6-1-2014

# A Narrative Study of Novice Elementary Teachers' Perceptions of Science Instruction

Roberta Harrell
*University of Denver*

# A NARRATIVE STUDY OF NOVICE ELEMENTARY TEACHERS' PERCEPTIONS OF SCIENCE INSTRUCTION

---

A Dissertation

Presented to

the Faculty of the Morgridge College of Education

University of Denver

---

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

---

by

Roberta Harrell

June 2014

Advisor: Kent Seidel, PhD

Author: Roberta Harrell
Title: A NARRATIVE STUDY OF NOVICE ELEMENTARY TEACHERS' PERCEPTIONS OF SCIENCE INSTRUCTION
Advisor: Kent Seidel, PhD
Degree Date: June 2014

ABSTRACT

It is hoped that, once implemented, the Next Generation Science Standards (NGSS) will engage students more deeply in science learning and build science knowledge sequentially beginning in Kindergarten (NRC, 2013). Early instruction is encouraged but must be delivered by qualified elementary teachers who have both the science content knowledge and the necessary instructional skills to teach science effectively to young children (Ejiwale, 2012, Spencer, Vogel, 2009, Walker, 2011). The purpose of this research study is to gain insight into novice elementary teachers' perceptions of science instruction.

This research suggests that infusion of constructivist teaching in the elementary classroom is beneficial to the teacher's instruction of science concepts to elementary students. Constructivism is theory that learning is centered on the learner constructing new ideas or concepts built upon their current/past knowledge (Bruner, 1966). Based on this theory, it is recommended that the instructor should try to encourage students to discover principles independently; essentially the instructor presents the problem and lets students go (Good & Brophy, 2004). Discovery learning, hands-on, experimental, collaborative, and project-based learning are all approaches that use constructivist principles. The NGSS are based on constructivist principles. This narrative study

provides insight into novice elementary teachers' perceptions of science instruction considered through the lens of Constructivist Theory (Bruner, 1960).

ACKNOWLEDGEMENTS

I wish to thank my family for their support during this entire process. To my husband, Steven R. Harrell, who motivated me to begin this journey, and supported me with patience and love along the way. To my two sons, Grant E. Harrell and Austin C. Harrell, whose love and encouragement kept me focused and determined along with my beautiful daughter-in-law, Cheri' L. Harrell.

I wish to acknowledge the exceptional support and guidance I received from my committee Chair, Dr. Kent Seidel, who believed in the value of strong elementary science education. I am grateful to my committee member, Dr. Susan Korach, whose wisdom and knowledge provided guidance in this research. To my committee member, Dr. Kristina Hesbol, who was kind enough to join my team on short notice and offer her wisdom and support.

A special "thank you" to Dr. Linda Brookhart for her timely feedback, insight, patience and encouragement that she provided me through the many facets of doctoral research.

This research could not have been accomplished without my two participants, "Cheri" and "Olivia." These two novice elementary teachers were willing to share with me their teaching experiences opening and honestly. For that I am very grateful.

To my University of Denver Ph.D. Cohort, with whom I have walked this journey and from whom I have made dear and lasting friends.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE: INTRODUCTION

## Background

The American educational system is not sufficiently preparing Kindergarten-12$^{th}$ grade students in science, technology, engineering, and mathematics (STEM) areas (National Science Foundation, 2007). The National Science Foundation notes that the United States possesses the most innovative, technologically capable economy in the world, however, the education system is failing to ensure that all American students receive the skills and knowledge necessary to achieve success in the 21$^{st}$ century (National Science Board, 2007). The elementary school is the most effective level for intervention leading to improved attitudes, higher achievement and increased access in science (Spencer, T., Walker, T., 2011; Augustine, 2005; Beane, 1988). This early intervention must be delivered by qualified elementary teachers who have both the science content knowledge, and the necessary instructional skills to teach science effectively to young children (Spencer, and Walker, 2011). The purpose of this research study is to gain insight into novice elementary teachers' perceptions about science instruction.

One of the highest priority actions for the nation, in the view of the National Academy of Sciences (2010), is to place teachers in every classroom qualified to teach the subjects they teach (p. 27). This is in response to their findings that the U.S. public school system compares abysmally with those of other developed and even developing nations, particularly in the area of science. According to the National Center for Educational Statistics (2003), ninety-three percent of United States public school students in fifth through eighth grade are taught science by a teacher without a degree or certificate in science While middle school ($7^{th}$ and $8^{th}$ grade) science teachers are required to meet state standards which include 24 semester credit hours in the science field, no such requirement is needed for elementary teachers who teach science to $5^{th}$ and $6^{th}$ grade students. The majority of Colorado teacher education programs require one science content course and one science methods course in order to complete an elementary (K-6) teaching licensure program. Leaders in science education are suggesting that earlier instruction and intervention is necessary to developing a strong science interest in young children (Vogel, 2009). The current system of teacher preparation may not be comprehensive enough to meet the growing demand for a more rigorous and more extensive science education in the early years of learning.

The National Research Council (NRC) Report (National Research Council, 2007) redefines what it means to be proficient in science, stating:

> ….learning to think scientifically is a matter of acquiring problem-solving strategies for coordinating theory and evidence, mastering counterfactual reasoning, distinguishing patterns of evidence that do and do not support a definite conclusion and understanding the logic of experimental design (p. 28).

A joint effort between Achieve—an organization dedicated to ensure all high school graduates are ready for college, careers, and citizenship—the NRC, the National Science Teachers Association (NSTA), and the American Association for the Advancement of Science, was forged to create new standards for science education to ensure that all students have a solid K-12 science education. Known as the Next Generation Science Standards (NGSS), these standards are projected to change the way science is taught in classrooms nationwide. Rich in content and practice, the NGSS are based on the *Framework for K-12 Science Education* developed by the National Resource Council (2013) and are intended to reflect a new vision for science education in the United States. In the new standards, student performance expectations will include a student's ability to combine practice and content knowledge, thereby focusing more on understanding as seen through application, as opposed to memorization of facts devoid of context. The *Framework* focuses on the importance of the integration of science content knowledge with the practice of science inquiry. The teacher's role will require a paradigm shift from the traditional presenter of science content information to a facilitator enabling students to use techniques associated with inquiry science.

**Theoretical Framework**

Bruner (1960) initiated curriculum change based on the notion that learning is an active, social process in which students' construct new ideas or concepts based on their current knowledge. Bruner asserted that if students are going to learn to think scientifically, teaching and learning of structure, rather than simply the mastery of facts and techniques was paramount. Bruner's Constructivist Theory framework for instruction more clearly defines the principles that are necessary for quality instruction that can be applied to subject matters across many different curriculums. Bruner developed a method of teaching through his Constructivist Theory called Discovery Learning (Bruner, 1967). Discovery Learning is a method of inquiry-based instruction that suggests it is best for the learner to discover facts and relationships for themselves. Bruner's Discovery Learning principles can be applied to quality science instruction when compared to the characteristics of successful science learning (NRC, 2012).

Table 1

*Connections Chart: Discovery Learning – NRC Report*

| **Bruner's Learning Principles (1961) p. 22** | **NRC's Report: Taking Science to School p. 251** |
|---|---|
| Promotes autonomy, responsibility, independence. | Knowing, using, and interpreting scientific explanations of natural world. |
| A tailored learning experience. | Generating and evaluating scientific evidence and explanations. |
| The development of creativity and problem-solving skills. | Understanding the nature and development of scientific knowledge. |
| Encourages active engagement and promotes motivation. | Participating productively in scientific practices and discourse. |

**Study Significance and Research Questions**

The Nation's Report Card (National Center for Education Statistics) informs the public about the academic achievement of elementary and secondary students in the United States. These report cards communicate the findings of the National Assessment of Educational Progress (NAEP). The NAEP 2011 Science Report showed an increase in $8^{th}$ grade students' scores from the 2009 test. Students performing at or above the basic and proficient levels rose from 50% in 2009 to 52% in 2011. Two interesting observations came out of the study supporting a constructivist approach for teaching science. Students doing hands-on projects in class more frequently scored higher on the NAEP science assessments as did students who worked together on science projects with classmates. A supposition can be made that if students had increased hands-on learning opportunities in collaborative groups beginning at the Kindergarten level, student scores in science may possibly rise even higher. After a determination of the skills and knowledge base necessary for effective science instruction, an analysis is needed to determine the connection of these skills and knowledge base to elementary teachers' perceptions of their science instruction. Through a theoretical framework using Bruner's (1966) Constructivist Theory of Learning, this study explores the following research question:

1. What are the perceptions of two novice elementary teachers' beliefs, practices, challenges, and motivations regarding science instruction?

This study of novice elementary teachers' perceptions of science instruction may provide some insights on ways to support elementary teachers in learning best instructional practices about science. The study is framed through the lens of Constructivist Theory (Bruner, 1960), and delves into two novice teachers' perceptions about science instruction. Bruner's Constructivist Theory was chosen as the lens for this research due to the correlation to the Next Generation Science Standards (NGSS) released in final draft form in February from the National Science Teachers Association (2013). It is hoped that, once implemented, these standards will engage students more deeply in science learning, and build science knowledge sequentially beginning in Kindergarten. Bruner's theoretical framework supports the belief that learners construct new ideas or concepts based upon existing knowledge, which is one of the principles defined in the NGSS. Constructivist Theory also aligns with the NGSS when defining the process of learning as active and involving transformation of information, deriving meaning from experience, forming hypotheses, and decision-making. Through Bruner's work, he presented the idea that children could be active problem-solvers and were capable of exploring more difficult subjects of instruction. This narrative study will explore novice elementary teacher's perceptions about teaching science based on Constructivist Theory principles.

**Definition of Terms**

**Constructivist Theory.** Constructivism is a theory to explain how knowledge is constructed in the human being when information comes into contact with existing knowledge that had been developed by experiences. Discovery Learning, hands-on, experimental, collaborative, and project-based are a number of applications that base teaching and learning on Constructivism.

**Constructivist Approach.** An approach to learning based the learners' ability to impose meaning on the world, and so construct their own understanding based on their unique experiences. Emphasis is on discussion and collaboration among a cohort of students to think and solve problems.

**Discovery Learning.** A technique of inquiry-based instruction based on a Constructivist approach to education.

**Full Option Science System (FOSS).** A research-based, inquiry-based science curriculum for grades K-8 developed at the Lawrence Hall of Science, University of California, Berkeley.

**Inquiry-Based Learning.** Describes approaches to learning that are based on the idea that when people are presented with a scenario or problem, and assisted by a facilitator, they will identify and research issues and questions to develop their knowledge or solutions. Inquiry-based learning includes problem-based learning.

**Next Generation Science Standards.** A new set of standards recently developed for science instruction in K-20 classrooms. These standards are arranged in a coherent manner across disciplines and grades, to provide all students with an internationally benchmarked science education. These standards are based on the *Framework for K-12 Science Education* developed by the National Research Council.

**Novice Teacher.** Teachers with three years or less teaching experience.

**PISA.** The *Programme for International Student Assessment* is a global study designed to test students' ability to apply skills needed in today's workplace in the areas of science and technology.

**Problem-Based Learning.** A student-centered pedagogy designed to enable students to learn about a subject through experience of problem-solving. Students learn both thinking strategies and domain knowledge.

**STEM fields**. Science, technology, engineering, and mathematics as collective fields of study.

# CHAPTER TWO:  LITERATURE REVIEW

## Overview

This chapter examines the need for improved science instruction in K-20 schools within the United States. Several related issues are examined including the U.S. students' science performance compared to other nations (PISA, 2007), the growing demand for a science-educated work force due to job force changes in the U.S., and the increased international competition for work in science-related fields.  Current practices for meeting national and state science standards in elementary classrooms are presented along with implications for meeting the changes defined in the new Next Generation Science Standards (NGSS). Barriers to delivering quality science instruction in elementary grades are studied including: students' readiness for learning science concepts, physical obstacles to presenting learning by doing, and perceptions by elementary teacher of their competence and attitudes toward teaching science. Demands upon schools with high stakes testing and limited funding add to the challenges of effective science instruction.

Pre-service teacher preparation programs need to redefine their course requirements to meet the need for a growing demand for science-focused elementary teachers.  Misconceptions about students' readiness to learn abstract science concepts serve as possible explanations for the lack of emphasis on science instruction in elementary teacher preparation programs. Rice (2003) commented on the challenges of helping future elementary teachers develop the attitude, self-efficacy, and teaching skills that will allow them to *try* teaching science. Perhaps more discrimination in the selection process for potential elementary science teachers should be required. Rice's findings agree with other researchers' suggestions that a constructivist approach to teaching science results in a deeper understanding of science concept as opposed to reading from a textbook and using worksheets (Rice, 2007). Elements essential for a constructivist model of instruction will be examined and reasons will be presented for utilizing a constructivist framework for analysis of the research questions for this study.

Viewing quality science instruction through a constructivist lens formed the foundation of this research work and is explored within the context of Bruner's (1960) constructivist framework. The work of Bruner (1960) serves as the vehicle for organizing the information and research regarding quality science instruction. In Bruner's *Process of Education* (1960), four emerging themes form the basis for learning: the role of structure in learning and how it may be made central in teaching; readiness for learning; intuitive and analytical thinking; and motives for learning.

There are two major strands of the constructivist perspective: cognitive constructivism and social constructivism. Bruner's early work was based primarily on the cognitive perspective, while his later works expanded his theoretical framework to encompass the social and cultural aspects of learning (Bruner, 1973). The definition of a cognitive structure is the mental processes which offer the learner the ability to organize experiences, and derive meaning from them. These cognitive structures allow the learner to push past the given information in constructing their new concepts. The learner will take pieces of their past knowledge and experiences and organize them to make sense of what they know, then base further concepts and solve additional problems based upon a combination of what they already processed, and what they think should be processed next.

Although different in emphasis, cognitive and social constructivists share the same basic assumption about learning. Jonassen (1994) proposed that there are eight characteristics that differentiate constructivist learning environments. These eight characteristics would be supported by both social and cognitive constructivists. The connections of these characteristics to the NGSS are listed in Table 2 below.

