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Deaf Education Preservice Teachers' Perceptions of Scientific Inquiry and Teaching Science to Deaf and Hard of Hearing Students

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I am submitting herewith a dissertation written by Shannon Carol Graham entitled "Deaf Education Preservice Teachers' Perceptions of Scientific Inquiry and Teaching Science to Deaf and Hard of Hearing Students." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

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Abstract

The purpose of this dissertation was to describe preservice teachers' perceptions of scientific inquiry and science teaching to deaf and hard of hearing students. Participants were four deaf education preservice teachers enrolled in a graduate level course on content area methods during their professional internship year. The instructor employed implicit and explicit reflective pedagogy for the science methods section and focused on scientific practices. Research questions guiding this study are as follows: 1) What are deaf education preservice teachers' perceptions of scientific inquiry? and 2) What are deaf education preservice teachers' perceptions of science teaching and learning among deaf and hard of hearing students? The researcher utilized instrumental case study criteria to guide the design of this dissertation. Data collection included interviews, surveys, and course artifacts. Thematic analysis of the data indicated that preservice teachers' perceive scientific inquiry as procedural and linear, incorporating largely physical and cognitive practices. Preservice teachers privilege content learning and vocabulary and consider the visual learning environment when teaching science to deaf and hard of hearing students. Inquiry science and language use in science were discussed, but were not as developed in the course artifacts (e.g. lesson plans). These findings suggest that transfer of knowledge occurred primarily from deaf education courses, as opposed to science or science methods courses. This study is an attempt to collect empirical evidence that can inform researchers and educators on potential implications in deaf education preparation and in science education preparation.

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List of Abbreviations

AAAS – American Association for the Advancement in Science

DHH – Deaf and hard of hearing

NAEP – National Assessment of Educational Progress

NCLB – No Child Left Behind

NOS – Nature of science

NRC – National Research Council

NSES – National Science Education Standards

NSTA – National Science Teachers Association

SI – Scientific inquiry

VNOS – Views of Nature of Science

VOSI – Views of Scientific Inquiry

Chapter 1

Introduction

Background and Context

Education reforms assert that instruction in science for students in grades K-12 should employ state and national standards to guide instruction on advancing scientific literacy and 21st century skills. Exemplary science education programs are described, in brief, as innovative learning environments in which students are provided with opportunities to think, talk, write, and do science (Abell & McDonald, 2006; National Science Teachers Association [NSTA], 2011a). In an effort to lead high quality science instruction, science teaching preparation and professional development standards specify that teachers need to become familiar with teaching and learning of science, improve flexibility in moving across high quality curriculum and revising appropriately into inquiry-oriented lessons, and implement strong questioning strategies, problem solving approaches, and investigative techniques (NSTA, 2011b).

Teacher preparation in science is frequently guided by the National Science Education Standards (NSES) composed of 8 key components, two of which explicitly draw upon authentic skills of scientists: nature of science (NOS) and scientific inquiry (SI) (American Association for the Advancement of Science [AAAS], 1990; National Research Council [NRC], 1996; NSTA, 2011b). NOS is a way of knowing science and SI is an approach to studying the natural world. A scientist to study the natural world typically holds sophisticated views of science and uses multiple strategies and tools in their field. Some examples include asking questions, designing methods, thinking critically about investigative processes, documenting observations and reflections, and communicating findings and inferences to scientific and non-scientific communities (Hand, et al., 2003; Yore, 2004).

Recent literature in science teacher preparation provides insight on effective approaches to addressing NOS and SI. First, science content needs to be specialized for teachers, in which they learn content that will be taught, experience the “hands-on/minds-on” aspect of science activities, and learn how to revise instruction into problem-solving and student-oriented tasks with consideration of NOS tenets (Abell, Appleton, & Hanuscin, 2010; Edgcomb, Britner, McConnaughay, & Wolffe, 2008; Forbes & Davis, 2010; Friedrichsen, 2001; Guziec & Lawson, 2004; McDevitt, Gardner, Shaklee, Bertholf, & Troyer, 1999; McLoughlin & Dana, 1999). Secondly, teacher education should provide teachers with the opportunity to become proficient in the field by participating in a scientific research investigation experiencing common SI practices. Teachers should practice talking about and discussing practices of science, interrelating and interpreting, conducting scientific research inquiry and using mathematics as data for reporting and solving problems (NRC, 1996; NSTA, 2011b).

