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The Impact of Beliefs and Curricular Knowledge on Planning for Science: A Multisite Case Study of Four Teachers

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The Impact of Beliefs and Curricular Knowledge on Planning for Science: A Multisite Case Study of Four Teachers

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Abstract

This descriptive multisite case study details how the beliefs and curricular knowledge of four science teachers in a southeastern school district affected their planning for science instruction. Through the analysis of interviews, think-aloud planning records for one unit of instruction, and related documentation, categories were identified and connections drawn to how their beliefs and knowledge influenced planning for instruction.

The four teachers in this study jointly expressed certain beliefs about how students best learn science. They expressed beliefs that students best learn science through hands-on activities, through discourse, and by building the student's knowledge base. The teachers also expressed beliefs about qualities that excellent science teachers should possess. These included that excellent science teachers should: possess personal curiosity, possess well-developed content knowledge, possess the ability to build a strong rapport with students, be flexible, be passionate, and possess well-developed knowledge of a variety of pedagogical strategies. Their beliefs about how students learn and qualities teachers should possess often overlapped and intertwined. Qualities of excellent teachers were generalized to reflect all teachers rather than science teachers specifically. Generally, the beliefs these teachers expressed influenced the activities they selected. However, sometimes these beliefs were compromised in response to institutional constraints.

Local and state standards played a significant role for these teachers as they planned for science instruction. Common Core standards also played a role in the planning process of the elementary science teachers as well. The *National Science Education Standards* (NSES) were not utilized as they planned for science instruction. Some of the participating teachers expressed a belief that their local and state standards were aligned with the NSES. Other factors including time, access to materials, and expectations of administration were influential on the planning process. Finally, recommendations are made for policymakers and administrators, for the professional development of teachers, and for pre-service teacher education. Questions are also raised which may guide future research.

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Chapter 1: Introduction

In 2010, President Barack Obama addressed the nation expressing concern over the recent performance of American students in science and math on the 2006 *PISA* (Programme for International Student Assessment). When compared to their peers in other developed nations, "American 15-year-olds ranked 21st in science and 25th in math" (Obama, 2010; OECD, 2007). The President's concern is shared by industry leaders. Will American students be able to effectively transition into the professional world if they possess knowledge deficits in the areas of math and science?

And what does the future look like for professions that require math and science? In 2009, the U.S. Bureau of Labor Statistics projected that specific engineering specialties will see a rapid shift in demand. The demand for civil engineers is projected to grow by 24%, employment opportunities for environmental engineers will increase by 31%, and the biomedical engineering field is projected to grow by 72% (U.S. Bureau of Labor Statistics, 2009).

In response to the performance of American students on international assessments of math and science, and a shifting national demand for scientists and engineers, increased attention recently been paid to the field of science education and the preparation of our K-12 students to enter science related professions. In 2012, the National Research Council published a document outlining broad expectations for future K-12 science education programs called the *Framework for K-12 Science Education* (2012). The *Framework* was the first step towards the refinement of the original *National Science Education Standards* (NSES). It was intended to inform the development of the *Next Generation Science Standards* (NGSS). The *Next Generation Science Standards* and the *Framework for K-12 Science Education* "reflect a new vision for American science education" and "guide standards developers, curriculum designers, assessment developers, state and district science administrators, professionals responsible for science teacher education, and science educators working in informal settings" (National Research Council, 2012, p. 2). Reformers hope these documents will influence the curriculum of, and instruction in, American schools so that we may better prepare our students of today for the science related professions of tomorrow.

As the American education system evolves in response to our country's future economic and employment needs, some problems emerge which must be addressed. How do we envision the future of science education? How will we communicate this vision to teachers, and will they be able and willing to fulfill the vision? In the section that follows, I expand on problems faced when implementing documents of reform into classroom practice.

Statement of the Problem

When educational reforms, such as the adoption of new standards or curricula are introduced into existing systems, these reforms often face problems of implementation. Teachers respond to changes in standards and curricula through their instructional decisions. These instructional choices are driven by their internal beliefs about science teaching and learning, and through their perceptions of philosophical alignment with reform documents.

Results from the 1993 and 2000 National Surveys of Science and Mathematics Education indicated that little change has taken place in daily classroom science instruction since the publication of the *National Science Education Standards* (Horizon, 2003). Published by the National Research Council, the NSES outlined what "students need to know, understand, and be able to do to be scientifically literate at different grade levels" (NRC, 1996, p. 2). In addition to providing content specific standards, the NSES outlined standards for science teaching, for the professional development of science teachers, assessments in science, and for science education programs and systems. The NSES was referenced by most states as they developed their own standards and guidelines for what students should learn in science. It has been championed by federal agencies, and proved to be influential in the selection of textbook and standardized assessments by states and school districts (Hollweg & Hill, 2003).

One of the core philosophies of the NSES is that student science experience should reflect "hands-on, minds-on" learning,

> Implementing the *Standards* will require major changes in much of this country's science education. The *Standards* rest on the premise that science is an active process. Learning science is something that students do, not something that is done to them. "Hands-on" activities, while essential, are not enough. Students must have minds-on experiences as well (NSES, 1996, p. 2).

Yet, since the publication of the NSES, the use of hands-on activities in the science classroom has remained relatively unchanged or has even slightly decreased over time (Horizon, 2003). This result is not surprising when one considers the influence that a teacher's internalized beliefs has on the introduction of new programs and standards (Jones & Carter, 2007).

Nespor (1987) asserted that because of the diversity of life experiences among teachers, attempting to change one's beliefs and/or actions with a singular prescribed approach is next to impossible. Ellis (2003) cautioned readers about this lack of connection between curricular reform and actual teacher practice, "adopting and implementing the materials do not guarantee that the teachers believe in and are practicing the approaches to learning and teaching espoused by the program" (p. 43). Considering the above, it is reasonable to assert that outsider-driven reform movements not predicated on the internal beliefs of teachers are unlikely to succeed (Anderson, 2007; Bryan & Abell, 1999; Smith & Southerland, 2007).

In addition to those beliefs that are subject-specific and epistemological in nature, a teacher's educational beliefs include "perceptions of self and feelings of self-worth (self-concept, self-esteem)" and "confidence to perform specific tasks (self-efficacy) (Pajares, 1992, p. 316). Elementary teachers particularly struggle to appropriately integrate new science pedagogy when they lack self-efficacy about their current practice (Weiss et al., 2001). Elementary teachers often feel unqualified to teach the science content, and feel less likely to develop a student's conceptual understanding of the subject matter. They also feel less comfortable managing student groups in hands-on or project based science work than secondary science teachers (Weiss et al., 2001).

A significant gap in confidence level exists between elementary science teachers and their secondary counterparts when it comes to teaching science. In the 2012 National Survey of Science and Mathematics Education (NSSME): Status of Elementary School Science Teaching only 39% of elementary teachers reported feeling well qualified to teach science. In particular, engineering and physical science were subjects identified by these teachers where lack of preparedness caused the greatest concern (Banilower, Smith, Weiss, Malzahn, Campbell, & Weis, 2013). In comparison, 80% of secondary chemistry teachers reported feeling well prepared to teach content such as properties of matter and atomic structure, and 68% of secondary biology/life science teachers reported feeling well prepared to teach cell biology. (Banilower, Smith, Weiss, Malzahn, Campbell, & Weis, 2013).

The National Science Teachers Association (NSTA) recommended that elementary teachers who are responsible for science instruction have college level coursework in life, Earth and physical science (NSTA, 2003). However, the number and type of college courses elementary teachers take in these sciences remains limited. In fact, only 36% of elementary teachers reported taking college coursework in life, Earth and physical science (Banilower et al, 2013). Historically, when elementary teachers have taken college level science courses, they are usually in the area of either life science and/or science education (Banilower et al. 2013). Considering that elementary teachers are often responsible for instruction in all of these disciplines, these numbers may suggest that elementary teachers possess underdeveloped subject matter knowledge of the content they are required to teach.

Seventy-two percent of elementary science teachers have reported the need for professional development in the aim of “deepening my own science content knowledge” (Kulp, 2002, p. 8). Yet despite these remarks, many elementary teachers are not participating in the professional development (PD) opportunities that might help them prepare for teaching science content (Ramey-Gassert, Shroyer, & Shaver, 1996). A National Science Foundation (2010) survey concluded that participation by elementary teachers in science professional development opportunities was limited or nonexistent,

> While teacher participation in professional development during a school year was almost universal at public middle and high schools, in 2004, 47% of public school fifth grade students were taught science by teachers who reported no staff development in science” (p. 1).

Even more disturbing, although the demand for quality professional development experiences in science is growing, the participation trend among elementary teachers is actually moving downward. In 2002, the NSSME stated that 50% of elementary science teachers reported having less than 6 hours of science professional development in the last three years

(Kulp, 2002, p. 9). That percentage has risen to 65% over the last 10 years (Banilower et al, 2013). This lack of prior educational experience in the sciences, and limited participation in professional development, may be the root of the problem that is low efficacy among elementary science teachers.

Additionally, a lack of familiarity with national science initiatives may be negatively impacting elementary teacher self-efficacy. In the National Survey of Science and Mathematics Education: Status of Elementary School Science Teaching (2002) 64% of elementary science teachers reported being unfamiliar with the *NSES* standards (Kulp, p. 6). Smith & Southerland (2007) reported similar results after conducting a series of workshops with elementary teachers. In their conversations with the teachers, many of them reported being "completely unfamiliar" with the NSES, or even the national movement towards science education reform. Secondary teachers are more likely to be familiar with the *National Science Education Standards* than elementary science teachers (Horizon, 2003). Interestingly, the science professional development opportunities that elementary teachers did most often attend were reported to be standards related (64%). However standards trainings were generally related to state assigned math and science standards, not national science standards (Banilower et al., 2013).

This issue of low teaching efficacy among elementary science teachers is concerning. Teachers who possess low efficacy are more likely to engage in teacher directed activities such as lecture and reading from the textbook (Czerniak & Lumpe, 1996). Teacher-centric methods contradict the recommendations of the NSES that inquiry act as the primary method by which our students learn science. The National Science Teachers Association (NSTA) has recommended that elementary generalists should be prepared to teach science,

> …with a strong emphasis on observation and description of events, manipulation of objects and systems, and identification of patterns in nature across subjects. They should be prepared to effectively engage students in concrete manipulative activities that will lead to the development of desired concepts through investigation and analysis of experience (NSTA, 2003).

But despite these decade old recommendations, science teaching is not evolving. Both elementary and secondary teachers continue to engage in methods that contradict those considered to be best practice in science education.

> Despite recommendations that students develop understanding of concepts first and learn the scientific language later, from 70 to 85 percent of science teachers at the various grade ranges indicate that students should be given definitions for new vocabulary at the beginning of instruction on a science idea (Banilower et al., 2013).

Many teachers retain traditional approaches to instruction such as presenting an "idea to students before having them consider evidence for it" and giving "definitions for new vocabulary at the beginning of instruction." (Banilower et al., 2013, p. 21). Teachers also consistently express that "hands-on activities should be used primarily to reinforce ideas students have already learned" (Banilower et al., 2013, p. 21). So if the underlying philosophies in documents of science education reform continually fail to be practiced by teachers, what causes for this might exist?

When teachers believe that an external locus of control exists which inhibits their instruction, they tend to only implement certain aspects of reform (Horizon, 2003). This is particularly true in the circumstance of high-stakes assessments and their influence on instruction. Some teachers believe that national visions of science instruction such as those proposed by the *National Science Education Standards* do not align with district or state assessments that they and their students will be held accountable to (Hollweg & Hill, 2003). Therefore, the attention teachers pay to national standards becomes secondary to state and district standards. vanDriel, Beijaard, & Verloop (2001) suggest that in order for reform projects to have an increased opportunity to succeed, policymakers should consider the beliefs that teachers possess about teaching and learning prior to implementation. Additionally, contradictions between beliefs and practice should be exposed and confronted to effectively facilitate change in practice.

While a small group of teachers did participate in the development of *The Framework of K-12 Science Education* and the *Next Generation Science Standards,* these documents will be new the majority of practicing teachers. Because the ideas found within these documents may conflict with the internal beliefs teachers possess about science teaching and learning, teachers may choose to modify, or even forego, implementing them. Additionally, although these documents have the potential to strongly influence the curricula these teachers may use in the future, many may not even be aware of the release of these documents, their potential impact, or the current policy changes taking place in science education.

Science teacher educators want to positively impact the daily instruction of our future classroom teachers. To do so, we must have a better understanding of how teachers' beliefs about science teaching and learning, and their curricular knowledge, affect planning for science instruction. We must be cognizant of what teachers believe regarding the role standards play in planning, know what standards they consult, and how national standards and guiding philosophies fit into this practice.

Purpose of the Study

The purpose of this study is to describe certain beliefs that elementary and secondary science teachers possess about teaching and learning, to describe the science curricular knowledge they possess about local, state and national science standards, and to describe how these beliefs and knowledge influence their planning for science instruction. More specifically, the three guiding questions for this study will be:

1. To what extent do beliefs about how students best learn science influence teachers as they plan?
2. To what extent do beliefs about qualities that excellent science teachers should possess influence teachers as they plan?
3. To what extent do local, state, and national standards influence teachers as they plan?

Need for the Study

Science education reform movements may continue to prove ineffective for changing the daily practice of teachers if we continue to ignore the influence that an individual's beliefs and knowledge has on the translation of reform curricula into planning. By describing the knowledge that elementary and secondary teachers possess about science curriculum, and by describing how beliefs and knowledge impact planning for science instruction, I hope to provide some insight to future policy makers and program developers. This may, in turn, increase the potential for science education reform movements to succeed.

Science teacher curricular knowledge can be described as "(a) knowledge of mandated goals and objectives (e.g., state and national standards) and (b) knowledge of specific curriculum programs and materials (Abell, 2007, p. 1128; Magnusson, et. al, 1999). Science curriculum knowledge, one aspect of pedagogical content knowledge (PCK), has rarely been researched (Abell, 2007). Those few studies previously conducted have generally involved teachers ranking existing goals. Furthermore, few studies that specifically address teacher knowledge of science standards have been conducted (Abell, 2007). My study will help fill this gap in the literature as it examines the science curricular knowledge of in-service elementary and secondary teachers. Specifically, I will focus on the role of local, state and national science standards in planning for instruction. Both the *Framework of K-12 Science Education* and the *Next Generation Science Standards* have only been released in the last year. This means that my study's examination of whether or not teachers access these documents as part of their planning process is very timely. No research currently exists which examines the implementation of these documents by elementary and secondary science teachers as they plan for instruction.

Research connecting PCK and teacher planning is limited (Hashweh, 2005). Hashweh (2005) recently described the renewed interest in teacher planning after the flurry of studies published in the seventies and eighties. Although research on the process and content of teacher planning may be adequate in the realm of teacher education, the literature on science teacher planning is less than sufficient (Abell, 2007). This fact is especially surprising when considering the recent push towards standards based science education reform (Abell, 2007). As this study seeks to examine a specific aspect of science teacher PCK and how it connects to teacher planning, I hope to address two gaps that exist in the research literature.

Appleton (2007) asserts that little research has been conducted in the last decade with the intent of informing future policy in elementary science education. The results of this study may inform future policy decisions regarding the introduction of national policies to teachers, and may also inform the design of future professional development programs. Additionally, Appleton (2007) describes a need for more research in the science classrooms of primary teachers (grades 1-3), insisting that the predominance of elementary science education research focuses on upper grade levels (4th through 6th). To address this need, I purposively solicited participation from primary teachers so that my study could fill a gap in elementary science education research.

Through this study, I hoped to generate interest among these practicing teachers regarding the *Framework of K-12 Science Education* and the *Next Generation Science Standards*. By making them aware of these documents, they may develop a greater understanding of the underlying philosophies, which may help inform and refine their future practice. Additionally, the results of this study may provide professional development program providers with important information about the factors that influence and inhibit the enactment of reform materials into practice. This may prove crucial to the design of future professional development opportunities.

Limitations and Delimitations

This study was limited by a factor outside of my control. Only four participants fully completed each phases of data collection. Some of the original 12 participants did not complete the required of think-aloud planning records, or failed to respond to my communications altogether. However, this limitation has allowed me to deeply explore the experience of my remaining four participants. As such, I believe that I have gained a greater understanding of these participants' experiences that would not have been achieved with a large sample.

In terms of delimitations, this study was delimited by factors of time, teaching experience, and data collected. I selected to collect interviews and think-aloud planning records during one academic year. This provides a snapshot into a teacher's beliefs at one time. If data had been collected over several years, different findings may have emerged. For practical purposes, I selected to delimit the time spent conducting this study.

I was particularly interested in experienced teachers of science. I defined experienced teachers as those who taught science for five years or more. I specifically solicited participation from elementary and secondary teachers who had five years or more science teaching experience.

I chose to delimit my collection of data to two in-depth interviews, audio recordings of each teacher as they thought aloud during their planning of one unit of science instruction, and the related documents that corresponded to each teacher's unit. Using interviews and audio recordings as the primary data collection method, I was unable to collect large amounts of data from a greater population of teachers which might enable me to generalize these results to science teachers as a whole population.

Assumptions

As a constructivist, I believe that pure objectivity cannot be achieved. I believe that "knowledge" is a social construction, meaning that what is 'known" is affected by the view of the "knower" and varies from person to person based on their life experiences. Because my view of my participants' knowledge is filtered by my own life experiences, I assume that I will not be able to fully grasp and understand the world experience of these teachers. Therefore, it became necessary to give my participants adequate opportunity to contribute to the findings of this study.

As a former classroom teacher, I possess beliefs about science teaching and learning which may have impacted choices I made during data collection and analysis. My beliefs about science teaching and learning align with those philosophies found in guiding national documents such as the *National Science Education Standards* and the *Framework for K-12 Science Education*. I assume that the philosophies within these documents have merits that should be communicated to teachers and eventually translated into their practice.

Definition of Terms

Where my personal definition of a term has aligned with a specific definition that exists within the literature, I have provided a reference. These terms have been listed alphabetically. In some circumstances, I have selected to define or interpret terms based on my own understanding of the word. In this case, I have provided no reference.

Attitudes - "learned predispositions to respond to an object or class of objects in a favorable or unfavorable way" (Fishbein, 1967, p. 257).

Beliefs - psychologically held understandings, premises, or propositions about the world that are felt to be true (Richardson, 1996, p. 103).

Constructivism - a belief system that reality is socially constructed through experience, and that "truth" is subject to change (i.e. no one universal truth exists) (Guba & Lincoln, 1998).

Epistemological - a philosophical concern with how knowledge is acquired.

Framework of K-12 Science Education - published by the National Research Council and "provides a sound, evidence-based foundation for standards by drawing on current scientific research—including research on the ways students learn science effectively—and identifies the science all K–12 students should know" (Achieve, 2012b). The document that preceded and informed the *Next Generation Science Standards*.

Knowledge - claims or assertions based on evidence (Richardson, 1996).

National Science Education Standards (NSES) - a document published in 1996 by the National Research Council which identified the content K-12 students should be responsible for and outlined the methods that teachers should use to teach the content.

Next Generation Science Standards (NGSS) - a document published by the National Research Council which identifies the science that all K–12 students master. Intended to refine and replace the *National Science Education Standards* (Achieve, 2012a).

Ontological - a philosophical concern that deals with the nature of reality.

Pedagogical Content Knowledge (PCK) - a specialized type of knowledge, subject-specific, where teachers understand how to help others learn. This includes representing ideas in a variety of ways (i.e. examples, explanations, analogies, illustrations, demonstrations) and considering student preconceptions when designing instruction (Shulman, 1986).

Resources – Any printed material referenced by teachers in the planning of their science instruction, including but not limited to: pacing guides, local, state and national standards, internet websites, lesson plans, texts, etc.

Science Curriculum Knowledge - "(a) knowledge of mandated goals and objectives (e.g., state and national standards) and (b) knowledge of specific curriculum programs and materials (Abell, 2007, p. 1128; Magnusson, et. al, 1999).

STEM – Science, technology, engineering and math.

Teacher Beliefs - beliefs about teaching (pedagogy) and learning, beliefs about the role and capabilities of students and teachers, beliefs about the purpose of schools in society, and beliefs about curriculum (Porter and Freeman, 1986).

Teacher Educational Beliefs – those beliefs that include teacher and/or self-efficacy, epistemological beliefs, beliefs about locus of control, and feelings of self worth/self-esteem. Also includes subject-specific beliefs (Pajares, 1992, p. 316).

Think-Aloud Planning Record (TAPR) - An audio recording completed by teachers in which they detail their planning for a unit of instruction.

Organization of the Dissertation

The remainder of this dissertation is organized into four chapters. In Chapter II, a review of the literature is presented with sections focused on the creation of the *National Science Education Standards*, their evolution into the *Next Generation Science Standards* as influenced the development of the *Framework of K-12 Science Education*, and summaries of research in the areas of teacher beliefs, and teacher knowledge focusing in towards science curricular knowledge, and teacher planning. Chapter III describes the research methodology used in this study with particular attention to qualitative methods, descriptive multisite case study, participant selection, data collection and reporting, analysis, and issues of trustworthiness. In Chapter IV, data and analysis are presented, are stated, and support is provided for the findings through examples, participant quotes, tables, and graphs. Lastly, Chapter V focuses on the conclusions drawn from this study, makes recommendations for policy makers, teacher educators, and professional developers, my personal reflections on what has been described, and generates new questions for future research.

Chapter 2: Review of the Literature

This study sought to examine how the beliefs and science curricular knowledge that elementary and secondary science teachers possess influence their planning for science instruction. Several different literature bases were consulted during this study. This section provides a summary of information related to each. The first section briefly reviews the emergence of the *National Science Education Standards* including the movement sparking their revision. The second section briefly introduces the *Framework of K-12 Science Education*, a new guiding philosophy for science education developed by the National Research Council. The third section provides a comprehensive review of teacher beliefs research. The fourth section reviews the literature on teacher knowledge narrowing towards science curriculum knowledge. And the fifth and final section summarizes existing research related to teacher planning.

National Science Education Standards

For over a decade, the *National Science Education Standards* (NSES) have been at the heart of science education programs around the United States. The majority of state education departments framed their guidelines for science education around what the *NSES* deemed as most valuable for K-12 students to know (Hollweg & Hill, 2003). The purpose of the original *NSES* framework was to provide a coherent, comprehensive document that outlined what science content was important to know in school, and what methods should be used to deliver this subject matter (Hollweg & Hill, 2003). Higher education systems designed to train K-12 science teachers, as well as primary and secondary schools themselves, have used the standards to guide their program development and instruction in the hopes of best preparing students to master scientific subject matter, and therefore be competitive when pursuing employment in science related professions.

The goal of the *NSES* (1996) was to create a "scientifically literate populace" (p. 2). The focus was making science accessible to all students regardless of their race, gender or age. The *NSES* described science learning as an "active process," meaning that "learning science is something that students do, not something that is done to them" (NRC, 1996, p. 2). Project 2061's *Science for All Americans* (1989) and the American Association for the Advancement of Science's (AAAS) *Benchmarks for Science Literacy* influenced the creation of the *NSES* (NRC, 1996). The design of the AAAS benchmarks was to provide "educators with sequences of specific learning goals that they can use to design a core curriculum—one that makes sense to them and will help students achieve the basic science literacy goals" (AAAS, 1993). This framework inspired the creation of the *NSES*, and in turn, moved us towards K-12 science education reform. The hope was that through the implementation of the NSES graduates would become more scientifically literate, better prepared for college level science course work, and have a better understanding of the natural world and scientific phenomenon we experience every day (AAAS, 1993; NRC, 1996).

The 1996 *NSES* document was organized into chapters that provided standards for science teaching, professional development, assessment, content, science education programs, and science education systems. The authors emphasized the importance of the implementation of all standards, rather than just focusing on the chapter relevant to the individual professional.

Eight categories of content standards were included:

- Unifying concepts and processes in science
- Science as inquiry

- Physical science
- Life science
- Earth and space science
- Science and technology
- Science in personal and social perspectives
- History and nature of science (NRC, 1996, p. 104)

The authors of the NSES made a point to address the order in which the categories were presented,

> The sequence of the seven grade-level content standards is not arbitrary: Each standard subsumes the knowledge and skills of other standards. Students' understandings and abilities are grounded in the experience of inquiry, and inquiry is the foundation for the development of understandings and abilities of the other content standards. (NRC, 1996, p. 104)

In addition to the content standards themselves, a section entitled "Developing Student Understanding" follows each standard and provides educators with potential issues that may be faced when delivering the subject matter to students. The "Guide to the Content Standard" outlines specific objectives for students under each principle.

The selection of the content standards was influenced by three acknowledged criteria: (a) the obligation to fulfill the needs of both the domain of science and existing school science programs nationwide, (b) the importance of meeting the developmental and learning needs of all students, and (c) the ability to fully implement the presented standards. Addressing the breadth of the subject matter, the authors stated, "The standards need to provide enough breadth of content to define the domains of science, and they need to provide enough depth of content to direct the design of science curricula" (NRC, 1996, p. 100).

But years after the implementation of the NSES, critics began to emerge. Some suggested that the NSES did not go far enough. Fadali & Robinson (2000) suggested that researchers indicated students were uninterested in, and unprepared for, careers in engineering and technology as a result of insufficient time spent on these disciplines in secondary school (p. T2E-6). They criticized the *National Science Education Standards* (NSES) stating that while an attempt is made to integrate engineering and technology into the framework,

> …the standards do not go far enough in providing students with exposure to engineering and technology. More ominously, the engineering-related segments of the standards are likely to be the ones that are least familiar to K-12 teachers and are therefore those that are least likely to be implemented (Fadali, 2000, p. T2E-9).

Fadali and Robinson's presentation may have mirrored those sentiments of advocates of engineering and technology fields, resulting in a shifting emphasis towards the development of new standards. Considering the growing need for engineers, the broad scope of the original *NSES* seemed to be no longer relevant to the needs of the education populace.

Other critics of the *NSES* claimed that the standards were "overstuffed but undernourishing." This meant that the content to be taught was significant in size, but did not promote a depth of understanding (Raizen, 1998, p. 12). In response to a national demand for fewer, higher and clearer standards, the Committee on the Conceptual Framework for New Science Education Standards (CCF-NSES) became responsible for creating a framework that shifted the focus of content from wide and shallow, to narrow and deep (NRC, 2012). This document became titled the *Framework for K-12 Science Education* (2012).

Framework for K-12 Science Education

Educators argued the requirement to cover such a broad range of subject matter left no time available for investigating, exploring, and participating in a meaningful discourse with students about the subjects in which they must demonstrate competency. Schmidt (2003) provided evidence supporting this complaint from the *Third International Mathematics and Science Study* (TIMMS), stating "The *TIMSS* found that the US intends to introduce in grades one through three nearly seven times the number of science topics as are typically intended in the *TIMSS* countries that outperformed the US" (p. 571). Most state programs required elementary teachers to cover an immense amount of subject matter over several science disciplines in just one academic year (i.e. Earth/Space, Physical Science, Life Science, Nature of Science). Coupled with the increased emphasis on reading and math in the elementary schools, and corresponding decrease of time spent in science instruction, this "mile wide and an inch deep" coverage of scientific concepts left students with incomplete conceptual knowledge (Schmidt, McKnight, & Raizen, 1997). By reducing the number of core concepts in the *NSES*, the CCF-NSES hoped to allow students more time to "engage is scientific investigations and argumentation and to achieve depth of understanding" (NRC, 2012, p. 11).

The creation of the *Framework for K-12 Science Education* was the first step the National Research Council took in order to inform the revision and re-release of the *National Science Education Standards*, renamed the *Next Generation Science Standards*. "The *Framework* provides a sound, evidence-based foundation for standards by drawing on current scientific research—including research on the ways students learn science effectively—and identifies the science all K–12 students should know" (Achieve, 2012b). A committee of 18 individuals recognized for their distinction and achievements in science, science education, and cognitive science worked together to create this seminal document.

The recommendations found within the Framework suggested that K-12 science education should be built around three dimensions: scientific and engineering practices, crosscutting concepts that unify the science and engineering, and core ideas found within four disciplinary areas: physical sciences; life sciences; earth/space sciences; and engineering/technology. Unlike the *NSES*, the new framework included engineering and technology as a fourth domain to be emphasized in science instruction. The reason behind its addition was due to the recent increased emphasis placed on STEM education in the United States, and the necessity for scientists to work in collaborative communities across disciplines. In order to achieve these goals, students must understand how engineering design and the scientific method differ.

The framework continued by listing the four strands of science proficiency:

1. Knowing, using, and interpreting scientific explanations of the natural world
2. Generating and evaluating scientific evidence and explanations
3. Understanding the nature and development of scientific knowledge; and
4. Participating productively in scientific practices and discourse

(NRC, 2012 p. 251)

Together, these three dimensions and four strands intended to help states and districts develop future science curriculum frameworks that were comprehensive and challenging for K-12 students.

The goal of the framework is to install in students a greater depth of core content science knowledge and hopefully increase their interest in the study of science and stay which is retained post-assessment. If the vision of the Framework is achieved, students will become,

> …critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives. They should come to appreciate that science and the current scientific understanding of the world are the result of many hundreds of years of creative human endeavor… We anticipate that the insights gained and interests provoked from studying and engaging in the practices of science and engineering during their K-12 schooling should help students see how science and engineering are instrumental in addressing major challenges that confront society today, such as generating sufficient energy, preventing and treating diseases, maintaining supplies of clean water and food, and solving the problems of global environmental change. (NRC, 2012, p. 9-10)

The *Framework for K-12 Science Education* was also intended to "guide the development of new standards that in turn guide revisions to science-related curriculum, instruction, assessment, and professional development for educators" (NRC, 2012, p. 2). These new standards would result from a revision of the *National Science Education Standards*, and would be called the *Next Generation Science Standards*.

Teacher Beliefs

In the period spanning the 1950's and 1970's, a large body of educational research was conducted that focused on the relationship between teacher attitudes, teacher behaviors, and student learning outcomes. This object of study, coined *process-product thinking* assumed that causality was unidirectional. Researchers believed that by studying teachers' attitudes and behaviors as influential on student outcomes, that a predictable model could be created which would aid teacher educators with program development (Doyle, 1990; Fang, 1996; Richardson, 1996). However, the late 1970's and early 1980's saw science education research shift away from the traditionally post-positivistic research paradigm in favor of a social constructivist view (Levitt, 2002). Research studies about process-product thinking were abandoned, and researchers began to contemplate a deeper motivation that guided teachers in their practice (Fang, 1996; Jones & Carter, 2007).

