis, it was evident that participants’ belief systems were beginning to show new instructional ideas that were added to participants’ prior belief systems through the use of the ISE model. New digital tools, such as Google Hangout and virtual museums, built on prior personal constructs related to use of technology in the classroom. The aforementioned outcomes resulted from the ISE model and its designed learning environments components, which allowed the teacher candidates in the study to have experiences as their students would.

Additional evidence of change in the treatment participants’ belief systems was that the use of environments as tools for teaching were observed in the microteaching opportunities, which allowed participants to experience science learning from a student’s viewpoint and gain a better understanding of the need to engage learners and tailor to student interests. Participants’ use of peer questioning techniques and multiple outdoor spaces also evidenced that their belief systems now incorporated ideas related to context. In addition, lesson plans included informal science experiences that were clearly influenced by the ISE model, indicating that the participants perceived themselves as users of ISE.

Summary of Results for Question 3

Since the quantitative results of this study were not statistically significant, I further investigated the reasons for the change in participants’ beliefs about science teaching. The
qualitative findings illuminated the details of the change in the participants’ beliefs. The integration of the quantitative results and the qualitative findings together provided clarity to specific types of changes in beliefs related to science instruction. Thus, the mixed method approach was valuable in investigating the goals of this research.

This research study supported the use of the ISE model in science methods instruction because the participants’ beliefs changed during the course of the study. All participants in the treatment group expressed a more in-depth view of informal science teaching. The learning for the participants in the ISE model occurred over time, indicating the need for the investment of time in the process of developing science educators and the need for the variety of experiences in different types of learning environments.

Implications

As the United States continues efforts to further improve science education, the implications of this study for science teacher education, teacher educators, and professional development, as well as the educational research community, become important.

Current Reforms for Science Teacher Education

The implications of this study range from general teacher education to, more specifically, science teacher education. Teacher candidates in this study had the opportunity to share their thoughts in regards to science teaching through drawings, their beliefs through their narratives, and their feelings through reflections. The data suggests that teacher candidates in this study initially lacked understanding about how to adequately teach science. Prospective elementary teachers lacking science content knowledge and pedagogical are less likely to teach science in elementary school (Kelly, 2000; Skamp, 1989). Since science methods courses play an important role in developing knowledge and instructional skills for future educators (Bryan, 2003; Roehrig
& Luft, 2006). The innovative course design in this study—through the use of the ISE model—provided experiences that allowed for better understanding of both science content and science teaching across multiple types of learning environments. The ISE experiences within the science methods course affected the teacher candidates’ overall science teaching belief systems. Teacher educators in the program within which this study was conducted should be aware of the impact of methods courses on teaching practice. A successful model for a methods course, as described in this study, could be replicated in methods courses covering other content areas. Providing teaching candidates with the opportunity to understand their current knowledge, beliefs, and experiences through drawings and reflections could help them confront and recognize their deficiencies. If these issues are not recognized during teacher education programs, they will be perpetuated in in-service teaching.

Therefore, I concur with the suggestions made by Crone et al. (2011) regarding the scope, sequence, and time given to informal science experiences in science methods courses. Teacher educators could also benefit from the examination of individual experiences within teacher preparation courses so as to better connect experiences across methods courses allowing for better scope and sequence. According to the results and findings of this study, I also agree with Crone et al. (2011) that needs have to be tailored to individual classes and it is impossible to explore all “avenues of informal education” (p. 295); therefore, the ISE model as shared in this study packages the informal environments and allows it to being adaptable for other science methods course instructors but also any other content methods course.

Modification to the Informal Science Education Model

As explained in Chapter Three, this study employed an ISE model to support future elementary educators and provide them with ISE opportunities. The degree of complexity of the
model could be further explored by teacher educators themselves as they plan, teach, and reflect on various types of authentic learning. Reflective practices should be used not only by prospective teachers in teacher preparation programs but also by teacher educators. Critical analysis and reflection would allow for a chance to addressing the bigger scope of reform efforts such as NGSS (2013). Furthermore, embedding ISE experiences in science pedagogical practice and using contemporary instructional tools should be properly scaffolded by teacher educators to support effective and meaningful learning for each cohort of teacher candidates since the implementation of ISE facilitates science content development, exploration of learning in multiple context, and incorporation of critical instruction skills needed in the classrooms of tomorrow.

I argue that training prospective elementary teachers using the ISE model can alter how they think about science instruction and how they can best teach science, inevitably changing their belief systems and affecting their future classroom. If teacher candidates are afforded opportunities to make meaningful use of different learning environments, this will impact their science instructional practices beyond the classroom to the promotion of scientifically literate citizens.