Despite teacher preparation efforts, science remains a daunting subject matter for most elementary teachers and one of the least taught subjects. Results from a survey on elementary science instruction revealed that teachers provide instruction in science for an average of 23 minutes per day as opposed to 53 minutes of mathematics and 114 minutes for language arts (Fulp, 2002). Literature suggests the negligence of teaching science at the elementary level is primarily grounded in teachers’ unfamiliarity, uncertainty, and lack of preference in teaching the subject (e.g. Appleton, 1995; Fulp, 2002). In Woodbury's (1995) dissertation, she found the majority of elementary teachers preferred to teach language or mathematics. This is similar to results of a survey from 500 participants, where only 13% of preservice and inservice teachers reported favoring science over other subjects (Shim, Young, & Paloucci, 2010).

Teacher preparation has the potential to address these reservations about teaching science and to provide preservice teachers with knowledge, skills, and tools to devise science lessons according to standards; however, requirements for science teaching preparation remains weak for elementary and middle school teachers (NRC, 2011). Included in the array of coursework typically required for a degree in education are a few courses in science, social studies, and mathematics; coursework in content areas remained similar after educational reforms. Prior to No Child Left Behind (NCLB), preservice teachers were required to complete between 6 to 12 credits of college level science classes (Good, 1974) and today, preservice teachers are expected to take 3 to 9 credits (Abell, et al., 2010). Science methods courses are also required as part of teacher preparation; however, coursework is typically limited to one semester, or none for teachers that go to alternative preparation programs (NRC, 2011).

College level content courses cover advanced topics that are irrelevant for elementary level instruction and do not support teachers to developing understanding of scientific practices (NRC, 2011). Additionally, the approaches to teaching content areas at the college level are usually led by instructors in a lecture format (NRC, 2000; Schwartz, 1987). For science, some labs are required; however, different instructors lead lab sessions and activities are frequently prescribed with expected outcomes. The opportunity to conduct the full process--design, proceed with data, organize and analyze data, and present results--is rare (Raphael, Tobias, & Greenberg, 1999). Moreover this coursework does not address the *why* of teaching science or *how* to do science (NRC, 2000; Schwartz, 1987; Thurmond & Lee, 2000), particularly necessary given that most teachers have never met or associated with scientists, visited a research facility, or conducted any type of scientific research (Morrison, Raab, & Ingram, 2007; NRC, 2000; Smith & Anderson, 1999). This approach to learning science has been criticized due to its false reflection of a true scientific inquiry and its proliferating of traditional methods of instruction.

Perceptions of science are derived from experiences of learning science, personal experiences with science, and media (Abd-El-Khalick & Akerson, 2004). In a study on preservice teachers' skills in teaching science, Roth, McGinn, and Bowen (1998) found that teachers' abilities to analyze scientific data and views of science were equivalent to those of middle school students. Without the experience of what scientists do to study the natural world, skills to plan inquiry-based instruction and opportunity to reflect on preconceived ideas of science, these underdeveloped skills and views will be reflected in teacher's pedagogy and not allow for advancement in student achievement according to educational reform goals (Abd-El-Khalick & Lederman, 2000; Appleton, 1995; Lederman, 1992).