Historically, research in *teacher beliefs* has been plagued with problems of definition. Part of the difficulty faced in the exploration of teacher beliefs is the inability to tangibly observe or measure a belief (Kagan, 1992). Beliefs "must be inferred based on what people say, intend and do" (Pajares, 1992, p. 314). Compounding this problem, true beliefs may be difficult for a person to verbalize, or they may even go unrecognized by the person being observed (Kagan, 1992). In an attempt to elicit the true beliefs of teachers, education research has promoted both quantitative and qualitative methods for data collection. Qualitative researchers have utilized reflective questioning as a tool for exposing teacher beliefs. Additionally, qualitative researchers have used in-depth teacher interviews, or have observed and analyzed the actual instructional practice of classroom teachers in order to describe those hidden beliefs that may go unverbalized. Quantitative researchers have traditionally used survey methods including Likert scale type statements in an attempt to quantify beliefs and examine patterns between teaching populations.

I begin this review of teacher beliefs research by attempting to clarify what is meant by teacher beliefs. Next, I discuss existing research about teachers' beliefs, including an examination of teachers' beliefs about science teaching and learning. This discussion includes:

how beliefs are shaped, how beliefs impact practice, and what conflicts exist between stated teacher beliefs and enacted practice including internal and external forces that act on teachers. Throughout each section, I discuss beliefs held by specific populations such as pre-service vs. in-service teachers, elementary vs. secondary teachers, and traditional vs. nontraditional students.

Defining teacher beliefs. In 1992, Frank Pajares published a critical review of teacher beliefs research entitled, *Cleaning up a messy construct*. In it, Pajares argued that the term teacher beliefs had been previously interpreted in a multitude of ways posing problems for researchers attempting to disseminate their findings (Pajares, 1992). Previous interpretations of the term beliefs included predispositions to action, individual representation of reality, propositions, assertions, preconceptions, and theories. He discussed at length the complication of confusing the term belief with other terms that possessed different connotations like attitude or knowledge. A review of the literature supports this statement as the terms knowledge and belief are rarely differentiated between (Richardson, 1996).

In attempt to resolve the on-going debate, Pajares thoroughly examined the existing teacher beliefs research and eventually developed his own definition. Before doing so, he was careful to draw the distinction between beliefs and educational beliefs. He cautioned researchers to refer to a teacher's beliefs as a *teacher's educational beliefs* rather than the more general teacher beliefs. He considered teacher beliefs to be an overly general term, which encompassed those personal beliefs that lie outside of educational matters (Pajares, 1992, p. 316).

In his own definition, Pajares argues that for any research on educational beliefs to be meaningful, researchers must go even further, drawing the distinctions between the various types of educational beliefs.

> The construct of educational beliefs is itself broad and encompassing. For purposes of research, it is diffuse and ungainly, too difficult to operationalize, too context free. Therefore, as with more general beliefs, educational beliefs about are required-beliefs about confidence to affect students' performance (teacher efficacy), about the nature of knowledge (epistemological beliefs), about causes of teachers' or students' performance (attributions, locus of control, motivation, writing apprehension, math anxiety), about perceptions of self and feelings of self-worth (self-concept, self-esteem), about confidence to perform specific tasks (self-efficacy). There are also educational beliefs about specific subjects or disciplines (reading instruction, the nature of reading, whole language). (Pajares, 1992, p. 316)

Similarly to Smith & Siegel (2004), I have found through my review of education research on teacher beliefs, that many researchers publish findings without taking the time to provide their own adequate characterization of the term belief. Frequently, researchers have failed to acknowledge the complexity of the term, instead exploring a singular facet of teacher beliefs. For instance, Brickhouse (1990) examined three teachers' conceptions of their own role in the classroom, their student's roles, and their conception of the nature of science. Although the term "teacher beliefs" was used in the title of the article, the term is never defined. In fact in the opening of the article, the author discussed Shulman's (1986) three types of teacher knowledge, which leaves the reader to assume teacher beliefs are equated with teacher knowledge.

In a study just two years later, Brickhouse and Bodner (1992) explored a male middle-school teacher's beliefs about effective science instruction, which he thought hindered his ability to teach. Again "teacher beliefs" is left undefined throughout the article. The author had, in a previous study, characterized teacher beliefs in the same sentence with knowledge, stating "teachers' knowledge and beliefs about the content, their role as teachers, how students learn, and the context of school are a part of a web of beliefs that influence and one another" (Brickhouse, 1989, p. 6). So again the readers were left to assume that the terms teacher beliefs and knowledge are synonymous.

Czerniak & Lumpe (1996) were concerned with how teacher beliefs influenced teacher action, more specifically, how teacher perceptions of the reform movement impacted their classroom practice. The authors used the Science Teacher Efficacy Beliefs Instrument (STEBI), a survey, to obtain teacher belief statements. Self-efficacy is just a singular aspect of the broader term teacher educational beliefs outlined by Pajares. Through my own examination of the STEBI, I have concluded that other teacher belief concepts, in addition to self-efficacy, may be examined with this instrument (teacher's role, locus of control). However the authors did not specifically identify these additional categories in their report.

Cronin-Jones (1991) interviewed teachers with a variety questions covering such topics such as self-efficacy, attitude, teacher role, management, assessment, discourse and student ability. She used the term "perceptions" interchangeably with beliefs throughout the opening pages of the article. She also indicated that her study utilizes grounded theory, the goal of the study being to create categories of teacher beliefs from the findings. This may be the major contributing factor to the lack of a beliefs definition in the initial stages of her study.

Jones & Carter (2007) acknowledged the complexity of the knowledge vs. beliefs debate in their summary of Smith & Siegel's (2004) five distinct relationships of belief and knowledge. They reported that in the past, researchers have attempted to distinguish between knowledge and beliefs in a variety of ways. This includes explaining the reciprocal and/or interchangeable nature of the terms, claiming that beliefs and knowledge are synonymous, assuming that beliefs are subsumed by knowledge, or by stating that beliefs involve naïve constructs whereas knowledge implies scientifically accepted constructs.

I will now provide some rare exceptions to the previously muddied waters of how to define teacher beliefs. Kagan (1992) provided a clear definition of belief when stating that a "teacher belief is a particularly provocative form of personal knowledge that is generally defined as pre- or in-service teachers' implicit assumptions about students, learning, classrooms, and the subject matter to be taught" (p. 65). Kagan, like Pajares, criticized historical teacher belief research as being either too narrowly focused on specific subject area content, or inconsistent in its application of the term teacher beliefs.

Richardson (1996) clearly described the difference between knowledge and beliefs through the use of the term evidence. She asserted that knowledge is based in evidence justifying the claim made, whereas a belief can exist without evidence to back up the assertion. More recently, Milner, Sondergeld, Demir, Johnson, & Czerniak (2011) clearly defended their own presupposition of the meaning teacher beliefs, stating that they could be "described as their convictions, philosophy, tenants, or opinions about teaching and learning" (Role of Teacher Beliefs, para. 1).

I believe that it is important for researchers exploring an abstract, inferred subject such as beliefs to qualify their definition of the term before beginning their study. In order for researchers to clearly communicate their findings, we must agree to the definition of the term before drawing generalizations about it.

For clarity sake, I have provided the reader with Richardson's general definition of "beliefs" in my Definition of Terms section. However, for the purposes of this research study, I will adopt a more specific definition of beliefs. For this study, I will be using Pajares' educational beliefs definition. In sum, Pajares believes that studies of educational beliefs should examine the following:

- Beliefs about the confidence to affect students' performance (teacher efficacy)
- Beliefs about the nature of knowledge (epistemological beliefs)
- Beliefs about causes of teachers' or students' performance (attributions, locus of control, motivation, writing apprehension, math anxiety)
- Beliefs about perceptions of self and feelings of self-worth (self-concept, self-esteem)
- Beliefs about confidence to perform specific tasks (self-efficacy)
- Beliefs about specific subjects or disciplines (reading instruction, the nature of reading, whole language) (Pajares, 1992, p. 316)

In the following sections, I address how teacher beliefs are shaped, what teachers believe about teaching and learning, and what factors (if any) cause teacher beliefs to change.

How teacher educational beliefs are shaped. Richardson (1996) provides three categories of experience that are thought to shape a teacher's beliefs: personal experience, experience with schooling and instruction, and experience with formal knowledge. Childhood experiences, experiences as both student and pre-service teacher education classes, and experiences as in-service teachers, are examples of events that can shape a teacher's beliefs. Pajares (1992) states that people construct their general "beliefs" in order to better understand themselves and to relate to the world they live in. He believes that beliefs are formed at an early age, and that as they are utilized over time, these beliefs become resistant to change. He goes on to say that even when individuals are presented with evidence that contradicts those beliefs, they will continue to maintain them. Adults are unlikely to change beliefs that have been engrained for extended periods of time unless they undergo a gestalt shift.

Teachers primarily form beliefs about education based on their experiences as young students (Bryan, 2003; Calderhead & Robson, 1991; Choi & Ramsey, 2009; Clark & Peterson, 1986; Kagan, 1992; Nespor, 1987; Richardson, 1996). Pajares (1992) believes that future teachers already have strong philosophies about teaching well before they enter teacher education programs. Some teachers tend to adopt instructional methods that are consistent with the way they were taught, or that have been influenced by memorable learning experiences from their past.

Teacher beliefs are also influenced through pre-service experiences, albeit to a far lesser extent than childhood experiences. As teachers pursue their educational goals, they are concurrently developing philosophies about teaching (Brickhouse, 1990). As time passes, if their philosophies about how students learn go unchallenged, teacher beliefs become more engrained and resistant to change (Kagan, 1992). This becomes problematic when teachers are presented with evidence that challenges or disproves their assumptions, but are unwilling to abandon their beliefs in favor of a more correct conception.

Formal educational experiences are considered to be the least powerful factor affecting beliefs about teaching and the teacher's role. "Most researchers involved in life history and socialization research agree that experiential effects of personal life, previous schooling, and student teaching are more powerful in building conceptions of teaching than the formal pedagogical education received in teacher education programs" (Richardson, 1996, p. 106).

Early childhood experiences and former educational experiences and are thought to have the strongest influence on a teacher's belief about their role in the classroom (Richardson, 1996).

Considering the diversity in early life experiences among practicing teachers, Nespor (1987) concludes that it would be next to impossible to use a prescribed approach to change all teachers' beliefs and actions. Therefore, in order to change engrained beliefs, a teacher's existing beliefs must first be acknowledged, and then the teacher must be introduced to an alternative belief (Nespor, 1987; Richardson, 1996).

An intensive reflection process may be beneficial in promoting belief changes among teachers. "Beliefs are thought to drive actions; however experiences and reflection on action may lead to changes in and/or additions to beliefs" (Richardson, 1996, p. 104). Research on pre-service teacher education programs indicates that beliefs are resistant to change for the duration of a teacher preparation program. However, if change has occurred, it has been when students were able to confront their initial beliefs about teaching and learning (Bryan & Abell, 1999). Even still, reported changes are often met with skepticism. Some researchers suggest that pre-service teachers are incapable of quality reflection until they have teaching experiences to draw on. Some believe that teacher education programs actually solidify beliefs rather than change them (Richardson, 1996).

Social influence has also been stated to have an effect on teacher beliefs. Pre-service teachers are more influenced by their mentors than by their university coursework or university supervisors (Kagan, 1992). Specifically, administrators and colleagues have been reported to impact a teacher's belief of their ability to make instructional decisions (Fang, 1996; Milner et al, 2011). Attitudes that these groups hold may also enhance or diminish the self-concept of beginning teachers (Fang, 1996).

One major challenge educational reformers face is how to transform the practice of teachers with engrained beliefs about teaching and learning. Teachers possess strong beliefs about the nature of science, teaching and learning, and the purpose of education. When outsider-driven reform movements are not predicated on the internal beliefs teachers, they are unlikely to succeed (Anderson, 2007; Bryan & Abell, 1999).

In response to this, Haney, Czerniak & Lumpe (2003) state that professional development has the potential to positively affect the beliefs of teachers. Because colleagues and administrators exert social influence on teachers, if the professional development experience involves collaboration and socialization, there is a stronger likelihood to affect change in beliefs. Collaboration, enactment and reflection models also seem to be effective methods for changing in-service teacher beliefs over time (Richardson, 1996). In studies where an in-service teacher's beliefs have been revealed, discussed and challenged in the context of day-to-day educational experiences, a sustained change in shown the teacher's beliefs over time (Anderson, 2007). Research has also shown that in order for education reform to be deep and lasting in nature, support must be provided for teachers at many levels including support from administration, parents and colleagues (Anderson, 2007).

What do teachers believe? Teacher educational beliefs are varied and individual. But some general themes about teacher beliefs have emerged in the research over time. The next four sections will discuss findings of previous studies focusing on four major themes: the teacher's role in instruction, various beliefs held by teachers about instructional strategies, teachers' beliefs about students, and teachers' beliefs about the nature of science.

Beliefs about the teacher's role. A number of studies have identified how teachers classify their role within the classroom. Classifications have ranged from the more traditional archetype of disseminator of information (Fang, 1996; Tilgner, 1990; Tobin & McRobbie, 1997), disciplinarian, behavior manager, group leader, and/or director (Clark & Peterson, 1986; Cronin-Jones, 1991; Laplante, 1997) to more progressive roles such as facilitator, encourager, diagnostician and model (Haney et al., 2003; Levitt, 2002).

Prior to their experiences in the classroom, pre-service teachers tend to view educators as dispensers of knowledge (Richardson, 1996). Researchers have indicated that students receiving training in pedagogy tended to be more constructivist in their views of the role of the teacher, whereas subject-matter specialists tended to view the teacher more as an authority figure (Richardson, 1996). In contrast, Levitt (2002), completed a study of 16 in-service elementary teachers of science, averaging 17 years of teaching experience, reported that teachers expressed the belief that the teacher's role should be flexible in order to accommodate students' needs.

Haney et al. (2003) found that teachers defined a successful classroom environment as one where the teacher has ample content knowledge and can communicate this knowledge effectively through their facilitation of student learning. Teachers also considered their role to be motivational in nature. They stated that teachers should be respectful to students, be enthusiastic about their profession, and that they should provide students with a variety of learning opportunities. In this study, teachers saw students as the constructors of knowledge with teachers as the guides. These results stand in contrast to many other studies where teachers perceive their role as information giver, and the student is categorized as the receiver of the knowledge (Laplante, 1997; Tilgner, 1990; Tobin & McRobbie, 1997; Roehrig & Kruse, 2005).

Kenneth Tobin conducted a series of studies that asked teachers to use metaphors to define their role as classroom teachers. Some of the words teachers used to describe themselves included preacher, policeman, mother hen, and entertainer (Tobin, 1990; Tobin & Espinet, 1989;

Tobin & Jakubowski, 1990). The authors discussed the changing roles teachers may experience as they grow. Sarah, a high school science teacher, initially identified a variety of roles she played including: facilitator, manager, and assessor. However, through reflection Sarah eventually would find her roles to include researcher, mentor, and curriculum developer. The researchers believed that this redefinition of role resulted from helping Sarah to become an empowered teacher (Tobin & Ulerick, 1989).

Some teachers have asserted that their job is to design instruction to be personally meaningful to their students. They have also stated that they should model positive attitudes towards science for their students (Levitt, 2002; Savasci & Berlin, 2012). Cady & Rearden (2007) reported that the results of a survey given to K-8 pre-service teachers of elementary science indicated the these teachers believed the role of the teacher is to make the subject matter interesting and to provide real world applications for the subject with their students.

Beliefs about instructional strategies. Cooperative learning has long been a favorite instructional strategy of science teachers. Many teachers believe that cooperative learning is a necessary component of effective science instruction, and report using cooperative groups one or more times a week (Banilower et al, 2013; Czerniak & Lumpe, 1996; Levitt, 2002; Lumpe, Haney & Czerniak, 1998). Teachers have expressed the belief that small group, cooperative learning actively engages students in the learning process, helps to teach students important social skills, and makes instruction meaningful and interesting to students (Levitt, 2002; Lumpe et al., 1998; Shymansky, Yore, & Good, 1991).

Roehrig & Kruse (2005) discussed one particularly reform-minded teacher's idea of science teaching, "Kelly's approach to teaching and her beliefs were conducive to the intents of LBC; she already used small cooperative group work, activities that required students to formulate their own understandings from data, and class discussion and sharing of ideas" (p. 419). Other teachers have stated that instruction should be explicit and direct because students learn best through repeated skill practice (Cronin-Jones, 1991). In some instances, teachers have expressed concerns about including cooperative learning activities. These include feeling discouraged due to time constraints, and more recently, and increased emphasis on assessment and accountability (Lumpe et al., 1998).

In addition to cooperative learning, hands-on instruction is often acknowledged by elementary pre-service and in-service teachers as an important method for maximizing student learning (Cady & Rearden, 2007; Shymansky et al., 1991). Yet, studies have also shown that hands-on/minds-on learning is not consistently being used in instruction. Czerniak & Lumpe (1996) reported that 45% of the K-12 teachers surveyed reported using hands-on/minds-on activities once or less a week. While Levitt (2002) and King, Shumow & Leitz (2001) both reported that teachers believed that student learning was increased through the use of hands-on activities in the classroom, the authors reported that the observed activities did not approach true inquiry.

Beliefs about students. The beliefs that teachers possess about students have varied in description over the years. Teachers have sometimes been reported to view students as receivers or consumers of knowledge, rather than constructors of knowledge (Laplante, 1997; Richardson, 1996). Laplante (1997) describes instructional strategies used by the two first grade French immersion teachers of science in his study as "teacher-directed," "emphasizing the transmission of knowledge," and "considering students as simple receptors of that knowledge" (p. 287).

These results contrast other studies where students are seen as active participants in knowledge construction (Haney et al., 2003; Levitt, 2002). In Levitt's (2002) study, sixteen elementary teachers were interviewed and observed teaching in an attempt to uncover their beliefs about elementary science instruction. The overarching theme that emerged was the need for science instruction to be student centered. The teachers used words like "worker, experimenter, investigator, gatherer of information, observer, discoverer, and helper" to describe the role of the student in science learning (Levitt, 2002, p.13).

Book & Freeman (1986) reported that elementary pre-service teachers tended to be more child-oriented. These teachers generally had more prior experience working with children before entering their pre-service education program. Female elementary pre-service teachers tended to possess more positive attitudes towards students than secondary male pre-service teachers (Khan & Weiss, 1973). Elementary pre-service teachers have also been reported to demonstrate a greater tolerance of behavior issues, but also possess a lower self-concept (Ben-Peretz, 1990; Khan &Weiss, 1973). In contrast, secondary pre-service teachers tended to be more subject matter oriented, less tolerant of behavior issues, but possess a higher self-concept (Ben-Peretz, 1990; Richardson, 1996).

Beliefs about the Nature of Science. *Nature of Science*, as defined by Norman Lederman (1992), “refers to the values and assumptions inherent to the development of scientific knowledge” (p. 331). These values and assumptions can include the belief that science is a creative endeavor, empirical, amoral and tentative. Lederman (1992) believed that pre-service elementary and secondary teachers do not currently possess adequate conceptions of the nature of science. In example, many teachers conceived of science as an "authority" where knowledge existed independently of the knower (Duschl, 1988; Tobin & McRobbie, 1997).

Pomeroy (1993) reported that elementary science teachers tended to espouse greater nontraditional views about science than secondary science teachers. He defined traditional views of science as the belief that science needs to be observable, measurable and objective, whereas nontraditional views relied more on subjectivity and inference. He also reported that secondary science teachers tended to espouse more traditional views about science education than elementary science teachers. The author credited this trend of more traditional views among secondary teachers to their understanding of the norms of, and acceptance within, the scientific community. She also suggested that elementary teachers might have certain beliefs about how students learn, developed from experience and observation, which alter their beliefs about the nature of science.

Tsai (2007) conducted a study using in-depth interviews of 37 secondary science teachers. He asked the teachers about their ideal teaching environment, how students can be most successful learning science, and how they would define scientific knowledge. More than half participants in his study held traditional beliefs about the teaching, learning, and nature of science. He called this consistency among the three belief systems as "nested epistemologies." The experienced teachers in his study were more likely to maintain consistent beliefs across teaching, learning and science. However, these experienced teachers more often possessed traditional or process views than constructivist. The most interesting finding in Tsai's study was that some of the teachers expressed traditional beliefs about the nature of science while simultaneously expressing constructivist views about the teaching and/or learning of science. He called these related belief systems.

Even when a teacher possesses progressive views about of the nature of science, their other beliefs can sometimes remain positivistic. Meaning, teachers can simultaneously express that knowledge is both static and changing. Furthermore, expressing progressive beliefs does not mean that they are always reflected in their practice. Tobin & McRobbie (1997) reported that even when Mr. Jacob's and his students had a view of science as changing, the curricular emphasis remained that of memorizing facts and content. In Mr. Jacob's narrative he claimed to view himself as a "transmitter of knowledge." He stated that he was able to transmit that knowledge verbally or visually to students (Tobin & McRobbie, 1997, p. 361).

Elementary and secondary pre-service teachers have been reported to hold positivistic views of schooling. This suggests that there is one correct answer to learn, and that a teacher's job is to help students learn content or to develop strategies for helping them learn (Bryan, 2003; Richardson, 1996). Professional development programs that give attention to the development of a teacher's understanding of the nature of science may potentially have an impact on their conceptions.

How beliefs impact instruction. Some have argued that belief systems are the "filter" through which teachers make instructional decisions, and that beliefs are strong indicators of teacher actions (Fang, 1996; Haney, Czerniak & Lumpe, 1996). Researchers have also suggested that a complex, interactive relationship exists between teacher beliefs and actions (Erbele, 2008; Richardson, 1996). Kagan (1992) stated that through her review of the literature it is possible to generalize that teacher beliefs are "relatively stable and resistant to change" (Kagan, 1992, p. 66). In fact, researchers have indicated that the instructional practice of more experienced science teachers tended to align closely with their beliefs, whereas beginning teachers tended to lack alignment between expressed beliefs and actions (Cronin-Jones, 1991; Lederman, 1999).

Novice student teachers tended to characterize former teachers in both positive and negative ways. These images of past teachers strongly influenced how they approach their teacher education program. Elementary pre-service teachers tended to be very confident in their own ability to teach, and expected to gain knowledge about teaching from the student-teacher experience which they did not believe can be obtained any other way (Book & Freeman, 1986). They held strong beliefs that learning to teach can only be accomplished through experience (Calderhead & Robson, 1991; Richardson, 1996).

When teachers are confident about, and satisfied with their practice, they will resist change to their existing practice (Tobin & McRobbie, 1997). Indeed many studies have been conducted that acknowledged the difficulties faced by movements intended to alter teacher practice (Levitt, 2002; Olson, 1981; Roehrig & Kruse, 2005; Smith & Southerland, 2007). This is mostly due to the fact that educational reform movements are externally driven rather than internally sought. Teachers with post-positivistic conceptions of the nature of science are unlikely to change their practice if they believe this is how students learn (Tobin & McRobbie, 1997).

Haney, Lumpe, Czerniak & Egan (2002) examined the relationship between teacher self-efficacy and lesson design. The researchers stated that teachers who scored high on the effective science teaching domain were more likely to design lessons that incorporated inquiry. These teachers were also more likely to attend issues of equity, collaborate with peers, consider prior student knowledge and experience in their lesson design, and make good use of available resources. In this case, the authors equated high efficacy with effective science teaching.

Beginning teachers who lack content knowledge tend to teach within the confines of a prescribed curriculum (Roehrig & Luft, 2004). A lack of content knowledge coupled with a lack of pedagogical training specific subjects such as science may greater inhibit the initial effectiveness of beginning teachers (Abell & Roth, 1992). However, having well-developed content knowledge does not necessarily result in instructional methods that are inquiry-based. In addition to possessing deep content knowledge, teachers who consistently use inquiry have tended to express contemporary views of the nature of science and student-centered beliefs about teaching (Roehrig & Luft, 2004).

Additionally, there are many internal and external factors that influence the instruction that takes place within a classroom. Clark and Peterson (1986) identified physical setting, curriculum, and community (principal, colleagues, citizens) as constraining factors affecting classroom instruction. In addition, classroom practice may be influenced by the teacher's conception of the nature of science, the teacher's perceived ability level of students, the choice of curricular program, time limitations, the availability of supplies, and administrative policies (Lederman, 1992; Milner et al., 2011).

Brickhouse (1990) found that the beliefs teachers maintained about the nature of science affected the way they approached their lessons. One teacher, who prized the scientific method as the way by which scientists discover "truth," approached lesson construction with the same linear notion. He discouraged students from deviating from the identified procedure in their pursuits of the "correct" answer. A teacher with widely different views on the nature of science, one who valued the discourse in terms of theory development, designed lessons where observations were used to reinforce or dispute existing theories. In both of the cases illustrated, the teachers' beliefs about knowledge translated into their lesson design. Pre-service teachers who possessed contemporary nature of science views were more likely to be student-centered in their approach and effectively implemented inquiry in their classrooms (Roehrig & Luft, 2004).

Cronin-Jones (1991) conducted a case study of two in-service middle school teachers who were required to implement twenty lessons from life science curriculum package that focused on wildlife species and their strategies for survival. The researchers found that when teachers held beliefs about how students learn which were not aligned with the intended curriculum, the teachers tended to modify the curriculum to align with their beliefs. This theme of teachers modifying prepared curriculum to match their beliefs about how students learn has emerged in other studies as well (Clark & Peterson, 1986; Olson, 1981; Roehrig & Kruse, 2005).

When teachers perceive student ability level as a mismatch for a particular instructional strategy, they may abandon that method altogether. Roehrig & Luft (2004) reported that beginning secondary science teachers who perceived their students of low ability, did not believe inquiry to be an appropriate instructional method for these students to learn. Instructional methods may also be impacted when teachers perceive a greater need for classroom control than the need to create an effective learning environment.

The conflict between teacher beliefs and practice. Often times, there is an inconsistency between a teacher’s expressed belief about teaching and the practice observed in their classroom. Sometimes this contradiction in the enactment of a teacher's beliefs occurs without their awareness of the disparity. Other times it is acknowledged and explained.

In instances where teachers have unknowingly enacted practices that are not in alignment with their expressed beliefs, teachers may have attempted to show their contemporary understanding through the use of educational catch phrases such as "inquiry, "hands-on," and "cooperative grouping" without deeply comprehending their meaning. King, Shumow & Leitz (2001) discussed this phenomenon stating that although the observed teachers in their study used words like "hands-on" and "inquiry-based," their actual practice was inconsistent with these terms. The authors stated that instead, the lessons were "traditional and expository in nature" (p. 106).

Savasci & Berlin (2012) also expressed an inconsistency between articulated teacher beliefs and classroom practice. The researchers reported that constructivist practice was observed with less frequency than teachers believed they were using it. The authors also stated that teachers in their study perceived the implementation of critical voice in their science instruction where it was often not observed. Although high school teachers indicated a preference for group work, teachers tended to use it sparingly, instead dedicating more time to individual student work.

Erbele (2008)'s quasi-experimental study of six middle school teachers of science revealed that of those who expressed beliefs consistent with the philosophy of the NSES, only two reflected these beliefs in their actual practice. The author suggested,

> Programs and initiatives will need to build in strategies and approaches to; address the influence of content background and its effect on teachers' knowledge and beliefs; be explicit about the relationships between connections and coherency in science for teachers; and recognize that the stability of the beliefs may be very strong and hard to change (Erbele, 2008).

This would suggest that stated beliefs about student learning sometimes do not align with a teacher's more deeply internalized beliefs.

In *Taking Science to School*, the National Research Council (2007) generalized about typical science instruction in the United States, "typical classroom activity structures convey either a passive and narrow view of science learning or an activity-oriented approach devoid of question-probing and only loosely related to conceptual learning goals" (O'Sullivan & Weiss, 1999). They attributed this pattern to a teacher's attempt to cover a broad required curriculum over a short amount of time. While many teachers have good intentions about teaching science, the daily realities facing these teachers may inhibit their ability to enact those practices.

Anderson (2007) identified many of the daily dilemmas that science teachers face. He stated, "although some of these dilemmas may be more perceived than real, they are nevertheless a part of the teacher's reality" (p. 816). The author identified five dilemmas teachers face when implementing inquiry including: time constraints, the inability to realistically implement the idealistic science classroom, the influence of perceived teacher and student roles, the pressure to prepare students for the next level of school, and issues of equity and student motivation.

Teachers often cite the lack of time to well prepare for science lessons, and a decreased emphasis by administration on science instruction (Griffith & Scharmann, 2008; Milner et al, 2011). This lack of time and support, coupled with lack of access to resources and curricular constraints, can often negate the teacher's construction of the ideal teaching environment (Abell & Roth, 1992; Griffith & Scharmann, 2008; Savasci & Berlin, 2012). With the increased emphasis placed on improving standardized assessment outcomes, teachers are sometimes asked to modify, or abandon, time allocated for science instruction in favor of providing time for additional reading and math instruction (Milner et al, 2011).

Novice science teachers also credit lack of content knowledge as one aspect of their teaching that constrains their ability to teach science in a way that aligns with their beliefs about how students learn (Roehrig & Kruse, 2005). While many elementary teachers have reported that they enjoy teaching science (Lederman, 1992; Milner et al., 2011), many have also stated that they lack the appropriate content knowledge to teach science. A lack of content knowledge can negatively impact a teacher’s confidence and ability to fully enact their beliefs in their practice.

Conclusion. The emphasis on teacher beliefs research has been increased dramatically since the 1970's, yet even more research is needed in this area to deeply understand the relationship between teacher beliefs and practice (Keys & Bryan, 2001). It has been suggested, "beliefs will ultimately prove to be the most valuable psychological construct to teacher education" (Bryan, 2003; Pintrich, 1990). Considering the existing research which indicates the connection between a teacher's educational beliefs, translation of curricula, and actual classroom practice, in order for any policy or curricular changes to science education to be meaningfully executed, we must consider teacher beliefs prior to implementation.

Science Curriculum Knowledge

Teacher knowledge, what it is and how it is acquired, has been studied for over half a century (Abell, 2007; Calderhead, 1996). Early research of the 1960's sought to describe teacher knowledge with the intention of determining how this knowledge influenced instruction and consequently student achievement (Calderhead, 1996). In the 1980's, a dramatic shift took place in the research base of teacher knowledge. Instead of continuing to attempt to examine what had previously been considered the "known," attention was directed towards the "knowers" - the teachers.

In the 1980's, Lee Shulman directed a research program that attempted to uncover what knowledge is essential for teachers to know. Shulman's model of teacher knowledge would eventually become the foundation upon which standards were developed for the preparation of future science teachers (Abell, 2007). "How might we think about the knowledge that grows in the minds of teachers, with special emphasis on content? I suggest we distinguish among three categories of content knowledge: (a) subject matter content knowledge, (b) pedagogical content knowledge, and (c) curricular knowledge" (Shulman, 1986, p. 9).