Science Teacher Education Programs

The results and findings of the study indicate that the participants who received the ISE intervention exhibited greater change in beliefs about science teaching than the participants in the comparison group. The design of the science methods course in this study supported teacher candidates learning across multiple learning environments. The conceptualization of the integration of the ISE model supports learning experiences within science methods courses by
• specifying specific objectives to meet the needs of individuals in specific teacher programs,
• involving the educational technology department in the adoption of designed learning environments such as virtual museum spaces,
• creating a relationship between community-designed learning environments, such as nature centers and university teacher preparation programs,
• investigating informal learning environments based on the six strands of learning proposed by the NRC (2009), similar to the model used in this study,
• applying a similar ISE model in secondary teacher education preparation, and
• investigating the preparedness of teacher educators to support ISE and the professional development and support needed to incorporate it effectively into the curriculum.

The overall essence of the ISE model in science methods courses created an interconnectedness focused on learning science in informal environments.

Science Teacher Educators

Studies of beliefs with regards to science teacher education have focused on predisposed beliefs, science content knowledge, and K-12 experiences. The current study showed that the ISE model was an influential for participants in the treatment group. The data indicated that ISE contributed to participants’ belief systems. However, for effective use of the an ISE model, teacher educators (as course instructional designers) can modify the amount of time and the sequence of experiences provided as appropriate for their particular course goals, context, and needs of the teacher candidates.
I also suggest that science methods instructors collaborate with educational technology specialists, along with informal educators, to best understand and apply the ISE model. The purpose of the collaboration would be to engage in encouraging and sharing weaknesses and strengths that are unique to tailoring a course designed for elementary teacher candidates. I believe that this collaboration would assist in adequately meeting the process of individual course design and broaden the experiences that science teacher educators can provide.

The professional development of science teacher educators should go beyond classroom instructional practices and advances in technology. To accomplish this, instructional consultants from informal learning environments, such as museum spaces, should support and follow up with the implementation process of the ISE model.

Professional Development

Previous studies have shown that educators need assistance in implementation of instructional skills along with the idea of not feeling abandoned (Bransford & Darling-Hammond, 2005). Recognizing this need as part of the process of bringing about change to best suit NGSS (2013) reform efforts is critical. Gradually through support, such as regular professional development, science educators can practice skills that are needed to achieve the goal of engaging learners not only in the classroom but in context, such as virtual spaces and outdoor learning experience (as in the study), and also, in science enrichment programs.

Experimenting with the different parts of the ISE model and campaigning for its use in elementary and secondary teacher education programs will take time. However, the reward of adopting the ISE model can be seen immediately by science educators through the use of reflective practice.

Recommendations for Future Research
In education, research must be current to ensure teaching practices are keeping abreast with changes and reform needs. From the results and findings of this study and from the literature reviewed, several recommendations for future research are presented next. This report suggests two specific areas for future investigation and study. First, longitudinal studies are needed that explicate the relationship among teacher candidates’ beliefs and classroom practices introduced and developed during methods courses to their actual student teaching and the beginning years of their teaching careers. Educators need to be provided opportunities to reflect on course content and to expand their practice from initial courses in teacher education. Therefore, such studies should investigate teacher candidates’ entering beliefs about science teaching across contexts throughout and beyond their teacher education preparation programs to find out how pre-service teachers’ beliefs change over time and what specifically may influence those changes.

Methodologically, the study affirmed the value of the use of qualitative methods, as used in past studies to study beliefs and better understand how changes in beliefs occur over time. However, in the light of the common use of quantitative data in studies of change in teacher belief, it should be noted that quantitative data in this study demonstrated change in beliefs but could not reveal exactly what changes occurred. The use of qualitative data revealed a more in-depth picture. I conclude that future studies investigating factors related to beliefs of teacher candidates should embrace mixed research methods so that quantitative and qualitative data could be compared and a holistic picture gained.

Finally, the present study was an effort to explore beliefs about informal science teaching and understand the impact of an intervention based on the ISE model. Future research could also focus on the
• development of survey instrumentation specific to informal science teaching beliefs,

• refinement of the informal science education model for successive cohorts of students,

• replication of study with a larger treatment group and overall sample size, and

• examination of demographic factors in teacher candidate beliefs.

Limitations of Current Research

Each research study has its own limitations and this is the case in the current study. One of the primary concerns of the current study was the sample size and its demographic representativeness. In order to collect enough quantitative data for statistical analysis, the collection was done over three semesters. Ideally, the administration of the instrumentation should have occurred simultaneously (during the same semester) for all participants. Having a second cohort for the ISE treatment group would also have strengthened the study.

It is also important to note that the survey instrument used in this study was evaluated and was found to be reliable and valid, but the instrument may not have adequately addressed change in beliefs specific to informal science education. Therefore, the current study may not have offered a solid foundation to examine change in beliefs in regards to ISE. It was clear that the use of Likert scale instruments to examine beliefs of science teaching was insufficient to assess beliefs of informal science teaching. Furthermore, the observation protocol in this study needs modification to better collect and organize documentation. Videos of microteach sessions would have strengthened the data collection.
My Own Reflection and Closing Comments

This study was guided by a personal interest in developing an ISE model for science methods courses in teacher preparation programs. The results of the study indicated that the intervention based on the ISE model was associated with change in teacher candidate beliefs about science teaching during the course of one college semester. As a teacher educator and researcher, I feel a responsibility to provide teacher candidates with content, theory, and practice across contexts in a supportive environment. This dissertation research contributed to my own development as a teacher educator. One of the strongest parts of the ISE model in this study was the outdoor microteach experiences because the teacher candidates were able to practice teaching in a context beyond the classroom walls.