Literature shows that teachers typically favored the expository approach to science instruction, relied on textbooks to expand their knowledge of science concepts, and focused on low level knowledge such as vocabulary or scientific concepts (Finson, 2010; Schmidt, McKnight, & Raizen, 1997; Tobin & Fraser, 1990; Woodbury, 1995). Since the dissemination of state mandated assessments, teachers have expressed distress about covering as many topics as possible (McDevitt, et al., 1999). From Fulp's (2002) survey, 68% of elementary teachers reported concentrating on scientific concepts as opposed to inquiry (41%) and NOS (7%). In terms of pedagogy, 67% used teacher-directed/group discussion approaches but only 8% of instruction time was used for students to design their own investigations and 5% for sharing their findings. The latter two aspects of SI do not explain the relatively high percentage of time spent for inquiry-oriented lessons. Pulling out facts from textbooks to teach topic-oriented lessons, providing hands-on instruction without critical thinking or reflection opportunities, prescribed inquiry lessons and teaching low level science concepts can lead to the proliferation of alternative frameworks of scientific phenomena and limit opportunities for students to develop literacy skills (Abd-El-Khalick & Akerson, 2004; Abell, et al., 2010).

Statement of the Problem

These issues are comparable to all education specializations, including deaf education. Teacher education in deaf education is essentially centered on theoretical practices specific to the needs of deaf and hard of hearing (DHH) students. In addition to general education requirements, preservice teachers in deaf education need to complete coursework in audiology, speech development, psychology of deafness, sign language, and literacy methods. Teacher educators in this field have presented concerns with this disparity between the course of study in deaf education and general license requirements, which include preparation for teaching across content areas (Humphries & Allen, 2008; Johnson, 2004; Lytle & Rovins, 1997). Traditionally, educators of the deaf earn licensure to teach students from K to grade 12 regardless of their content specialty or endorsements. Prior to NCLB requirements, 3.4% of teachers of the deaf had a Bachelors degree in science and low numbers were certified (Corbett & Jensema, 1981). Today, NCLB requires that all teachers become "highly qualified" which states that teachers must earn a bachelors degree and a teaching certification in their content area. While content specialties are becoming more enforced in all education settings, there is a serious decline in highly qualified science and math teachers in deaf education, and large numbers of teaching positions remain unfilled or filled by teachers that possess content certification with minimal preparation in content pedagogy (Mangrubang, 2005). There is no known study on addressing perceptions of scientific practices and science pedagogy among deaf education teachers.

Purpose and Significance of the Study

The purpose of this dissertation was to describe perceptions of the inquiry process in scientific fields and science teaching to DHH students. Empirical studies in deaf education are limited, making it challenging to be informed of current, effective practices and issues (Luckner, Sebald, Cooney, Young III, & Muir, 2005/2006). Moreover, the majority of studies in deaf education are concentrated on student learning. Teachers are the vehicles that drive high quality instruction; conversely, research on teacher preparation in deaf education is limited. The study is an attempt to collect empirical evidence that can inform researchers and educators on potential implications in deaf education preparation and in science education preparation.

Research Questions

1) What are deaf education preservice teachers' perceptions of scientific inquiry?

2) What are deaf education preservice teachers' perceptions of science teaching and learning among deaf and hard of hearing students?

Definition of Key Terms

1. *Deaf and Hard of Hearing* – inclusive of all individuals with varying hearing loss and cultural identity.
2. *Case study* – an inquiry of a phenomenon within a "bounded integrated system" (Stake, 1995).
3. *Nature of science* – the values and perceptions of the development of scientific knowledge (Lederman, 1992).
4. *Science inquiry* – a practice in the classroom that incorporates all processes of inquiry including formulating questions, creating and conducting investigations, collecting and recording data, generating conclusions based on empirical evidence, and communicating about claims (NRC, 2000).

Organization of the Study

This study comprises five chapters. Chapter one includes an overview of national reforms in science education and teacher preparation. Chapter two encompasses a critical review of literature in scientific inquiry, nature of science, and the implications in teacher preparation for general education and deaf education. Chapter three includes detailed methodology of the dissertation study. Chapter four comprises results from qualitative case study analysis. Chapter five closes with a discussion and implications of this dissertation study.