Table 2

*Connections Chart: Constructivist Theory - NGSS*

| **Constructivist Theory (1996)** | **NGSS (2013)** |
|---|---|
| 1. Constructivist learning environments provide multiple representations of reality. | S1. Ask questions & define problems |
| 2. Multiple representations avoid oversimplification and represent the complexity of the real world. | S2. Develop and use models (construct mental and conceptual models of phenomenon) |
| 3. Constructivist learning environments emphasize knowledge construction inserted of knowledge reproduction. | S3. Plan & carry out investigations |
| 4. Constructivist learning environments emphasize authentic tasks in a meaningful context rather than abstract instruction out of context. | S4. Analyze and interpret data |
| 5. Constructivist learning environments provide learning environments such as real-world settings or case-based learning instead of predetermined sequences of instruction. | S5 Use mathematics and computational thinking |
| 6. Constructivist learning environments encourage thoughtful reflection on experience. | S6. Construct explanations & design solutions |
| 7. Constructivist learning environments | S7. Engage in argument from |

| | |
|---|---|
| "enable context- and content- dependent knowledge construction." | evidence |
| 8. Constructivist learning environments support "collaborative construction of knowledge through social negotiation, not competition among learners for recognition." | S8. Obtain, evaluate & communicate information |

Consequences of ongoing poor performance by U.S. students in science will impact the entire economic future of the United States according to the *Gathering Storm Report Revisited* (Augustine, 2007). The importance of improved science instruction beginning at the elementary level is a key step in closing the science performance gap between the U.S. and other countries. Ensuring that pre-service elementary teacher preparation programs provide effective science content knowledge acquisition and increased efficacy in science pedagogy is the first tier to achieving this positive end result (O'Brien, 2010).

**Demand for a Strong Science-Educated Workforce**

The STEM crisis in the United States was brought to the forefront when the President's Council of Advisors on Science and Technology submitted the report, *Prepare and Inspire K-12 Education in Science, Technology, Engineering, and Math (STEM) Education for America's Future* (2010). The Council of Advisors on Science and Technology recommend a two-pronged strategy for transforming K-12 education. The first part is to prepare students with a strong foundation in science and teach students to apply knowledge in their personal and professional lives. Secondly, students need to be inspired and motivated to study science in school thus becoming anxious to pursue careers in science fields. The study was the result of decades of testing results that show

American students falling behind students from other industrialized countries in the areas of math and science. The *Programme for International Student Assessment* (PISA, 2009), a study designed to test students' ability to apply skills needed in today's workplace in the areas of science and technology, shows U.S. students performing below most other nations. The U.S. ranking of 15-year-old students has fallen to 17th in science among the 34 participating developing nations (National Science Board, 2010). Similarly, on the 2007 *Trends in Math and Science Study* (TIMSS), American 8th graders overall ranked 11th out of 48 nations, and were outranked not only by Singapore and Japan, but also by the Czech Republic, Hungary, and Slovenia. Even more distressing, only 10% of American 8th graders scored at or above the TIMSS "advanced" level. By contrast, 32% of students in Singapore reached that level (Gonzales, 2007).

In 2005, the National Academies conducted a review of United States' competitiveness in the rapidly evolving global marketplace, and offered specific actions that could be taken by federal policymakers to ensure the nation's position as a prosperous member of the global economy of the twenty-first century. The report, *"Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*" (2007) concluded that America was in danger of losing its economic leadership position, and suffering a decline in the standard of living of its citizens due to the possible inability to compete for jobs in the future in a global marketplace. Many of the recommendations that emerged from this report were focused on K-12 science education. Included in these findings was the strengthening of skills of current teachers in the area of science through workshops and other professional development opportunities. A second recommendation was to provide scholarships as incentives for individuals to pursue a science core degree accompanied by a teaching certificate (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2007).

Of all the nations surveyed by the National Science Foundation (2007), the United States ranked in the bottom 15 of the 93 nations studied, just ahead of Bangladesh, Cambodia, and Cameroon, of the percent of college graduates who receive degrees in engineering. These staggering figures provide implications for a need for change in science teacher training. In U.S. universities, temporary visa holders are more likely to earn a doctorate in a Science and Engineering (S&E) field than are doctorate recipients who are U.S. citizens or permanent recipients. Over the period 2001 to 2011, 84% of the doctorates earned by temporary visa holders were in S&E fields, compared with 63% of doctorates earned by U.S. citizens and permanent residents. Steve Jobs is said to have told President Obama that the reason Apple employs 700,000 people outside the United States is because it could not find 30,000 engineers in the U.S. (Isaacson 2012, p. 546). According to the National Academies Press (2007), China today graduates more English-trained engineers than does the United States.

**Science in K-12 Schools**

A solid science education program begins by clearly establishing what students need to learn about this multi-faceted domain of human knowledge (Lerner, Goodenough, Lynch, & Schwarz, 2012). The first step is setting clear academic standards which not only articulate the critical science content students need to learn, but also properly sequence and prioritize that content (Lerner, et al., 2012). The *National Science Standards* that were developed in 1996 by the National Research Council (NRC) were created to spell out "a vision of science education that will make a scientific literacy for all a reality in the 21st century." (p. 9). The release of the *Standards* was the culmination of an extensive process of consensus-building which served as a driving force behind improvements in U.S. science education. States and districts responded by adopting new science standards which included a focus on inquiry in the science classroom. Inquiry-based instruction is a term used throughout the *Standards* to stress the importance of scientific investigation (NRC, 1996). However, these *Standards* differentiated standards for science content and standards for science inquiry, which has since become a criticism of these *Standards*. Since that time, due to increased research on how students learn science and better ways of teaching science (NAP, 2013), science standards are again being revised through *A Framework for K-12 Science Education* (NRC, 2013). The *Framework* proposes a new approach to K-12 science education in hopes of capturing students' interest, and providing students with necessary foundational knowledge in the field. The *Framework* is grounded in the most current research on science and science learning, and identifies the science all K-12 students should know. Based on findings outlined in the *Framework*, the *Next Generation Science Standards* (NGSS) bring these findings into fruition. In the NGSS standards, student performance expectations include a student's ability to combine practice and content knowledge, thereby focusing more on understanding as seen through application, as opposed to memorization of facts devoid of context. The *Framework* focuses on the importance of the integration of science content knowledge with the practice of science inquiry. The teacher's role will require a paradigm shift from the traditional presenter of science content information to a facilitator enabling students to use techniques associated with inquiry science. This aligns with Bruner's Discovery or Constructivist Learning where essentially the standard classroom procedure is turned upside down with no lectures, no demonstrations, or no presentations (Cooperstein & Kocevar-Weidinger, 2004). Constructivist learning dictates that the concept follow the action rather than precede it; the concepts do not lead the activity. From the beginning, students engage in activities through which they develop skills and acquire concepts.

One of the major updates to the NGSS from guidelines in the *Framework* is the merging of three defined dimensions of science: (1) Science and engineering practice, (2) Crosscutting concepts, and (3) Core ideas. Past science standards at both the state and district levels have treated these dimensions as separate and distinct entities leading to preferential treatment in assessment or instruction. The merging of these dimensions, according to *Achieve* spokesperson, Stephen Pruitt (2013), is critical to ensure that students understand how science permeates modern life. Pruitt gives the example of changing a battery in a cell phone; the attitude about science in our culture needs to change; science is part of everyday living (Pruitt, 2013).

The following six conceptual shifts in the NGSS demonstrate what is new and different about NGSS. The table below also aligns the NGSS with theories of Bruner's Constructivist Theory in the empirical research from which they derive, and in practice the applications to which they can be put.

Table 3

*Connections Chart: NGSS–Bruner's Constructivist Theory*

| **NGSS (2013)** | **Bruner's Constructivist Theory (1966)** |
|---|---|
| K-12 Science education should reflect the interconnected nature of science as it is practiced and experienced in the real world. | *Personalized: instruction should relate to learners' predisposition, and facilitate interest toward learning.* |
| The Next Generation Science Standards are student performance expectations – NOT curriculum. | *Personalized: instruction should relate to learners' predisposition, and facilitate interest toward learning.* |
| The science concepts in the NGSS build coherently from K–12. | *Sequencing: sequencing is an important aspect for presentation of material.* |
| The NGSS focus on deeper understanding of content as well as application of content. | *Content Structure: content should be structured so it can be most easily grasped by the learner.* |
| Science and engineering are integrated in the NGSS, from K–12. | *Sequencing: sequencing is an important aspect for presentation of material* |
| 6. The NGSS and Common Core State Standards (English Language Arts and Mathematics) are aligned. | *Content Structure: content should be structured so it can be most easily grasped by the learner.* |

The revision of science standards appears to be timely. "The bar is almost always set too low," according to the report *Taking Science to School: Learning and Teaching Science in Grades K-8* (page VII) on the goals for science teaching to elementary students. The purpose of *Taking Science to School* was to synthesize what is known about how children in grades Kindergarten through $8^{th}$ grade learn the ideas and practice of science. The charge to this committee was to answer three broad questions: (1) How is science learned, and are there critical stages in children's development of scientific concepts? (2) How should science be taught in K-8 classrooms? (3) What research is needed to increase understanding about how students learn science? The resulting conclusions challenge the science education community, and question the priority of science in elementary schools. The findings show that the organization of current science curriculum and instruction in elementary schools does not provide the kind of support for science learning that results in deep understanding of scientific ideas, along with the ability to engage meaningfully in the practices of science. Four strands of scientific proficiency are presented that address the knowledge and reasoning skills which students must eventually acquire to be considered fully proficient in science. The study suggests that these strands of science proficiency are interwoven; not independent or separable in the practice of science. Taken together, these strands lay out broad learning goals for students.

The strands of science proficiency are:

1. Know, use, and interpret scientific explanations of the natural world.
2. Generate and evaluate scientific evidence and explanations.
3. Understand the nature and development of scientific knowledge.
4. Participate productively in scientific practices and discourse.

These strands suggest that teaching content alone does not lead to proficiency in science, nor does engaging in inquiry experiences without meaningful science content. The first strand of utilizing a child’s prior knowledge for explanations for the natural world align with Bruner’s first characteristic of effective instruction that emerged from his theoretical construct, which states that instruction should relate to learners' predisposition. While young students bring much with them to the classroom from their preschool years, they launch into quite extraordinary expansions of their knowledge and understanding between kindergarten and grade eight (BOSE, 2007). Understanding how their knowledge growth unfolds and can be supported requires an appreciation of the connections with earlier forms of understanding. Although young children's understandings of the world may contradict scientific explanations, and these conceptions about the natural world can pose obstacles to learning science, skilled elementary teachers can use a child's prior knowledge to build on in order to develop understanding of scientific concepts and ability to engage in scientific investigations (Clement, Brown, & Zeitsman, 1989). Thus, children's prior knowledge should be taken into account when designing instruction in strategic ways that capitalize on the leverage points, and adequately address potential areas of misunderstanding. Hollins (2010) believes that the most important aspect of teaching and learning is how well the teacher knows the learner, stating that teachers need to know learners as individuals; as members of social and cultural groups, as learners with particular characteristics; and as learners as a particular point in their academic, emotional, psychological, and social development (p. 397).

Good and Brophy (2004) define four aspects of constructivist lessons that align with the new NGSS. These include: (1) Learners construct their own meaning, (2) New learning builds on prior knowledge, (3) Learning is enhanced by social interaction, and (4) Meaningful learning develops through "authentic" tasks (p. 341). Essentially, the instructor presents the problem and lets the students go.

The survey attached to the NAEP Report Card (2011) found students of teachers who reported including hands-on activities most frequently scored higher than those who seldom did hands-on projects in class. This is consistent with Ernst (1994) who states that elementary teachers need to provide opportunities to their students to experience science with a hands-on process in order for students to understand science concepts. Ernst research on the inadequacy of elementary teachers' preparation programs led to recommendations that teacher preparation programs should develop a strong science content foundation, provide opportunities to observe quality science teaching, and provide opportunities to experience the inquiry-based process.

Chiappetta and Adams (2004) researched four aspects of inquiry-based instruction to help teachers conceptualize to use inquiry in the classroom. These include teaching through content, content with process, process with content, and process alone. Their study found that a combination of content and process is best, as opposed to isolating content from process or process from content when presenting science instruction. By combining the two aspects, students achieve solid science knowledge while also applying the scientific approach to learning through process. This approach is a critical component in the NGSS (2013), and consistent with Bruner's Constructivist Theory (1960).

Chiappetta and Adams (2004) suggest five values that can result from *content with process* instruction:

1. Understanding of fundamental facts, concepts, principles, laws, and theories.
2. Development of skills that enhance the acquisition of knowledge and understanding of natural phenomena.
3. Cultivation of the disposition to find answers to questions, and to question the truthfulness of statements about the natural world.
4. Formation of positive attitudes toward science.
5. Acquisition of understanding about the nature of science.

Despite novice elementary teachers entering classrooms often lacking science subject matter expertise (O'Brien, 2012), there is a growing belief that rigorous science instruction should begin at the elementary level. Murphy (Vogel, 2009), asserts if the

United States is to maintain its economic power, then a STEM-educated workforce is needed that can meet the demands of business in an increasingly complex and technology-driven economy. Murphy notes that STEM education needs to begin early with children; as early as elementary school, and possibly even younger.

> Children at birth are natural scientists, engineers, and problem-solvers. They consider the world around them and try to make sense of it the best way they know how: touching, tasting, building, dismantling, creating, discovering, and exploring. Yet, research documents that by the time students reach fourth grade, a third of boys and girls have lost an interest in science. By eighth grade, almost 50 percent have lost interest or deemed it irrelevant to their education or future plans. At this point in the K–12 system, the STEM pipeline has narrowed to half. That means millions of students have tuned out, or lack the confidence to believe they can do science. (Vogel, 2009, p. 2)

Ellen Kullman, member of President Obama's Council on Jobs and Competiveness, and Chair of the Board and Chief Executive Officer of DuPont, is an advocate for early intervention of strong science instruction at the elementary level. She states her concerns in an interview in Bloomberg's *Businessweek* in August 2012:

> We as a country have done a lot to enable opportunities around science. We're not educating our kids to take advantage of it. And it doesn't start in high school; it starts in grade school. It starts with a science curriculum in grade school that's relevant to the kids' world, which is a lot different than when the science curriculum was actually written, which was decades ago. . . It's got to be part of the core curriculum…. Because by the time a kid gets to eighth grade, it's almost too late. (Zhymoowitz, Carol. "Ellen Kullman on Her Grand Scheme for DuPont." Businessweek.com, 10 Aug., 2012, online publication.)