The structure of the science methods course allowed teacher candidates to

- Participate in designing 5E lesson plans specific to three major themes: physical, life and earth science, as well as their creating an engineering unit plan;
- Experience science lessons in informal learning environments, such as at the Elm Fork Education Center, and through Project WILD lessons and a virtual museum trip;
- Reflect on the content and the curriculum of the science methods course consistently;
- Improve skills necessary for science teaching and learning through leadership of a physical science demonstration and microteaching; and
- Observe, evaluate, and participate in a science lessons taught by peers.

These experiences were the products of a vision to promote positive shifts in the beliefs of prospective elementary teachers. I will continue to read new research literature regarding science teacher education and implement new practices to best support future teacher candidates.
REFERENCES


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http://www.nsta.org/about/positions/informal.aspx


Richardson, V. (2003). Preservice teachers’ beliefs. In J. Raths & A. C. McAnich (Eds.),

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APPENDIX A

PROJECT WILD LESSONS: OH DEER

Lesson Sources/References: Project WILD adapted for science methods course.

Concepts: (background for lesson) Students will be performing “Oh Deer” is a simulation game where students become “deer” and components of habitat. The students in the activity will discover the most essential things that animals need in order to survive. This activity will also demonstrate how animal populations increase and decrease from year to year and that limiting factors are the cause of the population change.

Objectives/Overview of activity:

1. Students will be able to identify and describe food, water, and shelter as three essential components of habitat.

2. Students will learn that a population will continue to increase in size until some “limiting factors” are imposed.
   - Limiting Factors – influences that prevent an animal population from reaching biotic (reproductive) potential.
   - Examples of Limiting Factors – food, water, shelter, space, disease, predation, climatic conditions, pollution, hunting, poaching, habitat destruction and accidents.

3. Students will learn limiting factors contribute to fluctuations in wildlife populations and that nature is never in “balance” but is constantly changing.

4. Students will learn that good habitat is the key to wildlife survival.

5. Students will learn that organisms respond to both internal and external stimuli.
   - Internal Stimuli – hunger or thirst
   - External Stimuli – presence of shelter or predators
6. Students will learn that energy flows through living systems such as food chains or food webs.

Texas Essential Knowledge and Skills: (Have participants look up)

Materials List and Advanced Preparations:

1. Colored armbands
2. Poster for graphing deer populations
3. Markers
4. Outdoor Sidewalk

**Key Terms:** Predator, Prey, Limiting Factors, Habitat, Population
<table>
<thead>
<tr>
<th>Safety: Follow the directions of the game. ENGAGEMENT</th>
<th>Time: 5 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What the Teacher Will Do</strong></td>
<td><strong>Sample Questions</strong></td>
</tr>
<tr>
<td>Describe the background information.</td>
<td>What does animals need to survive?</td>
</tr>
<tr>
<td>Introduce the game. Explain rules of game to students will be performing “Oh Deer” is a simulation game where students become “deer” and components of habitat. Instruct students to stand behind the lines on the concrete of sidewalk, deer behind one line and remaining students behind the other line.</td>
<td>What are limiting factors? Give some examples.</td>
</tr>
<tr>
<td>Number off by “4”. Distribute armbands to designate students who are deer. Deer Food Water Shelter</td>
<td>Answer any remaining questions from students and begin game.</td>
</tr>
</tbody>
</table>

**EXPLORATION**  Time: 10 Minutes

<table>
<thead>
<tr>
<th><strong>What the Teacher Will Do</strong></th>
<th><strong>Sample Questions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead students through the game.</td>
<td>What are the results of this round? How many deer do we have? Take a look at the resources.</td>
</tr>
<tr>
<td>Record the population of deer after each round on the poster.</td>
<td>Stop and pause after each round and have the student discuss amongst themselves the phenomenon.</td>
</tr>
<tr>
<td>Give student wait time in order to illicit responses.</td>
<td></td>
</tr>
</tbody>
</table>

**EXPLANATION**  Time: 5 Minutes

<table>
<thead>
<tr>
<th><strong>What the Teacher Will Do</strong></th>
<th><strong>Sample Questions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitate discussion for data analysis</td>
<td>Look at the chart. Let’s look at our numbers.</td>
</tr>
<tr>
<td>ELABORATION</td>
<td>Time: 5 Minutes</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------</td>
</tr>
<tr>
<td>What the Teacher Will Do</td>
<td>Sample Questions</td>
</tr>
<tr>
<td>Summarize the lesson</td>
<td>What do animals need to survive? What are some limiting factors? Is nature ever in balance? Give examples</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EVALUATION</th>
<th>Time: 2 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>What the Teacher Will Do</td>
<td>Sample Questions</td>
</tr>
<tr>
<td>Work with your shoulder partner</td>
<td>How can I use this activity in the future? How can I accommodate ELL students?</td>
</tr>
</tbody>
</table>
APPENDIX B

PROJECT WILD LESSON: HOW MANY BEARS

Lesson Sources/References: Project WILD activity adapted for science methods course.