Chapter 2

Review of Literature

The dissertation study centers on perceptions of scientific practices and teaching science to deaf and hard of hearing students. This chapter contains a review of literature on the practices of scientists and the nature of science, and a review of research on the implications of these for science teaching, teacher education, and deaf education.

Everyday Practices of Scientists

Let us begin with a story about a marine conservation biologist who investigated the feeding behavior of the endangered hawksbill turtles in Hawai`i island. Sam had just learned that the north side of Hawai`i Island was a popular feeding ground for the majority of the tracked female hawksbill turtles; however, there were no pending plans for protected areas. Hawksbill turtles are critically endangered worldwide and approximately 75 adults forage and nest within the Hawaiian Islands. Biologists and volunteers have monitored nesting sites and tracks for a decade; nevertheless, state conservation management needed more evidence. Sam took an interest in the issue and began meeting with stakeholders and federal and not for profit agencies to learn more on previous conservation and research efforts. Several meetings later, it was decided that Sam would investigate the feeding behavior of nesting females.

Sam reviewed literature on worldwide efforts that related to feeding behavior and learned that hawksbill turtles foraged primarily on sponges; although, variations in feeding preferences existed among and between the Atlantic and the Pacific Oceans. No such study had taken place with the Hawaiian hawksbill population. She also discovered various approaches to learning more about the feeding trends and what would be appropriate for a small population. Lastly, she learned that ten adult females that resided within the Hawaiian Islands were attached with a radio and/or satellite transmitter to determine their foraging grounds.

Sam started a log that included previous methods and findings and possible research questions. With consultation from stakeholders and other scientists, she decided to use multiple approaches to determine the primary diet of nesting females. Multiple approaches included satellite tracking, stable isotopes, and benthic surveys. The satellite transmitters were programmed to calculate dive depth and time, which allowed for Sam to learn the diving trends at the foraging ground. Sam collected tissues from the hind flipper of nesting females and marine invertebrates from the foraging grounds to compare stable isotope signatures. The correlation of signatures will help determine primary diet.

To proceed with fieldwork, Sam formed a team to help with the monitoring and collection of tissues. This team included biologists, graduate students, and volunteers with an interest in conservation. After several months of collecting data with her team, she accumulated enough to begin with the analysis. She referred back to her log to reflect on the methodology and document data. She used software that translated satellite data into location points. This process required a series of calculations. Sam continued to have questions about the process and future research. She conversed with stakeholders about the procedures and preliminary findings. After two seasons of collecting and analyzing data, she reached a conclusion. This conclusion required Sam and other scientists to critically reason on the findings and develop claims based on data, knowledge of literature, experience through the investigation, and social perspectives. Inferences and recommendations for further research were discussed with stakeholders and community members through publication and presentations.

This line of inquiry is one of multiple ways to learn about the natural world with the purpose to present claims that are grounded in evidence from the data (NRC, 2000). Comparable to Sam's process, scientists typically begin their work with being inquisitive to know more from what was observed or a scientific issue in need of more information or justification. This observation or environmental problem may not be fully comprehensible; subsequently, questions and hypotheses begin to formulate. The scientist will read a variety of reliable sources, inquire about the plausibility and validity of scientific claims and methodology, and communicate with other scientists to make sense of this observation or scientific issue. When necessary, the scientist will contemplate on a methodology and begin with the investigation process that is made up of various structures. As Sam did, the scientist will reflect and use multiple tools throughout the data collection process. It is during analysis when the scientist continues to reason and speculate with reflections from the investigative procedures. The unknown becomes inclusive, and inferences or claims with support from empirical data are typically disseminated into scientific communities and stakeholders. To summarize the work of a scientist, physical, cognitive, and social practices are utilized to "examine, review, and evaluate their knowledge and ideas and critique those of others" (NRC, 2011, p. 23).