Augustine (2005) in *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, agrees that waiting until high school or even middle school is too late to create a desire for science professions in students. At one time, Augustine stated that eighth grade was the turning point for students to choose a career in a science field; he now states that fourth grade or earlier is the pivotal year. At the height of a student's interest in science in the elementary years, students are not encouraged but discouraged from showing an interest in these fields. The elementary teacher's lack of knowledge in science may lead to the teacher not promoting or encouraging students to learn science or understand the importance of those subjects (Augustine, 2008).

Perhaps understanding or lack of student's readiness to learn abstract concepts impacts science instruction in elementary levels. Past beliefs that young children are unable to engage in abstract thinking and reasoning have been proven false by contemporary research which shows young children are capable of reasoning processes that are foundational to scientific thinking (Zembal-Saul, 2009).

The National Research Council in, *Taking Science to School (NCR, 2007),* report found the following:

> The commonly held view that young children are concrete and simplistic thinkers is outmoded; research shows that children's thinking is surprisingly sophisticated. Yet, much current science education is based on the old assumptions, and so focuses on what children cannot do rather that what they can do. Contrary to conceptions of development held 30 or 40 years ago, young children can think both concretely and abstractly (p. 3).

Bruner (1960) came to this same conclusion when he argued that schools wasted a great deal of time by postponing the teaching of important areas that require abstract thinking because they are deemed "too difficult." According to Bruner, any subject can be taught effectively in some intellectually honest form to any child at any stage of development.

**Pre-Service Teacher Preparation**

New views of proficiency in K-8 science that emphasize engaging children in the discourses and practices of science have raised the stakes for elementary teachers, and the teacher educators who prepare them. Suggestions in this paper for the need of earlier intervention of strong science instruction at the elementary level pose even greater challenges on pre-service teacher preparation programs. Minimal science course requirements for novice elementary teachers in pre-service programs are coming into question, along with the structure and make-up of teacher science methods and content courses. Creative college programs are emerging in universities across the U.S. to offer alternatives to meeting the challenges that the need for more rigorous science instruction presents. Elementary education majors at St. Catherine' (St. Kate's) are required to complete a STEM certificate for initial licensure (Vogel, 2009). The certificate is three interdisciplinary courses in biology, chemistry, and physics/engineering. The courses are co-taught by science and education faculty team members who collaborate to create a positive and productive learning environment for teachers-in-training. Content is academically rigorous and meets state and national standards. In addition, these elementary education majors receive STEM teaching experience prior to their student teaching assignment in the university's unique Eco-STARS partnership program. Eco-STARS includes training, mentoring by teachers at partner schools, and supervision by university education faculty to provide effective feedback. St. Kate's elementary majors emerge from this experience more confident, and comfortable in teaching science. In fact, many of them are being asked in their student teaching assignment to teach science and engineering.

A similar program is offered at the College of New Jersey (TCNJ) in their MST (Math, Science, Technology) Major (O'Brien 2010). This program developed from the belief that K-5 school years are crucial, setting the framework for all subjects including science, as well as critical thinking skills. O'Brien (2010) found that the number of K-5 teachers that are educated with a science specialization is substantially underrepresented. Therefore, the MST Major was developed. An interesting component of TCNJ's program is the inclusion of a teacher context in all science courses in the program. These courses are based on Benchmarks for Science Literacy ("Project 2061") (American Association for the Advancement of Science, 1993).

Elementary science teacher educators have begun to emphasize engaging preservice teachers in the evaluation and use of science curriculum materials as one means to more explicitly emphasize preservice teachers' analysis and engagement in science teaching practice (Beyer & Davis, 2009a; Davis, 2006; Dietz & Davis, 2009; Forbes & Davis, 2008, 2010a; Gunckel, 2011; Schwarz et al., 2008). This research has made important contributions to the field's collective understanding of how preservice elementary teachers learn to plan with, and enact science curriculum materials, as well as how curriculum materials and curriculum-focused teacher education experiences can be designed to promote preservice teachers' learning.

Conventional preservice teacher preparation programs have been criticized for consisting of weak pedagogy, lack of articulation among courses and field experiences, and general fragmentation (Zeichner, 2006). The requirements of elementary education teacher preparation programs vary by state. However, typical K-5 teacher preparation programs, including Colorado, require few science methods and content courses. The majority of Colorado teacher education programs require one science content course, and one science methods course to complete an elementary (K-6) teaching licensure program. It is important for teacher preparation programs to meet the minimum standards set by the National Council for the Accreditation of Teacher Education (NCATE), but more is needed to prepare candidates for quality teaching (Hollins, 2011). On February 15, 2013, the Council for the Accreditation of Educator Preparation (CAEP) Commission on Standards and Performance Reporting released draft recommendations for the next generation of accreditation standards for educator preparation programs. The goal of these standards is to raise candidate quality, build partnerships for strong clinical experiences, meet challenging levels of performance, and insist that preparation be judged by outcomes and impact on P-12 student learning. During the transition to these CAEP standards, programs seeking accreditation will have the option to use NCATE or TEAC (Teacher Education Accreditation Council) standards.

The lack of novice teachers' content knowledge base, coupled with their high anxiety and low self-efficacy, can lead to low teacher effectiveness in the classroom and lack of interest in science by K-5 students (Wilkins, 2008; Beilock, 2010). Moscovici (1999) found the majority of prospective elementary teachers did not feel qualified to teach inquiry science due to both their lack of training in this area in their preparation program, as well as their weak background in science content knowledge. If new teachers coming into the teaching field are prepared with the tools to instill the problem-solving, critical-thinking, and authentic learning that needs to be developed beginning in Kindergarten, our young people will begin their educational experience with a different mindset of what it means to learn. The school principal may need to take on the additional responsibility of providing the necessary professional development to their teachers to gain the necessary tools to deliver effective science instruction. By closely observing teachers and taking time to monitor their effectiveness in the classroom, a school principal can have a major impact on the future of science education in the United States of America.

**Change Initiatives**

The Next Generation Science Standards (NGSS) through the NRC's Framework have raised the bar for changes in science instruction and performance assessments in U.S. schools. The NGSS describes two goals for K-12 science education: (1) educating all students in science and engineering, and (2) providing the foundational knowledge for those who will become the scientists, engineers, technologists, and technicians of the future. The first goal takes into account what all students should know in preparation for their individual lives, and for their roles as citizens in the technology-rich and scientifically complex world (NRC, 2013). It is important to realize the wording of this goal includes "all students". As reported in *Taking Science to School,* all young children come to school with the capacity to engage in serious ways with the enterprise of science. This puts additional demand on elementary teachers coming into the classroom, and on the educational systems that prepare them.

Constructivist learning is often expressed in a variety of terms including inquiry learning, problem-solving, collaborative learning, and many others. Bruner's original theme in his theoretical framework is that learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. The learner selects and transforms information, constructs hypotheses and makes decisions, relying on a cognitive structure to do so (Bruner, 1960). It is the challenge for elementary science teachers to weave these constructs into their daily instruction in all disciplines, but especially in the area of science.

**Summary**

At no time in history has improving science education been more important than it is today. The strength of the United States economy is intricately linked to the strength of the U.S. education system. With major policy debates around alternative energy sources, nuclear waste, and carbon dioxide emissions it requires a scientifically informed workforce that is skilled and equipped for success in the global marketplace. Yet, after 15 years of focused standards-based reform, improvements in U.S. science education are modest at best, and comparisons show that U.S. students fare poorly in comparison with students in other countries (PISA, 2009).

Current views that support early intervention of a strong science education foundation are becoming more popular. As evidenced by the growing number of university programs that require a science minor or some type of STEM certification in their elementary teacher preparation programs, a stronger science foundation is needed for elementary education teachers. When industry leaders concur that to spark a student's interest in science, meaningful instruction needs to begin at the elementary level; our current educational system warrants review. Examining science instruction through a constructivist lens indicates that the emphasis for improved science instruction needs to be placed on the process of learning as much as teaching of content. This is consistent with the Next Generation Science Standards that are raising the bar for science instruction in the future. Through a collaborative process managed by Achieve—with input from the National Science Teachers Association, the National Research Council, and the American Association for the Advancement of Science—the NGSS are rich in both content and practice, and are arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education.

The U.S. government has long been aware of the failing science scores that U.S. students receive on international testing, compared to other countries (NSF, 2007). Many initiatives, research studies, and in-depth reports have been conducted offering suggestions for improving the current situation. The most recent, the Obama administrations' *Blueprint for Reform of the Elementary and Secondary Education Act* (*Blueprint*) is encouraging, given the connections to Bruner's Constructivist Theory and to the Next Generation Science Standards. The *Blueprint* provides over $1 billion in grants to states and school districts, including $300 million specifically for competitive science-targeted grants (U.S. Department of Education, 2010). These grants are to be used to develop high-quality instruction in science by supporting the transition to higher standards for science programs. The recommendations in the *Blueprint* also allow for grants to higher education teacher preparation programs that promote additional science instruction in graduation requirements. The *Blueprint* also sets standards for states to include within their state assessment and accountability requirements for their districts and schools for inclusion of a strong science curriculum. States may receive additional funding for programs that align with the mandates of the *Blueprint*. The chart below highlights the connections of the *Blueprint* which are consistent with either the Next Generation Science Standards or Bruner's Constructivist Theory:

Table 4

*Consistency between-the Blueprint, Bruner's Constructivist Theory, and Next Generation Science Standards.*

| **Blueprint Recommendations (2012)** | **Bruner's Constructivist Theory (1966)** | **NGSS (2013)** |
|---|---|---|
| **Targeted supports for teachers and schools—**Grants will be given to enhance science instruction for college readiness | Instruction should relate to learners' predisposition, and facilitate interest toward learning | |
| **Fostering innovation—** Investing in Education grant will focus on STEM projects | | K-12 Science education should reflect the interconnected nature of science as it is practiced in the real world |
| **Enhancing partnerships—** Supports partnerships between schools and science industry corporations | Instruction should relate to learners' predisposition, and facilitate interest toward learning | |
| **Improving assessments—** Improved assessments to include assessing of student's problem-solving and higher-order thinking skills | | The Next Generation Science Standards are student performance expectations |
| **Other subjects in accountability systems--**States will be allowed to incorporate science in their accountability systems Schools and districts will be held responsible for providing students with a broader education | | The NGSS and Common Core State Standards are aligned/K-12 Science education should reflect the interconnected nature of science as it is practiced and experienced in the real world |
| **Recognition and rewards—** Rewards offered to great science teachers | Rewards and punishment should be selected and paced appropriately | |
| **Strengthening preparation programs—**Increased funding | Content should be structured so it can be most easily | |

| | | |
|---|---|---|
| available to programs focusing on science | grasped by the learner | |
| **Relevant professional development and collaboration time—**Funding available for working together time for science teachers especially in the area of content development | Content should be structured so it can be most easily grasped by the learner | The science concepts in the NGSS build coherently from K–12/<br>Science and engineering are integrated in the NGSS, from K–12 |

# CHAPTER THREE: METHODOLOGY

## Background and Research Questions

The purpose of this narrative study was to examine two novice elementary teachers' perceptions of their ability to teach science, considered through the lens of the Constructivist Theory (Bruner, 1960).

The study employs a theoretical framework using Bruner's (1966) Constructivist Theory of Learning. This study examines the following research question:

> What are the perceptions of two novice elementary teachers' beliefs, practices, challenges, and motivations regarding science instruction?

A major theme in Bruner's theoretical framework is that learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. Bruner's work emphasized the importance of understanding the structure of a subject being studied, the need for active learning as the basis for true understanding, and the value of reasoning in learning. His Constructivist Theory is a general framework for instruction based upon the study of cognition. In Bruner's Constructivist Theory, learners engage in discovery learning, obtaining knowledge individually. Learners transform information, construct hypotheses, and make decisions, relying on a cognitive structure to do so. In order for discovery to occur, learners require background preparation in the form of a cognitive structure that provides meaning and organization to experiences, and allows the individual to go beyond the information that was presented to them.

Bruner emphasized teaching as a means of enhancing cognitive development; hence, the task of the teacher is to translate information to be learned into a format appropriate to the learner's current state of understanding. The instructor should try and encourage students to discover principles by themselves, and both learners and teachers should engage in an active dialog. Curriculum should be organized in a spiral manner so that the student continually builds upon what they have already learned. Bruner (1966) states that a theory of instruction should address four major aspects:

1. Predisposition towards learning.
2. The ways in which a body of knowledge can be structured so that it can be most readily grasped by the learner.
3. The most effective sequences in which to present material.
4. The nature and pacing of rewards and punishments.

Good methods for structuring knowledge should result in simplifying, generating new propositions, and increasing the manipulation of information.

**Research Design**

Clandinin and Connelly (2000) term narrative inquiry as stories lived and told; a way of understanding experience.  They describe the process as:

> “. . . a collaboration between researcher and participants, over time, in a place, and in social interaction with milieus. An inquirer enters the matrix in the midst and progresses in this same spirit, concluding the inquiry still in the midst of living and telling, reliving and retelling, the stories of experiences that make up people’s lives.” (p. 20)

Bruner (1986) uses narrative as an important means for discovering how we *construct* our lives. This narrative study is designed to discourse with two novice elementary teachers, relating to their perceptions about teaching science, including employing a constructivist approach. By looking critically and reflexively at these narratives, new voices or ideas may emerge.

Bruner (1996) argues that story-making is central to creating an understanding of the world into which a person can feel they will fit. He claims that all cultures have logical-scientific and narrative forms of thinking, and that not all cultures honor these two aspects in the same way. Bruner believes narrative thinking needs to be analyzed, understood and described on occasions, perhaps, using logical-scientific forms of thinking to carry out the analysis of the narrative data. This narrative study will strive to understand two novice teachers' perceptions about their beliefs, practices, challenges, and motivations regarding science instruction by tapping into their personal experiences.