Subject matter content knowledge refers to a teacher's mastery of the facts of a certain discipline, and how those facts are organized, tested, and validated (Calderhead, 1996). Curricular knowledge refers to a teacher's understanding of the materials relevant to their discipline, including "the ideas and issues they contain, and the concepts of organization, coherence, and progression that underlie them" (Calderhead, 1996, p. 716). Beyond these two types of previously accepted knowledge, Shulman asserted that classroom teachers have a third kind of specialized knowledge enhanced through instructional experience within a specific subject area and "developed by teachers to help others learn" (Abell, 2007, p. 1106). He called this kind of knowledge pedagogical content knowledge (PCK).

It should be noted here that Shulman saw curricular knowledge as distinctly separate from pedagogical content knowledge. Later, many researchers subsumed curricular knowledge under PCK, including Magnusson, Krajcik & Borko who claimed "it represents knowledge that distinguishes the content specialist from the pedagogue - a hallmark of pedagogical content knowledge" (1999, p. 103; Abell, 2007; Grossman, 1990). For the purposes of my review, I will adhere to Magnusson et. al's (1999) characterization of curricular knowledge as a component of PCK. As such, I will continue this literature review by explaining the greater concept of pedagogical content knowledge and then narrow my discussion towards a definition of science curricular knowledge.

Pedagogical content knowledge. Shulman (1987) identified pedagogical content knowledge (PCK) as a distinct kind of knowledge that only teachers possess (Magnusson et al., 1999). "It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1987, p. 8). He believed that PCK includes a teacher's ability to represent ideas through analogies, examples, explanations, illustrations, and demonstrations in order to make the content more accessible to his or her students (Shulman, 1986, Smith, 1999).

Over time, Shulman's model has been debated and reinterpreted. van Driel, Verloop, & de Vos (1998) reported that no universally accepted definition of pedagogical content knowledge has been accepted in the research community. For example, Grossman (1990) divided pedagogical content knowledge into four categories: conceptions of purposes for teaching subject matter, knowledge of students' understanding (including, and misconceptions of difficulties), curricular knowledge, and knowledge of instructional strategies. Informed by the work of Grossman, Magnusson et al. asserted, "the defining feature of pedagogical content knowledge is its conceptualization as the result of a *transformation* of knowledge from other domains (Wilson, Shulman, & Richert, 1988)." The authors stated that there are five components of science teacher PCK including:

> (a) orientations toward science teaching, (b) knowledge and beliefs about science curriculum, (c) knowledge and beliefs about students' understanding of specific science topics, (d) knowledge and beliefs about assessment in science, and (e) knowledge and beliefs about instructional strategies for teaching science (Magnusson et al; 1999, p. 97).

Abell (2007) categorized PCK to include "orientations, knowledge of learners, curriculum, instructional strategies, and assessment" (Abell, 2007, p. 1121). Regardless of the variety of ways PCK has been divided and defined, most researchers agree that two elements of Shulman's original model are universally acknowledged: knowledge of representations of subject matter and understanding of specific learning difficulties and student conceptions (van Driel et al. 1998 as cited in Hanuscin, Lee, & Akerson, 2011).

Teachers who possess well-developed PCK understand the various ways that subject matter can be effectively presented to address the various needs of learners within their classroom. Teachers who are knowledgeable about their individual students' learning needs become flexible with their instructional strategies. Through their familiarity with the preconceptions and misconceptions that students bring to the classroom, teachers guide and adjust their practice to confront possible learning roadblocks. I will continue now with a discussion of how teacher PCK is developed.

Developing PCK. Pedagogical content knowledge is thought to develop during a teacher's repeated experience teaching a particular topic in the classroom (Hanuscin et al., 2011). Similarly, van Driel et al. (1998) argued that PCK, or as they termed it: craft knowledge, involves the transformation of subject matter knowledge through experience. Craft knowledge, refers to the professional knowledge that teachers use in their everyday teaching including the strategies, tactics and routines they use (Brown & McIntyre, 1993; Calderhead, 1996). For the purposes of this review, I will accept "craft knowledge" as having approximately the same meaning as "pedagogical content knowledge."

Berliner (1998) suggested that there are five stages in the acquisition of craft knowledge. First, novice teachers seek out "rules and recipes to guide their actions" (Calderhead, 1996). Second, the teacher transitions to an advanced beginner stage where they come to understand that it is sometimes appropriate to break the rules. In this stage, they are also becoming more strategic with their instructional choices. During the third stage, the teacher attains a level of competence where they make conscious decisions and adaptations regarding their instruction. In the fourth stage, the teacher is thought to be proficient where the knowledge becomes intuitive and their actions more holistic. In the final stage, the teacher has become an expert where their practice is "characterized by a fluency and automaticity in which the teacher is rarely surprised and is fully adapted to an end role of the situation" (Calderhead, 1996, p. 717).

Although pre-service teachers may possess adequate understanding of the subject matter they are charged with teaching, their lack of experience in the role of teacher explains their lack of pedagogical content knowledge. Beginning teachers spend their first years of full-time teaching forming their own understanding of the subject matter and determining relationships between concepts (Calderhead, 1996). This knowledge building process is critical in a teacher's ability to eventually communicate these relationships to students.

Elementary teachers, in particular, often lack confidence in teaching science and their own scientific content knowledge (Appleton & Kindt, 1999; Smith, 1999; Tilgner, 1990). Elementary "teachers often think that they need to know the correct science content so that they can tell or show children the 'right' answers" (Smith, 1999, p. 173). Additionally, they may possess their own naïve conceptions of scientific topics (Smith, 1999). When teachers lack content knowledge, possess naïve conceptions, and are unable to recognize student misconceptions, pedagogical content knowledge is unable to adequately develop (Smith, 1999). Teachers who lack PCK do not probe student thinking with appropriate questions that reveal or refute their prior conceptions. Instead, these teachers tend to design lessons that focus on student engagement, discovery, or the scientific method (Abell, 1999; Appleton & Kindt, 1999; Smith, 1999).

Elementary teachers may develop greater pedagogical content knowledge by listening to children's expressions of ideas about science content. Engaging in activities where students can openly express their questions and thoughts is an activity of comfort for these teachers (Smith, 1999, p. 172). During this time, teachers begin to examine their own thoughts, knowledge and practice of the content. In fact, some experienced elementary teachers have reported this process of exploring children's ideas to facilitate the greatest change in their practice (Smith, 1999).

Alternatively, Grossman (1990) claimed that some pedagogical content knowledge is acquired through traditional curriculum and instruction courses in teacher education programs. Tamir (1988) stated that education programs attempt to teach pedagogy to pre-service teachers through theory courses, methods courses, and practical experiences. However, a student's knowledge of pedagogy may suffer when a lack of coordination exists between course instructors and practical experience supervisors. This is especially true when the pedagogical beliefs of mentor teachers in the field conflict with the beliefs of the academic instructors responsible for theory and methods. It is still debated whether or not pre-service teachers retain pedagogical knowledge after completing their coursework.

Examining PCK in teachers. Baxter and Lederman (1999) stated that pedagogical content knowledge is different from content knowledge and general pedagogical knowledge. Pedagogical content knowledge is said to be an internal construct where teachers combine content knowledge and pedagogy to help address students difficulties with certain topics. The research conducted on PCK in science education is thought to lack coherence, but this may be in part because of the complex nature of PCK, and the problems researchers face when assessing an internal construct (Abell, 2007).

The authors stated that observations can provide only a limited view of pedagogical content knowledge because researchers cannot see inside the teachers head to understand the decision-making process by which they chose certain methods and examples to address content.

Pedagogical content knowledge can often be held unconsciously. Sometimes teachers are unable to express their thoughts and beliefs about their practice, and sometimes they refrain purposefully from this expression.

Previous researchers have attempted to assess the pedagogical content knowledge of teachers. Methods included using instruments with Likert type, multiple-choice and short answer response formats (Kromrey & Renfrow, 1991). However, these formats used predetermined descriptions of certain kinds of teacher knowledge that teachers might consider to be desirable. This assumes that there are singular "right" answers to pedagogical questions (Baxter and Lederman, 1999).

Another way that researchers have attempted to assess pedagogical content knowledge has been through the use of concept maps and card sorts. Concept maps have been used which ask teachers to draw relationships between key terms of a particular topic or concept. The teachers may be asked to group words, draw pictures, or explain their thinking in order to expose their thoughts and beliefs about the concept. Similar to concept mapping, card sorts have been used in an attempt to assess pedagogical content knowledge. Card sorts require teachers to place cards in an arrangement that illustrates the relationship between pre-identified concepts or items. Both methods require teachers to draw relationships between ideas. However, both have been criticized for the level of restriction that is placed on the response (Baxter and Lederman, 1999).

Other researchers have attempted to address the restriction of these activities through the use of open-ended questions. By using the responses of the participants, the researchers were able to elicit categories to be sorted. Kagan (1990) suggested the concept maps should only be used to measure short-term changes in thinking, meaning this has little long-term value with pedagogical content knowledge.

Baxter and Lederman (1999) stated that most studies have relied on multiple methods to assess pedagogical content knowledge. These studies have triangulated data collected from interviews, concept maps and video-prompted recall. However, studies that use multiple methods to assess pedagogical content knowledge may be difficult to replicate and are challenging to complete because of their comprehensive nature. Studies such as these are often extremely time-consuming, labor-intensive, and require extensive resources.

Science curricular knowledge. One particular aspect of PCK, knowledge of science curriculum, can be further defined as the knowledge of mandated goals and objectives such as state/national standards and the knowledge of specific curricula and programs (Abell, 2007, p. 1128; Magnusson, et. al, 1999). Research in the area of teachers' existing science curriculum knowledge and its relationship to planning and instruction is limited (Abell, 2007). One exception is Peterson and Treagust's (1995) study of pre-service teachers. They found that knowledge of curriculum was an important component in the initial planning process. I now broaden this discussion to include some research on the application of national standards in science education.

Years after the *National Science Education Standards* were released, the actual impact of the document on daily classroom practice has been reported to be limited (Horizon Research, 2003). Many elementary teachers remain unfamiliar or only vaguely familiar with the document. Compared with 60% of middle and high school teachers, only one-third of elementary teachers reported being familiar with the *NSES* (Horizon Research, 2003). If one considers well-developed science curricular knowledge to include awareness of and application of the *NSES*, then these percentages would indicate a large percentage of science teachers nationwide who possess underdeveloped its science curricular knowledge.

In addition, teachers often adapt standards in order to blend with their current practice, resulting in a transformation of the original intent of state or national standards (Horizon Research Inc, 2003). Although this transformation into practice could be interpreted as a development of pedagogical content knowledge, this idea might be disputed if the larger conceptual scientific ideas and understanding are lost in translation. Meaning, even though one might be able to repeat the general content of the standard, if one loses the underlying principle or bigger idea behind the content, then this does not represent a mastery of knowledge.

Very little research exists on science curriculum knowledge. Recently, Abell (2007) stated that science curriculum knowledge, and specifically teacher knowledge of science standards, has rarely been researched (Abell, 2007). Those few studies previously conducted have generally involved teachers ranking existing goals. Understanding this knowledge, and how if affects a teacher's behaviour, will be an important direction for the future of science education research.

As we have seen in this section, a teacher's pedagogical content knowledge, and more specifically their science curricular knowledge, is an important factor influencing the methods a teacher selects prior to instruction. This knowledge of pedagogy and curriculum also directly influences they way they plan for science instruction. In the next section, I summarize the existing research on teacher planning.

Teacher Planning

Yinger (1980) once stated, "empirical studies of teacher planning have been conducted only since 1970, and the studies of this kind that have been published can still be counted on the fingers of one hand." (p.108). Since that time, research on teacher planning has become more common. However, studies that specifically focus on science teacher planning have been limited when compared to the abundance of research on teacher planning in general (Abell, 2007). In this section, I summarize the existing research related to teacher planning. I begin by describing teacher planning, then continue with an examination of the types of planning that may occur, and conclude this section with a discussion of the internal and external factors that influence teachers as they plan.

Describing teacher planning. Clark & Yinger (1987) described teacher planning as "a nested process" (p. 87). During planning, the teacher is constantly "reexamining, refining, and adding to previous decisions" (Calderhead, 1996, p. 714). This decision making process involves the teacher visualizing what will occur during instruction, examining what resources are available, and then devising a course of action (Clark & Yinger, 1987). Because teachers often interpret lesson objectives, and construct approaches to teaching those objectives that are influenced by their own prior knowledge and experiences, planning can also be considered a creative process (Calderhead, 1996; So, 1997; Yinger 1980). Planning involves the teachers' synthesis of the varied kinds of knowledge they posses, including knowledge of students, knowledge of content, knowledge of pedagogy and knowledge of curriculum, all so that they may effectively plan their lessons (Calderhead, 1996). Similarly, So (1997) indicated that the plan teachers have in mind prior to teaching considers the "ability and interests of individual pupils, the depth and breadth of subject content, stimulating and effective learning activities, timing, the learning environment, and the teacher's belief in a collective whole in terms of different extent, degree and complexity" (p. 82).

Experienced teachers tend to approach planning differently than beginning teachers. Planning is continuous process that occurs at random times throughout the day rather than during a set planning time (Livingston & Borko, 1989; McCutcheon, 1980). Experienced teachers are less likely to prepare formal written plans, relying instead on mental planning to prepare for teaching (Calderhead, 1996; Livingston & Borko, 1989; McCutcheon, 1980). When asked to elaborate about these mental plans, experienced teachers have described a sequence of actions that will take place during the lesson, and how these actions relate to the content being taught (Livingston & Borko, 1989).

When novice teachers participate in mental planning, in addition to the creation of a mental script of what will be said to students, written plans may also be produced (Livingston & Borko, 1989). Experienced teachers prefer to refine existing plans in lieu of creating them (Sardo-Brown, 1988). When implementing existing written plans, experienced teachers tend to be more flexible, adjusting instruction in reaction to the needs and responses of students (Livingston & Borko, 1989). Conversely, beginning teachers tend to adhere strictly pre-determined procedures as they are designed, even if the situation may call for a deviation from the plan (Calderhead, 1996).

Planning types. The types of planning that teachers engage in can be described in several ways. Planning can be undertaken in a formal or informal way, although generally, teacher planning is done informally. This informal planning involves the teacher engaging in a period of reflection during down time in which the teacher decides how to modify future activities based on what has occurred in the past. Although teacher planning is primarily informal in nature, some formal plans may be kept in response to administrative demands (Calderhead, 1996; McCutcheon, 1980). Calderhead (1996) stated that formal planning is not heavily valued by teachers and is considered to be a time-consuming process (Calderhead, 1996).

Planning can also be described as a specific length of time that the teacher has planned for instruction. Yinger (1980) described these levels as planning for individual lessons, for a single day, for a week, for a unit, for the term, or for the entire year. Unit planning was identified by teachers as the most important type of planning (Clark & Yinger, 1979; 1987).

Concerns of teachers during planning. Researchers have not always agreed on the most important concern teachers have when planning. Transmission of content has been reported to be a primary concern of teachers. Peterson, Marx & Clark (1978) reported that during the planning process teachers more frequently made statements concerning content than made statements concerning their selection of activities or instructional strategies. Other researchers have also reported that content is the primary concern of teachers when planning, however, this may not always act in concert with goals and objectives (Peterson, Marx & Clark, 1978; Sanchez & Valcarcel, 1999).

In contrast, several studies have reported that teachers place the heaviest emphasis on activities during planning (Appleton, 2002; Sardo-Brown, 1998; Shavelson, 1983; Yinger, 1980). Activities, called "the building block of planning," have been heavily relied on during planning for future lessons, along with previously established classroom routines (Shavelson, 1983; Yinger 1979, 1980). Appleton (2002) conducted interviews and observations with twenty primary teachers, and concluded that when elementary teachers plan, they tend to rely on "activities that work" (p. 1). Appleton qualifies the phrase "activities that work" as those activities which are hands-on, interesting to students, have a clear outcome or predictable result, are manageable with regards to supervision, draw from resources that are readily available, and lend themselves towards integration.

Sometimes the existing "activities that work" aren't enough for teachers as they plan. This may send teachers on a hunt for new resources, or require them to make modifications to the ones they already have. When elementary school teachers begin to plan for science instruction, they typically search through teacher resources, looking for summaries of both content and the activity, and then they judge those activities based on multiple values and their individual context (Appleton, 2006). When making modifications to activities, teachers have been reported consider student needs, climate, content and materials to inform those changes (Clark, 1983). It should be noted, that decisions made about activities and strategies do not have to be made in isolation; instead they could be made in concert with decisions regarding content and objectives (Sanchez & Valcarcel, 1999; Yinger 1980).

Yinger (1980) claimed that during planning teachers placed less priority on the materials and resources available to them during the lesson than content and routines. Additionally, less consideration was paid towards creating goals and objectives, designing evaluations and considering student interests. Other researchers have agreed with this assessment, reporting materials, a lack of materials, or errors within existing texts, are factors that influenced the planning process, but are of lesser importance when planning than the selection of activities (McCutcheon, 1980; Sardo-Brown, 1988). In the above paragraphs, I have started to allude to a variety of internal and external factors which influence planning. These factors warrant additional discussion and will be continued in the next section.

Internal and external forces that influence planning. A teacher's prior experience can significantly influence teacher planning (Calderhead, 1996). Prior experiences have been described as the personal experiences of teachers as students themselves or experiences they have had as classroom teachers. During planning for instruction, pre-service and beginning teachers tend to draw on the same planning process they followed during their pre-service education courses (Warren, 2000). Experienced teachers, however, tend to reflect on previous lessons, and pull successful components of those lessons into their current plans (Warren, 2000).

Aikenhead (1984) described the influence of prior experience on beliefs in his case study of five high school science teachers. The researcher reported that these teachers' beliefs, developed through their own experiences as university students and as classroom teachers, became a set of "theories in use." These "theories-in-use" were so strong, that they were resistant to change by curriculum innovators and educational researchers (p. 184). Aikenhead went on to suggest that attempting to modify the curriculum taught in these classes to reflect the science-technology-society approach promoted in NSTA's 1982 position statement would be fruitless.

> Before they could change their beliefs concerning legitimate science content, before they could evaluate the resulting effects on socializing students, and before they could retune their decision-making frameworks (their "theories-in-use"), the Prairie High teachers would need new experiences with the traditional influences that contributed to the present state of affairs. Otherwise, from their perspective, these teachers would not be true to the needs of their students (1984, p. 184)

The prior experiences of these teachers were highly influential in their beliefs about teaching. These beliefs impacted the day-to-day decisions teachers these teachers made about what and how to teach.

McCutcheon (1980) also detailed how a lack of appropriate pre-service and in-service education regarding the planning affected the quality of plans produced. The author asserted that since education programs often focus on planning in written form rather on mental planning, the form that teachers' plans most often take, the result can be a series of disjointed lessons that are not effective for teaching the required content.

External forces outside of the teacher's control can also affect the planning process. These external forces can be described as verbalized, or sometimes unverbalized, expectations by school/district administrators school with regards to time or content (Calderhead, 1996). Available time to teach the lesson and breadth of content to cover are often limitations teachers experience as they plan. McCutcheon (1980) reported that planning decisions regarding science and social studies often reflected constraints on time. The teachers made decisions about what to teach based on what could be covered within that available time frame.

Sardo-Brown (1988) also reported that the middle school teachers in her study did not create plans based on their own goals, but instead planned activities paying consideration to the schedule of available time. The time a teacher has to teach a given subject is typically decided at the administrative level and is therefore outside of their control. More than just a lack of instructional time for teaching the actual content, a lack of time to plan for the teaching of science has been reported to be problematic among teachers.

A decreased emphasis on science coupled with an increased emphasis on other subjects such as reading and math by administrators can also influence the way a teacher plans (Griffith & Scharmann, 2008; Milner et al, 2011). McCutcheon (1980) described elementary teacher planning as a "complex, simultaneous juggling of much information about children, subject matter, school practices, and policies" (p.20). In McCutcheon's study of the planning process of twelve teachers, including anecdotal records of observations, interviews and a variety of other records, the author concluded that elementary teachers rely heavily on their textbook for their design of scope and sequence, often not deviating from the provided lessons because of expectations of administration or mandates by the district.

Conclusion

In Chapter 2, I provided the reader with research findings in the areas of teacher beliefs, curricular knowledge, and teacher planning. In short, research indicates that students arrive in pre-service teacher education programs with engrained beliefs about teaching even before they set foot in a classroom as a teacher. Their prior experiences as students have shaped their beliefs about teaching. Once they have begun to teach, these previously held beliefs remain as long as they are satisfied with their practice. Curricular knowledge, awareness and implementation of state/national standards and subject specific curricula into practice, is particularly underdeveloped in elementary science teachers. Beliefs and knowledge play a role in the planning process of teachers, but that role still needs to be described in detail. Chapter 3 continues with an explanation of the methods of this study.

Chapter 3: Methodology

Chapter 2 reviewed previous research conducted in the areas of teacher beliefs, teacher planning and science curricular knowledge. In this chapter, I explain the methods I used for this current study. This includes a discussion of my theoretical framework, the selection of my methodology, and includes specifics related to the cases I selected.

Theoretical Framework

In *The Landscape of Qualitative Research*, Egon Guba and Yvonna Lincoln (1998) directly address the ontological and epistemological beliefs of constructivist researchers. Constructivists, also known as interpretivists, believe in multiple realities that are "socially constructed, complex, and ever changing" (Glesne, 2011, p. 8). The aim of a constructivist research study is to understand the world experience of the participant (Schwandt, 1994). Researchers work alongside participants as co-constructors of knowledge (Hatch, 2002). The researcher is cast as both participant and facilitator, and may even maintain a role of advocate for the participant (Guba & Lincoln, 1998).

It is not difficult for me to identify with the constructivist stance. At this point in my career, I cannot see myself acting as anything less than an advocate for teachers. I do not position myself as an authority, but rather as someone who seeks to understand another person's perspective. As a constructivist, I do not believe that a single reality exists that can be proven or disproven. I believe that reality is constructed in the mind of an individual as a result of their life experiences and through their social interactions with others. I believe that it is possible for multiple realities to exist simultaneously, and that a person's reality will change and fluctuate as a result of each experience or interaction.

Considering my beliefs, I selected to use a qualitative approach for data collection. Constructivist researchers commonly employ qualitative methods in their studies. I assert that human subject research that relies solely on quantitative measures to gather data cannot fully describe a person's lived experience and provides a limited view of one's reality. By spending extended time dialoguing with teachers and closely examining their words, I believe a better understanding of their life experiences and belief systems can be achieved.

Although many researchers may strive to maintain objectivity, I believe that pure objectivity cannot be achieved. The questions that we select, or the questions we do not select, are influenced by our beliefs and experiences. The way we word our surveys, or the limitations we place on the way someone would answer, directly relate to our beliefs and prior life experiences. Since I believe the acquisition of objectivity is impossible in research, I believe that researchers should consider their prior experiences when approaching data collection and analysis. They should disclose their own life experiences and beliefs to the participants throughout the study. These experiences and beliefs should also be disclosed to the readers of their study. I chose to remain as candid as possible with the teachers who participated in this study. Through my candor, I hoped to put my participants at ease. By building rapport with my participants, I hoped to experience a fuller disclosure of their personal truth.

While ontologically and epistemologically my beliefs closely align with the constructivist research paradigm, I must acknowledge my attraction to, and careful consideration of, the critical paradigm. Critical researchers believe that an individual's reality has historically been impacted by existing power structures. Knowledge is considered to be subjective and influenced by those who hold the power (Hatch, 2002).

I am interested in providing a voice to teachers, whom I consider to be an oppressed group. I would argue that teachers are oppressed because I feel that they currently exert very little control over the content they are required to teach. Standards and objectives are generally determined by an authoritative agency such as the district or state department of education, who are influenced by other large federal organizations such as the National Research Council or the National Science Foundation. However, since historically teachers have not been considered an oppressed group, adopting a purely critical stance as a researcher may be difficult to justify amongst my research peers.

In my experience as a classroom teacher, I struggled with the limitations placed on my practice by newly passed legislation and newly adopted curriculum. I lived in a constant state of internal conflict, divided between what I believed to be best practice in science instruction and what I was being asked to do by the authority figures in my life (i.e. principal, district, state). I was curious to discover whether or not these participating teachers have experienced a similar struggle, or if they have somehow balanced these power structures in a way that supports their teaching rather than detracts from it.

While I identify with critical theory, I question whether or not at this stage in my research career it would be appropriate to locate myself within this paradigm. I feel that, as a novice researcher, I must understand the participant's experience before I can attempt to liberate them from an oppressive authority. Therefore, at this stage in my studies, I choose to situate myself within the constructivist paradigm.

Selection of the Methodology

My study sought to describe what beliefs elementary and secondary teachers possess about science teaching and learning, their knowledge of science curriculum, and how these beliefs and knowledge influence their planning for science instruction. The approach I selected for this study was based primarily on my ontological and epistemological beliefs as a researcher, but was selected secondarily due to concerns of access and time. Since I believe that reality is socially constructed and that no singular reality exists, the more traditional forms of numerical data collection and analysis did not seem appropriate for me.

Considering my beliefs and research interests, I selected to employ a descriptive multicase study approach. Merriam (2009) defines a case study as "an in-depth description and analysis of a bounded system" (p.40). The end product in descriptive qualitative research case study is a thick description, or complete and literal description of the object of study (Merriam, 2009). In this case, I produced thick descriptions of four teacher cases at three different school sites. Stake (2006) describes multicase study research as being a collection of cases where "the cases in the collection are somehow categorically bound together" (pp. 5 -6). A bounded system can be further described as the boundaries around placed around what the researcher is studying. Examples of bounded systems could include programs, institutions, communities, or in this case, groups of teachers. For the purposes of this study, the attributes which bound the group to be studied is that they were all teachers of science in a particular Southeastern school district.

To understand how these teachers' beliefs and knowledge of curriculum are interpreted into their plans, I collected three types of data related to the planning of one unit of science instruction. The three types of data that were collected related to this unit of instruction included: interview transcripts, think-aloud planning records, and documentation considered relevant to their planning of one unit of instruction. Clark and Yinger (1987) identified unit planning as the type of planning most often identified as important by teachers. Therefore, I selected to request a unit plan from my participants, as opposed to a singular lesson plan. Other documents requested which related to the unit plan included, but were not limited to, self created or externally prepared unit/lesson plans, sticky notes, worksheets, websites, pacing guides and standards.

These methods were suitable for me because I believe that research should attempt to understand the lived experience of each participant and that the format should be flexible in its ability to allow participants to respond to the researcher. The interviews were semi-structured allowing the participants to guide the interview process, while still providing me with any important information I needed (See Appendix B). The think aloud recordings allowed the teachers to freely communicate their ideas and thoughts (See Appendix C).

Selection of Cases

In order to better understand the differences between the planning process and beliefs of elementary and secondary teachers, I selected two elementary and two secondary science teachers to participate in this study. All of the participants were employed with a public school district located in the Southeastern United States. In order to protect the participants, pseudonyms are used throughout this dissertation for each teacher's name, their school's name and their district's name. Informed Consent Forms obtained prior to participation guaranteed each teacher's right to withdraw from this study at any time (See Appendix A).

I obtained participants for this study through direct inquiry with principals located in this district. After sending out initial emails to principals, I was able to make contact with 12 teachers of science: 7 elementary and 5 high school. I narrowed my focus to four teachers after the think aloud planning record portion of data collection. The four teachers included two elementary teachers and two secondary teachers. The primary reason for this narrowing of focus was an inability to gain adequate data from multiple participants. Some of the original participants ceased communication with me during the study, meaning they did not return emails or phone calls. Others expressed issues of lack of adequate time, or other more important professional responsibilities, as a reason not to complete their think aloud planning. Some did not submit all of the requested documentation related to their unit plans. This narrowing of focus allowed me the opportunity to concentrate more time and attention on the exploration and analysis of the data provided by these four teachers. I believe this narrowing of focus did in fact result in a richer, more complete answer to my research questions.

Context of the Cases

According to 2012 estimates made by the US Census Bureau, approximately 440,000 people reside within the Klingston City limits. The median household income in this area is $47,000, which is just $3,000 above the state average. Approximately 13.7% of the citizens living in Klingston City earn an income that classifies them as living below the poverty level. Thirty-four percent of those persons in Klingston City over the age of 25 have college degrees. This percentage is significantly higher than the state average. Home to a research university, headquarters to several nationally recognized industries, and many other government institutions, Klingston City has a wide variety of employment opportunities available for its residents.

There are 50 elementary schools within this district. On average, three-fourths of the students in Klingston City Schools are Caucasian, 14% are African-American, 5% are Hispanic, 2% are Asian American and the rest of are other nationalities. Forty-seven percent of students Klingston City school district are on free and reduced lunch. According to the state's department of education website, the average per pupil expenditure in Klingston City is $8,479. This number is low when compared to both the state ($9,123) and national ($9,698) average. Approximately 90% of students eventually graduate from Klingston City Schools, and the students of this system regularly earn higher marks on statewide tests in reading, writing and math and on the ACT.

The population make up of the schools located in Klingston City varies. Some schools are small, racially diverse, and made up of primarily low-income families. Other schools are larger, located in suburban areas with primarily white middle-high income earning families. Klingston City Schools employs over 3,900 teachers district wide.

In 2008, Klingston City Schools appointed a new superintendent. As part of his five-year strategic plan, the superintendent intended to focus on the creation of effective educators through the successful implementation of a new teacher accountability model called TEAM. In the TEAM model, experienced classroom teachers are observed teaching four times a year. These observations scores coupled with student standardized test scores made up the majority of the teacher's end of the year evaluation score. The implementation of the TEAM model was initially met with pushback among teachers and administrators. The new evaluation model required teachers to spend more time focusing on planning and completing paperwork, and resulted in a loss of instructional time among those teachers tapped to evaluate their peers. The new evaluation system coupled with the recent adoption of Common Core Standards by Klingston City weighed heavily in the minds of the participants throughout this study.

To get a clearer picture of where these participating teachers worked, and to provide a bit of background on personal experiences that have influenced who they ultimately have become as teachers, I now provide some insight into the participants themselves.

The Participants

Trish. Trish was the first in her family to go to college. Growing up in a small mountain town, she attended a very small school comprised of no more than 75 students total in Kindergarten through 5th grade. Although she struggled early in school, science and social studies were consistently subjects that she enjoyed and thrived in academically.

Even though she enjoyed and excelled in science, she decided not to register for advanced science classes in high school, stating that the students in those classes intimidated her. "Like they were the people going to like, where we're from, you know they were the people going to (state university), or going to.... I don't know any of the other big-name schools there. And I was not part of that crowd."