Objectives/Overview of activity:

1. Students will be able to identify and describe food, water, and shelter as three essential components of habitat.
2. Students will learn that a population will continue to increase in size until some “limiting factors” are imposed.
3. Limiting Factors – influences that prevent an animal population from reaching biotic (reproductive) potential.
4. Examples of Limiting Factors – food, water, shelter, space, disease, predation, climatic conditions, pollution, hunting, poaching, habitat destruction and accidents.
5. Students will learn limiting factors contribute to fluctuations in wildlife populations and that nature is never in “balance” but is constantly changing.
6. Students will learn that good habitat is the key to wildlife survival.
7. Students will learn that organisms respond to both internal and external stimuli.
8. Internal Stimuli – hunger or thirst
9. External Stimuli – presence of shelter or predators
10. Students will learn that energy flows through living systems such as food chains or food webs.

Texas Essential Knowledge and Skills: (Have participants look up)
Materials List and Advanced Preparations:

5. Bandana

6. Large outside place

7. Poker Chips (food tokens)

8. Hula hoops

**Key Terms:** Predator, Prey, Limiting Factors, Habitat, Population

**Safety:** Follow the directions of the game. No one is to harm anyone by being rough.
<table>
<thead>
<tr>
<th>ENGAGEMENT</th>
<th>Time: 5 Minutes</th>
<th>What the Teacher Will Do</th>
<th>Sample Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Describe the background information. Introduce the game.</td>
<td>What does animals need to survive? What are limiting factors? Give some examples.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prey must eat a total of three food tokens each round to survive. Prey have two ways to prevent being caught by predators. They may “freeze” any time a predator is within five feet of them or they may run to cover (at least one foot must be within safe zone like the hoop or shelter). Predators capture prey by tagging them when they are not frozen, in a safe zone. Once a predator captures a prey, he or she leads the prey off the play area and takes the red bandanna from their victim. A captured prey may not re-enter the game during this round. Predators must capture at least two red bandanas each round to survive.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Answer any remaining questions from students and begin game.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXPLORATION</th>
<th>Time: 10 Minutes</th>
<th>What the Teacher Will Do</th>
<th>Sample Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lead students through the game.</td>
<td></td>
</tr>
</tbody>
</table>
### EXPLANATION

<table>
<thead>
<tr>
<th>What the Teacher Will Do</th>
<th>Sample Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitate discussion for data analysis</td>
<td>How is the game similar to predator/prey relationships?</td>
</tr>
</tbody>
</table>

### EVALUATION

<table>
<thead>
<tr>
<th>What the Teacher Will Do</th>
<th>Sample Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watch a video on predator/prey relationship, back in the classroom</td>
<td>How else can you start the lesson? Write a sample EXPLORE for this activity.</td>
</tr>
</tbody>
</table>

### ELABORATION

<table>
<thead>
<tr>
<th>What the Teacher Will Do</th>
<th>Sample Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitate discussion for data analysis</td>
<td>How is the game similar to predator/prey relationships?</td>
</tr>
</tbody>
</table>
APPENDIX C

PROJECT WILD LESSON: QUICK FROZEN CRITTERS

**Lesson Sources/References:** Project WILD adapted for science methods course.

**Concepts: (background for lesson)** Students will be performing “Oh Deer” is a simulation game where students become “deer” and components of habitat. The students in the activity will discover the most essential things that animals need in order to survive. This activity will also demonstrate how animal populations increase and decrease from year to year and that limiting factors are the cause of the population change.

**Objectives/Overview of activity:**

1. Students will be able to learn that a population will continue to increase in size until some “limiting factors” are imposed.

2. Limiting Factors – influences that prevent an animal population from reaching biotic (reproductive) potential.

3. Examples of Limiting Factors – food, water, shelter, space, disease, predation, climatic conditions, pollution, hunting, poaching, habitat destruction and accidents.

4. Students will learn limiting factors contribute to fluctuations in wildlife populations and that nature is never in “balance” but is constantly changing.

5. Students will learn that good habitat is the key to wildlife survival.

6. Students will learn that organisms respond to both internal and external stimuli.

7. Internal Stimuli – hunger or thirst

8. External Stimuli – presence of shelter or predators
9. Students will learn that energy flows through living systems such as food chains or food webs.