Data were gathered from personal interviews with two selected novice elementary teachers using an interview guide approach (Johnson & Christianson, 2004) to increase the comprehensiveness of the data, and make data collection somewhat systematic for each respondent. First, organized data of the recorded interviews were put into digital files; then transcripts of interviews were formatted with ample margin space for notes. Saldana's (2013) coding methods were used to organize the data. His *In Vivo Coding* was selected for the first coding cycle method, a method appropriate for studies that prioritize and honor the participants' voice followed by Dramaturgical Coding to categorize the responses into six categories of character analysis. For the second cycle coding method, Saldaña’s *Focused Coding* was selected to discover emerging themes to provide insight into the perceptions of two elementary teachers’ beliefs, practices, challenges, and motivations regarding science instruction.

**Participants**

This study was conducted in one metropolitan school district in Colorado. A teacher in each of two schools was selected; one with a focus on STEM (science, technology, engineering, and math) to eliminate barriers that a school may have toward the importance of science instruction at the elementary level. It is possible that a STEM-focused school may employ teachers with a stronger science background or interest. The second school was a regular, public elementary school with no specific vision or mission outside of providing a solid public education. Permission was obtained from the district’s central office through an identified research application requirement process. Written permission was received from the school principal, including a request for recommended participants based on the specific criteria (Appendix B). The request for participation and letter of consent teacher (Appendix C) was given to and collected from teachers prior to the interviews. This letter clearly stated the confidentiality agreement. The University of Denver Institutional Review Board’s (DUIRB) approval of the study was obtained.

A purposive sample of two teachers was used. The two regular classroom elementary teachers were selected, based upon the recommendation of the school principal.  The criteria included:

- *The teacher is a novice as a teacher with one to three years teaching experience*—Cheri, was in her second year of teaching first grade and at

STEM focused school and, Olivia was in her third year of teaching, in her second year of teaching fourth grade at a regular public school.

- *The teacher is not on a performance plan, meaning they are in good standing.* Both Cheri and Olivia were highly recommended by their respective principals as candidates who have exhibited quality science instruction in the classroom in the opinion of the principal.
- *Teachers received their teacher training from an accredited higher education teacher preparation program. Teachers selected completed their teacher training from an accredited college teacher preparation program in order to establish a similar level of preparedness*. Both teachers graduated from accredited undergraduate university teacher preparation programs, and are now in their Master's degree programs at different colleges of education.

## Instrumentation

**One-on-one teacher interviews**. While most narrative inquiries begin with telling stories to a researcher who is interviewing, or having conversations with participants who tell stories of their experiences, "a more difficult, time-consuming, intensive, and yet, more profound method is to begin with participants' living because in the end, narrative inquiry is about life and living" (Connelly & Clandinin, 2006, p. 478).  Therefore, a series of interviews was the instrument chosen in this study to provide in-depth information about the participants' perceptions of science instruction. An interview guide approach was used (Johnson & Christianson, 2004) to increase the comprehensiveness of the data, and make data collection somewhat systematic for each respondent. An interview protocol

(Appendix A) was used with the topic and issues to be covered in outline form, with the flexibility to decide sequence and wording of questions in the course of the interview. Topics and issues covered were specified in advance, with each interview session tied to a specific area of research. Interviews remained conversational and situational. The interviews were conducted in a comfortable, quiet, and safe location mutually decided between the interviewee and the interviewer. Interview sessions were digitally recorded and later transcribed. Four sessions, each approximately 90 minutes in length, were conducted for each interview. A pilot, modified interview took place with one novice elementary teacher to check for clarity of questions, estimated length of time, and quality of descriptors. This pilot interview participant teacher was a convenience sample that mirrored the same criteria as the selected study sample in order to achieve constructive feedback. Interviews were digitally recorded, transcribed, and analyzed for emerging themes based on similar concepts.

Clandinin and Connelly (1994) describe four directions that should occur in any narrative inquiry or interview process. These four directions provide the researcher with the ability to research an experience simultaneously by asking questions pointing in different directions. These four directions include: *inward and outward*, *backward and forward*. Inward includes feelings, hopes, aesthetic reactions and moral dispositions. Outward includes existential conditions such as the environment. Backward and forward refers to the past, present, and future. By interviewing only two participants, this researcher was able to ask questions, collect field notes, derive interpretations, and write a research text that addresses both personal and social issues by looking inward and outward to the two participants while also addressing temporal issues by looking not only to the current perceptions of science instruction but to its past and to its future.

For the first session, the first six questions were designed to capture the essence of the participant's background, beliefs and feelings about teaching in general. It was the desire of the researcher to gain insights into these two teacher's beliefs about teaching in general, then specifically, science instruction. Beilock's (2010) research of new teachers' possible high anxiety levels coupled with low self-efficacy leading to low teacher effectiveness prompted questions seven and eight. Findings from the report, *Taking Science to School: Learning and Teaching Science in Grades K-8*(page VII) prompted question nine. The results of the report challenged the science education community. According to the report, the organization of current science curriculum and instruction in elementary schools does not provide the kind of support for science learning that results in deep understanding of scientific ideas, along with the ability to engage meaningfully in the practices of science. The last question inquiring about the teacher's preservice training was triggered by Moscovici's (1999) research, which found the majority of prospective elementary teachers did not feel qualified to teach inquiry science due to both their lack of training in their preparation program as well as their weak background in science content knowledge.

These questions were asked of both interview participants during the first interview session:

1) Tell me about your road to becoming a teacher.
2) What other professions, if any, did you consider?

3) In three words or short phrases, describe your teaching experience thus far.
4) What do you enjoy best about teaching?
5) What do you enjoy least about teaching?
6) Tell me about your memories of receiving science instruction in elementary school? Middle school? High school?
7) Tell me a story about your experience teaching science to young children.
8) Describe any challenges you have faced teaching science in elementary school.
9) Describe your school's philosophy about science instructing, including materials provided, methodology suggested, time allotted, and support provided.
10) Tell me about training that you received in your teacher preparation program, peer mentoring, professional development, conferences, or other areas that you received in regards to science instruction for elementary students.

For the second session, the following questions were designed to capture the essence of the connections between the teacher's beliefs and practices of her science instruction with Bruner's Constructivist Theory and the Next Generation Science Standards (NGSS) (Table 1, p. 4). These questions were asked of both interview participants:

1) What comes to mind when I say, "constructivist learning"?
2) Tell me about your experiences, if any, as a student receiving instruction/training using a constructivist approach.

3) Tell me about your experiences and/or methods as a teacher for the following:

   a) Gathering background information from learners concerning predispositions about new science materials that will be presented to students.

   b) Encouraging students to discover learning for themselves.

   c) Allowing time for dialog between teacher and students during discovery time.

   d) Structuring a body of science knowledge so that it can be most readily grasped by the learner.

   e) Sequencing science material effectively for understanding by students.

   f) Including formative assessments for student feedback.

   g) Assessing student understanding of concept.

The third session included the following questions to gain a deeper understanding of the teachers' backgrounds. Questions one and two were designed to address comments made by Norm Augustine, one of the authors of *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (2005).* Augustine states that in order for students to become interested in science, the spark must be triggered by the time the student reaches fourth grade. These questions regarding the teachers' backgrounds assisted in determining if family influence contributed to an earlier interest in science. Question four also evolved from this statement to inquire into the teacher's motivations about science instruction. The third question is in response to the President's Council of Advisors on Science and Technology report, *Prepare and Inspire K-12 Education in Science, Technology, Engineering, and Math (STEM) Education for*

*America's Future (2010)*. The STEM crisis in the United States was brought to the forefront by this report, so it seemed appropriate that a question should be asked of teachers regarding their awareness of this STEM crisis. The remainder of the questions for this session was inspired from the Next Generation Science Standards which describe two goals for K-12 science education: (1) educating all students in science and engineering, and (2) providing the foundational knowledge for those who will become the scientists, engineers, technologists, and technicians of the future.

The third session consisted of the following questions:

1) Please talk about your background and growing up, i.e. rural or urban setting, schools attended, family dynamics, interests, hobbies, etc.
2) Have any family members pursued a science-related profession? If so, please expand.
3) What does the term STEM crisis in American mean to you? What do you see your role, if any, in this "crisis"?
4) Do you feel compelled to create a love for science discovery in your students? If so, is this your own passion or something that comes from your school administration or district? What additional tools or training would help you to better achieve this goal?
5) Describe your feelings about the time devoted to science instruction in your school day compared to the time devoted to literacy.

6) Please talk about the science units you will be teaching this year. What do you hope the "take-away" from your students will be for each of the units? What is the "big idea" for each unit?
7) What background knowledge do you bring to the table about the science content involved within these units?
8) What preparations have you done personally, as a team, and/or as a school to prepare to teach these lessons? Please describe in as much detail as possible the format for these preparations.

The fourth session was a review of the information that was gathered from the first three sessions to check for clarity and correctness of information provided. With the use of in Interview Guide Approach (Johnson & Christianson, 2004) the researcher had permission to decide the sequence and wording of questions in the course of each interview. Complete transcripts were reviewed with each teacher for clarity and correctness. A copy of these transcripts is included in Appendix E.

**Data Analysis**

**Interviews.** Data gathered from interviews were coded using Saldaña's (2013) *In Vivo Method* for first cycle coding. *In Vivo*, or "literal coding" enabled the voices of the teachers to be heard. Each *In Vivo Code* was enclosed in quotation marks to keep track of the codes that were participant inspired rather than researcher generated. A second first cycle coding was applied, *Dramaturgical Coding*, to approach the interview narratives as "social drama" (Saldaña, 2013). By adding this additional analysis of the responses to the interview questions, this researcher was able to better attune to the perspectives of each participant.  The interview transcripts were coded into six categories of character analysis by listing and reflecting on the: objectives, conflicts, tactics, attitudes, emotions and subtexts.     Saldaña's *Focused Coding* was selected for second cycle coding to allow connections to emerge for the teachers' beliefs, practices, challenges, and motivations regarding science instruction.  *Focused Coding* along with memo writing allowed this researcher to discover emerging themes.  From these themes emerged the two teachers' perceptions of their beliefs, practices, challenges, and motivations about science instruction. The transcripts were read over numerous times to get a sense of the whole story, while noting insights that emerged.

**Statement of Researcher Bias**

As a veteran educator, this researcher participated in science instruction in the classroom as an elementary teacher for nine years, a K-8 school principal for nine years including five years as the founding principal of a K-8 STEM focused school. Any bias toward support of a specific methodology or beliefs about what constitutes quality science instruction is unintentional.  Personal biases were controlled for by using clearly outlined processes for gathering and analyzing data. Three different coding devices were purposely utilized to prevent any unintentional biases from emerging.

**Timeframe for the Study**

The study began in the spring of 2013. Coordination with school district officials, principals and elementary science teachers under study began in May 2013 with completion of interviews by August of 2013. Data analysis of the interviews began after the recordings were transcribed. Follow-up involved sharing the transcripts with the teachers to clarify or expand on their interview answers. Final data analysis was completed in September 2013.

## Confidentiality and Other Ethical Concerns

For purposes of this study, the names of the selected teachers, schools, and districts have been changed to maintain confidentiality. Principals and teachers in the school were provided with a project information sheet. Teachers were guaranteed confidentiality. Only the researcher has access to participant identity.

## Limitations

The purpose of this narrative study was to understand novice elementary teachers' perceptions about science instruction. The perceptions of two teachers are not representative of all elementary teachers, and the experiences of these teachers may not be representative of other novice elementary teachers who teach science. The study was limited to a public school district in Colorado and two teachers, and the results cannot be generalized to any district, school, or other teachers.

## Summary

This narrative was designed to study novice elementary teachers' perceptions of science instruction. A qualitative design was used, including interviews with two teachers, to explore these perceptions. Data gathered from interviews were coded using Saldaña's (2013) *In Vivo Coding* and *Dramaturgical Coding* for first cycle coding followed by Saldaña's Focused Coding for the second cycle coding. The researcher began with coding each incident in the data with In Vivo Codes in the participant's own words, followed categorizing the responses to the six categories of character analysis in

Dramaturgical Coding. This researcher's memo writing serves *as a code- and category-generating method* (Saldaña, 2013). By weaving codes and categories within the narrative allowed trial and error to occur rather than set preconceived categories. Dey (2007) reminds us of the integrated nature of theory-building process by advising that we "do not categorize and then connect; we connect by categorizing" (p.178). Findings are presented in Chapter 4 to capture the essence of the novice elementary teachers' perceptions of science instruction. A discussion of these findings occurs in Chapter 5.

# CHAPTER FOUR: FINDINGS

This narrative study was designed to understand the professional stories of two novice elementary teachers' perceptions of science instruction. A qualitative approach allowed the researcher to capture their stories through a series of one-to-one interviews. The researcher sought to identify themes that emerged through the stories of two novice elementary teachers. This narrative study was framed by the following research question: What are the perceptions of two novice elementary teachers' beliefs, practices, challenges, and motivations regarding science instruction?

Two teachers who received their teacher training from an accredited college or university and were in good standing with three years or less of classroom teaching agreed to participate in this study. These two teachers were also recommended from school principals within the participating district for demonstrating a strong interest in science instruction in their respective school. For reporting purposes, pseudonyms have been assigned to the participants to maintain confidentiality.

Twelve hours of interviews were digitally recorded, and the researcher transcribed each interview. The two teachers were given the pseudonyms: Cheri and Olivia. A brief profile and the full narratives of each teacher are presented below. After the researcher constructed the narratives from the transcribed interviews, she coded the stories utilizing both first and second coding methods. The researcher started by coding each incident with an In Vivo Code (Saldaña, 2013) to capture the participants' actual words followed by Dramaturgical Coding to categorize the responses to the six categories of character analysis. This character analysis assisted in capturing connections, if any, between each teacher's perceived practice of science instruction and the inclusion or lack of inclusion of the strands of science proficiency which lay out the broad learning goals for students. Finally, Focused Coding (Saldaña, 2013) was applied to capture emerging themes from the data. The organized data charts along with the themes and unique elements that emerged from these categories are presented after the narratives.