When asked to describe some of the science teachers of her youth, Trish said that some were a little "Bill Nye-y," explaining that the enthusiasm shown by these teachers during instruction might be misinterpreted as them being somewhat "crazy." These teachers tended to begin class with lectures, but generally would follow up with assigning projects and experiments. Trish's other science teachers were more traditional. She talked most favorably about her experiences in science classrooms that were hands-on, but she was able to find value in traditional instruction as well, if she was allowed to actively discuss the material with the teacher. In one class, where the teacher preferred lecture as his primary means of instruction, she spoke appreciatively of his interaction with students, "I enjoyed his class because there was more discussion maybe in it. It wasn't just him sitting up there and spouting off stuff like... He wanted to know what we thought about it, and he engaged us in the reading, and stuff like that. So even though his was lecture, I remember a lot of it, and I really enjoyed the class." (Trish, 10/11/2012)

As a child, Trish aspired one day to be a prosecuting attorney. However, she eventually came to realize that although she was excellent at debating, she wasn't interested in doing it as a full time job. Her father's insistence that she attend a local Bible college limited the number and variety of program options available to her, and thus professions she could pursue. Although teaching was not her first ambition, after entering the teacher education program, she felt comfortable and capable as a teacher. Eventually, she decided that she enjoyed teaching enough to pursue it as a profession.

Trish currently teaches Kindergarten at a suburban elementary school in the Klingston City school district. Stonehedge Elementary serves approximately 975 students grades Kindergarten through fifth grade. Stonehedge is located in what has been considered to be part of one of the older, more tightly knit communities in the Klingston City School District. Ninety-four percent of the students at Stonehedge are Caucasian, 2.4% are African-American, 3% are either Asian or Hispanic, with the remaining children being from other nationalities. Twenty-eight percent of the students at Stonehedge are classified by the state Department of Education as economically disadvantaged. Trish teaches in a self-contained classroom where she is responsible for instruction in all of the core academic areas: reading, writing, math, science and social studies.

Trish was an enthusiastic participant in this study. After proposing my study during a faculty meeting, Trish not only volunteered her own time, but tried to volunteer a colleague as well. When I met with her in her classroom for the first interview, it was well after the school day had ended. That evening, the school was conducting an open house, so Trish's room was prepared in a manner to impress the parents. Since she intended to remain at school until after the open house was done that night, she figured that we would have plenty of time to talk.

During the interview, Trish was very expressive with both her voice and body and had excellent comedic timing when telling stories. She tended to add the letter 'y' to the ends of words when she wanted to ascribe a trait to something, or someone, that best reflected her feelings about it. For example, when asked if she could provide any unit summaries related to the nocturnal animals unit she replied, "It's not TEAM lesson planny, but it is plan booky."

I found Trish to be wickedly funny, self-effacing, and eager to please. Although I reiterated to the participants throughout the study that there was no "right" answer to my questions, Trish expressed a concern that she wasn't giving good responses. At one point she stated, "I feel like I'm giving you lame answers."

Trish had previously taught 2nd and 4th grade, in addition to the teaching experience she has acquired in Kindergarten. In this her 7th year of teaching science to elementary students, Trish explained that her science teaching is not what it should be. When asked to describe herself as a science teacher, she replied,

> If I'm going to be really, truly, and completely honest, I'm going to use half-assed. It's something that I love to teach. I enjoy teaching it. But when I get into the nitty-gritty part of my day, and people are breathing down my neck on what to expect, it's going to be the first thing to go. And so that's, when I have an opportunity to teach it, I teach the

> crap out of it. Like I do a great job at it. But it's not my number one goal. So it's not where I spend the majority of my time. And that's the honest truth of it. And I can't lie. (Trish, 10/11/2012)

Janet. Janet, an eight-year veteran, chose teaching as a second career. Although both of her parents were teachers, Janet earned a bachelor's degree in human services, and a Masters in family therapy. After years working in the mental health field, and with children placed in foster care, Janet returned to school to become a teacher.

As a child, Janet attended schools that were very small. When describing these schools, Janet remarked that unless a student moved in or out of the community, her classmates never changed. A self-described "super quiet kid," Janet preferred to go unnoticed in school. "The teachers wouldn't know what to say at conferences because I was so quiet they'd sometimes practically forget that I was there. And that's how I liked, I liked to be under the radar." Nevertheless, Janet did well in school and described not needing to truly study until she reached college.

When I asked about Janet about her own science teachers growing up, she explained that they varied in their ability to engage her. She described her dislike of chemistry in high school, "Chemistry I remember being too hard, me feeling like it was too hard because I just didn't understand all the chemical abbreviations and how the chemistry equations worked." She considered high school biology to be an easy class, but fun as well. However, college biology was a different story.

> I think the teacher was less dynamic and just more, it was just straight lecture, taking notes, memorizing information. And the labs, I don't remember them being all that interesting to me… It just seemed so removed from me, it wasn't something I was

> interested in, so it just didn't engage me, it was the thing I had to do because I had to get this credit, instead of oh this is interesting I want to know more about this. And bio- in my high school biology, he presented more topics, or he presented them in a way that I found interesting and I wanted to do it. (Janet, 10/16/2012)

Janet currently teaches Kindergarten at Morefield Elementary, an urban school serving approximately 250 students in Kindergarten through fifth grade. At Morefield Elementary, 77% of the students are Caucasian, 5.5% are Hispanic, and 17% are African-American, with the remaining percentages comprising children of other nationalities. Seventy percent of the students at Morefield are classified economically disadvantaged by the state department of education.

Janet teaches in a self-contained classroom where she is responsible for instruction in all of the core academic areas: reading, writing, math, science and social studies. During the initial interview, she described her preference for incorporating the five senses into her teaching stating that by doing so,

> It kind of helps kind of them narrow down their focus on what they're doing. And bring it down to what they can actually observe rather than what they imagine it might be, or what they guess I want them to say. (Janet, 10/16/2012)

When asked to describe herself as a science teacher, Janet used the term "evolving" and then elaborates on the difficulty of changing her instructional style from presenter of information to facilitator of exploration.

> When the standards changed, the thing that changed the most was it went from just that they understand this content, to that they use inquiry, that they use certain things and problem solving it became more of a problem solving standard, or the

> standards became more problem-solving. And so I've been trying to make that switch to, of instead of just presenting content, which my first couple of years of teaching is probably what I did, to how can I get them asking questions and them trying to find the answers. And I figured, I've learned to do some of that, I feel like I'm still learning how to do that. (Janet, 10/16/2012)

Sally. After graduating from college with an undergraduate degree in chemistry, Sally spent a few years working in various research laboratories. When her husband entered a Ph.D program requiring them to relocate to another state, Sally decided to leave the lab and concentrate on starting their family. During this time, Sally became a full time stay-at-home mom to her young children.

Once her youngest started first grade, Sally began volunteering in the schools, and then eventually transitioned to substitute teaching. After four years of substitute teaching, she decided to enter into an alternative certification program designed specifically for teachers who had been in the workforce and could translate some of their real world experience into the classroom. After completing the program, Sally was hired at a local high school to teach chemistry and physical science.

As a student, Sally attended a small city high school in a state located in the southeast. Although the high school small in size, they were ranked fourth academically in the state, and had a variety of course offerings. Sally enjoyed science classes as a student, and took every class that she could. She also described feeling comfortable, and capable, as a science student. When asked to describe her science teachers, Sally referred first to their credentials and industry experience,

> Well my chemistry teacher was actually somebody who had a BS in chemistry had gone back and gotten his certification to teach, and he was there I guess five or six years maybe and then went back to industry. The anatomy and physiology and biology teachers were teaching at the community college there in town as well as teaching full-time at high school. So as far as preparation, I felt that I had a very good solid footing as far as bases in the sciences. (Sally, 10/16/2012)

When asked about their methods, she described them as being very "hands-on," and recalled spending a good portion of class time in the lab.

During her interviews, Sally talked a lot about external limitations placed on her instruction. In particular, she spent time talking about the impact that class size has on student learning, stating that chemistry is a particularly difficult subject to teach when one-on-one instruction is limited. She also suggested that perhaps the state's requirement that all students pass one chemistry course in order to graduate is an unreasonable expectation of all students.

> I've taught classes as large as 34. And in chemistry, in particular, that's very difficult because now that it's required for graduation, and due to the nature of the course, it's difficult for students. I don't know that I agree with the state mandate that everybody take chemistry or physics. Because skill wise, because it's so math intensive, they don't do well. And they get frustrated. And you can see it. It's evident they shut down. I use as much as I can a one-on-one approach, and at least try and get around and double check with to see how they're doing with the chemistry. (Sally, 10/16/2012)

Sally also talked about the challenge time and breadth of content present in her instructional planning, "we've got a huge amount to cover in a very short period of time."

Interestingly, Sally referred to the curriculum required by the state and county as if both she and the administration mutually possessed it. Unlike the other participants who talked about standards and curriculum by saying "they" require this, Sally stated, "we require a little bit more, it's published on our science intranet website." Later on in the interview, Sally describes her experience with curriculum development at the county level. These experiences may play a part in her view that curriculum is dually owned by teacher and administrator, rather than externally imposed on the teacher by administration.

Sally currently teaches courses chemistry and Crime Scene Investigations at Bowling Green High School to sophomores, juniors and seniors. Bowling Green High School is a suburban high school located slightly west of the center of Klingston City. Bowling Green serves approximately 1900 students in grades 9 - 12. Eighty-three percent of those students are Caucasian, 9% African-American, and approximately 7% are either Hispanic or Asian-American. Twenty-two percent of the students at Bowling Green are classified economically disadvantaged by the state department of education.

Bowling Green High School utilizes a block scheduling system where there are 5 periods each day of approximately 90 minutes of instruction in each. Sally taught four periods of science. For this study, she submitted a unit plan for her Chemistry I CP (college prep) course.

Natasha. Natasha had been teaching high school science for 15 years. During this study, she taught courses in biology and marine biology to freshman, sophomores and juniors. She has also taught courses in physical science. Like Sally, Natasha taught at Bowling Green High School in the Klingston City School District. Bowling Green High School serves approximately 1900 students in grades 9 - 12. Eighty-three percent of those students are Caucasian, 9% African-American, and approximately 7% are either Hispanic or Asian-American. Twenty-two percent of the students at Bowling Green are classified as economically disadvantaged by the state department of education. Bowling Green High School utilizes a block scheduling system where there are 5 periods each day of approximately 90 minutes of instruction in each. Natasha taught four periods of science in either Biology or Marine Biology. For this study, Natasha selected to submit a unit plan for her Biology I course.

When asked about her early educational experiences, Natasha described herself as a student who enjoyed school and who liked to please others. She stated that although had no particular gifts, she excelled in school. She knew early on that she wanted to be in a profession that helped others. Having come from a family of teachers, she initially resisted teaching as a possible profession, and instead pursued a degree in biology with the intention of become a veterinarian. However, because of her many and varied interests, and her concern that she would become too "obsessed with being a vet," she decided instead to pursue teaching.

Natasha's own experiences as a student consisted of science teachers who instructed in a fairly traditional manner. Those hands-on experiences she was able to recall during middle school were described as being enjoyable, but also "silly." However, most of her childhood science experiences were considered not memorable.

> In middle school I remember I had a couple of science teachers and we did like science kinds of things where we made like silly things like hotdog solar cookers, and we did dissect a frog, and dissected worms and made pizza cells and we did lots of little activities like that. And I liked it… We did microscope stuff, but he would set up the microscopes. We didn't touch them, we just looked through them and drew stuff and then had a test on them. I don't remember my biology classes and vocabulary quizzes and that… But my teachers were, in the science, my

> freshman teacher was very traditional. You do vocabulary, you have the quizzes on Friday. You do the questions of the book you, so I don't even remember what we did, you know? (Natasha, 10/11/2012)

When asked about her own teaching style, Natasha described a preference for using a variety of instructional approaches in her science classroom. This was due in part to her belief that her students all had various learning strengths and weaknesses and through her use of several approaches she could reach them all. She also liked to mix up her instruction to avoid boredom.

Although Natasha had been teaching science for well over a decade, she still struggled identifying as a science teacher, "I don't think I'm a good example of a science teacher. I really don't" (Natasha, 10/11/2012). When asked to describe a science teacher that she looked up to, Natasha talked about some of her colleagues at Bowling Green High School. She particularly valued how one teacher was able to remain so organized and how another was able to emotionally connect with his students. But then Natasha followed up with,

> But I'm... I'm really not a science teacher. I guess that's probably it. I'm like a poser. Because I, you know usually you think of science as very analytical and very, and I can be logical, but I just... I don't know, I'm misplaced, misplacement? I'm here to connect with those kids that are lost, I don't know. I'm more flowy than that, I'm not as neat and tidy, as you can see from my classroom. You know it's like controlled chaos, is what Dr. Mowry used to call it, um…. I guess my ideal image of an ideal science teacher would be one that is fun, and engaged, and could be serious and teach the details. (Natasha, 10/11/2012)

Funny enough, although Natasha revealed those same elements in her own instruction, she expressed discomfort with her own abilities. In some ways, Natasha viewed herself more as a generalist than a science teacher per say. As I worked with her, I wondered if Natasha's wide and varied interests played a role in this issue of self-efficacy.

Positionality within this study

I am a 36 year old, white woman who was raised in a suburban area in southwest Florida. I currently hold a Masters degree in elementary education obtained at one of the state universities located in Florida. I am the product of a heterosexual, two-parent household where both of my parents completed college degrees. Education was valued tremendously in my family. My father was originally a high school English teacher and then transitioned to work with K-12 students in the district homebound program. I would classify my K-12 educational experiences as moderately successful. I maintained a high grade point average, completed honors coursework, and was a member of the National Honor Society.

My experiences particularly as a student of science were fairly unmemorable. Much like my participants, those few experiences I am able to recall in detail were hands-on in nature. Otherwise, my memories of my science teachers include listening to lectures, taking notes, and taking tests. I was, by no means, and exceptional student in my science courses. When I applied myself, I was able to earn A's and B's. When I did not, I earned much lower marks. At those times when I excelled, it was usually do to a personal challenge made by a teacher, or by my need to prove myself. My college science coursework was limited to courses in Astronomy, Botany and Nutrition and Science Education. During this time, I did not have a particular interest in Science Education, and was merely completed the required science coursework to complete my degree in Education. I received below to above average marks in these courses.

My work experience is primarily grounded in the field of education. I taught elementary school for 10 years before returning to pursue my Ph.D in Teacher Education. I taught at a total of three different schools of various socioeconomic levels. As my teaching career progressed, I became more involved at the district level in science education. First, I served as a school representative to the county office. During the summer, teachers were solicited to work on different curricular projects and I enjoyed working on these projects with veteran science teachers from across our county.

On various summer committees, I collaborated on the development of county wide pacing guides to be used with the adopted science text, the revision and alignment of core grade level expectations, and the development of a vocabulary project guide for teachers that identified essential science vocabulary by grade level and strategies for teaching vocabulary. I also collaborated on the development of a quarterly science assessment intended to measure elementary student progress towards mastery of state standards. As a result of these experiences, I felt comfortable in leading a professional development workshop for elementary science teachers shortly before I left teaching.

I consider myself to be a passionate advocate for quality science education. I enjoy reading practitioner and research journals from the field of science education, and regularly attend conferences related to science teacher education. I am particularly interested in how teachers interpret and apply standards into their practice.

Data Collection Procedures

This study took place from August of 2012 through May of 2013. The first interviews were conducted during October and November. After obtaining IRB permission from the relevant institutions, I contacted principals within the Klingston City School District in an effort to obtain their consent to contact potential participating teachers for this study. Once this consent was obtained, I emailed selected science teachers participants to solicit participation in this study. I briefly met with all of the interested teachers before the study began in order to clarify the process, answer any questions they might have about their participation, and to obtain informed consent. In a Table 3.1, I have illustrated the timeline during which this dissertation was completed. The gray boxes indicate that the event described was completed during that month.

Table 3.1: Research timeline

	2012					**2013**						
Task	*August*	*September*	*October*	*November*	*December*	*January*	*February*	*March*	*April*	*May*	*June*	*July*
Gain site access, identify participants, and obtain consent.												
Initial semi-structured interviews												
Think-aloud audio recording requested and obtained												
Second semi-structured interviews												
Data analysis												
Writing/ Revision												
Presentation/ Defense												

Using a descriptive multicase study research approach, I have created a thick description about how elementary and high school teachers' beliefs and curricular knowledge influence their planning for science instruction. My approach has been visually illustrated in Figure 3.2. After selecting the four cases for this study, I collected data in the form of interviews and think aloud planning records. I also collected other related documentation, such as lesson plans, for each participant. By using these three data sources, I was able to triangulate the data that helped me produce my findings.

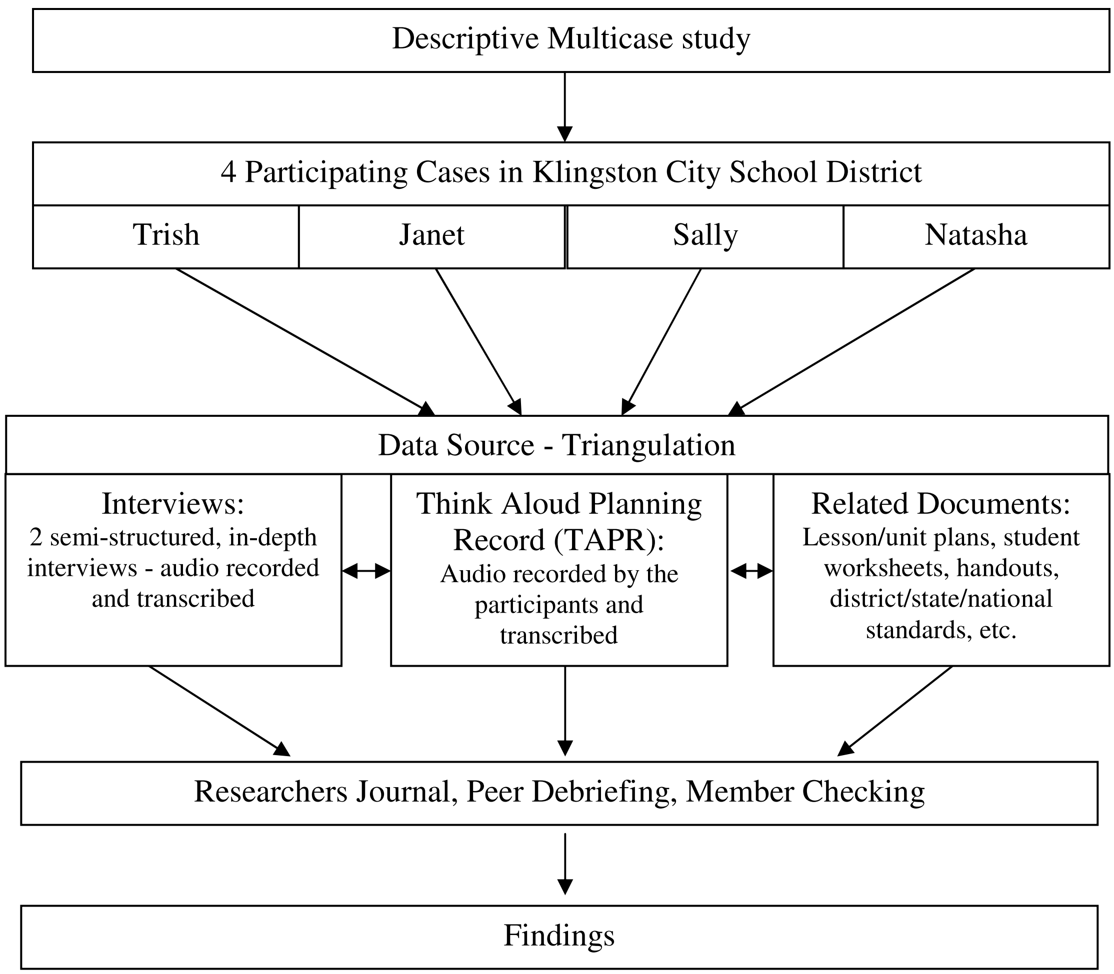

Figure 3.2: Visual illustration of research approach

A summary of what information was used to answer what research question has been provided in Table 3.3.

Table 3.3: Sources of data

Research Questions	Interview #1: Questions	Think Aloud Planning Record	Interview #2 Questions	Related Documents
What influence do beliefs about how students best learn science have as teachers plan for science instruction?	1. How do children best learn science? 2. Describe the methods you have found effective in teaching science. Other relevant statements by the participant in response to other questions also included in analysis.	X	1. What aspects of your unit reflect what you believe about how students best learn science? Other questions varied by participants	Unit/lesson plans, Powerpoint presentations, handouts, student worksheets, notes
What influence do beliefs about qualities that excellent science teachers should possess have as teachers plan for science instruction?	1. What important qualities should a science teacher possess? 2. What do you think are the important things a science teacher should know in order to help students learn science? 3. What is the teacher's role during a science lesson? 4. Describe a science teacher you look up to. Other relevant statements by the participant in response to other questions also included in analysis.	X	1. What aspects of your unit reflect what you believe about the most important qualities science teachers should possess? Other questions varied by participants	Unit/lesson plans, Powerpoint presentations, handouts, student worksheets, notes, Card sort task response
What influence do local, state, and national standards have as teachers plan for science instruction?	1. Tell me about the curriculum (or curricula) you use for science instruction. 2. When you plan out your instruction, how do you decide what you will teach next? 3. Tell me about the kinds of materials you like to use during your science instruction. 4. If you had unlimited resources, what would your ideal science classroom look like? 5. What documents most influence your science instruction? Other relevant statements by the participant in response to other questions also included in analysis.	X	Questions varied by participants	Klingston City Science standards (Kindergarten, Biology, Chemistry); State Science Standards, National Science Education Standards

Hashweh (2005) suggested that in order to accurately capture one's pedagogical content knowledge, defined as a personal and private knowledge that interacts with beliefs, a researcher must spend time talking to individual teachers. Therefore my data collection included two separate in-depth interviews with my participants. Each interview varied in length from 25 - 70 minutes. The length of the interview varied based on the responses of the teacher and their willingness to engage in the process.

For the first interview, I developed a semi-structured interview protocol (See Appendix B). During this interview, I talked with the each of the participating teachers about their beliefs regarding the teaching and learning of science. Specifically, I asked them questions about their methodological choices and their epistemic beliefs about how students learn science. I also asked them about their personal and professional experiences in science, about their adopted curriculum, and about their use of other resources with a focus on how resources factor into their teaching decisions.

Hashweh (2005) also indicated that asking teachers to talk-aloud during planning is an appropriate method for attempting to capture this knowledge. With this in mind, I asked each participant to create an audio recording, a think-aloud commentary, where they talked out loud as they planned for a science unit (Yinger, 1980). At the conclusion of the first interview, I explained the next step in this study to the participants: the Think Aloud Planning Record. In order to assist participants who might have felt uncomfortable with this process, I provided them with a bulleted list of talking points which could be used during the talk aloud planning recording (See Appendix C). The participants provided a wide variety of Think Aloud Planning Record products. They ranged from single audio recording describing a lesson, to multiple recordings done over several days. Recordings submitted by each teacher ranged from 10 to 100 min. in length when compiled. The length of recording reflected the teacher's willingness to engage in detail over audio recording. Limited recordings may have reflected a discomfort with the audio recording of the planning process. Since most planning is mental and informal, this process may have felt abnormal for some teachers, thus creating a limited think aloud planning record. The results and conclusions drawn in this study reflect this result.

Along with the think aloud planning record, the teachers were asked to submit any relevant documentation that went with the unit they described in the recording. These documents included, but were not limited to, lesson plans, handwritten notes, PowerPoints, student worksheets, pictures, and links to websites. The teachers were asked to submit any documentation they felt was relevant to their planning of the unit. If the teacher referenced either local and/or state standards, I obtained a complete list of standards used by these teachers, and then confirmed which version was used when several versions existed of the same document.

After each participant completed both the initial interview and the Think Aloud Planning Record, I transcribed the recordings and examined the transcripts. Using these transcriptions, I created a second semi-structured interview protocol for each participant. Each protocol was individualized, including questions which would deepen my understanding of the specific belief statements made by each teachers during either their interview or think aloud planning record. It was important to create individualized protocols in order to adequately respond to the variety of responses among the participants and extend my understanding of those responses.

As part of this second and final interview, I created a card sort task for the participants to complete (See Appendix D). In the first interview, each participant was asked, "what qualities do you think science teachers should possess?" After compiling these responses into a master list, I wondered if my participants would maintain their initial responses if confronted with this larger list. To test this, I wrote each quality individually onto a card, grouped the cards together, and developed a task that asked teachers to rank the qualities in order of importance from greatest to least. Although, this card sort task was just one small portion of the final interview, I hoped the results would help me gain a stronger understanding of what these participants truly valued in science teachers.

With consideration to my prior life experiences, and through my acknowledgement for potential biases in my analysis, I documented my feelings and reactions using a researcher's journal (Watt, 2007). Through journaling, I hoped to examine the sources of my knowledge, previous experiences that influenced my beliefs, and existing biases resultant from prior knowledge. I also completed the first interview protocol and card sort task on my own, so that I might examine my responses alongside my participants'.

I assumed the role of observer as participant during this study (Merriam, 2009). Each participant was made aware of the purpose of my study. I believe that when relationships are developed with the participants, trust and rapport will build between the researcher and the participant, with the hopeful result being a richer disclosure of the participant's "truth." Additionally, I used extensive member checking throughout this study in an attempt to accurately represent the voice of my participants. During the interviews, I used questions to confirm interpretations of statements made by the participants. I also shared the findings of this study with the participants, so that they could have an opportunity to add any final thoughts or reflections to the results.

Methods of Analysis

In the first stage of data analysis, I employed in-vivo coding and descriptive coding techniques (Saldana, 2009). In-vivo codes are words or phrases found directly in the actual language of the qualitative record, or used by the participant (Saldana, 2009). These can be thought of as direct quotes. Descriptive codes summarize larger passages of text into words or phrases that are representative of the lengthier text (Saldana, 2009). Using these two methods simultaneously helped me to retain the voice of my participants, while beginning to uncover preliminary patterns within the data.

In my second coding cycle, I coded the data using a values coding approach. In values coding, the researcher assigns codes that represent the attitudes, beliefs or values possessed by the participants within the study. In this case, the assigned values codes represented the attitudes, beliefs or values the teachers had about science teaching and learning (Saldana, 2009). The use of values coding is appropriate in case studies where the participants are interviewed and/or observed (Saldana, 2009). However, it should be noted that one’s expressed values might be different from values that can be inferred through their actions (Saldana, 2009).

Trustworthiness

In order to enhance the trustworthiness of this study, I have employed several methods during my analysis of the data that are accepted in the qualitative research community as appropriate. First, I used multiple sources of data to compare and cross check emerging themes during my analysis. These data sources included transcripts of interviews, think-aloud planning records, and printed resources referenced by the teachers. Merriam (2009) postulates that such an approach is a "principal strategy to ensure for validity and reliability" (p. 216). Golafshani

(2003) concurs stating, “engaging multiple methods, such as, observation, interviews and recordings will lead to more valid, reliable and diverse construction of realities” (pg. 604).

Member checking, otherwise called respondent validation, is another common method used by qualitative researchers to ensure credibility, or internal validity. In member checking, the researcher checks-in with participants during the data analysis phase to see if the interpretations that are being made "ring true" (Merriam, 2009, p. 217). My study claims face validity through my use of extensive member checking of my findings with the participants (Lather, 1986). I attempted to summarize statements made throughout the interviews, and the themes that emerged from these statements, back to the participants in order to confirm and clarify. Once my analysis was finalized, I presented my findings back to the participants to be certain I accurately reflected their beliefs about science teaching and learning. All of the participants agreed with my findings.

Through reflexivity, qualitative researchers can also claim validity. Through the verbalization of my personal biases and background, the readers of this dissertation can understand how a "particular researchers values and expectation influence the conduct and conclusions of the study" (Maxwell, 2005, p. 108). Merriam (2009) cites the use of rich, thick descriptions and the creation of an audit trail as two other methods to ensure the reliability and validity of qualitative research findings. In my study, I have provided rich, thick descriptions of the participants' backgrounds, unit plans, and beliefs about science teaching and learning. I have also described my methods in detail, including decisions I made for how to proceed when faced with certain dilemmas, and the how and why of my choices to collect and analyze the data. Therefore, I have utilized two other accepted strategies that may help my claim reliability and validity in my findings.

Merriam (2009) suggests that the selection of multiple cases is "a common strategy for enhancing the external validity or generalizability" of findings (p. 50). My research at this stage does not seek to generalize these findings to all teachers of science, nor attempt to claim external validity. However, I have made attempts to maximize descriptive validity through the use of audio recordings, transcriptions, and in vivo statements made by the participants in my findings.

Summary

Through this descriptive multisite case study, approached from the constructivist paradigm, I will explore how the beliefs and knowledge possessed by four teachers in the Klingston City School District influences planning for science instruction. The data collected for this study included eight semi-structured interviews, nine Think Aloud Planning Records, and 154 pages of other documentation related to the science planning of these teachers. My analysis included repeated reading and analysis of transcripts and documents, coding for themes, and was followed by member checking to ensure trustworthiness and quality.

Chapter 4: Data Presentation and Analysis

In Chapter 3, I detailed the methods used to gather the data that will help me describe how the beliefs and curricular knowledge of teachers influences their planning for science instruction. The three guiding questions for this study were:

1. To what extent do beliefs about how students best learn science influence teachers as they plan?
2. To what extent do beliefs about qualities that excellent science teachers should possess influence teachers as they plan?
3. To what extent do local, state, and national standards influence teachers as they plan?

In order to provide additional context for the readers of this dissertation, I have included an overview of each teacher's unit plan in the appendices portion of this paper (See Appendices F – I). I believe these descriptions may assist readers in visualizing what science instruction looks like for each of these teachers.

In this chapter, I address each of these research questions in turn. Questions are answered using evidence gathered from interview transcripts, the planned units these teachers produced, and additional related documents.

Research Question #1 - To What Extent Do Beliefs About How Students Best Learn Science Influence Teachers As They Plan?

During the first interview, each teacher was asked directly, "How do students learn science best?" Each teacher responded to this question briefly. As a provision of evidence in support of these belief themes about how students best learn science, I have used quotes from the participants throughout the findings. For example, when responding to the question, "how do students best learn science?" Trish said,

> Hands-on. Being able to see it and experience it. You can't just sit there and talk to them about it and you can’t just read it out of a textbook. They've got to touch it. They've got to blow things up. (Trish, 10/11/2012)

I reduced this statement to the theme of "hands-on" which I believe represents the core idea of this response. However, a response to a direct question is not the only way to examine one's beliefs.