What are the characteristics of a scientist? What did Sam need to conduct her work with the Hawaiian hawksbill turtles? The new framework for K-12 science education describes these characteristics using three dimensions: practices, crosscutting concepts, and disciplinary areas (NRC, 2011). The first dimension includes eight diverse operations (whether physical, social, or cognitive) that are necessary through the research process. They include asking questions, developing or using models, creating and conducting investigations, analyzing and making sense of the results, using mathematical thinking, making inferences, proposing a claim with evidence and evaluating and presenting scientific information. The second dimension comprises crosscutting concepts to employ the scientific process. For example, scientists typically seek for patterns or understand structure or function, to identify relationships, to understand change, and use various mathematic applications. Scientific practices and crosscutting concepts are applied into disciplinary core areas, which make up the third dimension and can differentiate scientists based on content expertise. Four broad areas are distinguished: physical science, life science, earth and space science, and engineering, technology, and applications of science. Detailed description of these dimensions are provided in Table 1 (NRC, 2011, p. 10-29).

> Scientific inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating results (NRC, 1996, p. 23).

With regard to science teaching, the scientific inquiry process “encompasses not only an ability to engage in inquiry but an understanding of inquiry and of how inquiry results in scientific knowledge” (NRC, 2000, p. 13).

Table 1. Relationship of Strands and Dimensions

Strands from *Taking Science to School*	**Dimensions in Framework**	**How the Framework is Designed to Deliver on the Commitment in the Strand**
1. Knowing, using, and interpreting scientific explanations of the natural world	Disciplinary core ideas, Crosscutting concepts	*Specify big ideas, not lists of facts:* Core ideas in the framework are powerful explanatory ideas, not a simple list of facts that help learners explain important aspects of the natural world. Many important ideas in science are crosscutting, and learners should recognize and use these explanatory ideas (e.g., systems) across multiple scientific contexts.
2. Generating and evaluating scientific evidence and explanations 4. Participating productively in scientific practices and discourse	Practices	*Learning is defined as the combination of both knowledge and practice, not separate content and process learning goals*: Core ideas in the framework are specified not as explanations to be consumed by learners. The performances combine core ideas and practices. The practices include several methods for generating and using evidence to develop, refine, and apply scientific explanations to construct accounts of scientific phenomena. Students learn and demonstrate proficiency with core ideas by engaging in these knowledge-building practices to explain and make scientifically informed decisions about the world.

Table 1. Continued

Strands from *Taking Science to School*	**Dimensions in Framework**	**How the Framework is Designed to Deliver on the Commitment in the Strand**
3. Understanding the nature and development of scientific knowledge	Practices, Crosscutting concepts	*Practices are defined as meaningful engagement with disciplinary practices, not rote procedures:* Practices are defined as meaningful practices, in which learners are engaged in building, refining, and applying scientific knowledge, to understand the world, and not as rote procedures or a ritualized "scientific method." Engaging in the practices requires being guided by understandings about why scientific practices are done as they are—what counts as a good explanation, what counts as scientific evidence, how it differs from other forms of evidence, and so on. These understandings are represented in the nature of the practices and in crosscutting concepts about how scientific knowledge is developed that guide the practices.

Unfortunately, misconceptions of how to implement scientific practices in the classroom continue to exist. Instruction is typically focused on *skills* and *content knowledge*, rather than on having students engaged and implementing crosscutting concepts on authentic problems and addressing how scientific practices contribute to the body of knowledge in science. It is suggested that to understand best practices in how scientists study the natural world, instruction should be centered on the “integration of the knowledge of scientific explanations and the practices needed to engage in scientific inquiry and engineering design” (NRC, 2011, p. 1-3) including argumentation, NOS, and scientific discourse (NRC, 2007). Cognitive, physical, and social practices are outlined in the National Assessment of Educational Progress as identification and utilizing science principles, using SI, and technological design (NAEP, 2011).