**Participant Profiles**

Cheri appeared excited and honored to have been recommended to participate in this study. Cheri taught first grade in a STEM-focused school in a Colorado suburb. Cheri was in the process of pursuing her masters in math and science curriculum. She was one of five teachers on the first grade team. Her school had a high ELA (English Language Acquisition) population, and 95% of the students qualify for free or reduced price lunch. The forty-five different languages spoken at Cheri's school posed challenges to communication with parents as well as to instruction and state test scores. However, these challenges along with other trials did not seem to deter Cheri from expressing a very positive attitude toward teaching. Her love for students and the profession became clear during the conversations with the researcher. Comments throughout the interview such as, "This is a fun place to work," "I enjoy watching kids learn new things," and "I was just trying to have fun with the kids," were common. Cheri's answers to the interview questions were succinct and direct. She seemed very honest and open to sharing her perceptions as a novice teacher with this researcher.

Olivia taught fourth grade on a team of six teachers in a suburban, public, year-round school, in the same school district as Cheri's school. However the school community had a much different make-up. ELA was less than 5%, English was the predominant language, and the parents were very involved in their children's education, "sometimes to a fault" according to Olivia. At Olivia's school, test scores were some of the highest in the district. Olivia went into great detail in her responses to the interview questions, openly stating her strong opinions about science instruction and teaching in general. Olivia shared her goal of one day moving into school administration.

**Cheri's Story**

Cheri's story began in the same school district in which she would eventually teach. She attended the neighborhood public school with her only recollections of elementary science class being dissecting owl pellets and watching chicks hatch. She sadly recalls that the unfortunate chicks that didn't hatch were picked apart for scientific discovery. Later, Cheri excelled in high school science, taking all AP science classes. She credited her success in high school science to a specific chemistry teacher who gave her the right amount of encouragement. Cheri added that she wasn't the smartest student in the class but the teacher had the ability to know when to drive her to delve deeper into certain content areas. Cheri's parents both worked in professional fields unrelated to science. According to Cheri, she and her brother were always expected to attend college, which they both did. Her initial interest was to pursue an economics degree with the intention of working in non-profit organizations around the world. However, a part-time job in a before/after school program hooked Cheri on the idea of becoming a teacher.

Cheri described the joy she discovered while working with young children in this position. After only a few short months at this job, Cheri made the decision to become a teacher and went on to receive her degree in teaching.

Cheri described her method of determining success in her work as influencing the growth of the whole child. Cheri viewed her work at a STEM school as a plus in making a difference in the lives of her students. She believed the emphasis on science instruction in her classroom as contributing in a small way to the STEM crisis in America by hopefully encouraging her students to consider science professions in their futures.

Cheri considered science at the center of the life skills that all students need to be successful in the future. She gave the example of students' investigations during science period as establishing the lifelong skills of problem solving, team building, critical thinking and collaboration. She viewed teaching these skills as important in making a difference in the lives of her students.

Cheri described her classroom, with its range of student reading levels from basic recognition of letters to high fluency of above grade level material, as an exciting and challenging opportunity. She gave the example of one student who came to her class knowing only five words and left reading at grade level, an accomplishment of which she was proud and from which she gained deep job satisfaction. Cheri stated that she spends a great deal of time gathering background information from her students to see where they are coming from before she ever begins a new unit. She asserted that her students' understandings regarding certain topics can be quite diverse and often requires a great deal of clarification before students are ready to truly comprehend the new information.

Cheri described this challenge as one that she especially enjoys planning to meet, by striving to be creative to reach each student at his or her level of understanding. Cheri stated that she often starts with basic vocabulary, getting very creative with the introduction of new words, which is especially helpful to her ELA students even though it may be a review for some. She was quick to add that all students enjoy the vocabulary games and activities she designs to make the learning fun.

Cheri described the students who are “the expert on everything” and how she allows these students space to explore independently. She stated that she meets with these independent learners individually to discuss their learning and answer any questions they may have regarding their research. She also described how she allows class time for these students to share their information with classmates, which she notes is a bonus opportunity to strengthen the child’s presentation skills.

Cheri conveyed that her own love of science may enhance her science instruction. She noted the advantage of the one hour of science instruction that is required every day and realized that this is a luxury not enjoyed by most elementary school teachers. Her school’s STEM focus enabled this extended science period. She stated that she designates this time for students to explore somewhat independently in order to discover learning for themselves. She indicated that she follows her Full Option Science System (FOSS) curriculum manual and gives students prompting questions to steer them in the direction of the learning objectives for each unit. Cheri believed the FOSS system benefits new teachers by providing a detailed teacher’s guide. New to these science units, Cheri found the FOSS program helpful in delivering the basic instruction, however, she discovered that it is necessary for her and her teammates to supplement the program to take students to a deeper level of understanding. She believed that kids learn best by exploring, commenting that, "The kids won't understand the lesson if I just sit there and talk. It's more of what they notice and want to talk about." Cheri's classroom was set up in table groups, which she says allows her to go around to each cluster, asking each student a question about their investigations. She added that her students who are still struggling with the English language may need more individual attention which this configuration allows her time to do.

Cheri stated that she tries to meet all learning styles in her instruction. She gave an example of an insect unit where she had her students "act out" the different stages of an insect's life. She allowed her students to come up with ways to express how they would look and act if in the larva stage of an insect's life. Cheri felt that this was a great activity for her kinesthetic learners and would often hear them say later, "Oh yeah, that's what I did when I was a larva."

Cheri believed that her students' science notebooks are another way for her to check on individual student's needs and understandings. She commented that she reviews these regularly and addresses any concerns she has with a student immediately, to clear up any misunderstandings. Cheri also uses the final, culminating project at the end of each unit as an assessment of each student's understandings of the big picture.

Cheri stressed the importance of students' understanding that science is more than "what we do at school." She viewed this challenge common to all elementary teachers of enlarging student's definition of the meaning of science. She believed that students will look at science careers as much more vast than traditionally thought. Cheri stressed the processes of science as being as important, if not more so that the content itself. She believed that if students understand that science means investigating, problem-solving, critical thinking, and collaboration and not just studying a list of topics, then students will not stereotype science careers or science professionals to fit in a small box.

Cheri believed that her students need to know that there is not just one way to do science; that science in not just experiments or observations, but the whole of everything is science. She stressed her message to students that science doesn't answer all of the questions and that it changes all the time. Cheri believed that this understanding needs to start in Kindergarten for students to truly understand what science means. Cheri utilized the open lab available to her at the nearly high school, which she believed expanded her students' horizons of what science is all about.

**Olivia's Story**

Olivia's story began in Ohio where she grew up, and attended public schools until fifth grade when she and her mom relocated to Colorado. Olivia enjoyed reading and spending time with her grandparents, and she credited explorative adventures with her grandfather for her love of science. Olivia's recollections of science in elementary school included an egg drop activity, and making "something" to look through to see an eclipse of the sun. She recalled science being a lot of fun in elementary school and driven by whatever the teacher enjoyed doing. Olivia also remembered doing Invention Convention, but not much else. Olivia's mom was a working mom who did not have a lot of extra time to help her with her schoolwork. Olivia believed that due to her mom not having a college degree, her mother made it a point to stress the importance of education and especially of receiving a college degree. Olivia felt it was her own self-motivation to get her school work completed and to continue on through college. She credited this need for independence at a young age a great benefit as an adult. Olivia commented that this self-direction aids her in the teaching profession; to use Olivia's words, "If you are not going to do it for yourself, no one is going to do it for you!" Like Cheri, Olivia did not begin her college career in education. Olivia was pursuing a Psychology degree with expectations of becoming a therapist in a medical facility. It was during an internship in her senior year that Olivia began to question her decision. She describes her impact on the lives of her patients as less than fulfilling. After undertaking volunteer work at a school with young children, she discovered teaching to be more satisfying. She changed majors and completed the necessary coursework to graduate with her teaching credentials then went on to secure her elementary teaching license. Looking back, Olivia commented that this decision was a reflection on her outstanding high school science teachers who instilled a love for learning. Olivia described her science classes as challenging but worth the academic investment of time and energy. She believed her passion for science instruction grew from these classes and the teachers. It is now her goal to become a teacher who can impact students in a similar manner. Olivia sensed that teaching is a career that she stumbled upon, but feels confident it was truly her calling.

Success in her job as a teacher was described by Olivia in terms much broader than higher TCAP scores or report card grades. There emerged in Olivia's story a strong life skill focus, on equipping students behaviorally as well as academically for their futures. Olivia's described her goal of creating an exploratory classroom to be used by her students as a doorway to support student growth in all areas. Her desire was to create much more in her students in the areas of self-confidence, critical thinking, problem solving and team building. Olivia highlighted various ways of connecting with her students and measuring success in a variety of ways, outside of grades and test scores. While Olivia articulated commitment to an academic priority, she was clear that her role extended beyond academics. Olivia expressed a strong desire to educate the whole child, stating that she speaks to them often about going to college and their future ambitions.

Olivia was attracted to the teaching profession with the hope of making a difference in the lives of children. She stated that her decision to change from a Psychology major in college with the ambition to be a therapist, to that of an Education major with the goal to become a classroom teacher, was ignited by her experience as a volunteer in an elementary school. She stated that she immediately felt the sense of purpose she was seeking in a profession and felt fortunate that she now had the opportunity to impact her students' lives every day in a positive way. In her own words, Olivia explained, "I just like watching the kids in general when they get something. Not necessarily the content, but when they get how important to be organized, how important to do your best . . . watching them acquire all of these skills that will make them successful later. I talk to them all the time about college and they think I'm crazy because they are only nine, but what they don't understand is that they have all these skills now, when the material gets harder, they won't struggle so much. I love imparting how important education is to them, even in $4^{th}$ grade, because some of them don't have someone telling them that at home. So that is my favorite part of teaching."

Olivia's school implemented the character program by Stephen Covey, *The Leader in Me*, where one of the 7 habits includes, "Begin with the end in mind." Olivia stated that she tells her students that their end plan will go further than fourth grade or high school or even college. Olivia's goal was to consistently encourage her students to think farther into the future by making every day count. Olivia's passion for making a difference in the lives of her students was evidenced throughout the conversations with this researcher.

Olivia believed that it is her job to challenge students to take risks. She conveyed that she loves having parent help in the classroom however she believes parents are reluctant to let their student fail. She strongly felt that students can learn from their mistakes as confirmed by a poster on the wall in her classroom which states: "Our most successful moment comes from our biggest failure."

Olivia was quick to add that in order to challenge all students with inquiry-based or problem-based learning the key for the teacher is to gather as much background information as possible in order to understand where each student is coming from, in order to keep them moving on. For example, Olivia stated that she begins each unit with a KWL (Know, Wonder, Learn) chart with students, where they respond in a group setting then also individually in their science notebooks. Olivia shared that she reviews these writings to take a pulse of each student's background knowledge and discover ways to challenge each student individually. Olivia admitted taking advantage of her school's gifted and talented teacher to assist in designing projects for students who have already mastered the objectives of the unit, to encourage them to dig deeper into the topic.

Olivia described another method of challenging individual students through interactions with their peers. Olivia stated that she spends a great deal of time discussing effective group procedures and practices for meaningful teamwork and collaboration. Discussions about and modeling of effective listening techniques with appropriate questioning and commenting can add to a student's growth according to Olivia. She stated that she encourages all students to share during group investigations, reminding them that every comment is important and may be something that others have not considered. Olivia stated that she constantly walks around the room during group discovery time to ensure that all students feel comfortable sharing within their table group.

Olivia had positive comments about the new Common Core Standards for math, reading, and writing that her school district has recently implemented. Although science standards have yet to be included, Olivia believed these new standards are forcing teachers, in a positive way, to encourage students to think more critically in all subject areas. She had confidence that as these standards are implemented in the younger grades, students will have the confidence needed to take risks to share new ideas out loud in the classroom.

Olivia shared that the need for a broader view of science needs to come from the top down. She believed that science needs to be incorporated into all areas of instruction, but she concurred that until the legislators alter testing requirements and teacher performance evaluations, the focus in schools will continue to be reading and math, totally separate from science. Olivia perceived science as promoting greater higher level thinking than reading, writing, and math. She believed when students study science there is a puzzle that must be solved, which automatically brings critical thinking and problem solving into play. She indicated that she constantly tells her students that "there are no right or wrong answers" if you have the evidence to back up your answer. She pointed out that she extends this same philosophy to other areas, to encourage students to think critically in all subject areas.

Olivia compared teaching science in a regular classroom to teaching cooking in a bare room as opposed to a kitchen. Again, Olivia referred back to legislators and other decision makers who make high level decisions for school design and allocation of monies. To quote Olivia, "People outside of education and their perspective of what success looks like in the classroom are very different from what success looks like to the teacher. But they are the ones who evaluate us and they are the ones who sadly drive our educational system when they are not actually involved in it. That is very hard for me."

**Combined Data and Emerging Patterns**

The next step of *In Vivo* coding, required careful analysis attuning to words and phrases that appeared to call for highlighting, bolding, or emphasis if spoken aloud. These key phrases were listed from each teacher and noted in the data analysis organizer for the first cycle coding. These words or phrases were then reanalyzed as possible dimensions of categories and placed into one of the six categories or codes of *Dramaturgical Coding*: Objectives, Conflicts, Tactics, Attitudes, Emotions, and

Subtexts. The "objectives" included not only what the teacher wanted to do but what she wanted other people to do. The "attitudes, emotions, and subtexts" provided clues to the internal perspectives of the teachers during certain situations. The second cycle coding, *Focused Coding*, was then applied to categorize the data into the four areas of the research question:

> What are the perceptions of two novice elementary teachers' beliefs, practices, challenges, and motivations regarding science instruction?

Each dramaturgical code was color coded as a belief, practice, challenge, or motivation regarding science instruction. This regrouping allowed the researcher a fresh look for commonalities to determine emerging themes. Five overlapping patterns emerged from analysis of the beliefs, practices, challenges, and motivations including: up to teacher to lead students, teacher must be an expert in science content, students need to be involved in the learning, teaching can be overwhelming, observing students learning is fun.