Beliefs statements made by these teachers in response to a direct question seemed to represent a limited view of their true beliefs. Therefore, I decided to examine other statements from other parts of their interviews. These statements were also indicators of what these teachers' believe about how students best learn science. For example, Sally’s answer to another question was,

> We may work on a few notes to begin, or review previous day's material. We try to get them to working either hands-on or in pairs. I just tell them either work with your shoulder partner or with your face partner, and sometimes I have all four of them working together. (Sally, 10/16/2012)

Sally clearly believed students best learn science through class discourse, hands-on activities, and through fact, skill acquisition / knowledge base building. To confirm if the expressed beliefs of these teachers were translated into their lesson plans, I looked for evidence in their think aloud planning records.

For example, when Janet described her role during a science lesson, she indicated that she felt it was important to guide her students through the question development process, and work with them on conversational skills. In her unit plan, she regularly selected to facilitate student learning through whole group discussion or in small groups. Considering that Janet both expressed a belief about discourse, and incorporated opportunities for discourse into her unit plan, I believe this demonstrates her firm belief that students best learn science through discourse.

Although this study examined expressed beliefs, it should be noted that sometimes teachers have beliefs that go unexpressed (Kagan, 1992). Unexpressed beliefs may occur for a variety of reasons. When teachers are asked to describe beliefs about teaching and learning, they may assume that certain beliefs need no explanation, such as the belief that all students can learn. Teachers may be unaware of their beliefs, or may not possess the language to describe their beliefs. They may also be unwilling to publicly share their beliefs, or be uncomfortable responding to the question in the presence of the person who has asked.

Beliefs expressed by teachers can be affected by current events in or out of the classroom. For example, if an administrator has recently evaluated a teacher, it may affect how that teacher responds to a question about their pedagogy. Teachers may also provide initial statements that can be viewed as politically correct in the teaching profession. Specialized teacher language such as “hands-on learning” and “differentiation” are commonly accepted buzzwords in the education realm. These terms may be used when teachers believe there is a “correct” way they should respond. The results of this study should be reviewed with these additional considerations in mind.

Trish. When Trish was asked directly how students best learn science, a singular theme emerged from her response, “hands-on.” But other beliefs were revealed during the interview, which proved to be more influential in her planning process.

The majority of the activities Trish used during her nocturnal animals unit centered around discussion of vocabulary words, reading text related to the unit topic, and writing facts related to the unit topic. For example, Trish made statements like, "we are going to look at some different facts" or "we will go over all of our facts that we've learned" throughout her think aloud planning record. As Trish explained in her TAPR, what she most wanted her students to get out of her nocturnal animals unit was,

> Because of my shorted (sic) period of time, I want to make sure that I can get the most pertinent information that I really want to focus on exactly, what that is that I want them to take away from this unit. In this case, for my bats unit, what I really want them to take away from is that bats are nocturnal animals, and that nocturnal animals come out at night. Those are the two things ultimately that I want them to take away from this. That they understand that animals come out at different periods of the day. But to know that, what nocturnal means, that bats are nocturnal, and maybe a fact about a bat (Trish, 11/20/12).

In her own words, Trish demonstrated the value she places on vocabulary comprehension and recall of facts.

Multiple beliefs about how students best learn science were revealed during Trish's interviews and reemerged in her unit plans. In the list below, I have ordered them to reflect the emphasis within her unit plan. For example, her students spent considerable time on fact and skill development rather than in hands-on activities.

1. By building the student's knowledge base (facts/skills)
2. Through class discourse
3. By integrating instruction with other subject areas

4. Through personal reflection/meaning making
5. By provoking curiosity for the subject matter
6. Through hands-on activities

Trish’s beliefs often intertwined as she planned, meaning many of her beliefs were blended together into a single activity. The predominance of activities Trish planned to teach focused on factual recall and the development of vocabulary. However, through her use of two different types of charts to organize prior knowledge, newly gained information, and questions for future exploration, Trish also demonstrated her commitment to other beliefs about how students best learn science. These included provoking personal curiosity, personal meaning making and discourse.

Another example of how Trish’s beliefs about learning intertwined as she planned included her preference to incorporate personal meaning making opportunities during facilitated whole class discourse. During personal meaning making, students connect newly introduced content to their personal, prior experiences. In Trish’s classroom, this tended to occur when students shared personal stories related to the content. In this exchange, we can see the value she placed on both personal meaning making and discourse.

> Even I feel like for a kindergartner, them being able to tell me what they already know about something like when I read about how bats eat fruits blah, blah, blah, or then they say where is do bats live, that is probably the better one, oh bats live in caves and yada, yada, and then they tell me oh well my grandpa had a bat in my attic, and they used to come out every night. They're are drawing on their life experiences, what they've seen, and applying it to, they observed it, but they didn't

know what they were observing, so I'm making the connection between those two things. (Trish, 10/11/2012)

During science instruction, Trish often elected to use facilitated whole group discussion rather than small group discussion. Each of her five days of activities around the nocturnal animals unit included a facilitated whole group discussion segment. Trish expressed that the age of her students, and their lack of prior life experience, inhibited their ability to fruitfully discuss the topic in small groups. She believed that it was necessary to model for Kindergarten students how to ask questions, how to engage in conversation, and how to provide an answer that relates to the original question. Facilitated whole group discussion allowed this modeling to take place.

I've got that "We can ask questions like a scientist" poster over there, but the fact is that they don't know the difference between a statement and a question. And so I'll say, "We're going to ask some questions. Questions are something that you want to know. And they're like, and I'm like look at this picture of a dolphin, what would you want to know about that dolphin? "I swam with dolphins once." That's not a question. You're telling me something. What do you want to know about it? And so you do lots of modeling there with them on how to ask a question. So they just don't, I mean you start from ground zero with them, they just don't know anything. (Trish, 10/11/2012)

In the following exchange, I asked Trish about her frequent use of reading and writing activities as part of science instruction.

We have so, we have to fit so much in a day, if I can fit that in the way. And with the common core wanting it to be 60% nonfiction, I mean that's definitely something that I think about… that is totally intentional. Because if I can't get it

> everywhere I can, I mean it has to be cross-curricular. I feel, for them to start locking onto it. It can't be compartmentalized. Everything has to bleed together. (Trish, 2/21/13)

Trish expressed a belief that by integrating reading and writing with science, students would be able to make more sense of the content. But reading and writing did not drive her science planning. Instead, during planning she considered how she could relate the content the current lives of her students.

> What drives my science planning is what they are doing at that point in the year. Because it's something that they're experiencing outside of school, it's going to be easier for me to teach. (Trish, 2/21/13)

Interestingly, Trish seemed conflicted about the role of integrating other subjects into her science instruction. Although the majority of her activities required either reading or writing, when asked directly about what aspects of her unit did not reflect her stated beliefs about how students best learn science, she replied,

> Um, I think at point in the year, getting them to write sentences about what they've learned about bats, maybe didn't reflect what they believe about science. It may be reflected more about what I believed about interconnecting subjects… if I would say to them, what did you, what facts did you write about bats? Probably not a single one of them would be able to tell me. But from the pictures that they drew from the stuff that we've read, all the graphic organizers, all that stuff, like me modeling for them, they would be able to tell me facts about bats. Or about what animals need or about how nocturnal animals live. Because even when we read stories now where there's a nocturnal animal, I'll say okay well what does

> nocturnal mean? And anybody in the class can say, it means an animal is awake at night. So they've you know processed that. But I think the writing part of it, maybe isn't what I think science should be for them for kindergarten. (Trish, 2/21/13)

In the first interview, Trish expressed a belief that students best learn science through hands-on instruction. The evidence of this belief being enacted in her unit plan was limited. But Trish had her reasons for this. When asked during the final interview how her nocturnal animals unit aligns with her expressed belief that students best learn through hands-on instruction, she replied,

> I still think that they best, they best learn by using hands-on things and by being able to see things, because science is more about experience and observations then it is anything else. And just talking to them about bats, without showing them, without letting them diagram and manipulate things. I think that like my philosophy of science is still the same. You know that they learn best by, um, being able to manipulate things. And observe it and see it and touch it for themselves. Now I can't bring a bat to them, but I feel like them watching bats fly on video, using their senses to pretend to be like a bat um, and then in a different unit, like, like, in a different science unit we actually ate things like the animals that we were studying, so we ate like them too. So we try and use all of our senses so that they can experience it. And if their experiencing it like that too, it's probably going to make more of an impression, happy impression in their memory, so that they'll remember those things. (Trish, 2/21/13)

In this exchange, Trish identified her echolocation activity as being most beneficial for students as they learned about the topic. She expressed the belief that simulated play, in particular, makes more of an impression on student learning then other activities. In some circumstances, Trish chose to set limits for experiences which could have been hands-on, instead opting for students to simply observe. Rather than have every student conduct an experiment, she selected to use student volunteers to demonstrate. This was due in part to the developmental age of her students and her desire to provide a model of appropriate behaviors for them.

> I might ask for volunteers, I have my fair and share sticks and the helping hand always gets to come up and do something. I have that kind of a situation where they would just come up and do it one at a time, but the majority of them are observing it. (Trish, 10/11/2012)

In instances where direct observations were considered to be unreasonable, Trish supplemented her lessons to include video. Bringing an actual bat to the classroom was not reasonable. Although Trish was unable to provide her students with first hand experiences observing bats, she believed that her students could still benefit from watching video footage of bats. So Trish chose to incorporate the Magic School Bus video into her unit plan.

Throughout the interviews, Trish expressed a belief that her students would not be able to reasonably complete an activity if they had not yet reached a certain stage in their cognitive or physical development. The lack of readiness coupled with a lack of experience with classroom rules and procedures affected her selection of activities during planning. Trish explained her convictions,

> Early in the year like in October, you're still, as a kindergarten teacher, you're still going over a lot of procedures. So there's some stuff that... Let's just say if I

> taught the unit in April or March… that I couldn't do with them in October. Because, you know, they don't have the vocabulary, or they don't have that well to pull from, I'm creating that. So that, that plays a large majority into it too. Um, so like in October, I have to reduce like the amount, like they may can only write one sentence. They may not be able to do a "can", a "have", and an "are" sentence. They can only do one sentence of those three. And then using materials, like I happen to have a really good class this year, so when we did echolocation, and I blindfolded them, like I knew that that would not be a problem behaviorally. But if I had kind of a ruckusy class, I wouldn't even attempt to do it. Because somebody would end up hurt, or you know people would-- it would just end up badly. So behavior, I can make behavior modifications based on what I think my class can and can't do too. (Trish, 2/21/13)

What this shows is that Trish felt the need to limit certain hands-on experiences because she felt her students to immature to participate.

To summarize, the predominance of activities Trish planned to include in her nocturnal animals unit required students to read, discuss, or write facts about animals. This demonstrates the influence of Trish's beliefs about the importance of integrating other subjects into science instruction and participating in facilitated whole class discourse. Through facilitated whole class discourse, Trish was able to realize another belief: personal meaning making. Trish's unit plan also demonstrated her commitment to the idea that students learn science best by building the student's knowledge base. Although Trish expressed a desire to include hands-on activities in her science instruction, her use of hands-on was limited.

Janet. Through her interviews, Janet revealed multiple beliefs about how her kindergarten students best learn science. These beliefs were evident in both her interview transcripts and her think aloud planning record.

1. Through class discussion (whole class or small group /pairs)
2. Through hands-on activities
3. By integrating science instruction with other subjects
4. By building the student's knowledge base (facts/skills)
5. By giving individual students assigned jobs or responsibilities
6. By provoking curiosity for the subject matter
7. By drawing to reinforce understanding

When Janet was asked directly, "How do students best learn science?" she replied, "I think they best learn it by seeing it themselves, experimenting with it, exploring it, rather than just somebody telling them how it works." Janet valued providing her students with opportunities to physically explore during science. She also stated that she often thought about what her students could observe with their senses as she planned for science instruction.

> What materials can I get in their hands? What can we go look and find so they can actually interact with it? So, the last thing we did leaves, we did a study on leaves. And we read a little bit about the parts of leaves, and why leaves change colors, and then we went for a walk and they had to gather leaves, and then they had to sort. (Janet, 10/16/2012)

For Janet, the majority of activities in her unit plan that she might classify as hands-on were related to sorting. Janet expressed a belief that sorting was an important skill for her kindergartners to master. This was based in part on her devotion to local school demands.

> It's one of the first things that they learn, and it's one of the big ones that they push for kindergarten right now with common core and with the TEAM evaluations. Categorization is one of the big ones. And they discussed with us at the beginning of the year that. At our school been kind of broken down the TEAM evaluation, whether, I can't remember what part of that is, if it's the problem solving part, or the, but there's one part where they broke it down kind of by grade level of, if you start focusing on categorization here, then as they move up, they can focus on another part of it. So we've already discussed at our school that we would really work on them being able to categorize things, so we try to pull it in anytime we can. (Janet, 2/27/13)

But for Janet, sorting was not enough. As she reflected on her unit during the final interview, she stated,

> I wish there were more things like an actual animal in there, or more hands-on where working with real things to learn the standard in my room, and I don't have enough of that for science. So that part I wish was different (Janet, 2/27/13).

Janet expressed a desire to provide her students with first hand experiences with animals and also that the absence of this experience needed to be addressed. Later in this dissertation, I will discuss factors that inhibited Janet’s ability to realize this belief.

Janet’s belief that discourse was important to the learning of science was evident throughout her science lessons. Each activity that Janet planned for included an opportunity for discussion that Janet saw as vital to building student understanding. Janet selected to use both facilitated whole group class discussion and peer/small group discussion in order to help her students understand the science content.

Like Trish, Janet elected to use facilitated whole group discussion as an opportunity to model appropriate conversational skills for her students. Through discussion, Janet was able to expose what students believed about the content, so that she could guide her instruction appropriately. When asked what aspects of her unit aligned with her beliefs about how students best learn science, Janet identified discourse as most important.

> I do think that the discussion part is good, so that they can say what they're thinking, because a lot of times I've forgotten over the years how I used to think as a kid. And then when I hear them telling me what's going on in their head, I think wow I never would've thought, I never would've thought that a child would think that helicopters was alive because it moved. So to see that, and to hear that's where they're coming from, is really helpful to me to guide them (Janet, 2/27/13).

Janet expressed a belief that it was important for her students to build their knowledge base on the topic of study. She did this by providing students with informational texts to read. Other times, Janet disseminated important information during facilitated whole class discussion. Janet would also have her students draw or sort objects as a check for their mastery of content post instruction.

Janet revealed other beliefs about learning through the activities she chose for her animals unit. For example, Janet revealed a belief that it was important to integrate science instruction with other subjects. This was evident through her selection and utilization of various student texts to build their knowledge base. She also revealed a belief that students should draw to reinforce understanding their understanding of content. Her students were often required to draw their answers into charts, and she used this information as a way for them to demonstrate mastery of the content.

To summarize, Janet's beliefs were consistently reflected in her unit plan for science instruction. Janet stated her belief that students learn best through hands-on instruction, and she incorporated sorting activities as a way to teach the students new material. She expressed that she would prefer to provide first hand experiences with animals for her students, and wished that her plans could include more of those.

Janet also revealed other beliefs about learning science such as the importance of engaging in whole group and small group conversations, building the student's knowledge base, drawing to reinforce understanding, and integrating science with other subjects. These beliefs were evident in her interview transcripts and her think aloud planning record.

Sally. Sally possessed multiple beliefs about how her high school students best learn science. When asked directly, "how do students best learn science?" Sally revealed two beliefs about learning. But other statements made during the interviews revealed additional beliefs. In total, Sally expressed five beliefs about how students best learn science. These beliefs included that students best learn science:

1. Through hands-on activities
2. Through class discussion (whole class or small group /pairs)
3. By building the student's knowledge base (facts/skills)
4. Through repeated and varied exposures to the content/skill
5. By establishing relevance to everyday life

During Sally's initial interview, she made a statement that suggested that students best learn science in two ways: through the use of hands-on activities and by establishing relevance between the content and everyday life. Through an examination of Sally's think aloud planning record and the related documentation that she provided, Sally demonstrated an alignment between her expressed beliefs about how students best learn science and her planning for science instruction.

During the interview, Sally also revealed a belief that students best learn science through discourse. This belief was evident in her unit plan as she frequently utilized small group discussion during her science instruction. By putting her students in small groups, Sally believed that her students could more easily make sense of the material.

Sally expressed a belief that small groups provided the opportunity for her students to safely ask or answer questions. Moreover, in small groups her students tended to reword responses in a way that made the content more accessible to the other students.

> Students tend to not be afraid to ask questions of somebody they don't feel is so much smarter than they are. They don't feel intimidated… It, sometimes it's easier for them to understand. If they've had to, somebody rephrase it in words other than what I use, sometimes they can put it in terms easier for them to understand. (Sally, 2/20/13)

During small group discussions, Sally moved about the classroom to work with students one-on-one. In Sally's mind, these opportunities to dialogue with small groups were very important because she viewed chemistry as a very complex and difficult to master topic.

> I ask them to explain to me as much as they know, and then we pick up on misconceptions or areas where there are gaps, and we try and bridge those and talk through, okay that's not exactly how that works. This is why it works this

> way. And that for some reason works better one-on-one, or three on one, where you can talk to them in smaller groups. (Sally, 10/16/2012)

Sally also revealed a belief that students best learn science by building their knowledge base through fact and skill acquisition. During her interview, Sally described her primary role as deliverer of content. So it was not surprising that Sally's instruction also included PowerPoints in lectures where students were responsible for taking important notes on what she was sharing. In Sally's think aloud planning record, part of the activity on day one included a portion where students were required to read materials related to the topic, and add to their journals important vocabulary. Through Sally's instructional choices, she demonstrated a belief that students best learn science through fact and skill acquisition.

Sally also expressed a belief that content needed to be presented in a variety of fashions in order to reach the diverse learning needs of her students. Throughout the interviews, she talked frequently about the importance of differentiation in her lessons. By making certain adjustments to her lessons such as altering the task complexity, changing up the presentation format, and providing additional time for students to wrestle with the material, Sally believed that her students had best chance possible to learn.

> If they have math issues, then I might reduce the number so it makes it easier for them to calculate. And following any IEP designations that happen to be given, with the Smarties and the different focus than the different segments of the class period, and then having a lab to reinforce, I think hits all different types of learning styles, ones that are visual, ones that are audio, and ones that are kinesthetic. They've participated in several different things that might hopefully help them grasp the concept. (Sally, 2/20/13)

Sally’s expressed beliefs were actualized in her unit plans through a variety of hands on activities. Her students participated in several “percentage of a whole” calculation activities such as the Smarties activity, the nuts and bolts activity, and the copper two sulfate activity. These activities were completed with partners and incorporated a discussion the relevance of percentage composition to the everyday lives of her students. These instructional choices demonstrated how Sally’s beliefs about learning intertwined. Her intertwining beliefs included the importance of relevance, discourse, hands-on activities and repeated, varied exposures to the learning process of her students.

In sum, Sally’s five beliefs about how students best learn science were evident throughout her plans for science instruction. Her beliefs about hands-on learning and discourse were most influential as she planned for science. However, Sally also demonstrated other beliefs about learning through her instructional choices. By including PowerPoint presentations and note taking as part of her regular instructional routine, Sally demonstrated a belief that students learn science by acquiring certain facts and mastering certain skills. Sally also varied her instructional approach repeatedly to address the needs of her diverse learners.

Natasha. Like the other teachers who participated in this study, Natasha possessed multiple beliefs about how students best learn science. Her unit plans reflected these beliefs and appeared to suggest that her beliefs were interwoven during planning.

Natasha revealed seven beliefs about how students best learn science that were evident in both her interviews and her unit plans. These beliefs included that students best learn science:

1. Through class discussion (whole class or small group /pairs)
2. Through hands-on activities
3. By building the student's knowledge base (facts/skills)

4. By establishing relevance to everyday life
5. Through repeated and varied exposures to the content/skill
6. Through personal reflection / personal meaning making
7. By provoking curiosity for the subject matter

The belief that was most prevalent in Natasha's unit plan related to discourse. Natasha provided a variety of opportunities for students to participate in either whole class or small group discourse. Through these discussions, Natasha was able to establish relevance between the content and everyday life, and provide opportunities for students to connect to the content personally. This demonstrates how Natasha's beliefs about learning intertwined as she planned.

On the second day of her think aloud planning record, Natasha described leading a class discussion on the resistance of some bacteria to antibiotics as a way to address the controversial, yet required, topic of evolution,

> What's interesting is that this is a controversial topic, sometimes, depending on how it's taught. I know it should always be a controversial topic I guess with living in the South, but if you talk about it just being change over time, sometimes the students never really... They're like oh yeah antibiotics, things change over time. Bacteria aren't as immune to them. And they're okay with that. (Natasha, 12/20/12)

Through this discussion, Natasha hoped to relate evolutionary changes in populations to a current and relevant societal issue these students face. Natasha also used discussion to actualize another belief, the importance of provoking student curiosity for the subject matter, potentially providing her students with necessary fuel to undergo a conceptual change.

> You talk about how medicine is changed because of these bacteria that have changed, so we can't kill them with the same antibiotics. And so you get that discussion going on, and that "wow I wonder why that is." And then that motivates them to be curious, and to look at the data little bit more openly hopefully (Natasha, 2/24/13).

Natasha believed that personal meaning making through discussion was pivotal in how her students were able to learn the material.

> I think that interaction stuff is really pivotal. You have to have some of the discussion. You have to have some of the practice, in my mind anyway. Maybe not all kids, but the majority of the kids, because some of them are written, some of them are visual, some of them are orally, we kind of need to tie all that together, I think. But when they actually can somehow connect to the material, to me that's, you know, that's- that's when the learning is actually solidifying. (Natasha, 2/24/13)

Unlike the other three teachers, Natasha did not refer to hands-on experiences when asked directly, “how do students best learn science?” However, other statements she made during the interviews indicated that she did believe this. Natasha expressed that the provision of hands-on lab experiences for her students was critical when confronting their possible misconceptions about science. Through these explorations, the students had opportunities to use data to build their understanding.

> Especially with something that they've already attached an emotional, either yes or no to, with classification and evolution, they have to actually interact with the information in some sort of way intellectually, physically, whatever…. so that

> they can actually learn something from that material to replace, or to enhance, what they already think they know about it…. So when they're doing a lab and they're saying "oh, look over time, I've got on the white background, I do have more white organisms that live, even though there are some that aren't white, wow that surprises me they live. Well what does that mean?" You know, the population can change over time. And you, if they see that, even though you told them about it, but if they see that, and then you talk to them about it afterwards, they've actually looked at it and interacted with it caused this to happen, then they're more likely to say "oh yeah, populations change over time." (Natasha, 2/24/13)

Her belief that students best learn science through hands-on activities was evident throughout Natasha's think aloud planning record. Every day, she included some kind of hands-on activity for her students to complete. On day two of her think aloud planning record, Natasha included a simulation for the students to complete called "Hunting the Pom-Poms Nest." In this simulation, students went through rounds of eliminating either black or white pom-poms on field of black and white. The simulation was intended to demonstrate for students how certain adaptations enable species to increase their likelihood of survival. Experiences like these allowed students to "engage" with the material. Natasha felt "engagement" was critical to building student understanding of the content.

As I was listening to Natasha talk, it occurred to me that many different teachers might interpret the phrase "engage with the material" differently, so I asked the Natasha to elaborate on her understanding of the word engage.

> When I was in school the thing was constructivism. And you hear less of that now, but it's where kids construct their own meaning out of the information that they encounter. And kind of get rid of some of their pre-existing mis-thoughts. I don't know, that's almost a little fluffier that I mean, but in general, if the kids don't, especially with something that they've already attached an emotional, either yes or no to, with classification and evolution, they have to actually interact with the information in some sort of way intellectually, physically, whatever. So that they can actually learn something from that material to replace, or to enhance, what they already think they know about it… And I think that might be a more easy way for them to kind of learn that material. With the cladograms that they're actually constructing a simple one, and we're talking through it as they do it, where they're putting those little things- the traits on there, they're like "oh everything above this line has this trait, everything below this line doesn't." So we're putting them in order based on these traits. Oh I see, that's what she's talking about. Rather than, I mean the notes give you an introduction, the worksheet gives you practice afterwards, but it's in class where we're together working through this paper. Oh maybe this does, maybe I get this now. (Natasha, 2/24/13)

Natasha expressed that in order for her students truly build knowledge around the concept, the teacher must facilitate a discussion in order to directly address student misconceptions. She used the hands-on experiences in her classroom as evidence to confront their prior beliefs. Here again, class discourse took center stage for Natasha as she provided personal meaning making opportunities for her students.

When I asked Natasha what aspects of her unit she felt most aligned with her beliefs about how students learn she stated,

> I think the discussions, seeing pictures, um, the interacting with the material, I think that is how they learn. I mean I know I have practice sheets in there to help them learn, but ultimately what makes that stuff stick, I think is how they engage with material. And that those practice sheets just kind of reinforce, they're not the actual glue. (Natasha, 2/24/13)

In the above example, Natasha reemphasized the importance of discussion as students learn science, but she expressed mixed feelings about the value of the practice sheets. Practice sheets have a role in student learning, but just as reinforcement for previous instruction. The "glue" Natasha referred to consisted of a blend of experience and facilitated discussion.

Finally, Natasha revealed a belief about the need for her students to acquire information related to the content. Her use of PowerPoints and notes with every day's activity reflected this belief. She particularly enjoyed using lots of visuals in each presentation.

> I tend to maybe give some notes on those. Like I use PowerPoints, typically I don't like to have PowerPoints, but the world seems to like them. I like the pictures, and I like the animations, because you can click on these animations and show them the little (indiscernible) molecules moving and all that. (Natasha, 10/11/2012)

But Natasha felt conflicted about this instructional choice. When asked what aspects of her unit did not align with her beliefs about how students best learn science, Natasha replied, "I do tend to get too note heavy, probably…to try to- to make up for the lack of time" (Natasha, 2/24/13).

Overall, Natasha possessed many beliefs about how students best learn science that were evident in her unit plans for science instruction. Natasha's belief that discourse is important to student understanding of science was most influential as she planned for science instruction. She also frequently included a variety of instructional approaches, including hands-on activities, and opportunities for personal meaning making in her lessons. During planning, her beliefs intertwined as she attempted to create a singular learning experience for her students.

Summary. The four participating teachers in this study all demonstrated a general alignment between their beliefs about how students best learn science and the activities they planned to teach. Certain beliefs proved more influential to the planning process than others. All of the participating teachers regularly utilized small and whole group discussion as part of their lessons demonstrating a belief that students best learn through discourse. Facts were disseminated daily through PowerPoint presentations or during whole group discussion. This demonstrated a belief that students best learn science by building their factual knowledge base. Hands-on activities were expressed as important, and also used, by all four teachers during science instruction. However, the elementary teachers planned a larger chunk of time for participation in discourse and fact/knowledge base building activities rather than hands-on activities.

Each teacher's beliefs about how students best learn science tended to intertwine during the planning process. This means that the teachers tended to incorporate more than one of their beliefs about learning into their plans at a time. Each lesson within a unit could include elements of discourse, hands-on activities, and personal meaning making at one time.

Ultimately, ten total categories emerged during my analysis of the data and are listed in table 4.1.

Table 4.1: Beliefs about how students best learn science

Elementary and Secondary Teacher Beliefs about How Students Best Learn Science				
	Trish	**Janet**	**Sally**	**Natasha**
Through hands-on activities	X	X	X	X
Through class discussion (whole class or small group /pairs)	X	X	X	X
By acquiring the necessary facts/skills or by building the student's knowledge base	X	X	X	X
By establishing relevance to everyday life	X		X	X
By provoking curiosity for the subject matter	X	X		X
Through repeated and varied exposures to the content/skill			X	X
By integrating science instruction with other subjects	X	X		
Through personal meaning making	X			X
By drawing to reinforce understanding	X	X		
By giving individual students assigned jobs or responsibilities		X		

Research Question #2 - To What Extent Do Beliefs About Qualities That Excellent Science Teachers Should Possess Influence Teachers As They Plan?

In this section, I begin by describing the methods I used to elicit belief statements from the participants regarding qualities science teachers should possess. Then, I briefly describe the commonly held beliefs among the four teachers. Finally, I attempt to describe the extent to which these beliefs influenced their planning for science instruction using data from the interviews and think aloud planning records as evidence.

Beliefs about what qualities science teachers should possess. In this section, I describe the beliefs that these teachers held about the qualities that excellent science teachers should possess. I begin by discussing how I determined these beliefs and explain my struggle with the viability of these methods. I include a general initial list of qualities deemed as valuable by these teachers. A detailed, individualized description is reserved for the next section, where I will attempt to discuss how their beliefs influence their planning process.

In the initial interview, the teachers were asked directly "what important qualities do you think a science teacher should possess?" Their responses were varied. The belief that a science teacher should possess personal curiosity was the most popular response, followed by a need for a teacher to possess well-developed content knowledge. Other answers included that excellent science teachers should be patient, flexible, resourceful, and humble, and that they should possess the ability to connect content to everyday life for the students or make it relevant to their lives.

Additional questions from the first interview helped to reveal other beliefs about important qualities that science teachers should have. These beliefs included that science teachers should have the ability to build a strong rapport with their students and that they should possess well-developed knowledge of the students as individuals. In addition, these teachers reported the need for excellent science teachers to have a repertoire of a variety of instructional strategies in order to meet the needs of their students.

In all, during the first interviews, eighteen total themes emerged as qualities that excellent science teachers should possess. I have listed these initial themes below in no particular order.

Excellent science teachers should.....

1. Possess personal curiosity
2. Possess the ability to build a strong rapport with students
3. Possess well-developed content knowledge
4. Be passionate
5. Possess well-developed knowledge of the students as individuals
6. Be creative / Have great ideas
7. Possess well-developed knowledge of a variety of pedagogical strategies
8. Be resourceful
9. Possess the ability to tell a story well
10. Possess the ability to connect content to everyday life (make it relevant)
11. Possess the ability to engage in a meaningful discourse
12. Possess the ability to provoke curiosity in students
13. Be flexible
14. Be reflective
15. Be humble
16. Be patient
17. Use humor in their instruction
18. Be organized

Each participant contributed just a few qualities to the above list, but when compiled together I was surprised at both the diversity and quality of the list. I wondered how the teachers would respond if presented with this list directly.

For the second interview, I provided my participants with cards that listed each quality separately. I asked them to arrange the cards from left to right in order of importance. Meaning, qualities that were more valued were placed on the left, and less valued qualities were placed on the right.

During this task, I was surprised to find that some of the initial qualities teachers identified as important were ordered in this list to be least valuable. Furthermore, qualities that went unmentioned in the first interview became most important during the card sort. I questioned whether or not beliefs about qualities science teachers should possess were as stable as beliefs about how students learn.