All the skills mentioned earlier are what need to be addressed in the science classroom, not by telling what science terminology or principles mean or by memorizing the steps to the scientific method, but by doing, talking, reading, and writing with guidance of the instructor. Some examples of grade level standards in regard to "*abilities* necessary to do scientific inquiry" include planning and proceeding with investigations (K-4), reasoning and logically making connections between evidence and explanations (5-8), and communicating and defending a scientific claim based on a collection of empirical evidence (9-12) (NRC, 2000). For "*understanding* scientific inquiry", K-4 students need to use various formats of investigations depending on the questions, students in grade 5 through 8 need to understand that use of mathematics is essential during inquiry, and students in grades 9 through 12 should understand that new scientific knowledge and methods originate from previous investigations and discourse among science communities (NRC, 2000).

In addressing the *why* of teaching science and *how* to do science, preparation should be inclusive of the nature of scientific inquiry and its role in the development of scientific knowledge as well as the implementation of cross cutting concepts and practices as outlined in the K-12 science teaching framework (NRC, 1996, 2011). An excerpt from NSTA supports these propositions.

> Experience science as inquiry as a part of their teacher preparation program. Preparation should include learning how to develop questioning strategies, writing

> lesson plans that promote abilities and understanding of scientific inquiry, and analyzing instructional materials to determine whether they promote scientific inquiry (NSTA, 2004, p. 2).

In summary, SI is portrayed as physical, cognitive, and social practices and cross cutting concepts as highlighted in the K-12 science teaching framework (NRC, 2011) utilized to study the natural world and contribute to the body of knowledge in science. In reference to science teaching preparation, considerations should be inclusive of these practices through implicit experience and explicit teaching.

Nature of Science

The Nature of Science is universally defined by a number of scientists, science education researchers and philosophers: science is simply the study of the natural world. Lederman (1992) defines NOS as the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge or the development of scientific knowledge. Over the years the field of science has developed slowly into an exceedingly expansive subject, broad enough that the true understanding of science is ambiguous. Where is that fine line between science and non-science fields? As described in Halloun (2004), disciplines should be discriminated by physical, social, and mental reality types. These reality types are what separate science from other disciplines such as history, sociology, and religion. For example, physical realities make up the physical system (e.g. plants, animals) and phenomena (e.g. photosynthesis, animal reproduction). The latter reality type fits in the science discipline. Other disciplines are more appropriate in social (e.g. people, community, culture) and mental domains (e.g. psychology, behavior, language).

Common assumptions that emerge in everyday perspectives of science are some factors that prompted the development of NOS principles. For example, people often assume that scientific experiments are driven solely by theories and scientific explanations are based on observations alone, a universal scientific method exists, or scientific explanations are exclusively objective and secured. In a study on teachers' perceptions of scientists, one teacher interviewed a scientist and reported the following excerpt:

> He didn't think there is one scientific method rather there is a universal procedure in which you make a hypothesis and use many methods and techniques to get the answers. He thinks a good scientist makes better guesses more often, but that not being correct does not make a bad scientist (Morrison, et al., 2007, p. 394).

Textbooks in schools explicitly propagate these misconceptions, particularly the scientific method (Duschl & Grandy, 2008; McComas, 1996). Although these procedures are essential components for communicating science, the processes are not always adhered to in a specific investigation. Scientific reasoning is complex and can include either or both deductive and inductive analytic processes. This claim has been criticized by a number of science philosophers and scientists; science is comparable to utilizing multiple tactics to problem solving. Dr. Julian Tobias, a physiology professor in the mid 1900's, describes the work of scientists as non-linear or non-cyclic:

> Most people in the world thrive on certainty and an absence of puzzlement, which brings them mental comfort and security. Scientists, on the other hand, thrive on doubt and the existence of natural puzzles, which brings them energy and an urge to find answers. Doubt and a joy in solving puzzles are the main engines in the practices of science. (1911-1964)

In an effort to elucidate NOS, discriminate science from other disciplines, and address misconceptions, principles were compiled and disseminated into national standards for science education and embedded in the cross cutting concepts and practices from the K-12 science teaching framework (AAAS, 1990; McComas, Almazroa, & Clough, 1998; NRC, 1996, 2006, 2011). The tenets are as follows:

1. There is no universal scientific method.
2. Science is socially and culturally embedded.
3. Scientific knowledge is tentative.
4. Scientific knowledge is empirical, based on observation and inferences
5. Creativity is not segregated from development of scientific knowledge
6. Theories and laws have distinctive definitions.
7. Science is subjective.