**Up to teacher to lead students**

The first pattern that emerged was the idea that it was up to the teacher to lead or direct students. Both teachers expressed this in session one, interview questions 10 and 11; in session two, interview questions 3b and 3d; and session three, interview questions 4 and 6. Cheri expressed a desire to let her students explore on their own but at the same time she wanted them to use the correct vocabulary as they explored, thus feeling the need to lead them. Cheri also described the need to prompt her students as they were observing, stating that, "…using prompting, trying to get them to go in the direction I want them to go. So we do insects, I say to them, look at the bodies, look at their legs, what about this or that; prompting them to where I want them to be." Olivia also described the need for her to lead discussions when she described use of focus questions to "get their minds going." Both Cheri and Olivia credited the FOSS program with providing the necessary tools to guide their students through each lesson, stating that they followed the program with fidelity. They considered this a benefit, especially for new teachers to ensure that all material was presented correctly. Although limited, the training presented for delivering the FOSS curriculum to teachers was appreciated by Cheri and Olivia. Cheri expressed the need to add to the FOSS curriculum to add depth for teaching critical thinking skills but still maintained the structure of the FOSS curriculum was a well-developed program. Beginning with focused discovery time questions to a structured formative assessment program, FOSS provides a format that is followed closely by both teachers.

**Teacher must be an expert**

A second pattern that emerged from the interviews was the belief from both participants that the teacher must be the expert in all science concepts being taught. Interview questions 9, 10, & 11 from session one, questions 3d and 3g from session two, and questions 7 & 8 from session three included comments from both teachers on the importance of knowing the content of the material they would be teaching. Olivia stated that her fourth grade team takes the FOSS kit post-test for each science unit prior to instructing to ensure a thorough understanding of the material. She felt this was necessary to guarantee her ability to answer any questions that might be asked during her instruction. Olivia's comment of, "I go through the manual with a fine tooth comb" illustrated her commitment to understanding the material as thoroughly as possible prior to providing instruction. She also commented that, “If you don’t prepare for FOSS you will fail.” Olivia strongly believed that if the teacher is not able to explain concepts to students it will be hard for students to understand the true meaning.

Cheri also commented on the need to understand the totality of the science concepts to be taught to her students. She noted that her masters’ class in science instruction emphasized the importance of elementary teachers’ understanding of concepts through the high school level in order to provide correct information to students. Cheri stated that her professors “. . . pushed the content as well as how to teach it.”

The importance of student participation in science instruction was a theme throughout the interviews. Especially in the answers to interview questions in session two which focused on the methodology of teaching science to elementary students. In question 3b regarding engaging students to discover learning for themselves, Cheri described the boy who was an “expert in everything” and the need to allow him time to explore and “figure out what he wants to figure out.” Even with the leading that she provides to students, Cheri still maintained that students need time to explore with the freedom to share observations and ideas. She described her classroom arrangement of table groups in order to ensure that she can interact with every student to allow them time to share an observation or ask a question.

Olivia’s comment “If all students are doing is following my directions, how are they supposed to develop the desire to learn?” expresses her belief of the need for student involvement in learning. With the caveat of utilizing the leading questions provided in her FOSS manual, Olivia stated her desire for students to express their discoveries with peers to learn from each other. She commented on her desire to teach students to problem solve with each other to learn to work collaboratively. Olivia stated that she encourages her students to explain their thinking process out loud to help themselves and each other.

**Teaching can be challenging**

As evidenced in interview session 1, question 6, "What do you enjoy least about teaching," the two novice teachers expressed a sense of frustration with the many duties that are required of elementary classroom teachers. Parent concerns, state testing, limited space and time, meetings, and learning material to be covered were just a few of the concerns. Question 9 in the same session, "Describe any challenges you have faced teaching science in elementary school" generated a common answer of "lack of time!" This was in reference to the time needed for preparation, set-up and clean-up, and actual discovery/teaching time. This was verified in and session three, question 5 about the amount of time devoted to science instruction. Even though Cheri's school mandates an hour a day for science instruction, she still feels challenged to cover all required material. Olivia feels even more challenged with her 45 minutes allowed for science and not necessarily every day. Olivia expressed the necessity of extra time needed to thoroughly review the background material provided in FOSS to adequately prepare for delivering the curriculum.

**Observing students learning is motivating**

When asked in session one, question 5, “What do you enjoy best about teaching?” Cheri and Olivia shared their delight in watching their students have fun while learning. Olivia expressed her willingness to “put up with chatter” to allow students to have fun working together in groups. As a first grade teacher, Cheri commented on the satisfaction of watching the tremendous growth that her students achieved in just one year. Especially in science instruction, Cheri described the excitement she observes while students are allowed hands-on time with living things. Both teachers felt that science was an especially great subject matter for students to enjoy and have fun.

These five emerging patterns were reflected on in relation to the research question, relevant literature, the theoretical framework of constructivist learning, and my experience as a principal of an elementary school. Three fundamental themes resonate from within the five patterns that provide a comprehensive understanding of the lived experience of the two participants. These three global themes are: learning, leading, and motivating. By analyzing these three themes, the research question of, “What are the perceptions of two novice elementary teachers’ beliefs, practices, challenges, and motivations regarding science instruction?” can be determined. Better understanding novice teachers’ views will help educators and school leaders better consider how to support novice teachers in improving their teaching of science. Descriptors from the interview transcripts that define these themes are listed Table 5 and then discussed below. These themes will be discussed further in Chapter 5 for the relation to the data, research question, literature, and theoretical framework.

Table 5

*Global Themes*

| Theme | Descriptors |
|---|---|
| Learning | "This year I felt that I was learning as I went."<br><br>"I am actually working on my masters in math and science, so the math class I took this summer talked a lot about constructivist learning."<br><br>"They (FOSS) have a couple of pages of background information that the teacher can read to give background information to the teacher before teaching to the students."<br><br>"The teacher believed we needed to understand everything that we are going to teach our kids beyond high school."<br><br>"In my Nature of Science class we have definitely talked about that there is not just one way to do science. It's not just experiments, not just observations, but the whole everything that is science."<br><br>"So that one I had to study because I never really studied insects in depth."<br><br>"There is professional development for each unit."<br><br>"Our team does everything as a team, so we talk about what we are going to do each day in science."<br><br>"We were all very stressed about taking on a new FOSS kit."<br><br>"I came into education when everything was changing; it's still changing."<br><br>"There is never enough time in the day to get everything done."<br><br>"I am spending so much time doing paperwork that I miss connections with the kids."<br><br>"We go through each investigation, they pull everything out to show you want you might want to set up in advance." |

| | |
|---|---|
| | "For this unit, we trained for 2 hours.""I could never teach it unless I sat down and went through that thing six times."<br><br>"We as teachers take the post test and compare to see what we know and frankly there are some questions on there I can't answer automatically.'<br><br>"That is something that I was always taught in my teacher prep program."<br><br>"I find myself getting frustrated when they don't understand it." |
| Leading | "So you say, 'here, explore with this for a bit.'"<br><br>"With our science lessons we will do a lot of group conversations before we start to find out what they already know about it and where they are at with their understanding of whatever topics we are going to talk about."<br><br>"So it was just pushing the ones that need the pushing and letting the ones explore what they wanted to explore with the topic."<br><br>"I still guide what they need to know."<br><br>"Definitely using prompting, trying to get them to go in the direction I want them to go."<br><br>"So I say to them, 'look at their (insects) bodies, look at their legs, what about this or that . . . prompting them to where I want them to be."<br><br>"The kids won't understand the lesson if I just sit there and talk. So it's more of what they notice and want to talk about."<br><br>"I make sure each student tells me something about what they are noticing about what we are doing."<br><br>"I never accept an answer without asking, 'why?'" |

| | |
|---|---|
| | "I talk to them all the time about college."<br><br>" . . . explaining things to them in a way they understand and makes sense; that's not over their heads."<br>"I always do  KWL chart on the subject because it is the easiest thing for me to do a quick gauge on what they know, what they want to know, and what they learned."<br><br>"I try to use a lot of real life examples to explain why we need to thing this way."<br><br>"I push the a lot."<br><br>"I try to encourage them to explain their thinking to someone else." |
| Motivating | "Watching their growth is just very fun to do."<br><br>"Science is my passion.  It is a lot easier to teach if you enjoy it."<br><br>"My class is lucky because we just go 14 new Nooks donated to us."<br><br>"It (science) is just a fun subject for them to get into non-fiction texts."<br><br>"I am a teacher because I love education."<br><br>"I think it's satisfying because you see the kids learning and growing and you feel like you are doing something and making a difference."<br><br>"I feel really good when I go home after a lesson that works."<br><br>"I just like watching the kids in general when they get something."<br><br>"I did look around and see that the kids were really so happy."<br><br>"My goal is to make kids realize that hard work can be fun."<br><br>"It's fun to learn new things." |

> "I am taking on the job of science liaison this year because I like science and feel like it is important."
>
> "Since I'm enthusiastic, I want to spark that."

## Emergent Themes

### Learning

As expected from a novice in any profession, each participant described the large amount of new material that was expected in her new role as a teacher. This included general classroom management skills, curriculum content understanding, common teacher duties, time management, and understanding of standards. Specific to science instruction, the teachers shared the usage of the FOSS curriculum, so comparing their perceptions of this program was interesting. Both teachers stated a goal of following the program with fidelity but added that a great deal of learning on their part was required to accomplish this end. A sense of being overwhelmed with the amount of learning in so many different areas was expressed by both novice teachers.

### Leading

Both teachers felt a responsibility to be the leader in the classroom during science instruction. As the teacher, Cheri and Olivia both expressed a definite sense of responsibility to direct their students in the correct direction to achieve the outcome listed in their science program. Despite references to allowing students time to explore and discover learning on their own, an underlying premise to keep the exploration defined and within parameters was evident.

### Motivating

Motivating was the third theme given to describe the positive experiences, joys, and job fulfillment that each teacher expressed in their new role as a teacher. Even in the midst of describing a concern or problem they were facing in their daily routine, both Cheri and Olivia were each quick to add a positive comment about the excitement of watching their students learn and have fun in the classroom. This theme of motivating applied both to the teachers' new experiences as a teacher as well as the affect she was having on her students.

**Summary**

This study examined the perceptions of two novice elementary teachers' beliefs, practices, challenges, and motivations regarding science instruction. The emergent patterns were: up to teacher to lead students, teacher must be an expert in science content, students need to be involved in the learning, teaching can be challenging , observing students learning is motivating. Each of these patterns was discussed in relation to the interview responses. From these patterns, three themes emerged: learning, leading, and motivating. Learning referred to both knowledge acquired around teaching methods and curriculum content information. Leading referred to the teacher's role as the person in charge of directing the learning taking place in the classroom. Motivating was the third theme given to describe the positive experiences that the teacher experienced in her new role as well as the affect she had on her students' learning. In Chapter Five I will discuss and interpret the data and provide an analysis of the connections to the literature and research question. Recommendations for further research will be provided.

# CHAPTER FIVE: DISCUSSION

## Introduction

According to the National Science Foundation (2007), the United States of America educational system is not sufficiently preparing Kindergarten through high school students in science. According to Spencer and Walker (2011), the elementary school is the most effective level for intervention leading to improved attitudes, higher achievement and increased access in science. This early intervention must be delivered by qualified elementary teachers who have both the science content knowledge, and the necessary instructional skills to teach science effectively to young children (O'Brien, 2009). To examine this topic, the following research question was posed: What are the perceptions of two novice elementary teachers' beliefs, practices, challenges, and motivations regarding science instruction?

Through responses to probing interview questions, two elementary teachers spoke out about science instruction. Their interviews were recorded and transcribed. Chapter 4 described the method used to analyze the data through coding for narrative studies. This coding enabled themes to emerge that help to define the teachers' beliefs, practices, motivations, and challenges regarding science instruction.

## Learning

Cheri's and Olivia's desire to have a solid foundation in the science content they are responsible to teach to their students supports the highest priority of the National

Academy of Science (2010) to place teachers in every classroom qualified to teach the subjects they teach (p.27). Spencer and Walker (2011) also believe that early exposure to science material must be delivered by qualified elementary teachers who have both the content knowledge and instructional skills to teach science effectively. A tailored learning experience, the second principle of discovery learning, requires a teacher who is confident in the science content to assist students in discovering developmentally appropriate information. Even with a strong science background, both Cheri and Olivia still find it necessary to devote a great amount of time to independent study for their own knowledge and understanding of the concepts before teaching.

One caution that should be considered in these two novice teachers' belief that they must be the expert in all science content areas may be their lack of confidence. For new teachers to admit the need to learn with their students may be unsettling to them. Novice teachers should realize that they will continue to be lifelong learners even in their new role as a teacher. The school principal should be the constant reminder to the novice teacher of this fact. Novice teachers need to know that it is acceptable if students add understanding to their own knowledge base in a particular content area. This confidence in allowing the student to discover learnings that are new to the teacher could also be helpful in the teacher's new role of facilitator.

**Leading**

Constructivist learning dictates that the concept follow the action rather than precede it; the concepts do not lead the activity. From the beginning, students engage in activities through which they develop skills and acquire concepts. Without defining their style of teaching, each of the novice teachers described in detail their methodology for science instruction, as well as their personal beliefs about what constitutes effective science teaching. Coincidentally, these *beliefs* align with constructivist learning including gathering students' background knowledge prior to beginning a new science unit, allowing time for independent and group exploration, providing targeted questioning strategies as students construct their own understandings, a tailored plan for instruction to ensure dissemination of relevant science content knowledge, and providing motivating materials and tasks to engage students in their own learning. While I believe both teachers sincerely trust their teaching is meeting all of these criteria, their dependence on a set curriculum (FOSS) appears to be adding a rigid structure that prohibits the free form that is associated with true constructivism. Bruner clearly states that standard classroom procedures are turned upside down with no lectures, no demonstrations, or no presentations (Cooperstein & Kocevar-Weidinger, 2004).