I decided to look deeper into their statements and just examine those qualities consistently stated as valued by each teacher throughout the study. For example, Janet made a belief statement about flexibility being an important quality of science teachers during the initial interview. In the final interview, she identified it as the number one most important quality of good teachers. Therefore, flexibility was included on her final list.

No one theme emerged as consistently valued among all four participants. The need to possess well-developed content knowledge was shared among three, and the need to be personally curious was shared among two. In the next section, I will attempt to address how these beliefs may or may not have influenced their planning for science instruction.

The influence of beliefs about qualities that science teachers should possess in planning for science instruction. Now that I have explained how I arrived at the beliefs these teachers possessed about qualities that excellent science teachers should possess, I can now continue with an exploration how these beliefs may or may not influence their planning for science instruction. In this section, I first address the individual participant beliefs and planning, and then briefly summarize my concerns regarding this response.

Trish. Overall, three beliefs about the qualities that excellent science teachers should possess were consistently expressed as important by Trish through multiple data sources. Trish believed that excellent science teachers should:

1. Be passionate
2. Possess well-developed content knowledge
3. Possess well-developed knowledge of a variety of pedagogical strategies

Throughout the interviews, Trish repeatedly expressed valuing passion as an important quality of teachers. In the first interview, she described a science teacher from her childhood and the passion with which she taught.

> If you're passionate you're going to inspire students. You know, if you're burning about something sometimes people will just, if you're on fire people just come to watch you burn, that's what my dad always said. (Trish, 2/21/13)

Revisiting the theme of passion for teaching, later in the interview she stated, "I think a job as an educator is to be able to make things look interesting, for you to be excited about things to get other people excited about things" (Trish, 2/21/13).

Trish expressed that through her structuring of the unit itself, and her choice of activities to engage the students, that she demonstrated her knowledge of the students as individuals, a variety of instructional strategies, and creativity. In example, when asked how her unit of instruction reflected these beliefs about qualities that excellent science teachers should possess, Trish stated,

> Having content knowledge, giving that hook, providing that curiosity for my students and being passionate myself, I think that that played out in the items that I chose. Because I, it needed to be cute, but needed to strike their interest, needed have lots of pictures, I needed to have an equal representation of books and visual aids. So I think all of that played into it. So as I'm looking at the left side, I'm seeing my own personal planning and setting up the things, and creating the

> activities, er choosing activities that I chose, or going out and creating or searching the things I found that I was lacking or that I wanted. (Trish, 2/21/13)

Initially, Trish talked about the importance of teachers being patient and flexible. These qualities she felt were especially important in kindergarten classrooms because her students needed lots of opportunities to share personal stories and make mistakes. However, during the card sort activity completed in the second interview, Trish was presented with other qualities that excellent science teachers could possess. Initially, Trish identified patience and flexibility as valuable qualities in excellent science teachers. During the final interview, patience and flexibility were passed over in favor of qualities such as personal curiosity and well-developed knowledge of the students as individuals.

> Most important, I said personal curiosity and a well-developed knowledge of students. Because I feel like those two things, if you have those two things, everything else will fall into place, I'm a minimalist. I feel like if you've got a strong, wonder basis, things will fall in line (Trish 2/21/13).

Just behind that in importance was her belief that excellent science teachers should be creative, passionate, and have good ideas. She also expressed a belief that science teachers should have a well-developed knowledge of a variety of pedagogical strategies, have a well-developed content knowledge, and have the ability to provoke curiosity in students.

> The next most important, I think being creative and having good ideas, being able to have well developed instructional strategies, content knowledge, the ability to provoke curiosity, and being passionate, I feel like all, I think all of those things literally are the same thing altogether. I think they are all super important, under the… Because I think personal curiosity that’s just in yourself, and you’re

> developing your knowledge of students, like that's about you, that's your initiating quality, and if you're a good teacher you're going to have all of the other things I just said, being creative, well-developed knowledge of instructional strategies- depending on what age level you're going to teach-, your content knowledge, being able to inspire students if you're passionate you're going to inspire students. You know, if you're burning about something sometimes people will just, if you're on fire people just come to watch you burn, that's what my dad always said (Trish, 2/21/13).

While primarily Trish's activities centered around reading and writing facts related to the nocturnal animals unit, discussion was an important aspect of each lesson. Through the use of discussion, Trish married her beliefs about how students best learn science and beliefs about qualities that science teachers should possess. I felt that it was unclear what role beliefs such as well-developed content knowledge and passion for the subject matter beliefs played in Trish's planning process. One might assert that by generating her own questions at the onset of the unit, and then looking for the answers throughout, that she was modeling these facets to het students. However, I would argue that this applies more directly to personal curiosity and resourcefulness.

In sum, Trish's beliefs about the qualities that excellent science teacher should possess are somewhat muddied and overlapping. While at one moment she might express certain belief, if presented with other belief options, she might express a different answer. I believe that it is difficult to conclude what role, if any, Trish's beliefs about qualities science teachers should possess played in her planning process.

Janet. In the initial interview, Janet identified several qualities that she deemed as important for science teachers to possess. The qualities included that excellent science teachers should possess:

1. Personal curiosity
2. Humility
3. Resourcefulness
4. Well-developed content knowledge
5. The ability provoke curiosity in students
6. Flexibility
7. Well developed knowledge of the students as individuals
8. Well-developed knowledge of a variety of pedagogical strategies

After the final interview, only two qualities emerged as most important, flexibility and the ability to engage in a meaningful discourse. Interestingly, the ability to engage in a meaningful discourse was not verbally expressed as valued by Janet during the initial interview. However discourse was an important aspect of her daily science instruction. Flexibility, which became her number one quality valued in excellent science teachers, was also mentioned during the first interview. Therefore, the only quality of excellent science teachers that Janet consistently expressed as valued throughout the study was flexibility.

I asked Janet about why flexibility was so important to her.

> Flexible I find important because once you do, if you are talking to them and you find out that they're coming from a different perspective than you thought, and if you want to get them to understand what you want them to understand, you're going to have to, you know sometimes I have to change in the middle of a lesson

> to meet that student's need, to get them to understand what I need them to know. So that's why I'll put that at the top. (Janet, 2/27/13)

For Janet, being flexible was necessary in order to respond to the immediate academic needs of her students. This needed to not only occur on a day-to-day basis, but also from year to year. Academically her students had diverse needs. She needed to be flexible enough to adjust her instruction in response to these needs.

Here, the quality of flexibility overlapped with Janet's second most valued quality after the card sort, the ability to engage in a meaningful discourse. The two qualities are found in tandem to create an optimal learning environment for her students. But for Janet the need to be flexible went beyond her interactions with students, and included interactions with administrative bodies.

When Janet was asked during the final interview what aspects of her unit she believed reflected her belief that excellent science teachers should be flexible, she stated,

> I had threw my unit, most of my unit out and put in something else, because we needed to address writing and you know integrate those two. Um, if I wasn't very flexible, I think I would have probably had a heart attack when they told me to do that. (Janet, 2/27/13)

For Janet, flexibility was important when it came to the way she responded to administrative pressures. She needed to be able to adapt, even throw out, her plans when administrative bodies suggested she do so.

In many ways, Janet's belief that science teachers should be flexible overrode the other beliefs she possessed about teaching and learning. By implementing another teacher's plans on two of the three days of instruction, she was unable to insert her own beliefs into the plans. For example, Janet stated during the first interview that it was important for teachers to possess a well-developed knowledge of a variety of instructional strategies, and specifically identified hands-on learning as being most valuable as students learn science. However, her new plans did not allow for that.

> I did say even before that I felt like more hands-on, where they're dealing with a real animal or things like that would have been good, and it would be good in any science lesson and mine didn't, especially that unit, didn't have much of that. (Janet, 2/27/13)

Janet's expressed belief that excellent science teachers should be flexible was evident in her planning for science instruction in two respects. First, she allowed opportunities for students to engage in conversations, and used their responses to adjust her instruction to meet their needs. Second, Janet demonstrated an ability to be flexible through her willingness to abandon her original plans in favor of implementing district suggested plans. However, this singular belief may have interfered with the actualization of other beliefs she possessed about qualities science teachers should possess and beliefs about how students best learn science.

Like Trish, Janet's possessed beliefs that overlapped. The changes in her expressed beliefs from the first interview to the final interview may have been strongly affected by the recent training conducted by the district. But Janet was also aware of when her beliefs lacked alignment with her plans, and this self-awareness may impact her future planning when administrative constraints are limited.

> I think they should get the desire to know more about how things work, and how the world works, and to think... Well, and this is where mine lacked, but to know they could go out and try things out, they could do an experiment, they could

> figure out for themselves what is going on with a, well, with animals it's a little different, but in science in general. You know, if they're curious about how something works, I want them to have the desire and the knowledge to know that they could go and try to figure it out. (Janet, 2/27/13)

In this exchange, Janet acknowledges that although she values the ability for excellent science teachers to provoke curiosity in students, she did not feel that it was evident in her plans. Perhaps through this process, Janet may begin to acknowledge her beliefs and intentionally make an effort incorporate these beliefs into her future plans.

Sally. Sally was by far the most consistent regarding her expressed beliefs about qualities science teachers should possess throughout the study. When she was asked in the initial interview to describe what qualities she valued in excellent science teachers, Sally replied,

> They need to have a natural curiosity. I think they need to be comfortable with lab work, instructing students as far as lab is concerned, and I think all of us are comfortable enough in the lab that we can walk in and pick up and go. Content knowledge I think is key (Sally, 10/16/2012).

This response, that science teachers should be personally curious and possess a well-developed content knowledge, was repeated in her second interview during the card sort response. Sally identified the ability to build a strong rapport with students as valuable during the first interview. This quality also was highly valued by Sally during the card sort task.

During the second interview, Sally acknowledged several other qualities as being equally valuable to these initial three. These included that excellent science teachers should: be passionate, possess well-developed knowledge of the students as individuals, possess the ability to connect content everyday life for students (make it relevant), and possess the ability to provoke curiosity in students. However, three emerged as repeatedly valued by Sally throughout the study. These three were that excellent science teachers should possess:

1. Personal curiosity
2. Well-developed content knowledge
3. Possess the ability to build a strong rapport with students

When I asked Sally to expand on those qualities she most valued, she stated,

> I think if the teacher doesn't generate that curiosity in themselves, then the students aren't going to be curious to expand their knowledge in an area…If you don't have a rapport with your students, then nothing you say is going to matter. (Sally, 2/20/13)

It's difficult to attempt to examine how Sally's beliefs about possessing personal curiosity and the need to build rapport with her students have factored into her lesson planning for science. I found no specific evidence to indicate how these two beliefs factored into her planning. However, this does not mean that these two beliefs did not factor into planning, just that the evidence I collected was limited in its ability to describe the influence of these two beliefs.

Sally did explain what she believed about how her lesson plans reflected her beliefs of other important qualities such as the need for excellent science teachers to be passionate and to know the students as individuals.

> I think one of the things I had as most important is a well-developed knowledge of students as individuals, and I mean you have to know how they learn best. I try to incorporate different methods in every lesson. And then I think it's important to be passionate about what you teach. Because that passion that you have for

your subject matter, generates interest on the students' part. And if the teacher approaches the subject as boring, then that's what the student is going to get out of it (Sally, 2/20/13).

As with Trish and Janet, Sally's beliefs about teaching and learning appear to be connected. In the above, Sally connects knowledge of her students as individuals with varying her instructional methods. She also connects passion for her subject with provoking curiosity among her students, making the content relevant to real-life, and the importance of varying her instructional methods.

In her think aloud planning record, Sally describes using PowerPoints to disseminate important content to students. This instructional choice may relate to her belief that science teachers should possess a well-developed content knowledge and her view that her primary role is that of deliverer of content. Through PowerPoint lectures, Sally is able to communicate necessary information to her students.

Natasha. Natasha possessed a variety of beliefs regarding qualities that excellent science teachers should possess. In the first interview, Natasha expressed over half of the eighteen belief themes presented earlier. Natasha valued:

1. Personal curiosity
2. Humility
3. The ability to connect content to everyday life
4. The ability to build a strong rapport with students
5. The use of humor in instruction
6. Organization
7. The ability to engage in a meaningful discourse

8. Well-developed content knowledge
9. The ability to provoke curiosity in students
10. Well-developed knowledge of the students as individuals.

During the card sort, Natasha struggled. At one point she stated, "This is a terrible activity!" Later on she said, "I don't like this activity, I quit!" Natasha struggled because she believed that all of the qualities were important and she had difficult ranking some qualities over others. In fact, although the task was intended to be open-ended, and the teachers were told that any product was correct, Natasha worried that she would ruin my dissertation if she placed half of the qualities in one column. Nevertheless, two qualities emerged repeatedly as valued by Natasha over both interviews:

1. Personal curiosity
2. Well-developed content knowledge

Natasha's numerous and varied beliefs were evident and intertwining throughout her unit plans. For instance, Natasha planned a variety of activities during each period including whole class discussions, hands-on activities that ranged in complexity, opportunities to discuss in small groups, and more passive activities such as taking notes during lectures. Her use of facilitated whole class discussion reflected her belief that excellent science teachers should be able to engage in a meaningful discourse with their students. During these discussions, Natasha also attempted to connect content to everyday life and provoke curiosity in her students about the subject matter through her injection of humor and her use of stories. This variety in activities reflects Natasha's belief that teachers should have well-developed knowledge of a variety of instructional strategies.

Her use of lectures and PowerPoints demonstrated her belief that excellent science teachers should possess a well-developed content knowledge. At those points in her lesson, she disseminated expert knowledge to her students, but enjoyed using humor and stories to do so. She used hands-on experiences as opportunities to engage students in discourse with other students and as a way to provoke curiosity about the subject matter.

To emphasize Natasha's view that these qualities were interconnected, I have provided an excerpt from the final interview,

> For my fourth layer, I have they should be able to tell stories, use humor, possess-connect content to everyday life and engage in a meaningful discourse. Because these things are important. But without the caring, and without the knowledge, you're discoursing in meaningful discourse about nothing. And I don't think you can do one without the other" (Natasha, 2/24/13).

Furthermore, when asked what aspects of her unit she believed aligned with her top two beliefs after the card sort, personal curiosity and passion, Natasha discussed her use of discussion and provoking curiosity among her students about the tentative nature of science. She followed up with a statement relating to the need to reflect and change constantly over her units.

Natasha's belief about excellent science teachers needing to have the ability to engage in a meaning discourse dominated her planning for science instruction. The majority of activities she planned involved discussion as a whole class or in partners. But other beliefs about qualities that science teachers should possess were embedded in these activities as well.

Summary. These teachers had many varied beliefs about qualities that excellent science teachers should possess. Some of these included that excellent science teachers should be personally curious, have a well-developed content knowledge, have the ability to build a strong rapport with students, and have a well-developed knowledge of a variety of pedagogical strategies. They also believed that excellent science teachers should be flexible and passionate. Their beliefs related to both practice and personality traits. The participants did not see these qualities as being distinct to science teachers, but rather qualities that all teachers should possess. Some teachers' beliefs appeared to be influenced by current events, while others appeared more stable. The evolving nature of these beliefs, coupled with the complexity of measuring impact of beliefs about personality traits on physical plans, made it difficult to comfortably determine what influence these beliefs had on planning for science instruction.

In Table 4.2, I provide a chart that summarizes the beliefs about qualities science teachers should possess during this study. X's represent a quality that was expressed by the participant as important during both the first and second interview.

Table 4.2: Qualities that excellent science teachers should possess

Elementary and Secondary Teacher Beliefs about Qualities Excellent Science Should Possess				
	Trish	**Janet**	**Sally**	**Natasha**
Well-developed content knowledge	X		X	X
Personal curiosity			X	X
Possess the ability to build a strong rapport with students			X	
Flexibility		X		
Be passionate	X			
Possess well-developed knowledge of a variety of pedagogical strategies	X			

Research Question #3 - To What Extent Do Local, State, and National Standards Influence Teachers As They Plan?

In this section, I answer my third research question, “To what extent do local, state, and national standards influence teachers as they plan?” To begin the answer for this question, I explore the importance these teachers placed on local, state, and national standards as part of their planning. Then, I discuss the role high-stakes testing plays in the planning process of teachers. Next, I explain how teachers sometimes extend their instruction beyond the standards. Finally, I examine an underlying assumption made by these teachers regarding the relationship between local, state, and national standards.

The role of standards in planning process. Among these participants, local and state standards appear to have the greatest influence on the planning process, followed by concerns for Common Core (national) standards in reading. This was evident in both the expressed intent of these teachers as they plan and their implementation of standards during the planning process. The Kindergarten teachers and the high school teachers had used two different methods to determine whether they would focus on local, state or national standards during planning. For the high school teachers, standards were selected by considering which test their students would take to assess mastery of the standards. This phenomenon will be discussed fully later in this section. The Kindergarten teachers selected to use the standards they were required to teach by the district and their administrator.

Throughout the interviews, and through my examination of their think aloud planning records and related plans, all four participants demonstrated referencing either local or state science standards as part of their planning process. For this study, local standards are defined as the science content standards developed and published by the district. National standards of science were not consulted during unit planning. Although the *National Science Education Standards* were not used by Kindergarten teachers in this study, a different set of national standards did emerge as important to these teachers as they planned: Common Core standards.

When Janet planned, it was not national standards of science that influenced her decision making, but rather national standards of reading, writing and math. In the following exchange, Janet stalks about the recent "push" by the county to incorporate Common Core standards in science instruction.

> We've been um, we've been strongly encouraged to integrate it into writing so that we have more time in the day for writing and um, then they get. And so they, right now they're supposed to be focusing on nonfiction writing... It's one of the first things that they learn, and it's one of the big ones that they push for kindergarten right now with common core and with the TEAM evaluations. Categorization is one of the big ones. And they discussed with us at the beginning of the year that. (Janet, 2/27/13)

As the teachers in this study planned for science instruction, consulting the standards was frequently the first step in the planning process. Janet began her planning for her unit on animals by stating, “So the first thing I’m going to do is look at the science standards.” When asked during the second interview to expand on her planning process, Janet stated,

> I start usually with the standards of this is what I need to cover, and then if I know, okay last year I did it this way I’ll go get the folder out and see, you know, what do I have from last year and then I’ll either decide to do that, or I’ll modify it or adapt it. (Janet, 2/27/13)

Natasha spent several minutes of her first TAPR going over the state standards strand by strand to make sure she was choosing the correct standards to address in her unit, and to see if any of the ones that had previously been taught warranted revisiting.

The fact that none of the participating teachers in this study utilized the *National Science Education Standards* during planning was primarily due to three factors. One, half of the participating teachers were unaware that national standards existed for science. Two, an assumption was made by these teachers that local, state and national standards were in fact aligned. Three, the teachers did not feel responsible for teaching *National Science Education Standards*. In Janet's final meeting she expressed that no one at the district had ever promoted using the *NSES*, so it must not be important to use during planning. In my final meeting with the high school teachers, they also expressed that their limited time to teach local and state standards, coupled with the fact that they would be evaluated based on local and state standards only, impacted their decision to disregard the NSES during planning.

> So much paper is thrown at us everyday, I would never go to bed if I read all of it, so I prioritize it. National Standards, since no one from the county has ever stressed it as important, I haven't listed it as a priority. (Janet, 2/27/13)

Another teacher explained that NSES standards were not assessed, so they did not need to be considered. This phenomenon will be explored more fully in the next section.

When I asked Janet directly if she had ever looked at the *National Science Education Standards*, Janet's demonstrated that her knowledge of trends in national curriculum was limited to simply Common Core standards.

> I have not. I would, I kind of wish that we would go to common core science like we have math and reading. But I have not gone to the try to look them up. And

> they are not, when I go to the reading and math common core that's all that's on there, so I don't know if they just don't have them? or? (Janet, 2/27/13)

Through this statement, Janet demonstrates a lack of awareness concerning recent trends in science education, particularly those recent efforts to overhaul the *National Science Education Standards* (1996) into the recently released as the *Next Generation Science Standards.*

Like Janet, the *National Science Education Standards* played no role in Trish's planning for science instruction. When Trish was asked directly whether or not the *National Science Education Standards* ever played a role in her planning, she simply answered, "no." But again Common Core standards played a significant part in Trish planning process for science, "We have to fit so much in- in a day, if I can fit that in the way. And with the common core wanting it to be 60% nonfiction, I mean that's definitely something that I think about" (Trish, 2/21/13).

It should be noted that although her planning for science was influenced by these new requirements in reading and math, Trish did not necessarily agree with the way it impacted her science instruction. She expressed a frustration with the lack of priority the district placed on science instruction and the increasing emphasis on core subjects like reading and math,

> The other part of the issue down here is that, reading and math take such a priority that if you don't, literally they say if you don't get to science and social studies that's okay. And kids who have to get pulled four or five times a day, they can be pulled during that time, because it's not part of the core standards, or the core curriculum. They still want you to teach science, they never say don't teach science. But it's just like if you get to, then that's the icing on the cake. (Trish, 10/11/12)

While the two Kindergarten teachers had never looked at, or even heard of the *National Science Education Standards*, the two high school teachers were aware of them. But simple awareness did not equal inclusion. Instead, they expressed a belief that their local science standards were aligned to both state and national standards, and therefore there was no need to refer to them. Some also asserted that the local standards were even more rigorous than the state standards. As such, they did not examine the standards for themselves, and simply assumed alignment.

> Klingston City has taken the state standards, and expanded what is in the state standards to give students a more in-depth study in the subject matter. Our students here are getting a lot more information than students might be getting in other rural school systems. (Sally, 2/20/13)

In my brief examination of the standards, I did note that in the case of these participants, the Klingston City schools science standards were, in fact, in almost direct alignment with state science standards. Meaning, the science standards published by the district were almost a verbatim replication of the science standards that exist at the state level.

However, claims of alignment went beyond local and state level. Some of the teachers asserted that a direct relationship existed between local, state and national science standards.

> Okay, for biology, we have a state end of course test. And so we're very heavily focused on the state objectives for biology. There are county objectives which.... in high school we're, I mean it seems like you're always going to curriculum revisions and all this kind of stuff if you want to be in that mix. And so when you go to those meetings you know how the state curriculum aligns with the county curriculum. And in Klingston City it's, we're very aligned to it. And in fact

> there's additional things as well. And then that ties to the national curriculum, we're probably not as aware sometimes all the national curriculum objective by objective, but you better believe that our countywide and our statewide, some people only focus on state, but I focus on both. (Natasha, 10/11/12)

Upon hearing such claims, I decided to inquire further with the Klingston City science supervisor, in order to clarify the relationship that exists between Klingston City local science standards, state standards, and the National Science Education Standards. In email correspondence, I asked the supervisor who was responsible for the development of the Klingston City Standards and received this reply,

> Teachers developed the Klingston City Standards based from the State Standards. The state standards were created based on the National Science Standards. Therefore the state determined from the national standards what to teach in each grade level for the state. We use the state standards directly, and then make some additional enhancements to increase rigor for our district. (Science supervisor, 2/15/13)

In this reply, the science supervisor, like the participants, expressed a direct relationship between local, state, and national science education standards. My study does not seek to examine whether or not the *National Science Education Standards* are aligned with, or accurately reflected within, the Klingston City schools local standards. However, upon initial glance, questions might be raised as to how much of the original intent of the *NSES* remains after the state interpreted the standards for their own use.

For example, the *National Science Education Standards* does not suggest that K-4 teachers deliberately delineate between living versus non living things. This stands in contrast to the Klingston City and state Kindergarten standard, "Recognize that some things are living and some are not." In the *NSES*, this ability to distinguish between living and nonliving things is left to emerge organically through a child's first-hand experiences.

> Children's ideas about the characteristics of organisms develop from basic concepts of living and nonliving. Piaget noted, for instance, that young children give anthropomorphic explanations to organisms. In lower elementary grades, many children associate "life" with any objects that are active in any way. This view of life develops into one in which movement becomes the defining characteristic. Eventually children incorporate other concepts, such as eating, breathing, and reproducing to define life. As students have a variety of experiences with organisms, and subsequently develop a knowledge base in the life sciences, their anthropomorphic attributions should decline (NSES, 1996, p. 128)

I have raised this issue of the assumed alignment of standards made on the part of the participants during the planning process in order to make a point. By assuming that the local, state and national science standards are aligned, these teachers may believe that national standards are directly influencing their planning for science, when that may or may not actually be the case.

To role of high-stakes testing in standards selection. In deciding which set of standards to consult, the high school teachers primarily considered what test would be used to assess student mastery of the standards. If the students were taking a science test that was written by the state, the teachers would consult the state standards during planning. If the students were held accountable to standards mastery on a county developed assessment, the teachers would consult the science standards provided by the county.

To be clear, any test that the high school teachers referred to during either interviews, or the TAPRs, is considered to be a high-stakes assessment. At no point did the teachers make reference to daily or weekly assessments that they themselves had written. High-stakes tests are traditionally administered to students only once a year, and generally towards the end of the school year. Should their students fail to perform well on these tests, it would affect not only their ability to be promoted, but it also could potentially impact the teacher's overall performance evaluation. At the high school level, 25% of the student's final grade was made up of their score on the end of course exam. Needless to say, student performance on these tests weighed heavily in the minds of these teachers as they planned.

Sally clearly expressed that what her students will be responsible for on the county developed end-of-course exam guided her instructional decisions. "I gauge mainly what I'm planning by Klingston City, because at the end of the term it's the Klingston City EOC that my students are going to be taking" (Sally, 2/20/13). For this reason, Sally selected to use Klingston City standards as she planned for science instruction. From her involvement with curriculum development at the county level, Sally was familiar with the expectations her students will be asked to meet on this test.

> I use primarily the Klingston City standards, I mean that's, because that's what our kids are going to be tested on and their questions... Because I've been involved in writing that county EOC, there are questions that hit each CLE (Course Level Expectation) on the exam. So that's what I'm going go by because that's what's on the test. Even though we are not to teach to the test, but the information is there in this CLE. (Sally, 2/20/13)

When planning for upcoming instruction, Sally adjusted the time spent on a given topic based on the weight those topics were given on the end of course exam. Topics that were more heavily weighted garnered more instructional time than other topics.

> The bigger topics that are more heavily weighted on the end of course exam, we're going to most of us are going to spend at least seven or eight days with that material. (Sally, 10/11/12)

But county tests were not the only tests that Sally was concerned with. During the second interview, when asked about what she hoped her students would gain from the unit on percentage composition of a whole she stated,

> Those are some of the types of questions that they're going to see on, let's say in an ACT or an SAT... they have to be able to read a table, pull information from a table, or look at a graph, and be able to pull information from that graph, and answer questions about it. (Sally, 2/20/13)

This issue of accountability, driven by the relationship between standardized tests and local/state standards was a reoccurring notion among the high school teachers. Natasha explained this in her think aloud planning record,

> What role do standards play in my science instruction? Huge. I teach my standards. And then I build my lessons around the standards. Whether it's county standards in marine ecology, or state standards in biology with County standards taken into consideration and added in. National standards are there, but they're not as pressing, because they are taken into account for the state standards, so I focus on the testing in biology. And in Marine, I focus on the standards, because that's what I'm supposed to teach. And I do the best I can to teach the standards.

> A few I don't hit upon as much, because I don't feel they're as important, but I do teach my standards, because that's what I've been hired to do. (Natasha, 12/20/12)

On those occasions when Natasha looked at the *NSES*, it was driven by personal curiosity more than her desire to incorporate these standards into her plans. She asserted that since there was no *National Science Education Standards* test, the test that her students will actually take dictates the standards she should reference. I asked Natasha about the occasions she had looked over the NSES and what had prompted it,

> The curiosity. I mean, see, supposedly the state standards are aligned with the national standards. And so, so but, I mean you do, they're putting so much emphasis on test scores, that you have to focus on the area that your state is focusing on, unfortunately. Whereas it's not a national test. (Natasha, 2/24/13)

Unlike the high school teachers, the Kindergarten teachers were not required to administer a high-stakes assessment to their students until this last school year. Even still, that assessment did not measure science proficiency. In fact, the kindergarten report card merely requires a participation grade for science. In Klingston City Schools, the teachers are not required to demonstrate mastery of content at this early grade level.

I wondered, if the assessment did not drive the way these kindergarten teachers selected their standards, what did? In our final meeting, I asked Janet about this she stated that the state science standards were probably the “first thing I was shown” at the university. This may suggests that when high-stakes assessments are not driving standards selection, pre-service teacher education programs may potentially influence how teachers apply standards in their instruction.

Now that I have described the role of local, state and national standards in the planning process of these teachers, I will continue by describing how the teachers extended their instruction beyond the standards.

Extending instruction beyond the standards. Sometimes, the teachers viewed those standards as a baseline for instruction. To clarify, the teachers construed standards as the minimum that students should learn, but believed that there were also other important concepts or connections that could and should be included in their science instruction. In those cases, the teachers felt comfortable to extend their lessons include elements that they personally believed were important to teach.

For example, in Trish's nocturnal animals unit, she indicated that her lesson was based on those science standards provided by the school district. But she described the state science standards for Kindergarten as being "slim," and chose to extend her lessons to include other information that she valued which related to that standard. Trish believed that the standards lacked substance, meaning the content within the standards remained disconnected to the real world and disregarded the importance of problem solving.

> When I taught fourth and second grade, it was always important to go deeper, problem solving wise. Because in just the standards and curriculum, there's not a lot of problem solving, or even real world connections built in there, like you have to go and search them out find them and apply them. (Trish, 10/11/2012)

Natasha also talked about wanting to go beyond simple teaching of the standards and to relate the concepts to certain issues that she believed were important, current and relevant to her students' lives. Through these connections, she believed that teaching the standards would become "more interesting" and "more worthwhile."

Natasha: The kids bring in stories, and you know you go to the doctor's office and you come back, and you get these stories and you're like wow, how does this relate to your life? And so I don't forget to do that, because if it's just "well you need to learn the parts of the cell," without any incorporation of why.... or here's some cool things about the cell that aren't in the standards, but they directly, indirectly relate to the standards, if you don't do that, then it is really boring but...

Horton: So you like to look at the standards as sort of like a jumping off point and then connect it to the students' everyday life? Or to like a real-life scenario in some way?

Natasha: Yeah, I mean yeah, yeah. And I like to teach them how like all miraculous this stuff is. I'm like, wow. You know, photosynthesis, I mean to me that's not my gig. I'm not lovely about the photosynthesis, but if they can learn it, a) they're amazing, and b) they can learn, wow this is how some real scientists work. This is how some real scientists study. This is how we take air and turn it into food that we eat, and how our body turns that back into air- you know, it's the carbon dioxide- you know. If you can kind of tie it to them, and they think oh I've never thought about it like that, then it makes those standards more interesting and more viable, and more, more worthwhile. (Natasha, 2/24/13)

Related findings affecting teacher planning for science instruction. Several themes repeatedly emerged as heavy influences on the planning process of these teachers that were unrelated to the original research questions.