Texas Essential Knowledge and Skills: (Have participants look up)

Materials List and Advanced Preparations:

- Envelopes (one per student)
- 2” X 2” cards from colored construction paper
- Large Outside Area
- Blindfold

**Key Terms:** Predator, Prey, Limiting Factors, Habitat, Population

**Safety:** Follow the directions of the game. Students must walk into the "forest."
<table>
<thead>
<tr>
<th>ENGAGEMENT</th>
<th>Time: 5 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What the Teacher Will Do</strong></td>
<td><strong>Sample Questions</strong></td>
</tr>
<tr>
<td>Introduce the game. Black bear habitat limits black bear populations, especially through the influences of shelter, food supply, and the social tolerances or territoriality of the animal. Shelter or cover is a prime factor. Black bears need cover—for feeding, hiding, bedding, traveling, raising cubs, and denning. With limits of space, adult bears will kill young bears or run them out of the area. These young bears must keep moving around either until they die or until they find an area vacated by the death of an adult. When food supplies are reduced by factors such as climatic fluctuations, competition becomes more intense.</td>
<td>What does animals need to survive? What are limiting factors? Give some examples?</td>
</tr>
<tr>
<td>Explain rules of simulation activity, they will be performing “How may bears?” is a simulation game where students become “bears.” The components of habitat will be designated by construction paper. The color of the card determines the type of food it represents: Orange – nuts (acorns, walnuts, hickory nuts) Blue – berries and fruit (blackberries, elderberries, raspberries, wild cherries) Red – meat (mice, rodents, beaver, muskrats, young deer) Green – plants (leaves, grasses, herbs)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXPLORATION</th>
<th>Time: 10 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What the Teacher Will Do</strong></td>
<td><strong>Sample Questions</strong></td>
</tr>
<tr>
<td>If you follow the table when making the food cards, there should be less than 80 pounds of food per student, so there is actually not enough food in the area for all the “bears” to survive. Lead students through the game. (Each time adding a “disabled” bear)</td>
<td>Have the students write their names on an envelope, which will represent each student's &quot;den site&quot; and should be left on the ground. What are the results of this round? Stop and pause after each round and have the student discuss amongst themselves the phenomenon.</td>
</tr>
<tr>
<td>EXPLANATION</td>
<td>Time: 5 Minutes</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>What the Teacher Will Do</strong></td>
<td><strong>Sample Questions</strong></td>
</tr>
<tr>
<td>Facilitate discussion for data analysis. In each round, include: Assign one student as the injured bear and tell him or her to &quot;hunt&quot; by hopping on one leg.) Another bear is a young female who investigated a porcupine too closely and was blinded by the quills. (Assign one student as the blind bear; he or she must hunt blindfolded.) The third special bear is a mother bear with two fairly small cubs. She must gather twice as much food as the other bears. (Assign one student as the mother bear.)</td>
<td>Tell the students each bear needs 80 pounds to survive. Which bears survived? Is there enough to feed all the bears? How many pounds did the blind bear collect? Will she survive? What about the mother bear? Did she get twice the amount needed to survive? What will happen to her cubs? Will she feed her cubs first or herself? Why? What would happen to her if she fed the cubs? What if she ate first? If the cubs die, can she have more cubs in the future, and perhaps richer, years?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EVALUATION</th>
<th>Time: 2 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What the Teacher Will Do</strong></td>
<td><strong>Sample Questions</strong></td>
</tr>
<tr>
<td>Reflection</td>
<td>How can you use this lesson in a school which does not have an outdoor space?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ELABORATION</th>
<th>Time: 5 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What the Teacher Will Do</strong></td>
<td><strong>Sample Questions</strong></td>
</tr>
<tr>
<td>Summarize the lesson and record “den” data. Go back to class and have students record the number of cards in there envelope. Have students write about their experience.</td>
<td></td>
</tr>
</tbody>
</table>
# APPENDIX D