In summary of the tenets, science is frequently preconceived as factual information, linear and objective; on the contrary, science and scientific knowledge is the result of human activity (Bybee, 2004) and not abided by structured and sequential procedures (NRC, 2000; NSTA, 2004). Scientists are the people that put together scientific knowledge based on observations, experience, prior knowledge, and culture. Scientific knowledge is produced by scientists but not without creativity. It takes critical thinking, reflection, and communication to generate all the scientific concepts and theories published in text and proliferate to science and non-science communities. Theories are generally robust with extensive observations and inferences but not necessarily permanent. People unintentionally or purposefully observe new objects or scientific events and bring on new scientific ideas to challenge current theories.

Similar to SI, NOS is embedded in the K-12 science teaching framework. The cross cutting concepts and practices need to be extracted from the inquiry process and explicitly addressed (NRC, 2011). Some examples of NOS contents are acknowledgement of science as a human endeavor, discussing NOS tenets, recognition of historic perspectives and cultural developments of science and progression of scientific knowledge (NRC, 2011; NSTA, 2011b).

NOS in science education is not a method of instruction; it is embedded in pedagogy and makes up a part of the curriculum (Abd-El-Khalick, Bell, & Lederman, 1998). Developing knowledge of and preparing lessons integrating NOS tenets are explicit in teaching standards. Preparation in science should include the opportunity for preservice teachers to “examine beliefs, as well as develop an understanding of the tenets on which the standards are based (NRC, 1996, p. 28). Additionally, preservice teachers should practice analyzing literature to discuss NOS tenets, distinguish science from pseudoscience and other non-science fields, experience SI, distinguish methodology, and reflect on decisions of these methods (NSTA, 2003). Informed views of the tenets and experiences of integrating NOS in the classroom allows for selecting high quality literature according to the “rules” of science, valuing empirical data and acknowledging the culturally influenced decisions, accepting subjectivity of scientific claims and creativity as scientists develop inferences (Lederman & Niess, 1997).

In summary, NOS is a way of knowing science and distinguishes science from other fields. Seven tenets were derived to facilitate explicit instruction on improving views of science and applications in science education.

Implications of SI and NOS in Teacher Education

NOS relates to SI and is often interchangeable or explicated in the literature. Due to the nature of this literature review, the following section will include research related to both SI and NOS in teacher preparation.

Discussion of NOS tenets and opportunities for candidates to experience SI seldom take place during teacher preparation (Backus & Thompson, 2006). Completing college level science courses did not necessarily improve teachers' views of science or understanding the work of a scientist. Preparation in content areas is weak in providing students with opportunity to make sense of data collected from an experiment or scientific investigation (Akerson, Cullen, & Hanson, 2009; NRC, 2011). And, science textbooks are not always aligned with NOS tenets, particularly the scientific method (Abd-El-Khalick, Waters, & Le, 2008).

Naturally, teachers with limited experience with inquiry and NOS will be likely to hold naïve views and alternative conceptions of scientific concepts and principles. McComas (1996) found most teachers hold limited understanding of the tenets. Science is perceived as factual and objective, and inquiry is thought to be linear (Akerson, et al., 2009; Bybee, 2004). Often teachers have not met or talked with a scientist. Morrison, Raab, & Ingram (2007) conducted a study on the impact of mentorship on teachers' perceptions. Teachers shadowed and interviewed scientists about their work. From one of the interviews, one teacher responded, "I will have to admit that I had the stereotypical picture of the nerdy scientist sitting in a sterile lab somewhere making concoctions and wasting taxpayer's money" (p. 396). NOS views and understanding of SI are deeply rooted from learning science prior to college and most often difficult to change if not adequately addressed (Abell, et al., 2010; Akerson, et al., 2009; Gates, Krockover, & Wiedermann, 1987).