Certain external factors were highly influential in each teacher's planning process. These external constraints included but were not limited to: instructional time allotted for teaching of science, the expectations placed on teachers by administration, and the availability of materials needed for the lesson. The teachers talked about selecting, modifying or discarding pre-developed lesson plans and/or activities due to lack of time, lack of access to materials, and the need to comply with administrative expectations.

In my final meeting with Janet, she expressed that lack of time and access to material had a larger influence on her planning process than her beliefs about how students learn. Moreover, she stated that she was often in a state of cognitive dissonance during these times. Janet believed that she sometimes needed to compromise her beliefs about how students best learn science when selecting lessons that reflected her concerns for time and materials.

In the next chapter, I will refer to these constraints as institutional restrictions because of the external nature of these factors and the inability of these participants to exert control over these factors.

Summary

The four participating teachers in this study expressed beliefs about how students learn science best. These beliefs about how students learn directly influenced instructional choices. Certain beliefs, such as the role of discourse in learning, emerged as more influential to the planning process than expressed beliefs about hands-on learning.

These teachers expressed several beliefs about the qualities that excellent science teachers should possess. These beliefs related to either pedagogy or personality traits. The participants did not see these qualities as being distinct to science teachers, but rather qualities that all teachers should possess. The evolving nature of these beliefs, coupled with the complexity of measuring impact of beliefs about personality traits on physical plans, made it difficult to comfortably determine what influence these beliefs had on planning for science instruction.

The influence of standards on the planning of these four teachers was significant. Local and state standards seemed to have the strongest impact their planning for science instruction followed by Common Core standards in reading, writing and math. The *National Science Education Standards* did not play a concrete role in the planning for science instruction of these teachers, although some teachers asserted that the local, state and national standards were aligned. Standards were consulted at the beginning of the planning process. Standards were viewed as the minimum of what should be taught and instruction would sometimes be supplemented to include additional content that the teachers found valuable.

Institutional constraints such as lack of time, lack of access to materials, and expectations of administration also impacted these teachers as they planned for science instruction. In the next section, I will explore how these findings may guide future policy makers and program developers as they prepare teachers to implement the *Next Generation Science Standards.*

Considering the stories I have presented of the influence of standards on the planning process of these teachers, I have constructed two diagrams to illustrate my understanding of their planning process. The first diagram is a simplified visual of the planning process, Figure 4.3. It begins by the teacher reflecting on issues of accountability with either testing or administrative requirements. Next, they choose local, state and/or national standards to reflect these concerns. Then, they revisit previously taught lessons and ask themselves a group of questions related to time, materials, personal beliefs and test preparation. Finally, they decide whether or not to use, modify or abandon these previous lessons in favor of new lessons.

Planning Unit of Science Instruction

Reflect on questions of high-stakes or administrative requirements

↓

Choose standards to address: local, state or national

↓

Examine previously taught lessons

↓

Reflect on questions of time, materials, upcoming tests, and beliefs about learning

↓

Decide to use, revise or abandon previous lessons in search for new lessons

Figure 4.3: Basic diagram of planning process of science teachers

Figure 4.4 is a more detailed diagram of the planning process. I believe that as these teachers began to plan for science instruction, they may have answered two veiled questions that guided their decision-making, "Which high-stakes assessment will my students take?" and "Which set(s) of standards does administration expect me to consult?" The answers to these questions told the teachers which set of standards to consult.

Next, the teachers revisited previously collected lessons, notes and materials on the unit they intended to teach, and determined the appropriateness of those existing materials. Appropriateness was determined by multiple factors including time, beliefs about how students learn, materials availability, ability to prepare them for the assessment. If the lesson failed to meet any of these four factors, the teachers either attempted to modify the existing resource, or discarded it and searched for a replacement. This process was a cyclical movement, meaning the teacher continuously analyzed, decided, and took action until they were satisfied with their new pool of resources for instruction, and unit teaching could begin.

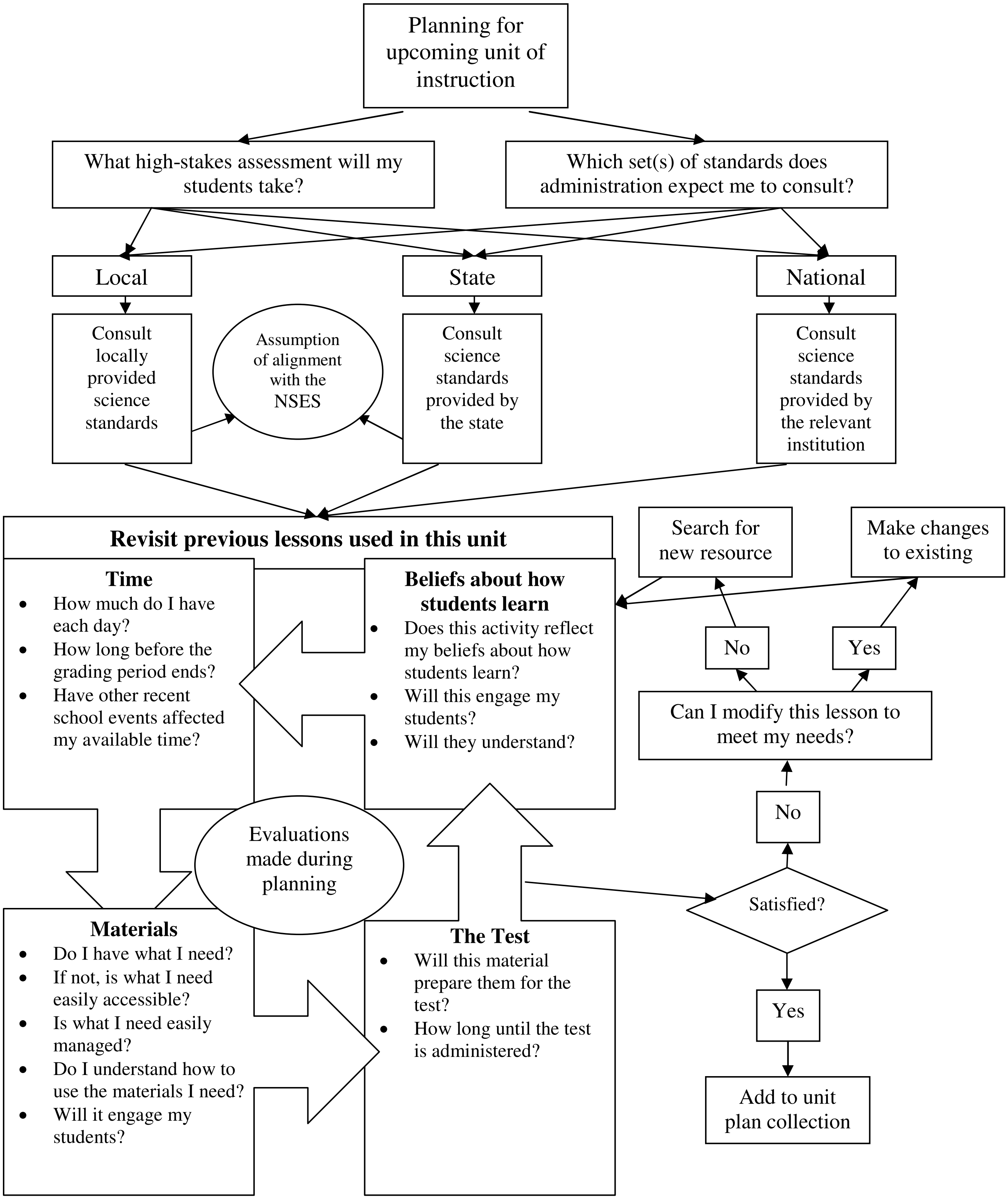

Figure 4.4: Expanded diagram of science teacher planning process

Now that I have summarized these findings, in the next chapter I explain how these findings may impact teacher education.

Chapter 5: Conclusions and Recommendations

This study was designed to examine how the beliefs teachers possess about science teaching and learning, and their curricular knowledge, influences planning for science instruction. The questions guiding this study were:

1. What influence do beliefs about how students best learn science have as teachers plan for science instruction?
2. What influence do beliefs about qualities that excellent science teachers should possess have as teachers plan for science instruction?
3. What influence do local, state, and national standards have as teachers plan for science instruction?

In Chapter 1, I introduced a current problem in science education and presented the need for this study. Chapter 2 included a summary of existing literature on teacher beliefs, science curricular knowledge, and teacher planning. I also provided the reader with additional information about documents of reform in science education. An outline of the methods I used to collect and analyze the data related to my research questions was included in Chapter 3. And finally, Chapter 4 included a presentation of my findings related to the research questions.

In Chapter 5, I present conclusions and recommendations I have drawn based on my findings. This chapter includes recommendations for education policy makers including the introduction and implementation of new curricula with teachers. In addition, recommendations for future professional development of in-service science teachers, and recommendations for teacher education programs are presented. This chapter concludes with a presentation of questions for future education research. I would like to remind the reader that this qualitative study involved only four teachers from one district, and the conclusions are not meant to generalize to all teachers.

Conclusions

Based on the data and the findings, I have come to several conclusions regarding the influence of these beliefs and standards as teachers plan for science instruction. These conclusions are:

1. The beliefs teachers have about the teaching and learning of science are complex, interconnected and constantly growing and changing.
2. Qualities valued in excellent science teachers are the same as qualities valued in good teachers in general.
3. The need to adhere to local, administrative expectations precedes, and sometimes supersedes, the application of personal beliefs regarding how students best learn science in the planning process.

These statements need some explanation. In the next five pages, I will elaborate on each of them individually.

1. The beliefs teachers have about the teaching and learning of science are complex, interconnected and constantly growing and changing. The teachers in this study expressed many beliefs regarding the teaching and learning of science. The responses these participating teachers initially provided when directly asked, "how do students best learn science?" seemed to be very politically correct. The teachers knew what the "right" answer was, and what they should say when asked a question of this nature. But their belief systems about how students learn went deeper than just their initial responses to a direct question. Through statements made and actions taken over the course of the study other beliefs were revealed. I believe that these beliefs were more often reflected in the instructional choices they made during unit planning. Furthermore, although expressed beliefs can provide a glimpse into a teacher's mind, sometimes beliefs may go unexpressed. Considering this, the study of beliefs is a complex matter.

For the teachers in this study, the beliefs they held about learning appeared interconnected upon examination of their unit plans. For example, beliefs about the learning of science, such as the need to use discourse and the need to provide opportunities for personal meaning making, were blended within individual lessons in order to create the optimal learning environment for students. The beliefs these teachers expressed about how students best learn science were consistently connected to their beliefs about teachers and the qualities they should possess. After comparing these two seemingly different lists side by side, I noted that themes such as provoking curiosity, using discourse, and relating content to everyday life were present in both (See Table 5.1). The beliefs these teachers possessed about teaching and learning appeared to be simply interconnected. This demonstrates the complex nature of beliefs and the need for researchers to use a variety of data sources when attempting to describe a teacher's beliefs.

Adding to the complexity of studying beliefs is the influence of recent events on beliefs about student learning. Some beliefs appeared fairly stable over the course of this study. However, others were affected by experiences that caused them to reprioritize their beliefs. We must be careful as researchers to not rely on hasty judgments based on superficial observations. Researchers need to examine a variety of belief statements made over an extended period of time in order to improve our accuracy in describing a teacher's beliefs.

In previous research, Tsai (2002) found that teachers' beliefs about teaching were closely aligned with their beliefs about learning. The results of my study concur with his finding. Tsai

Table 5.1: Comparison of Beliefs About Learning Science to Beliefs About Qualities Excellent Science Teachers Should Possess

Beliefs About How Students Best Learn Science	**Beliefs About Qualities That Excellent Science Teachers Should Possess**
Through hands-on activities	
Through class discussion (whole class or small group /pairs)	Possess the ability to engage in a meaningful discourse
By acquiring the necessary facts/skills or by building the student's knowledge base	Possess well-developed content knowledge
By establishing relevance to everyday life	Possess the ability to connect content to everyday life (make it relevant)
By provoking curiosity for the subject matter	Possess the ability to provoke curiosity in students
Through repeated and varied exposures to the content/skill	Possess well-developed knowledge of a variety of pedagogical strategies
By integrating science instruction with other subjects	
Through personal meaning making	
By drawing to reinforce understanding	
By giving individual students assigned jobs or responsibilities	
	Possess the ability to build a strong rapport with students
	Be passionate
	Possess well-developed knowledge of the students as individuals
	Be creative / Have great ideas
	Be resourceful
	Possess the ability to tell a story well
	Be flexible
	Be reflective
	Be humble
	Possess personal curiosity
	Be patient
	Use humor in their instruction
	Be organized

also suggested that a teacher's beliefs may be discipline specific. This did not appear to be the case in my study.

When Tsai suggests that teacher beliefs are discipline or content specific, he referred specific beliefs related to teaching science versus teaching other subjects such as reading and math. One difference between this study and Tsai's study is that elementary science teachers were included in my study. Tsai's study focused on only secondary teachers. Generally, high school science teachers tend to teach one subject: science. Elementary science teachers are typically different than secondary teachers in that they are generalists. Generalists teach multiple subjects, such as reading, math, science, and social studies. Therefore, I did not find it surprising that the teachers pulled strategies, skills and activities from other subject areas to enhance their students' learning of science. This suggests that beliefs among generalists teachers may vary from teachers of a single subject.

Bryan (2003) described one prospective elementary science teacher's beliefs about teaching and learning as complex and intertwining. In her study, the teacher was able to possess multiple, sometimes competing, beliefs about how students learn at one time. Bryan refers to these beliefs as dualistic. Dualistic beliefs can be described a beliefs about how students learn that stand in epistemological contrast to one another. For example, a constructivist teacher has a different view of learning different than a traditionalist teacher. The constructivist might assert that children learn best by connecting personally to the content, while the traditionalist believes students best learn through transmission of knowledge. But Bryan also says beliefs can intertwine and support each other much like the twigs in a bird's nest. 'Nested' epistemologies tend to be more common among experienced teachers, which was the case with this study as well (Tsai, 2002).

Like the teachers in Bryan's study, the teachers in my study possessed multiple beliefs about teaching and learning. The teachers in my study also possessed beliefs that were intertwining. Most times, the beliefs worked in concert, meaning lessons reflected many beliefs at one time. Some beliefs, such as the importance of discourse in instruction, were more regularly realized in the planning process than others.

Unlike Bryan, my study focused on veteran elementary and secondary science teachers, whose beliefs have solidified over may years of experience. Bryan saw her teacher's beliefs as competing. I would assert that the teachers in my study have found value in the use of multiple methods through years of experience. This ability to maintain and enact multiple views of learning may be reinforced by administration, other teachers, curriculum and prior experience as a student. These teachers may also have not had the opportunity to expose and confront their beliefs about learning. Considering the complex nature of beliefs, education reformers have quite the challenge ahead of them if they seek to change the practice of classroom teachers.

2. Qualities valued in excellent science teachers are the same as qualities valued in good teachers in general. Albert Einstein once said, "I have no special talent. I am only passionately curious." Like Einstein, passion and curiosity were important qualities valued by the teachers in this study. Interestingly, the teachers in this study did not distinguish between qualities that excellent *science* teachers should possess and qualities that simply all *teachers* should possess, regardless of discipline. In their minds, important qualities like the need for flexibility, passion for the subject matter, and personal curiosity were not specific to science teachers. One teacher suggested that perhaps passion and personal curiosity were naturally easier for science teachers. But all of the participating teachers agreed that the qualities found in the card-sort task were important for all teachers, not just science teachers.

Previous studies that have attempted to describe characteristics valued in excellent teachers involved surveying college students and teacher educators. These studies did not use in-service teachers as participants or focus on science education in particular. This finding may contribute to a new body of literature on teacher qualities that are valued by science teachers.

3. The need to adhere to local, administrative expectations precedes, and sometimes supersedes, the application of personal beliefs regarding how students best learn science in the planning process. Each teacher was held accountable to cover a specific set, or sets, of standards in a given time frame. Their instructional choices demonstrated a concern for these standards first as they began planning for science instruction. Once standards had been considered, then the teachers selected lessons that both addressed the standard and considered their beliefs about how students best learn science. In some cases, the beliefs of these teachers impacted their interpretation of the standard. For example, two teachers described the need to extend their teaching beyond the content required in the standard. They believed that certain information was important to include as a way to engage students and create relevance to their lives. But planning always began by consulting the language of the standards, and beliefs were applied after the fact.

Sometimes beliefs about how students best learn science were compromised in consideration of local administrative expectations. Administrative expectations included that teachers would adequately prepare students for high-stakes assessments, within a given time frame, and comply with the application of local, state and some national standards into their lessons. The teachers talked about selecting, modifying or discarding pre-developed lesson plans and/or activities due to these constraints. For example, the elementary teachers in this study were instructed to incorporate Common Core standards of reading and writing into their science plans. Janet specifically abandoned her original science plans, ones that reflected her beliefs about how students best learn science, in response to new administrative expectations. Natasha, a secondary teacher, also described eliminating an important activity from during her unit planning process due to the limited time available before the end of course exams. In our final meeting she also expressed that not using the NSES was not optimal, but that time played a major factor in her decision to exclude them. Finally, the high school teachers reminded me in our final meeting that their professional evaluations were tied to the teaching of local and state standards. So even though they would like to teach national standards, and believe they have value for their students as they learn science, the teaching of local and state standards must take precedence.

Other administrative expectations, such as following locally established rules and procedures, can inhibit a teacher's ability to apply their beliefs during planning. Although Janet expressed a belief that students best learn science through hands-on experiences, the "red-tape" she encountered forced her modify her planning for science, and henceforth limited the opportunities Janet could provide in terms of concrete experience. In the Klingston City school district, teachers must go to considerable lengths to have a classroom pet. In her Think Aloud Planning Record, Janet said, "This basal suggests having a classroom pet to watch. I do not have a classroom pet, and it's a whole lot of red tape to get one, so that's not going to be part of this lesson or this unit."

Brickhouse & Bodner (1992) described the impact of institutional constraints on the way a participating teacher executed his science lesson. Three levels of institutional control are said to exist: personal, bureaucratic, technical.

Personal control involves the impact of supervisors, such as principals, on the teachers' work; bureaucratic control involves regulations and social hierarchies; and technical control is a result of scheduling of classes, building designs, texts and other materials for instruction, and the events that occur within the classroom (Brickhouse & Bodner, 1992, p. 480).

The findings of this study concur with Brickhouse & Bodner's findings regarding the importance teachers place on institutional constraints as they plan for science instruction. Personal, bureaucratic and technical controls are interconnected. For example, teachers may feel the influence of supervisors at the same time they are required to include certain standards in their lesson plans. For the teachers in this study, planning was affected by all three controls: personal, bureaucratic, and technical. They selected, and then modified, standards and lessons in response to administrative requirements and technical restrictions.

Recommendations

Now that I have presented conclusions based on the findings of this study, I can provide recommendations for the future. In this section, I recommend actions that we can take for the future in the areas of policymaking and administration, professional development, and pre-service teacher education. I also suggest questions for future research in science education.

Recommendations for policymakers and administrators. I assert that in order for the NGSS to become prevalent in the daily practice of classroom teachers, we must consider two important factors poised to inhibit the future influence of this document. First, we must limit the administrative roadblocks teachers face during planning. Second, we need to eliminate the use of contradictory or hidden messages with our teachers.

I began this dissertation by stating, "outsider-driven reform movements not predicated on the internal beliefs of teachers are unlikely to succeed" (Anderson, 2007; Bryan & Abell, 1999; Smith & Southerland, 2007). The newly released *Next Generation Science Standards* will surely become influential to textbook developers, professional development programs, and state agencies. But how can we be certain that this document, in its entirety, will indeed reach the very people it was intended to affect?

The *National Science Education Standards,* published more than 16 years ago, promoted the use of inquiry among science teachers. Yet the use of inquiry in today's science classroom is irregular and minimal (Barrow, 2006). Furthermore, although researchers have agreed that students should develop conceptual understanding before attempting to master scientific terminology, more than 70% of science teachers in grades K-12 believe vocabulary should be introduced at the beginning of instruction on a science concept. Many more believe that hands-on activities should primarily be used to reinforcement to conceptual development rather than as a catalyst (Banilower et al., 2013). The participants in my study also focused heavily on vocabulary as part of their instruction and their hands-on activities rarely approached true inquiry. This corroborates with the results of the self-report survey done by Banilower. Despite all that we have learned, why have we been unable to fully translate this into the daily practice of classroom teachers? Surely advocates of the recently released *Next Generation Science Standards* have an uphill battle to face if they ever intend to impact daily science instruction.

As evidenced in the findings, the teachers who participated in my study attempted to translate their beliefs about how students learn science best into their plans. One challenge they faced during planning were institutional restrictions such as pre-established timelines, lack of access to materials, and administrative expectations. Such restrictions impacted their methodological choices, and sometimes caused them to make alternate choices which violated their beliefs the possessed about how students best learn science. Institutional restrictions, even those intended to safeguard our students, can have the unfortunate unintended consequence of limiting a student's ability to have meaningful interactions with the environment.

Institutions should not blanketly draw assumptions about the prior experience of students before they enter school and limit teachers accordingly. Our teachers know their students and what they need. They know how to provide those missing experiences to their students that help fill in knowledge gap. Institutions must support teachers in providing these experiences for our students if we want to create optimal, effective learning environments. "Red tape" should be minimized so that teachers can actualize their beliefs about how students learn science best.

One of the state standards that Klingston City kindergarten teachers are responsible for teaching is that students should "recognize that living things require water, food, and air." In the same standards document, a suggestion was provided for how these teachers could check for student understanding of this topic. The suggestion stated, "The learner will record information about the care, feeding, and maintenance of a living thing." One only has to think back to Janet's think aloud planning record to understand how institutional restrictions created “red-tape” and interfered with her notions that learning science should be hands-on.

Administrators may view certain restrictions as insignificantly impacting students overall. Restrictions may even be viewed as reasonable when one considers the potential distractions a class pet may cause (noise, smell, mess, pest control). However, the experience of caring for a hamster, a fish, or a turtle creates multiple concrete moments for students solidifying their understanding of the world. Furthermore, moments such as these provide teachers with opportunities to relate larger concepts and ideas to concrete experiences.

Another concern we must address is the use of contradictory or hidden messages with teachers. Smith and Southerland (2007) warn about the dangers of "muted or contradictory messages" found within the documents of reform and the lack of support given locally to teachers who are attempting to put those philosophies into practice (p. 418). I believe that teachers feel discouraged and confused when the documents that are supposed to guide their instruction (adopted textbook, local/state standards) come into direct conflict with the policies of the very bodies that support them. How can teachers implement reform practices when they are not provided the time, resources or training possible to do so? How can teachers be expected to fully execute student led inquiry when science is restricted to 20 minutes a day? If we want our teachers to celebrate change, we must be clear about what those changes are, and provide them with the necessary support to execute change.

Recommendations for professional development. I believe that in order for documents of reform, such as the *Next Generation Science Standards,* to have a chance to successfully impact the daily practice of our nation's teachers, we must change our current practice. We need to provide teachers with the opportunity to engage, explore, critique and synthesize the *Framework of K-12 Science Education.* Smith and Southerland (2007) warn,

> When curriculum intended to shape pedagogy and guide the selection of science content based on national standards and benchmarks is viewed merely as a list of topics, the messages of reform in state curricula are likely too implicit for the average classroom teacher. (Smith & Southerland, 2007, p. 418)

Simply allowing the states to dictate how documents of reform reach our classroom teachers may result in a truncated view of what science education reformers are trying to accomplish.

We cannot afford to allow state departments of education to filter the Framework or the NGSS for their own purposes, cherry picking the content and ignoring the pedagogical approaches suggested.

By providing teachers with professional development (PD) opportunities to expose and confront their underlying beliefs about how students learn, and then providing them with an opportunity to examine and synthesize the *Framework for K-12 Science Education*, we may be able to truly affect the daily practice of science teachers. Bryan (2003) concurs with this suggestion, "If gains are to be made in terms of reforming science teaching, teacher educators need to tailor instruction to address the existing conceptions of those who are expected to enact the changes" (p. 860).

This opportunity is especially important for elementary teachers. The majority of elementary teachers today still operate as generalists rather than specialists. This means they are expected to teach, and be accountable for, content and standards in multiple disciplines rather than just one. However, even though these teachers are expected to cover a broad range of subjects, they are not afforded more time to plan. Their limited planning time must be divided between multiple subjects. This division of time results in an inability to become deeply knowledgeable about any one subject. Couple this with the fact that currently science instruction is deemphasized in favor of extra reading and math instruction, and what results is an inability to enact meaningful change in the practice of elementary science teachers.

I believe that the only solution for this is time. Teachers need time to examine and time to explore. They need time to dialogue and time to reflect. But time is the one thing they are not afforded during the school year. In order to create meaningful change in the practice of our elementary science educators, we need to provide them with that time during professional development. By providing elementary teachers with the opportunity to expose and confront their beliefs about science teaching and learning, and giving them time to dissect and synthesize the *Framework for K-12 Science Education*, we can increase their science curricular knowledge. This may also positively impact their self-efficacy as science teachers, and increase their personal interest in the subject matter. Through professional development, we may be able to truly affect the daily practice of elementary science teachers.

Secondary teachers tend to be more familiar with documents of reform than elementary teachers. However, the benefits still apply when we provide secondary teachers with additional professional development time as well. The *Framework for K-12 Science Education* highlights the importance of using a full range of instructional approaches in order to well cover the four strands of proficiency. Secondary teachers need time to collaborate with their peers. They need time to examine each content strand and consider what approach is most beneficial for addressing that area. They need time to share ideas, design approaches, and conduct research on effective methods. By providing additional time and support for professional development to our secondary teachers, we allow them the opportunity to develop plans that are richer, and that better address the needs of their students.

Teachers need to be treated as professionals. They must be allowed to compare their beliefs with philosophies found in documents of reform such as the *Framework for K-12 Science Education* and the *Next Generation Science Standards*, and allowed the professional freedom to interpret these documents into their practice. We must give them the opportunity to draw on their own expertise of working with students as they interpret documents of reform. Hewson (2007) beautifully stated what could occur if reformers choose to disregard the role of teachers in this process,

> What teachers do is not a formulaic following of rules but nuanced, professional practice in which teachers constantly make important decisions and judgments in how they interact with their students to facilitate their learning. What this means is that if teachers are not involved, educational reform will not happen. (p. 1180)

Recommendations for pre-service teacher education. Kagan (1990) suggested that most pre-service teachers leave teacher education programs with the same beliefs that they entered with. The formal teacher training they receive at the university does little to alter the beliefs they hold about teaching prior to the program. If this is true, what role do teacher educators play in refining the belief systems of the teachers of tomorrow?

Freeman (1991) suggested that an important part of teacher development is allowing teachers the opportunity to make their implicit beliefs about teaching and learning explicit. I believe that we must incorporate opportunities for pre-service teachers to expose their existing beliefs about teaching and learning prior to their internship. These beliefs must be stated, explored, and tested through classroom experience. Then they must have opportunities to reflect on how their beliefs hold up in the face of experience. Although reflective elements are already built in to most teacher training programs, reflection without explicitly exposing beliefs prior to the activity holds little value. Teacher educators must be much more intentional in identifying the beliefs pre-service teachers have before and after their classroom experiences.

Recommendations for future research. Observations I made during the course of this study led me to make several recommendations for future research. I present nine questions that may guide future researchers and program developers as we concern ourselves for the future of science teaching.

The influence of teacher beliefs on the planning process of science teachers is far more complex than I anticipated prior to this study. In order to fully understand how beliefs about personality traits of teachers influence their planning for science instruction, future researchers may seek to examine much time is spent planning, the quality and complexity of lessons produced, the physical reaction of the students to a planned unit, or the amount of non-instructional time students spent on the content outside of assigned work.

Talking with the high school teachers, I noticed that their participation at the county level with curriculum development was significantly higher than the elementary participants. This raised questions about self-efficacy that results from experiences such as these. Possible research questions include:

1. What relationship exists between the participation of elementary teacher in science leadership roles, self-efficacy, and student outcomes?
2. How are academic outcomes affected when elementary teachers have the opportunity to work with colleagues at the regional level during curriculum development?
3. How does participation in science leadership roles affect elementary teacher participation in professional development?

For these teachers, many had never stated their beliefs about science teaching and learning aloud. I could hear their surprise as they expressed thoughts about learning. I wondered what the power of this expression would have on them in future planning sessions. This raised questions such as:

4. When a teacher's beliefs about how students learn science best are exposed and confronted, how is the teacher's practice affected over time?

5. How can we develop professional experiences that allow teachers to confront their own beliefs about student learning while still providing them with the most current understandings of best practice in science education?
6. Do experiences that allow teachers to confront their own beliefs about student learning translate into greater conceptual development among students?

Since none of the teachers in this study spent significant time with the NSES, I wondered how practice would be affected if they were allowed to fully engage with documents of reform. This raised the following question.

7. When teachers are allowed to study, digest, discuss and evaluate documents such as the *Framework of K-12 Science Education*, what impact does this experience have on their beliefs systems, planning for science instruction, actual day-to-day practice?

Finally, in my last meeting with the secondary teachers, new questions were raised about the process of planning for science. Natasha pointed out that her own limitations as a teacher played an additional role in selecting lessons from outside sources. She commented that when she considered pre-developed lessons from outside sources, that she sometimes discovered that they required certain talents and knowledge she did not possess. Therefore, she would not select lessons if the methods did not speak to her strengths as a teacher or asked her to operate outside her comfort zone. She also asserted that her own enjoyment for teaching certain lessons factored into her planning process. She felt that her excitement for teaching the lesson translated to her students' enthusiasm for learning the subject matter. So she would disregard lessons that did not excite her. This made me wonder how a teacher's self perception affected their planning for science. I also wondered what got teachers excited about teaching certain lessons.

8. How does a teacher's view of self affect their planning process?

9. What excites science teachers to teach certain lessons?

Through the examination of questions such as the above, I believe that we can help science education fulfill the vision that was set forth long ago, where "teachers are empowered to make the decisions essential for effective learning, in which interlocking communities of teachers and students are focused on learning science, and in which supportive educational programs and systems nurture achievement" (NRC, 1996, p. 2).