## COURSE SCHEDULE

<table>
<thead>
<tr>
<th>Week</th>
<th>Discussion Topic and Reading Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Course Introduction</td>
</tr>
<tr>
<td></td>
<td>Current Trends in Elementary Science Teaching</td>
</tr>
<tr>
<td></td>
<td><strong>Chapter 1:</strong> Inquiring Minds in the Classroom</td>
</tr>
<tr>
<td></td>
<td><strong>Chapter 2:</strong> Discovering Science through Inquiry Science Notebooks</td>
</tr>
<tr>
<td></td>
<td>Designing a 5E Lesson</td>
</tr>
<tr>
<td></td>
<td><strong>Chapter 3:</strong> Planning for Inquiry</td>
</tr>
<tr>
<td></td>
<td>TEKS and Vertical Alignment</td>
</tr>
<tr>
<td></td>
<td>Safety in the Elementary Science Classroom</td>
</tr>
<tr>
<td></td>
<td><strong>Science Notebook: Science Safety Stations</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Chapter 4:</strong> Inquiry and Assessment</td>
</tr>
<tr>
<td></td>
<td>Diagnostic, Formative &amp; Summative Assessments</td>
</tr>
<tr>
<td></td>
<td>Science Inquiry Skills; Inquiry/Hands-on to Minds-on</td>
</tr>
<tr>
<td></td>
<td><strong>Science Notebook Activity: Formative/ Summative Assessment</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Chapter 5:</strong> Inquiry and Science as Practice</td>
</tr>
<tr>
<td></td>
<td>Integrated Process Skills &amp; Designing a 5E Lesson</td>
</tr>
<tr>
<td></td>
<td>Effective Practices of Science Vocabulary Instruction</td>
</tr>
<tr>
<td></td>
<td><strong>Science Notebook Activity: Water Cycle and Narrative Procedure</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Chapter 6:</strong> Inquiry Experiences for All Children</td>
</tr>
<tr>
<td></td>
<td>Designing a 5E Lesson/ 6E Lesson</td>
</tr>
<tr>
<td></td>
<td><strong>Science Notebook Activity: Measurement and Density</strong></td>
</tr>
<tr>
<td>Chapter 7: Inquiry Learning Opportunities</td>
<td></td>
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<tr>
<td>----------------------------------------</td>
<td></td>
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<tr>
<td>Chapter 8: Professional Development in Support of Inquiry</td>
<td></td>
</tr>
<tr>
<td>Science Notebook Activity: Hands-on/Minds-on</td>
<td></td>
</tr>
<tr>
<td>Project WILD Part 1</td>
<td></td>
</tr>
<tr>
<td>Project WILD Part 2</td>
<td></td>
</tr>
<tr>
<td>Elm Fork Education Center Visit</td>
<td></td>
</tr>
<tr>
<td>Science Notebook Activity: Pre/Post Visit</td>
<td></td>
</tr>
<tr>
<td>Microteaching: Lesson Presentation</td>
<td></td>
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<tr>
<td>Microteaching: Lesson Presentation</td>
<td></td>
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<tr>
<td>Microteaching: Lesson Presentation</td>
<td></td>
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<tr>
<td>Microteaching: Lesson Presentation</td>
<td></td>
</tr>
<tr>
<td>FINAL EXAM</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E

MICROTEACH OBSERVATION PROTOCOL

Name

Gender: ___Female  ___ Male

Topic for Microteach Lesson

1. Describe the microteach lesson.
   a. What is happening in the classroom?
   b. What is the teacher doing?
   c. What are the other students doing?

2. Describe teachers and the students interaction
   a. Try to capture examples of the questions being asked by teachers and how students respond.
   b. Try to capture the questions students ask teachers and the teachers’ responses.
   c. Are the students in cooperative learning groups?
   d. Do the students have an opportunity to interact with one another? Is so, how do they interact?

3. Describe the use of informal science education
   a. What types of informal space are used by the teacher?
   b. What resources are used by the teacher? (e.g., visual aids, worksheets, media etc.)

4. Describe the use of educational technology
   a. Is technology being used as part of the microteach?
   b. If so, how, and for what purpose?

5. What else does the teacher do? What else do the students do?

   My Reflection of the Microteach Lesson

1. What is the teachers overall approach to classroom instruction?
2. Did the students seem to be clear on the procedure of the activity or confused?
3. What components of the lesson/task did students seem enthusiastic about? Include specific examples of student comments and actions to illustrate.
APPENDIX F

INTERVIEW PROTOCOL

Name

Gender: ___Female   ___ Male

GENERAL

1. What got you interested in teaching?
2. Tell me about your favorite teacher, educator, or role model?
3. What are your strengths as a science teacher? Name/List 3 of your professional qualities?
4. What areas can you improve upon as a science teacher?

ASSESSMENT

1. How do you know if you (personally) have learned something?
2. How do you know if a student in your elementary/middle school setting has learned something?
3. Which assignment did you enjoy the most in the science methods course this semester: The Engineering Unit, The Virtual Field trip or Movie in Science? Why?

INSTRUCTIONAL CLASSROOM METHODS

1. What do you consider to be the key elements of a science lessons?
2. What are some specific “teacher tools” that you can use in your student teaching next semester?
3. What are do you think of the instructional style of this course?
4. Name a specific activity or time of the science methods course has been the most memorable?
5. What informal learning environments? Name a couple of examples?
6. How would you incorporate informal science teaching in your classroom?
7. What are the advantages of informal science lessons?
8. How do you know if a student in your elementary/middle school setting has learned something when visiting an informal learning environment?

CLOSURE
1. What did you think of the textbook adopted for this course?
2. What is the most important concept/idea you have learned this semester related to science teaching?
3. List one to three new ideas that you can use in teaching science in the future?
4. What advice would you give instructors of science methods courses? How can we better support you in becoming a teacher?
## APPENDIX G

**DEDUCTIVE ANALYSIS**

Framework adapted by Katz et al. (2011)