In the NGSS standards, student performance expectations include a student's ability to combine practice and content knowledge, thereby focusing more on understanding as seen through application, as opposed to memorization of facts devoid of context. The teacher's role will require a paradigm shift from the traditional presenter of science content information to a facilitator enabling students to use techniques associated with inquiry science. Although both Cheri and Olivia expressed this belief, in practice they both described a structured science program with defined steps for the teacher to follow. While describing the exploration time provided to students to make discoveries on their own, they added the caveat that the FOSS program provides the framework to lead students through these discovery periods. An assumption may be made that the novice teacher's lack of experience and confidence with teaching as well as with the curriculum may be the reason for this dependence on a rigid program. This assumption is supported by Moscovici (1999) who found that the majority of prospective elementary teachers did not feel qualified to teach inquiry science due to both their lack of training in this area in their preparation program, as well as their weak background in science content knowledge.

Good and Brophy (2004) define four aspects of constructivist lessons that align with the new NGSS. These include: (1) Learners construct their own meaning, (2) New learning builds on prior knowledge, (3) Learning is enhanced by social interaction, and (4) Meaningful learning develops through "authentic" tasks (p. 341). Essentially, the instructor presents the problem and lets the students go. This letting go appears to be challenging for both novice teachers. Perhaps additional emphasis in teacher preparation programs for equipping new teachers with the necessary skills to confidently act as a facilitator to instruction in the classroom would help to alleviate this anxiety. In spite of Olivia's comment that she tolerates a higher level of student chatter than many of her peers, references to the structure of experiments, order of steps, prompting of questions and leading by the teacher was evident. Perhaps one can presume that part of this inability to let go may come from the lack of confidence that new teachers often experience in their first few years of teaching. The noise level and perceived confusion can be unsettling for new teachers, especially if an administrator is present.

Research shows that children at birth are natural scientists; they consider the world around them and try to make sense of it by touching, tasting, building, dismantling, discovering, and exploring (Vogel, 2009). Without defining their style of teaching, each of the novice teachers described in detail their methodology for science instruction, as well as their personal beliefs about what constitutes effective science teaching. While clear connections can be made with these beliefs to constructivist learning, the actual practice by both teachers appears to be blurred. Table 2 found in Chapter 2 is reproduced below in Table 18 with the addition of the novice teachers' actual practices inserted to define the similarities/differences to constructivist learning and the Next Generation Science Standards. This information could be beneficial to a school principal to determine if a teacher's classroom practices align with both Contructivist Theory and the NGSS. In the case of these two teachers, it appears that both teachers adhere to a very regimented science program and are not allowing the freedom of discovery to occur in their students that should define a constructivist learning environment as well as adhere to the Next Generation Science Standards.

Table 6

*Classroom Practices*

| **Constructivist Theory (1996)** | **NGSS (2013)** | **Classroom practices as described by the teachers in interview transcripts** |
|---|---|---|
| 1. Constructivist learning environments provide multiple representations of reality. | S1. Ask questions & define problems | Follow FOSS program's guiding and probing questions to direct investigations. |
| 2. Multiple representations avoid oversimplification | S2. Develop and use models (construct | All materials used are supplied in the FOSS kit. |

| | | |
|---|---|---|
| and represent the complexity of the real world. | mental and conceptual models of phenomenon) | These appear to include both construct and conceptual models of the phenomenon. Additional time given for students' construction of mental and conceptual models is unclear. |
| 3. Constructivist learning environments emphasize knowledge construction inserted of knowledge reproduction. | S3. Plan & carry out investigations | Students are encouraged to construct knowledge but within firm guidelines. Construction of learning based solely on background knowledge seems limited. |
| 4. Constructivist learning environments emphasize authentic tasks in a meaningful context rather than abstract instruction out of context. | S4. Analyze and interpret data | Tasks are prescribed in the FOSS curriculum for students to analyze and interpret. |
| 5. Constructivist learning environments provide learning environments such as real-world settings or case-based learning instead of predetermined sequences of instruction. | S5 Use mathematics and computational thinking | All instruction is delivered in predetermined sequences of instruction. Some indication of case-based learning was implied. |
| 6. Constructivist learning environments encourage thoughtful reflection on experience. | S6. Construct explanations & design solutions | Time is given for reflection and discussion of observations with a set goal of pre-determined outcomes. |
| 7. Constructivist learning environments "enable context- and content-dependent knowledge construction." | S7. Engage in argument from evidence | Dialog exchange regarding discoveries is allowed with guiding questions. Both small group and large group discussions for content construction and argumentation appears to occur. |

| | | |
|---|---|---|
| 8. Constructivist learning environments support "collaborative construction of knowledge through social negotiation, not competition among learners for recognition." | S8. Obtain, evaluate & communicate information | Group discussions are encouraged. Physical set-up of classroom environment is conducive to group discussions. |

Cheri's and Olivia's support of the principles of constructivist learning were either implied or directly stated throughout the interviews however when each teacher explained their science block in detail, true constructivist learning was missing. Even though FOSS believes that the best way to learn science is to do science, FOSS' methodology is based on teacher-led instruction. Over the years, the definition of constructivist learning has been distorted to include any inquiry based strategy that is utilized in the classroom. However, the original definition of constructivism includes much more student-directed cognitive structure as opposed to teacher led. Bruner's (1973) definition of a cognitive structure is the mental processes which offer the learner the ability to organize experiences, and derive meaning from them. These cognitive structures allow the learner to push past the given information in constructing their new concepts. The learner will take pieces of their past knowledge and experiences and organize them to make sense of what they know, then base further concepts and solve additional problems based upon a combination of what they already processed, and what they think should be processed next.

Cheri and Olivia each stated a purposeful effort to gather their students' background information prior to beginning a new science unit. This activity follows the constructivist approach however using this information to allow students to base further concepts and understandings was not implied. Rather than allowing each student to independently use their own experiences as a starting place to make sense of what they know, the teachers saw this information as a guide to planning their instruction for the entire group. Cheri stated the importance of this discussion time in her school given the high number of ELA students that may lack the background or knowledge of the subject being taught, however, each student's starting point needs to be where they are at, not where others are beginning. Olivia begins each new unit by putting up a KWL (What they Know, what they Want to know, what they want to Learn) chart on the board to lead the discussion. This discussion would be more in line with constructivism if each student were allowed to complete their own chart however even suggesting that students already have an idea of what they want to learn goes against true constructivism.

**Motivating**

Olivia expressed her aspiration to make a difference in the lives of her students by emphasizing the importance of education when she said, "I am a teacher because I love education. That's what is important to me; to help these kids discover how powerful education can be."

When Cheri described what she enjoys best about educating students, she commented that, "It is so much fun watching the kids learn new things and get excited about it. Just watching their growth is fun to do."

Cheri feels fortunate to teach in a school district that supports STEM education, specifically science instruction, at all grade levels. Within the district, a new IST (Institute of Science and Technology) facility, with state-of-the-art lab equipment geared for middle and high school students, has opened its doors to elementary students at Cheri's school. Cheri noted that this is one of her students' favorite field trip. To walk just a few steps to this state-of-the-art facility allows students to learn from the actual design and maintenance of the building. For example, the ceilings are curved to increase air flow and reflect light around the room. Clever design touches also add to the authentic learning that takes place in the building. The windows of the facility are designed with the 1,1,2,3,5,8 Fibonacci pattern. Geodetic lines of latitude and longitude run through the floors of the building. The north side of the building overlooks the center point of one of the two arcs that form the shape of the building. Allowing students to experience and learn from innovations is encouraging, exciting, and very fun.

**Conclusion and Recommendations for Future Research**

The importance of improved science instruction beginning at the elementary level may be a key step in closing the science performance gap between the United States and other countries. Ensuring that science curriculums based on constructivist learning principles are selected for elementary schools, training to go along with these programs for all teachers is provided, and preparing pre-service elementary teachers with effective science content knowledge acquisition and increased efficacy in science pedagogy could be a first tier to achieving this positive end result.

This study examined the research question:

> What are the perceptions of two novice elementary teachers' beliefs, practices, challenges, and motivations regarding science instruction?

The two teachers interviewed shared their perceptions about teaching science to elementary students. Without labeling their instruction as constructivist learning, Cheri and Olivia each described their beliefs for teaching science with the same principles included in constructivism however their practices did not align with their beliefs. Both teachers follow a structured science curriculum with fidelity, which means that the approach embedded in the science program is transferred to the classroom, which in this case is not constructivism.

Further research involving discussions with other novice elementary teachers about science instruction may shed light on the future of constructivist learning in elementary classrooms. Specifically, research conducted to determine if a positive correlation occurs between constructivist learning and improved science understanding if constructivist principles are implemented beginning in Kindergarten and continue through high school. Related research to determine if the skills of constructivist learning such as critical thinking, are able to transfer to other subject areas, thus allowing inquiry-based learning to take place outside of science time, would be significant.

As individual schools, school districts, states, and country grapple with the stark realities of lagging achievement in science, the components of constructivist learning serve well at every level of the work. Teams working to address the barriers to improving quality science education in America must embrace an awareness of the complexities of the problem, and the contexts in which it continues.

The research reported here suggests a relationship exists between novice elementary teachers' beliefs about quality science instruction and constructivist learning.

However, the teachers' beliefs and their actual practice conflicts. The findings express the perceptions of only two teachers about science instruction. Although this study, due to its small sample size, held no predictive power and its results are not generalizable, the research indicating a positive connection between students' science understanding capabilities and constructivist learning indicates the need for continued research in this area.

If new teachers coming into the teaching field are prepared with the tools to instill the problem-solving, critical-thinking and authentic learning that needs to be developed beginning in Pre-Kindergarten according to constructivist learning theory, elementary students may begin their educational experience with a different view of what "learning" means.

## REFERENCES

Augustine, N. (2008). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. National Academy Press, Washington D.C.

Banilower, E., Cohen, K., Pasley, J., Weiss, I. (2010). *Effective science instruction: What does research tell us? Second edition*, Portsmouth, NH: RMC Research Corporation, Center on Instruction.

Beilock, S. L., Gunderson, E. A., Ramirez, G & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America (PNAS), 107 (5) 1860-1863.*

Bencze, John Lawrence (2010). Promoting student-led science and technology projects in elementary teacher education: Entry into core pedagogical practices through technological design. *International Journal of Technology and Design Education*, 20 (1), 43-62.

Board on Science Education (BOSE) (2007). *Taking science to school: Learning and teaching science in grades K-8.* Center for Education (CFE). Washington, D.C.: The National Academies Press.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2003). *How people learn: Brain, mind, experience, and school.* Washington, D.C.: National Academy Press.

Bransford, J., Darling-Hammond, L., & LePage, P. (2005*).* Introduction. In L. Darling-Hammond & J. Bransford (Eds.), *Preparing teachers for a changing world: What teachers should learn and be able to do. San Francisco, CA:Jossey-Bass.*

Brooks, Jacqueline Grennon (2004). Expert Interview: Concept to Classroom, Educational Broadcasting Corporation.

Bruner, J. (1960). *The process of education.* Cambridge, MA: Harvard University Press.

Bruner, J. (1961). The act of discovery. *Harvard Educational Review*, 31 (1) 21-32.

Bruner, J.S. (1966a). *On knowing: Essays for the left hand.* New York, NY: Atheneum.

Bruner, J.S. (1966b). *Toward a theory of instruction*. Cambridge, MA: The Belknap Press of Harvard University Press.

Bruner, J. (1973). *Going beyond the information given*. New York: Norton. p. 218-222.

Bruner, J. (1996). *The culture of education.* Cambridge, MA: Harvard University Press. p. 224-254.

Bruner, Jerome S., Goodnow, Jacqueline J., and Austin, George A. (1956). *A study of thinking.* New York: Wiley.

Bruning, R. H., Schraw, J. G., Norby, M. M., & Ronning, R. R. (2004). *Cognitive psychology and instruction.* Columbus, OH: Pearson.

Chiappetta, Eugene L., Adams, April D., Inquiry-Based Instruction, *The Science Teacher,* Feb 2004: 71, 2: ProQuest Central Pg. 46.

Clandinin, D. J., and Connelly, F. M., (2000). *Narrative inquiry: Experience and story in qualitative research*. San Francisco, CA: Jossey-Bass.

Clandinin, D.J., and Connelly, F.M. "Personal Experience Methods." In N.K. Denzin and Y. Lincoln (eds.), Handbook of Qualitative Research. Thousand Oaks, Calif.: Sage, 1994.

Clandinin, D. J., Huber, J., Huber, M., Murphy, S., Murray Orr, A., Pearce, M. and Steeves, P. (2006). *Composing diverse identities: Narrative inquiries into the interwoven lives of children and teachers*. New York: Routledge.

Clement, J., Brown, D. E., and Zietsman, A. (1989). Not all preconceptions are misconceptions: Finding 'anchoring conceptions' for grounding instruction on students' intuitions. *International Journal of Science Education, 11*, 554-565.

Colaizzi. P. F. (1978). Psychological research as the phenomenologist views it. In R. Vaile & M. Kind (Eds.). *Existential narrative alternatives for psychology* (pp. 48-71). New York: Oxford University Press.

Cooperstein, S., and Kocevar-Weidinger, E., (2004). Beyond active learning: A constructivist approach. *Reference Services Review,* 32(2), 141-148.

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

Dey, I. (2007). *Grounding grounded theory: Guidelines for qualitative inquiry*. San Diego, CA: Academic Press.

Ejiwale, James A. (2012). Facilitating teaching and learning across STEM fields. *Journal of STEM Education: Innovations and Research*, 13, (3).

Ernst, E.M. (1994). *Improving the preservice science and science education preparation of elementary teachers.* Unpublished dissertation, George Mason University, Fairfax, VA.

Glaser, B.G. & Strauss, A.L. (1967). The Discovery of Grounded Theory: Strategies from qualitative research. New York: Aldine DeGruyter.

Gonzalez, Patrick, (2009). *Highlights from TIMSS 2007: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context,* Washington, D.C.: National Center for Education Statistics http://nces.ed.gov/pubs2009/2009001.pdf.

Good, T. L. and Brophy, J. E. (1994). *Looking in Classrooms.* New York: HarperCollins College Publishers.

Hewson, P. W., A'Beckett Hewson, M. G. (1984). The role of conceptual conflict in conceptual change and the design of science instruction, *Instructional Science*, 13, (1), 1-13.