Reflections and Reservations

I fear that the findings of this study may be misinterpreted to suggest that in order for the NGSS to be successfully implemented into the daily practice of science teachers that it must be tested. While it is true that the high school teachers in this study were highly concerned with the high-stakes assessments, I do not believe that adding one more log to high-stakes fire would benefit teachers in any way. Today's teachers are angry and exhausted. In fact, in my last meeting with Natasha and Sally they expressed frustration with the increasing draws on their instructional time. They stated that with the limited time before testing, they have to be selective about which concepts and standards they cover. They went on to explain that they would love to include NSES in their lessons, but that "We just can't do it all." Natasha and Sally are just two examples of teachers who are frustrated by high-stakes testing and the limits such testing places on their day-to-day instructional decisions.

If science educators of tomorrow are to achieve the visions set forth by the AAAS so long ago, they must be supported on their journey. In addition to providing these teachers professional support, we must provide them with the financial means, the time and resources for training, and the moral support to fight for science in the daily schedule. We must provide them with opportunities to engage with the *Framework of K-12 Science Education* and to confront their own beliefs about science education. If science education is to truly evolve, we must listen as well as we talk.

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Appendices

Appendix A: Informed Consent Form

The Differences in Elementary and Secondary Teachers' Beliefs about Science Teaching and Learning, Science Curricular Knowledge, and their Influence on Planning

INTRODUCTION

You are invited to participate in a research study intended to describe the similarities and differences that exist in elementary and secondary teachers beliefs about science teaching and learning, their curricular knowledge, and how these two things impact their planning to teach science. We, the researchers, intend collect information via interview, think-aloud planning records, and document analysis, which will help us describe these beliefs and knowledge, and how they influence planning.

YOUR INVOLVEMENT IN THE STUDY

We will begin the study by interviewing you about what you think about science teaching and learning. We will talk with you about your prior experiences with science, your training for teaching science, and we will ask you about those factors that you feel influence your instructional choices. Each interview will not be formally structured, and will last only as long as you are interested in participating.

Next, we will ask you to create one audio recording of a "think-aloud" planning session for a unit of science instruction. This entails you basically talking about how you plan from the beginning of developing a unit plan to the end. We will provide you with talking points to guide you through the talk aloud if needed. Your unit does not need to be created specifically for this activity, but instead should be one you already intend to implement. With your consent, we would also like to examine your lesson plans and/or other appropriate materials (i.e. worksheets, handouts, etc) you reference which are relevant to the lesson. We will use these documents to gain a better understanding of your instructional practice and what you believe about science teaching.

We will conclude the study with a follow-up interview based on what you expressed in the first interview and the think-aloud record of the unit you planned for. We will also talk about recent changes in national/state/local science documents which may influence your instruction. At this last interview, we will share our first analysis of the interview/planning/document data. We will check in with you at this time to be certain that we have represented your thoughts accurately and to allow you the opportunity to add to our findings. The total time spent with you face to face will vary based on interview length, but should not exceed four hours. The total time this study may require of you should not exceed six hours.

The interviews will be audio taped and transcribed. We, the researchers, guarantee that any recordings, transcripts and documents collected during the course of this study will be kept confidential and that your name, or the name of your school, will be in no way connected to the results of this study. Any research reports and/or publications of these findings will use pseudonyms in place of names. Audio recordings will be destroyed at the completion of the study.

________ Participant's initials

RISKS
In an effort to protect you from an possible risk of your responses affecting either the quality of your work life or job security, all necessary precautions will be taken to protect your identity.

BENEFITS
Reflective teaching is a valued practice among educators**.** Through reflection on your instructional methods, planning process and curricula choices, you may learn more about your own practice. You will have an opportunity to review your science instruction through the interview discussions, which may help you see your teaching from an outside perspective. You may also learn more about the national trends and curriculum changes in science education.

CONFIDENTIALITY
All of the information provided during this study will be kept confidential. Data will be stored securely and will be made available only to persons conducting the study unless you specifically give permission in writing to do otherwise. No reference to you, your school, or your district will be made in oral or written reports which could link you to the study. Pseudonyms will be used instead of names.

EMERGENCY MEDICAL TREATMENT
The University of Tennessee does not "automatically" reimburse subjects for medical claims or other compensation. If physical injury is suffered in the course of research, or for more information, please notify the investigator in charge, Dr. Thomas Turner, at (865) 974-4230.

CONTACT INFORMATION
If you have questions at any time about the study or the procedures, (or you experience adverse effects as a result of participating in this study,) you may contact the researcher, Dr. Thomas Turner, Theory & Practice in Teacher Education (TPTE)**,** A222 Jane and David Bailey Education Complex, 1122 Volunteer Boulevard, Knoxville, Tennessee 37996-3442, Phone: 865-974-4230, Fax: 865-974-6302, E-mail: thom@utk.edu. If you have questions about your rights as a participant, contact the Office of Research Compliance Officer at (865) 974-3466.

PARTICIPATION
Your participation in this study is strictly voluntary. If you choose to participate, or not to participate, you will not be adversely affected in any way. If you decide to participate, you may withdraw from the study at any time without penalty. If you withdraw from the study before data collection is completed your data will be returned to you or destroyed.

CONSENT
I have read the above information and I have received a copy of it. I agree to participate in this study.

Participant's signature ______________________________ Date __________

Investigator's signature _____________________________ Date __________

Appendix B: Semi-Structured Teacher Interview Protocol for Elementary and Secondary Teachers

Instructions: The following questions act as a guide for the interview, however it is within the researcher's discretion to deviate from the below questions in order to uncover important information, put the interviewee at ease, follow a line of discussion they wish to follow, or to clarify provided information.

Theme: ***Prior Experience***: *Getting background on the teacher's experiences with science*

Lead Off Question: **Tell me about your science background.**

Possible Follow up Questions

1. What was science like for you as a student?
    a. Tell me what you remember most about your science classes.
    b. What kinds of science classes have you taken in school?
    c. What prompted you to take these classes?
2. Describe a memorable professional development experience you have had in science.
    a. What prompted you to participate in these PD?

Theme: ***Knowledge***: *Pedagogical Content Knowledge (Shulman, 1986)*

Lead Off Question: **Describe an average day in your science classroom.**

Possible Follow up Questions

1. If I were to walk in your classroom while you were teaching science, what would I see?

Lead Off Question: **Describe the methods you have found effective in teaching science.**

Possible Follow up Questions

1. What do you think are the important things a science teacher should know in order to help students learn science?
    a. What is the teacher's role during a science lesson?
2. Tell me about one of your most successful science lessons.

Theme: ***Knowledge***: *Curricular Knowledge (Shulman, 1986)*

Lead Off Question: **Tell me about the curriculum (or curricula) you use for science instruction.**

Possible Follow up Questions

1. When you plan out your instruction, how do you decide what you will teach next?
2. Tell me about the kinds of materials you like to use during your science instruction.

3. If you had unlimited resources, what would your ideal science classroom look like?
4. What documents most influence your science instruction?
    a. Does your school follow an adopted science curriculum?
    b. Use a textbook?
    c. Use supplementary materials?
    d. Provide a lab experience?
    e. Follow a county pacing guide?
    f. Reference a set of standards?

Theme: ***Knowledge***: *Personal-Practical Knowledge (Beattie, 1995)*

Lead Off Question: **What important qualities should a science teacher possess?**

<u>Possible Follow up Questions</u>

1. Describe a science teacher you look up to.

Theme: **Beliefs** (Pajares, 1992): The nature of knowledge (epistemological beliefs),

Lead Off Question: **How do children best learn science?**

Theme: **Beliefs** (Pajares, 1992): Required-beliefs about confidence to affect students' performance (teacher efficacy)

Lead Off Question: Describe what you think about when a student comes to you and is struggling with a science concept.

<u>Possible Follow up Questions</u>

1. How much influence do you have over a student's understanding of science?
2. How much influence do you have over student understanding when compared to other factors outside of your instruction?

Theme: **Beliefs** (Pajares, 1992): Causes of teachers' or students' performance (attributions, locus of control, motivation, writing apprehension, math anxiety),

Lead Off Question: **What are some of the other factors that you think influence your students perform in science?**

<u>Possible Follow up Questions</u>

1. Which of those factors have the largest impact?
2. Which of those factors have the smallest impact?

Theme: **Beliefs** (Pajares, 1992): Perceptions of self and feelings of self-worth (self-concept, self-esteem); Confidence to perform specific tasks (self-efficacy).

Lead Off Question: **How would you describe yourself as a science teacher?**

<u>Possible Follow up Questions</u>

1. How would you describe your ability to teach science?
2. What are your strengths as a science teacher?
3. In what ways do you think you could improve as a science teacher?

Appendix C: Think-Aloud Planning Talking Points

Dear Teacher,

Thank you for consenting to record your planning process today. Below, I have given you a series of talking points in case you feel stuck while you are recording. Feel free to answer for as long as you like, or answer in any way you see fit to help me understand what you do when planning for science instruction.

Please begin the record of your planning session by just talking about the unit you are preparing to teach. Talk through the unit development step by step until you are satisfied that it is in the final form it will take before you teach it. This can be as formal or informal as you would normally plan for teaching.

If you feel like you have told me everything you can about this unit, then consider talking generally about what a typical planning session looks like for you.

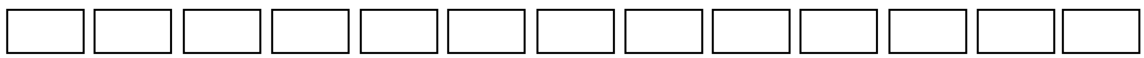
1. What is the most important part of your planning process?
2. What form does your lesson plan take?
3. How do you decide what resources to use?
4. What resources do you find most beneficial in designing science instruction?
5. Which resources do you most often reference?
6. What documents, or other resources, do you reference?
7. What role, if any do standards play in your science instruction?
8. Which standards most guide the decisions you make as a science teacher?
9. Is there anything else you would like to tell me about your planning for science instruction?

Appendix D: Qualities that Excellent Science Teachers Should Possess
Card Sort Activity

Dear Teacher,

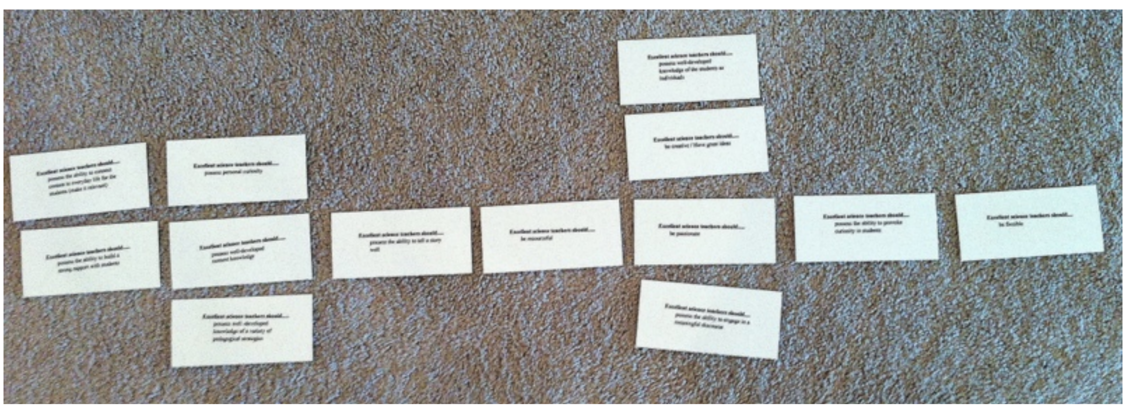
In this envelope you will find qualities of excellent science teachers that have been mentioned by various participants throughout this study. I would like to you to look over these statements and then arrange the cards in order of importance moving from the left to the right side of your table. I have pictured this in Figure 1 below to help you.

Figure 1.
Qualities that are most important <-------------------> Qualities that are least important



This task is flexible. If you struggle with valuing one quality over another, you can value them equally by placing cards one on top of another (see Figure 2 below). If you think an important quality is missing from what was provided, you can add it by using one of the blank cards I have included in your envelope. You can also discard a card altogether if you do not find it to be a valuable quality in an excellent science teacher.

Figure 2.
Qualities that are most important <--------------------> Qualities that are least important



The most important part of the task is that you talk through what you are thinking as you are handling the cards. Please talk about *why* you value certain qualities over, or equally to, others.

When you think you are done, if possible, please take a picture of the completed card arrangement and email to me at jhorto22@utk.edu. This will help me more accurately represent your beliefs in my data records.

Thanks again,

Appendix E: University of Tennessee IRB Application

FORM B APPLICATION
IRB # ____________________________

Date Received in OR ________________

THE UNIVERSITY OF TENNESSEE

Application for Review of Research Involving Human Subjects

I. IDENTIFICATION OF PROJECT

1. **Principal Investigator:**
Jessica Horton
Doctoral Candidate (Graduate Student)
Theory & Practice in Teacher Education (TPTE)
College of Education, Health, & Human Sciences
Phone: 865-591-1569
Email: jhorto22@utk.edu

Co-Principal Investigator:
Dr. Thomas Turner
College of Education, Health, & Human Sciences
Theory & Practice in Teacher Education (TPTE)
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1122 Volunteer Boulevard
Knoxville, Tennessee
37996-3442
Phone: 865-974-4230
Fax: 865-974-6302
E-mail: thom@utk.edu

Department: Theory and Practice in Teacher Education (TPTE)

2. **Project Classification:** Dissertation Research

3. **Title of Project:** The Similarities and Differences in Elementary and Secondary Teachers' Beliefs about Science Teaching and Learning, Science Curricular Knowledge, and their Influence on Planning

4. **Starting Date:** August 1st, 2012 and/or after IRB approval

5. **Estimated Completion Date:**
   Data Collection: September 1st, 2012 - May, 2012
   Data Analysis: October 1st, 2012 - May 2012

6. **External Funding** *(if any)***:**
   There is no external funding needed for this research project.

II. PROJECT OBJECTIVES

The purpose of this study is to describe the beliefs that elementary and secondary teachers possess about the teaching and learning of science, to describe what science curricular knowledge they possess, and to describe how their beliefs and knowledge influence their planning of science instruction. More specifically, the three guiding questions for this study will be:

1. What similarities and differences exist in the beliefs of elementary and secondary science about science teaching and learning?
2. What similarities and differences exist in the science curricular knowledge of elementary and secondary science teachers, in particular their knowledge of *Next Generation Science Standards* and the *Framework of K-12 Science Education*?
3. In what ways do elementary and secondary teachers' beliefs about science teaching and learning and their science curricular knowledge influence their planning for science instruction?

III. DESCRIPTION AND SOURCE OF RESEARCH PARTICIPANTS

I will request participation from four to seven elementary and four to seven secondary science teachers employed within public school districts located Eastern United States. A request for research will be submitted to Knox County Schools in Tennessee, but requests to districts such as Monroe County Schools, TN, Fort Thomas Independent Schools, KY, or another district yet to be named, may be completed in order to obtain an adequate number of participants.

The principal investigators will comply with the appropriate IRB procedures as determined by the county in which these teachers are employed. Approval for the participation of these teachers by their district and principals will be obtained, in addition to those informed consent forms acquired from the participants, and will be submitted to University of Tennessee prior to the beginning of any research.

IV. METHODS AND PROCEDURES

Data collection will consist of two in-depth interviews, a think-aloud planning record, and a document analysis of related unit/lesson plans. Each interview will be audio-recorded and will last approximately 30 - 120 minutes in length. Audio-recordings will help ensure that the researcher accurately represents what each teacher has stated during the interview. Using a semi-structured interview protocol (See Appendix B), I will interview each teacher about their beliefs regarding the teaching and learning of science. In particular, I will ask teachers about their methodological choices, their epistemic beliefs about how students learn science, about their personal and professional experiences in science, about their adopted curriculum and use of other resources with a focus on how resources factor into their teaching decisions.

After the first interview, I will ask each participant to create an audio recording, a think-aloud commentary, where they talk out loud as they plan for a science unit. I will give them a bulleted list of points to hit in their talk aloud such as to talk about what they do first, next, etc, and to discuss any print or web resources they reference (See Appendix C). They will also provide me with relevant documentation to this think-aloud record (i.e. unit/lesson plans) which help me understand their planning process for science. I will use their responses on the audio recording to craft questions for the second interview which may help clarify and expand on their original responses.

Throughout the study, I will provide opportunities for the participants to reflect and expand upon their interview responses. I intend to use extensive member checking in an attempt to accurately represent the voice of my participants. Once both interviews have been completed and my data coded and themed, I will share my findings with the participants so that they can add any final thoughts or reflections to the results.

V. SPECIFIC RISKS AND PROTECTION MEASURES

In an effort to protect participants from the risk of their responses affecting either the quality of their work life or job security, all necessary precautions will be taken to protect the identity of the teachers. No identifiable information, such as the teacher's name or school, will be recorded. Pseudonyms will replace the names of each teacher, their school and their district in any records made throughout the study. I will remind the participants throughout the study that their participation is strictly voluntary. I will assure them that if they choose not to participate, or withdraw at any time, that they will not be adversely affected by the decision.

All relevant materials, including, but not limited, interview transcripts and think-aloud records will be kept in a locked and secured location at the University of Tennessee. After the study is complete, all data, transcripts and recordings will be destroyed.

VI. BENEFITS

Reflective teaching is a valued practice among educators. Through reflection on their instructional methods, use of curriculum, and why they teach elementary science the way they do, these teachers may learn more about their own practice. Teachers will have an opportunity to review their science instruction through the interview discussion, which may help them see their teaching from an outside perspective. They may also learn more about the *Framework for K-12 Science Education* and the *Next Generation Science Standards* developed by the National Research Council, poised to be a highly influential document in their future science instruction and enacted curriculum.

Through the final report provided to the county where the teachers are employed, and to the University of Tennessee, these institutions may benefit by hearing more about what their teachers value as quality science instruction, and how new curricula are implemented. This knowledge may help them provide the appropriate training and professional development experiences for teachers as science education continues to evolve nationally.

VII. METHODS FOR OBTAINING "INFORMED CONSENT" FROM PARTICIPANTS

I will meet with each teacher individually prior to beginning data collection and explain the purpose of the study and their requested participation responsibilities. At this time, I will present the Informed Consent Form which explains that all necessary precautions will be taken to protect their identity, that their participation is strictly voluntary, and that the form guarantees their right to withdraw from the study at any time (See Appendix A). I will provide them with as much time as necessary to consider participation and to answer any questions they might have about the study or their part in it.

The informed consent form provides that no identifiable information will be recorded which could link the teacher's response to their name, their school, or their district. Pseudonyms will be used throughout this report for each teacher's name, school's name and their district's name. I will also explain to the participants that all of the transcripts and recordings will be destroyed once the study is complete.

VIII. QUALIFICATIONS OF THE INVESTIGATOR(S) TO CONDUCT RESEARCH

Jessica Horton is a doctoral candidate and graduate student from the University of Tennessee. She has passed the Collaborative Institutional Training Initiative (CITI) course which affirms her ability to conduct minimal risk research. Dr. Turner, a professor of education at the University of Tennessee, will train Jessica Horton to follow the procedures outlined by the Human Subjects Committee on ensuring confidentiality and the voluntary nature of participant recruitment.

IX. FACILITIES AND EQUIPMENT TO BE USED IN THE RESEARCH

No university facilities or equipment are required to complete this research.

X. RESPONSIBILITY OF THE PRINCIPAL/CO-PRINCIPAL INVESTIGATOR(S)

By compliance with the policies established by the Institutional Review Board of The University of Tennessee the principal investigator(s) subscribe to the principles stated in "The Belmont Report" and standards of professional ethics in all research, development, and related activities involving human subjects under the auspices of The University of Tennessee. The principal investigator(s) further agree that:

1. Approval will be obtained from the Institutional Review Board prior to instituting any change in this research project.

2. Development of any unexpected risks will be immediately reported to Research Compliance Services.

3. An annual review and progress report (Form R) will be completed and submitted when requested by the Institutional Review Board.

4. Signed informed consent documents will be kept for the duration of the project and for at least three years thereafter at a location approved by the Institutional Review Board.

XI. SIGNATURES

ALL SIGNATURES MUST BE ORIGINAL. The Principal Investigator should keep the original copy of the Form B and submit a copy with original signatures for review. Type the name of each individual above the appropriate signature line. Add signature lines for all Co-Principal Investigators, collaborating and student investigators, faculty advisor(s), department head of the

Principal Investigator, and the Chair of the Departmental Review Committee. The following information should be typed verbatim, with added categories where needed:

Principal Investigator: ____

Signature: ________________________________
Date: _________________________

Co-Principal Investigator ____

Signature: ________________________________
Date: _________________________

XII. DEPARTMENT REVIEW AND APPROVAL
The application described above has been reviewed by the IRB departmental review committee and has been approved. The DRC further recommends that this application be reviewed as:

☒**Expedited Review -- Category(s): _______**6 and 7**___**

OR

[ ] Full IRB Review

Chair, DRC: ________________________________

Signature: _________________________________
Date: __________________

Department Head: ________________________________

Signature: _________________________________
Date: __________________

Protocol sent to Research Compliance Services for final approval on (Date):
____
Approved:
Research Compliance Services
Office of Research
1534 White Avenue

Signature: _________________________________ Date:__________________

Appendix F: Trish's Unit Plan Summary

In Trish's Think Aloud Planning Record, she described her plans for a five-day Kindergarten unit on nocturnal animals. On the first day, Trish intended to begin a KWL chart with students to find out what they already knew about bats and to have them generate questions about what they would like to know about bats. Afterwards she planned to have the students read facts about bats, and then highlight key vocabulary for them through discussion. Finally the students would answer questions about the bat facts they learned using pictures. On the second day, Trish planned to start class by having the students complete a "Bats can, bats have, and bats are chart." Next, as a class, they would read a nonfiction easy reader about bats. Then after completing the reading, she intended to review as a class they information from the text, and add it to the "can, have, are" chart.

On the subsequent days, she planned to use a graphic organizer/foldable, spend time discussing what it meant to be nocturnal versus diurnal, and talk about what advantages there were with both ways of life. At this time, she would also have students identify different nocturnal animals and write about a favorite nocturnal animal.

In the final interview, Trish talked about adding an echolocation activity to the unit prior to implementation. In it, the students were blindfolded and then attempted to move about the room. After this experience, Trish led the class in a discussion on how increased acuity in hearing benefits nocturnal animals. On the final day of the unit, she described how they would talk as a class about what they learned during the unit, complete the KWL chart, and watch a Magic School Bus video about bats.

During her Think Aloud Planning Record, Trish described the challenge of trying to engage tired, young students at the end of the day. Although Trish was allotted only 20 minutes for science instruction, she expressed a need to incorporate reading and writing into her science instruction because of the limited time available to teach these subjects. In addition to meeting science standards, Trish mentioned the importance of meeting Common Core standards through her instruction. She indicated that during planning, she tends to find, and then modify, pre-developed lesson plans from the Internet. She remarked that she frequently visited websites that provided lesson plans such as Teachers Pay Teachers, Pintrest, and Discovery Education. However, she also indicated that these lesson plans would generally need to be adapted for her class.

Appendix G: Janet’s Unit Plan Summary

Janet's unit, as originally described in the Think Aloud Planning Record, was not implemented as planned. During the period of time between her planning of the animals unit and the actual teaching of it, the kindergarten teachers at Janet's school were required to attend a training conducted by the kindergarten supervisor. In an attempt to raise writing scores, the teachers were trained on how to incorporate nonfiction writing into their science instruction. She modified two of the three days of her previously planned unit to accommodate this request. The training included a demonstration of a particular unit constructed by two other kindergarten teachers in the district. In Janet's final interview, she explained that they had been "strongly encouraged" to follow the lead of these teachers.

This study only seeks to examine the influence of beliefs and knowledge on how teachers plan for science instruction, and not the actual teaching itself, I will simply describe the unit that Janet had originally planned. Janet's original unit on animals was planned to be taught over three days during periods lasting approximately 30 minutes.

On the first day, Janet planned to have her students sort pictures of various things into two categories, alive and not alive. She intended to use this information formatively so that she could gauge what her students already knew about living and nonliving things. During this time she would use probing questions to elicit their beliefs and would require students to provide evidence for their assertions. At the end of the lesson, the students would be asked to draw two living and two nonliving things into a T chart.

On the second day, Janet intended to begin instruction by discussing with the class as a whole group the topic of "pets and their basic needs." She intended to use a large poster from the science textbook to help illustrate those ideas. Next, she planned to break the class into groups of four to answer basic needs questions about an assigned animal like a fish, a cat, or a dog. She would end the period by having students share their answers with the class in a group presentation.

On the final day of the unit, Janet planned another sorting activity where students would sort a group of animals into swim, fly, and walk categories. She intended to use a classification board to sort as a whole group, and to talk with the students as they sorted in order to extend their understanding of the features of these animals (wings, feet, etc). Specifically she wanted to talk about characteristics such as wing shape or the function of a foot during this whole group time. At the end of the lesson, she planned to have her students draw two animals that fit into each category and to write the names of them below the picture.

During planning, Janet frequently looked at the science standards first and then consulted for her science textbook for possible activities to address those standards. After looking at the activity suggested in the textbook, she made a judgment as to whether or not that activity was valuable. If she found it to be suitable, she included it in her unit plan. She explained that if she deemed an activity to be unsuitable, she frequently visited the Internet to find a suitable replacement activity.

Often times, Janet needed to modify certain activities to meet the needs of her students both cognitively and physically. In one case, Janet took the initiative to modify a group activity in an effort to maintain harmony among her students so that they could focus on learning. Janet believed that it was important to help her students come up with questions, learn to have conversations with their peers, and to make general observations, so she identified a preference for activities that hit on those elements.

Appendix H: Sally's Unit Plan Summary

The teachers participating in the study were asked to submit a unit plan, however the think aloud planning record that Sally submitted was more like a thorough description of one day of instruction, and an allusion to the remaining instructional activities. I followed up with Sally in order to clarify my understanding of the unit. To the best of my ability, I will summarize the unit as Sally described it.

Sally's unit was completed over three days in ninety minute blocks of time. Her unit was planned for her chemistry one honors class. On the first day, Sally began with a discussion of real world situations where knowing the percentage composition of something might be important. Then she followed up with an activity where students calculated the percentage of each color in several packages of Smarties. This activity was done with a shoulder partner.

After students completed the Smarties activity, she introduced a Powerpoint on "the mole," and then afterwards, her students took notes independently as they read from associated materials. During this time they also recorded vocabulary in their chemistry log. Finally, her students completed a nuts and bolts exit ticket where they were asked to demonstrate their mastery of the skill by calculating the percentage of each nut or bolt from a bag.

On the second day, the students completed a lab where they were required to calculate the percentage of water in a hydrate. Students were grouped according to Kagan grouping standards, meaning in a group of four students a high achieving student is paired to work with a medium-low achieving student, and a medium-high achieving student is paired to work with a low achieving student. When asked during the final interview what it was about this grouping strategy that appealed to her, Sally replied, "typically that tends to work better, I mean as far as one student not talking over the other, or talking down to the other. You get more of a dialogue and question-and-answer type situation." In the TAPR, Sally explained that activities students completed over these two days would prepare them for a future lab that they would complete percentage composition of copper two sulfate. On the final day of the unit the students took a quiz to demonstrate mastery.

Sally spent a lot of time in her think aloud planning record describing her preparation and organization of the materials needed for the lesson. This included a lengthy discussion of preparing the percentage composition bags for both the Smarties activity and the nuts and bolts exit ticket. She also described her choice of grouping and purpose behind this.

After listening to Sally's think aloud planning record, I believe Sally described an almost exact replica of an activity she had used in previous years. As such her time "planning" for this activity may simply have been a revisiting and preparing of previously used materials. I view this as perhaps a different type of planning than how she would plan if faced with a new topic. When she initially planned this activity she aligned it with her standards at that time, so Sally had no reason to revisit her science standards at the onset of her TAPR. In the future, it would be interesting to examine how Sally responds to changes in the standards she is required to teach.

Appendix I: Natasha's Unit Plan Summary

Natasha planned implement her unit on evolution and classification over four days of science instruction for her biology one class. Her instructional periods lasted 90 min. in length. On the first day, Natasha reviewed with her students a compare and contrast activity they had previously completed, she showed her students a PowerPoint presentation, and then had her students work on a cladogram activity.

On the second day, Natasha began by reviewing with students the answers to their homework on cladograms. Next, she led the class in a discussion on antibiotics, asking questions like why have some bacteria become resistant to antibiotics. She followed up discussion where students were asked to compare kidney beans and then had to relate what they observed to the concept of changing populations. Finally, she had students listen to, and take notes on, a Powerpoint she developed on natural selection and evolution. After, the students began a lab called “Hunting the pom-poms nest: A simulation of natural selection.”

On day three, Natasha let her students finish the pom-pom lab, and then began her evidence of evolution PowerPoint for the students to take notes on. She finished with having the students do a worksheet on homogenous and analogous structures. And on the final day, Natasha displayed convergent/divergent evolution pictures and then discussed with the class, and then she had her students complete a foldable flipbook where students would illustrate vocabulary related to the unit. She also gave her students time in class to complete part of a quiz.

Natasha described her planning process as a reflection on both her previous lessons from this unit from past years and those events as they are currently unfolding in her class, "I usually sit down and say, okay well here's you know, here's what I did last year, I think this will work this time, or I don't think this will work this time." Natasha remarked that during planning, she thinks about the personality of her class and her own interests in continuing to use that material. She frequently tries to mix up her lessons to incorporate things that she's heard from colleagues or found on the Internet.

Vita

Jessica Horton was born and raised in Fort Myers, Florida in 1976. After graduating from Fort Myers High School in 1993, she moved to Gainesville, Florida in order to attend the University of Florida. During her five years at UF, she completed both her Bachelors degree in Education and her Masters degree in Elementary Education. After graduation, Jessica took her first teaching position at the same school where she interned: Glen Springs Elementary. Her first position was teaching Title I Reading to students in Kindergarten through 5^{th} grade.

In 1999, she moved to Tallahassee, Florida and took a position teaching 5^{th} grade at Caroline Brevard Elementary. In her two short years at Caroline Brevard she assumed several leadership roles including organizing the school science fair, hosting a workshop for parents and coordinating a lock-in for fifth graders in preparation for the state standardized assessment. In 2001, she transferred to Killearn Lakes Elementary in Tallahassee where she remained teaching 5^{th} grade until 2008. During those years, Jessica organized a grade level orienteering challenge, served as school representative to the district science committee, and became heavily involved with curriculum development at the county office.

2008 was a year of major change for Jessica. After giving birth to her second son, her entire family moved to Knoxville, Tennessee. After spending a year as stay at home mom, she decided to return to graduate school and pursue a Ph.D in Teacher Education at the University of Tennessee. She specialized in elementary and science education. During her time at UTK, she was responsible for supervising elementary and middle school pre-service teachers during their internships. She also was actively publishing in practitioner journals and presenting at national conferences. Towards the end of the program, her family relocated to Cincinnati, Ohio where she currently resides. Jessica remains a passionate advocate for quality elementary science education.