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal 1</strong>&lt;br&gt;Experiences, excitement, interest and motivation to learn about phenomenon in natural and physical world.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Smiling figure and specific indicators such as the use of descriptive words”fun” other exclamations of excitement, interest, and motivation</td>
</tr>
<tr>
<td>3</td>
<td>Smiling figures or comments that indicate excitement, interest or motivation</td>
</tr>
<tr>
<td>2</td>
<td>Figures with facial expression but ambiguous in regards to excitement, motivation, or interest</td>
</tr>
<tr>
<td>1</td>
<td>Negative facial expression or comments suggesting lack of interest, or motivation in drawing</td>
</tr>
<tr>
<td>0</td>
<td>No evidence (facial expression or comments) of excitement, interest, or motivation in drawing</td>
</tr>
<tr>
<td><strong>Goal 2</strong>&lt;br&gt;Come to generate, understand, remember and use concepts, explanations, arguments, models, and facts related to science.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, and facts (4 or more present)</td>
</tr>
<tr>
<td>3</td>
<td>Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, and facts (3 present)</td>
</tr>
<tr>
<td>2</td>
<td>Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, and facts (2 present)</td>
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<tr>
<td>1</td>
<td>Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, and facts (1 present)</td>
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<tr>
<td>0</td>
<td>No evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, and facts present</td>
</tr>
<tr>
<td><strong>Goal 3</strong>&lt;br&gt;Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing and sense-making (4 or more present)</td>
</tr>
<tr>
<td>3</td>
<td>Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing and sense-making (3)</td>
</tr>
<tr>
<td>2</td>
<td>Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing and sense-making (2)</td>
</tr>
<tr>
<td>1</td>
<td>Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing and sense-making (1)</td>
</tr>
<tr>
<td>0</td>
<td>No evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing or sense-making</td>
</tr>
<tr>
<td>Grade</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>4</td>
<td>Evidence of learning with others, using scientific language and using scientific tools (4 or more)</td>
</tr>
<tr>
<td>3</td>
<td>Evidence of learning with others, using scientific language and using scientific tools (3)</td>
</tr>
<tr>
<td>2</td>
<td>Evidence of learning with others, using scientific language and using scientific tools (2)</td>
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<tr>
<td>1</td>
<td>Evidence of learning with others, using scientific language and using scientific tools (1)</td>
</tr>
<tr>
<td>0</td>
<td>No evidence of learning with others, using scientific language and using scientific tools</td>
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</tbody>
</table>

Goal 5
Participate in scientific activities and learning practices with others, using scientific language and tools
## APPENDIX I

### DEDUCTIVE CODEBOOK

<table>
<thead>
<tr>
<th>Six Strands of Learning</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strand 1:</strong> Developing Interest in Science:</td>
<td>Teacher provides a positive learning environment</td>
</tr>
<tr>
<td>Experiencing excitement, interest, and motivation</td>
<td>Teacher as a resource</td>
</tr>
<tr>
<td><strong>Strand 2:</strong> Understanding Scientific Knowledge</td>
<td>Teacher discusses science reasoning</td>
</tr>
<tr>
<td><strong>Strand 3:</strong> Engaging Manipulating, testing, exploring, predicting, questioning, and observing.</td>
<td>Teacher promotes science inquiry</td>
</tr>
<tr>
<td><strong>Strand 4:</strong> Reflecting on learning</td>
<td>Teacher guides learning</td>
</tr>
<tr>
<td><strong>Strand 5:</strong> Engaging in using scientific languages and tools</td>
<td>Teacher poses questions</td>
</tr>
<tr>
<td><strong>Strand 6:</strong> Identifying as someone who knows about, uses, and sometimes contributes to science.</td>
<td>Students have responsibility to learn</td>
</tr>
<tr>
<td></td>
<td>Teacher gives feedback</td>
</tr>
<tr>
<td></td>
<td>Teacher provides materials to facilitate learning</td>
</tr>
<tr>
<td></td>
<td>Teacher demonstrations</td>
</tr>
<tr>
<td></td>
<td>Teacher as an expert</td>
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</table>
## APPENDIX J

### INDUCTIVE CODEBOOK

<table>
<thead>
<tr>
<th>Codes</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feelings: fun, happy, excited, interesting, positive experience</td>
<td>Affective</td>
</tr>
<tr>
<td>Role of science teaching, real-world, problem-solving, inquiry, experimenting, science equipment, hands-on</td>
<td>Pedagogical Practice</td>
</tr>
<tr>
<td>Classroom, labs, playground, museum, outdoor</td>
<td>Environment</td>
</tr>
<tr>
<td>Biology, dinosaur, plants, human systems</td>
<td>Science Content</td>
</tr>
</tbody>
</table>

Sample Coding Key: affective (designated with A), tools (designated with T), real-world (designated with RW), science processes skills (designated with SP), pedagogical approaches (designated with PP), learning environment (designated with LE) and more specifically informal learning environment (designated with ILE).
APPENDIX K

INDUCTIVE CODING SUMMARY SHEET

Codes were placed in the chart for each person in chronological order, “Pre” and “Post” were source codes for the pre-intervention and post-intervention.