Hymowitz, C. (2012). Ellen Kullman on Her grand scheme for DuPont, *BloombergBusinessweek: The Interview Issue*, Retrieved from http://www.businessweek.com/articles/2012-08-09

Isaacson, W. (2011). *Steve Jobs,* New York, NY: Simon and Shuster.

Johnson, B., Christensen, L., (2004). *Educational research: Quantitative, qualitative, and mixed approaches.* Boston, MA: Pearson Education, Inc.

Lerner, L. S., Goodenough, U., Lynch, J., Schwarz, M., (2012). *The state of state science standards.* Washington, D.C.: Thomas B. Fordham Institute.

Lock, R. (1990). Open-ended, problem-solving investigations: What do we mean and how can we use them? *School Science Review*, 71(256), 63-72

Merleau-Ponty, M. (1962). *Narrative of perception.(*C. Smith, Trans.). London, England: Routledge & Kegan Paul.

Neufeld, P. (2005). Comprehension instruction in content area classes. *The Reading Teacher*, 59 (4), 302-312.

National Academy of Sciences, National Academy of Engineering, Institute of Medicine, (2007). *Is America falling off the flat earth?* Washington, DC: National Academies Press.

National Academy of Sciences, National Academy of Engineering, Institute of Medicine, (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* Washington, DC: National Academies Press.

National Academy of Sciences (NAS) (2010). *Rising above the gathering storm revisited: Rapidly approaching category 5.* Washington, D.C.: National Academic Press.

National Center for Education Statistics (NCES) (2003). Qualifications of the Public School Teacher Workforce: Prevalence of Out-of-Field Teaching 1987-1988 and 1999-2000. Washington D.C.: U.S. Department of Education 2003.

Nations Report Card (2011). Retrieved from http://nationsreportcard.gov.

National Research Council (NRC). (2000). *Inquiry and the national science education standards: A guide for teaching and learning.* Washington, DC: National Academic Press.

National Research Council (NRC). (2013). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington. D.C.: National Academic Press.

National Science Board http://www.nsf.gov/nsb/meetings/2007/0807/major_actions.pdf

National Science Foundation (NCF). (2012). *Doctorate recipients from U.S. universities: 2011,* Arlington, VA (NSF 13-301).

Nilsson, P., Loughran, J. (2012). Exploring the development of pre-service science elementary teachers' content knowledge. *Journal of Science Teacher Education*, 23(7), 699-721.

O'Brien, S. (2010). Characterization of a unique undergraduate multidisciplinary STEM K-5 teacher preparation program, *Journal of Technology Education,* 21(2) 35-51.

Pasley, J. D., Weiss, I. R., Shimkus, E. S. , Smith, P. S. (2004). Looking inside the classroom: Science teaching in the United States, *Science Educator, Vol. 13, No.1*

Pruitt, Stephen, (2013). *Developing the next generation science standards*, MSP webinar.

Rice, Diana C., Roychoudhury, Anita (2003). Preparing more confident preservice elementary science teachers: One elementary science methods teacher's self-study. *Journal of Science Teacher Education*, Vol. 14, Issue 2, pp. 97-126.

Ross, J. A. (1998). *The antecedents and consequences of teacher efficacy*. In J. Brphy (Ed.), Advances in research on teaching (Vol. 7, pp. 49-74). Greenwich, CN: JAL.

Saldaña, J. (2013). The Coding Manual for Qualitative Researchers. Thousand Oaks, CA: Sage Publications, Inc.

Sikes, P., and Gale, K., (2006). *Narrative approaches to education research*. Retrieved from: http://www.edu.plymouth.ac.uk/resined/.

Singh, K. (2007). Quantitative social research methods. *Reference and Research Book News*, 22(2) Retrieved from http://search.proquest.com/docview/199629110?accountid=14608

Smith, M. K. (2002). 'Jerome S. Bruner and the process of education'. *The encyclopedia of informal education.* Retrieved from: http://www.infed.org/thinkers/bruner.htm.

Spector, B. S., Burkett, R, Leard, C., (2012). Derivation and implementation of a model teaching the nature of science using informal science education venues. *Science Educator,* 21(1) 51-61.

Spencer, T. L., Walker, T. M. (2011). Creating a love for science elementary students through inquiry-based learning, *Journal of Virginia Science Education*, v4, n2.

TIMSS: Trends in International Mathematics and Science Study. (2003). National Center for Education Statistics, Institute of Education Science, U.S.

Vogel, T. (2009). Department of Education. Washington, D.C. Education Associate Dean Tony Murphy ensuring that St.Kate's is 'full STEM ahead', *St Kate's News*, Retrieved from: http:// minerva.skate.edu

Wilkins, J., L., M. (2008). The relationship among elementary teachers' content knowledge, attitudes, beliefs, and practices, *J. Math Teacher Education, 11*, 139–164

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom Practice? *Science Education, 87(1),* 112-143.

U.S. Department of Education, Office of Planning, Evaluation and Policy Development, *ESEA Blueprint for Reform,* Washington, D.C., 2010.

Zembal-Saul, Carla, (2009). Learning to teach elementary school science as argument. *Science Education*, 93(4) 687-719.

Zeichner, K. (2006). Reflections of a university-based teacher educator on the future of college-and university-based teacher education. *Journal of Teacher Education*, 57(3), 326-340.

## Appendix A: Interview Protocol – Session One

| |
|---|
| **Interview Protocol for Project:** A NARRATIVE STUDY OF THE BELIEFS, KNOWLEDGE, MOTIVATIONS, PRACTICES, AND FEELINGS OF NOVICE ELEMENTARY TEACHERS AND SCIENCE INSTRUCTION. |
| **Time of Interview:** |
| **Date:** |
| **Place:** |
| **Interviewer:** |
| **Interviewee:** |

**Questions:**

1) Tell me a little bit about yourself, on your road to becoming a teacher, when you first thought about becoming a teacher, and how you ended up where you are at now.
2) What other professions, if any, did you consider?
3) In three words or short phrases, describe your teaching experience thus far.
4) Please expand on these phrases.
5) What do you enjoy best about teaching?
6) What do you enjoy least about teaching?
7) Tell me about your memories of receiving science instruction in elementary school? Middle school? High school?
8) Tell me a story about your experience teaching science to young children.
9) Describe any challenges have you faced teaching science in elementary school.
10) Describe your school's philosophy about science instructing, including materials provided, methodology suggested, time allotted, and support provided.
11) Tell me about training that you received in your teacher preparation program, peer mentoring, professional development, conferences, or other areas that you received in regards to science instruction for elementary students.

## Interview Protocol – Session Two

| |
|---|
| **Interview Protocol for Project:** A NARRATIVE STUDY OF THE BELIEFS, KNOWLEDGE, MOTIVATIONS, PRACTICES, AND FEELINGS OF NOVICE ELEMENTARY TEACHERS AND SCIENCE INSTRUCTION. |
| **Time of Interview:** |
| **Date:** |
| **Place:** |
| **Interviewer:** |
| **Interviewee:** |
| **Questions:**<br>1) What comes to mind when I say "Constructivist Learning"?<br>2) Tell me about your experiences, if any, as a student receiving instruction/training using a Constructivist approach.<br>3) Tell me about your experiences and/or methods as a teacher for the following:<br>a) Gathering background information from learners concerning predispositions about new science materials that will be presented to students<br>b) Encouraging students to discover learning for themselves<br>c) Allowing time for dialog between teacher and students during discovery time<br>d) Structuring a body of science knowledge so that it can be most readily grasped by the learner<br>e) Sequencing science material effectively for understanding by students<br>f) Including formative assessments for student feedback<br>g) Assessing student understanding of concept<br>h) Developing critical thinking skills |

## Interview Protocol – Session Three

| |
|---|
| **Interview Protocol for Project:** A NARRATIVE STUDY OF THE BELIEFS, KNOWLEDGE, MOTIVATIONS, PRACTICES, AND FEELINGS OF NOVICE ELEMENTARY TEACHERS AND SCIENCE INSTRUCTION. |
| **Time of Interview:** |
| **Date:** |
| **Place:** |
| **Interviewer:** |
| **Interviewee:** |
| **Questions:**<br>**1)** Please talk about your background and growing up, i.e. rural or urban setting, schools attended, family dynamics, interests, hobbies, etc.<br>**2)** Have any family members pursued a science-related profession? If so, please expand.<br>**3)** What does the term STEM crisis in American mean to you? What do you see your role, if any, in this “crisis”?<br>**4)** Do you feel compelled to create a love for science discovery in your students? If so, is this your own passion or something that comes from your school administration or district? What additional tools or training would help you to better achieve this goal?<br>**5)** Describe your feelings about the time devoted to science instruction in your school day compared to the time devoted to literacy.<br>**6)** Please talk about the science units you will be teaching this year. What do you hope the “take-away” from your students will be for each of the units? What is the “big idea” for each unit?<br>**7)** What background knowledge do you bring to the table about the science content involved within these units?<br>**8)** What preparations have you done personally, as a team, and/or as a school to prepare to teach these lessons? Please describe in as much detail as possible the format for these preparations. |

## Interview Protocol – Session Four

| |
|---|
| **Interview Protocol for Project:** A NARRATIVE STUDY OF THE BELIEFS, KNOWLEDGE, MOTIVATIONS, PRACTICES, AND FEELINGS OF NOVICE ELEMENTARY TEACHERS AND SCIENCE INSTRUCTION. |
| **Time of Interview:** |
| **Date:** |
| **Place:** |
| **Interviewer:** |
| **Interviewee:** |
| **Questions:**<br>**1.** Please take your time and review the information I have gathered from our previous meetings to ensure for accuracy and correctness.<br>**2.** Do you see any areas that need further clarification in order to more clearly state the intentions of your answers?<br>**3.** Are there any areas that you feel are misrepresented or need to be altered? |

## Appendix B: Teacher Consent Form

You are invited to participate in a research study entitled A NARRATIVE STUDY OF THE BELIEFS, KNOWLEDGE, MOTIVATIONS, PRACTICES, AND FEELINGS OF NOVICE ELEMENTARY TEACHERS AND SCIENCE INSTRUCTION. This study is being conducted in partial fulfillment of the requirements of dissertation research for the Morgridge College of Education at The University of Denver. The study is conducted by Roberta Harrell. Results will be used to contribute to a better understanding of elementary science instruction and to complete dissertation research. Roberta Harrell can be reached at rharrell8@msn.com or at 303-956-1506. This project is supervised by: Kent Seidel, Ph.D.,, Associate Professor – Education Research, Practice, & Policy, Morgridge College of Education, University of Denver, 346 Ruffatto Hall, 1999 East Evans Avenue, Denver, CO 80208-1700, Voice 303.871.2496, Fax 303.871.4456

Participation in this study should take about 5 hours of your time including approximately 1 hour to preview information and 4 hours of one-on-one interviews. Participation will involve responding to questions about your reflections on teaching elementary science. Participation in this project is strictly voluntary. There are no known risks associated with participation in this research. If, however, you experience discomfort you may discontinue participation in the interview at any time. We respect your right to choose not to answer any questions that may make you feel uncomfortable.

Your responses will be identified by code number only and will be kept separate from information that could identify you. This is done to protect the confidentiality of your responses. Only the researcher will have access to your individual data and any reports generated as a result of this study will protect your identity. However, should any information contained in this study be the subject of a court order or lawful subpoena, the University of Denver might not be able to avoid compliance with the order or subpoena. Although no questions in this interview address it, we are required by law to tell you that if information is revealed concerning suicide, homicide, or child abuse and neglect, it is required by law that this be reported to the proper authorities. If you have any concerns or complaints about how you were treated during the interview, please contact Susan Sadler, Chair, Institutional Review Board for the Protection of Human Subjects, at 303-871-3454, or write the University of Denver, Office of Research and Sponsored Programs, 2199 S. University Blvd., Denver, CO 80208-2121.

You will be provided a copy of this page for your records. Please sign below if you understand and agree to the above. If you do not understand any part of the above statement, please ask the researcher any questions you have. I have read and understood the foregoing descriptions of the study called A NARRATIVE STUDY OF THE BELIEFS, KNOWLEDGE, MOTIVATIONS, PRACTIVES, AND FEELINGS OF NOVICE ELEMENTARY TEACHERS AND SCIENCE INSTRUCTION. I have asked for and received a satisfactory explanation of any language that I did not fully understand. I agree to participate in this study, and I understand that I may withdraw my consent at any time. I have received a copy of this consent form.

___ I agree to be audiotaped ____ I do not agree to be audiotaped
Name (Please print):__________________________________________
Signature: ____________________________________________________ Date: ____________

___________ I would like a summary of the results of this study to be mailed to me at the following postal or e-mail address:
Interview Identification:__________

## Appendix C: Principal Permission Form

### Principal's Consent Form for Research

### I. Research Background

Title of the Study: A NARRATIVE STUDY OF THE BELIEFS, KNOWLEDGE, MOTIVATIONS, PRACTICES, AND FEELINGS OF NOVICE ELEMENTARY TEACHERS AND SCIENCE INSTRUCTION.

Name of Researcher: Roberta Harrell
32 Long Spur
Littleton, CO 80127
303-956-1506
rharrell8@msn.com

Organization: University of Denver
This project is supervised by: Kent Seidel, Ph.D., , Associate Professor – Education Research, Practice, & Policy, Morgridge College of Education, University of Denver, 346 Ruffatto Hall, 1999 East Evans Avenue, Denver, CO 80208-1700, Voice 303.871.2496, Fax 303.871.4456

### II. Agreement (to be completed by principal)

I, ____________________, principal of __________________school, understand

- the study and what it requires of the staff in my school,
- that the privacy and confidentiality of any staff will be protected,
- that I have the right to allow or reject this research study to take place in my school,
- that I have the right to terminate the research study at any time,
- that I have the right to review all consent forms and research documents at any time during the study and up to three years after the completion of the study.

☐ I grant permission to the researcher to conduct the above named research in my school as described in the proposal.

☐ I DO NOT grant permission to the researcher to conduct the above named research in my school as described in the proposal.

______________________________________________________

Signature and date