<table>
<thead>
<tr>
<th>Codes</th>
<th>Pre-Intervention</th>
<th>Post-Intervention</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RW</td>
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<td></td>
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<td>SP</td>
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<tr>
<td>LE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ILE</td>
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<td></td>
</tr>
</tbody>
</table>
APPENDIX L

KIM’S EDUCATIONAL PHILOSOPHY

<table>
<thead>
<tr>
<th>Strand</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strand 1: Intention of teaching</td>
<td>A philosophy of education is the most important thing to develop during one’s teaching career and will continue to grow as the teacher develops professionally. The classroom lesson and teaching instructions are inspired by one’s philosophy. My philosophy is inspired by my beliefs. The student centered philosophy, progressivism, is the main philosophy that considers the three styles of learning. They types of learning include auditory, visual and kinesthetic learners. As an educator, I believe that a teacher should incorporate all the three learning styles as much as possible. Some ways to….One of the ways I will demonstrate this [is by letting] my student choose topics for their projects… [Another] activity…having my class learn as a whole by partaking in educational games that will help them study for quizzes. I believe that every child is different and they have a special gift that makes them unique. People should learn from one another instead judging just because they view them as different. In the classroom as teacher, I would have the students learn and understand about diversity. An influential philosopher, Jon Dewey, believed that teachers should educate students more about real world problems and social interaction in school. I believe that teachers should develop meaningful lesson by using real life situations so the students have a greater opportunity to master the lesson. Since I want to teach elementary school students, I believe this philosophy aligns best with them. As a teacher, I want to provoke curiosity, connect content to my lessons that are relevant and interesting to my students. As I continue to grow professionally through school and experiences, my philosophy [will] continue to evolve with me. Which I believe will only improve my classroom as the years progress.</td>
</tr>
<tr>
<td>Strand 2: Understanding the theory of “Dewey, believed that teachers should educate students more about real world problems”</td>
<td></td>
</tr>
<tr>
<td>Strand 3: Understanding that learning is a process and “teachers should develop meaningful lesson by using real life situations so the students have a greater opportunity to master the lesson”</td>
<td></td>
</tr>
<tr>
<td>Strand 4: Identifying her reasoning for beliefs “student centered philosophy, progressivism, is the main philosophy that considers the three styles of learning”</td>
<td></td>
</tr>
<tr>
<td>Strand 5: Being mindful of having the need for discussion by having “people learn from one another… social interaction in school”</td>
<td></td>
</tr>
<tr>
<td>Strand 6: Anticipating that her professionally identity</td>
<td></td>
</tr>
</tbody>
</table>
will “continue to evolve with me”
APPENDIX M

EXCERPTS OF EDUCATIONAL PHILOSOPHY STATEMENTS

<table>
<thead>
<tr>
<th>Participant</th>
<th>Excerpts from Educational Philosophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td>The philosophy I most identify with is progressivism. To me, the definition of progressivism is the teacher presents learning scenarios where students can put their background knowledge and life skill to use… The students decide what they want to learn,… student-centered… The students take their own responsibility of learning.</td>
</tr>
<tr>
<td>Jasmin</td>
<td>As modern-day teachers … from ordinary to extraordinary. Today’s presence of technology within the classroom creates the opportunity to accommodate students with all different learning styles…. Overall, establishing meaningful, long-lasting student to student and teacher to student connections among all in the classroom is a goal outline in my personal teaching philosophy that I hope to accomplish each and every year as a teacher</td>
</tr>
<tr>
<td>Sonya</td>
<td>In all of my lesson planning, I try to make them as engaging and interactive as possible as I can. I believe students learn better by actually doing. … have students control over their learning by giving them choices within different topics. I believe in allowing students to do more hands-on activities, such as trial and error activities. This way they can see how certain concepts real to the real-world. I would implement group work, because I know children learn a lot from one another… We as teachers should continue to encourage students to pursue the topics that they are interested in know more about. Students will be learning these different concepts through exploration and research and from there they will begin to discover how much they can learn from each other.</td>
</tr>
<tr>
<td>Pam</td>
<td>Students enter the classroom as individuals and this should be embraced. We are not factory workers and the goal is not to create the same product. Students are unique and our goal is to reach their potential. I want to create lifelong learners who will questions “What can I do to contribute in this world?” We need to help students develop critical thinking skills that will continue outside the walls of the school. Benjamin Franklin said, “Tell me and I forget, teach me I remember, and involve me and I learn”. As a teacher, this will guide me to help my students succeed. Children will learn by doing not just by example I want to find a way to incorporate hands on experiences for the students. If children are involved in their education, it will have a lasting effect. I agree with the teachings of Dewey that children should be involved in physical activities, hands-on learning and social interactions….</td>
</tr>
<tr>
<td>Dave</td>
<td>If I was asked about the four main philosophy and which ones I thought were important I would definitely say Progressivism and Social Reconstructionism. I think that Progressivism is an emphasis on preparing for the real-world, and Social Reconstructionism is about making sure that real-world is something you are a part of. The older I get the more I see a value of community, and I the more I see how much of an impact one action can make in a life… write lessons with a greater picture in mind, a picture full of tangible connections and insight…</td>
</tr>
<tr>
<td>Mary</td>
<td>I believe that as teachers, it is our responsibility to help teach children the ways in which technology can be used for good and how it will help them in their future lives. When I begin my final semester of student teaching in the fall I will keep this as one of my main focuses when planning lessons. I will also keep a focus on building from student’s prior knowledge as we increase what they know from the previous years….</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>