Somewhat distinctive differences exist between secondary and elementary teachers' views. Often secondary level teachers have more informed views than elementary teachers. It is believed that the disparity in views may relate to academic preparation; however, contradictory findings exist in the literature. For example, Wood (1972), Billeh and Hasan (1975), and Scharmann (1988) found that perceptions of science are not influenced by content knowledge or level of science instruction; however, Brickhouse (1993) found that understanding of NOS tenets relates to academic preparation in science. After one year of instruction on NOS and implementation in the classroom, researchers reported teachers' views improved individually but not in comparison to other teachers. The researchers believe that content background influences how teachers learn and execute NOS tenets in pedagogy (Akerson, et al., 2009). In addition to learning content areas, secondary teachers are likely to have scientific research experience and/or collaborate with scientists (Bell, Blair, Crawford, & Lederman, 2003). These factors may have some influence on the inconsistency in views between elementary and secondary teachers. Based on the variability of results in the literature, teachers with limited association with scientists, scientific inquiry experience, and academic preparation continue to hold less informed views than secondary teachers.

Informed views of inquiry and NOS impact the philosophy and selection of strategies to teaching science. Teachers with naïve views of science or minimal experience with inquiry are predisposed to rely on textbooks to guide instruction on experimentation processes (McComas, et al., 1998). An alternative framework of science is likely to be proliferated (McComas, 1996) and instruction limited to low level science skills (Finson, 2010). Using science writing as an example of low level skills in SI, Baker and Saul (1994) found that elementary students' writing in science was limited to documenting factual information and investigative methods and Keys (1999) reported that contents in science notebooks from middle school students lacked inferences or reflections. Additionally, the structure and format for these writing tasks reflected what the teacher believed about science writing. Unfortunately, the type of writing assigned is not truly reflective of the work of a scientist (McComas, et al., 1998).

In advancing students' scientific literacy skills, Lederman (2006) describes an example of high level science tasks.

> Students need to reflect on what it is they are doing. They need to be engaged in discussions of why scientific investigations are designed in certain ways. Students need to discuss the assumptions inherent to any scientific investigation and the implications these assumptions have for the results. Furthermore, students need to discuss the fact that science is done by humans and the implications this has for the knowledge that is produced (p. 315).

High-level science instruction is influenced by several factors, one of which is teachers possessing informed views of NOS principles and accurate portrayal of the practice of science (e.g. Khishfe & Abd-El-Khalick, 2002; Lederman, Schwartz, Abd-El-Khalick, & Bell, 2001; McDevitt, et al., 1999). Research shows that carefully structured preparation in science teaching including NOS impacted in ways teachers explicitly taught NOS in the classroom (Lederman, et al., 2001) and positively influenced the views of science among students (Khishfe & Abd-El-Khalick, 2002). The design of preparation in science is essential. Simply improving views of NOS does not necessarily transfer to practice (Lederman, 1992) and doing science does not always relate to understanding science (Abd-El-Khalick & Lederman, 2000; Lawson, 1982). The following quote, which while centered on students can also apply to teachers, exemplifies how implicit instruction in science is insufficient.

> Assumptions that K-12 students will come to understand the NOS simply through the performance of scientific inquiry and/or investigations is no more valid than assuming students will learn the details of respiration by breathing. For students to develop the desired understanding of NOS teachers need to make explicitly connections between science-based activities and the NOS (Abd-El-Khalick, et al., 1998, p. 430).

Engaging teacher candidates in doing science inquiry improves some components of scientific inquiry skills and content knowledge; however, it does not address personal views of science or pedagogical tools (Bell, et al., 2003; Brown & Melear, 2007; Lunsford, Melear, Roth, Perkins, & Hickok, 2007; Melear, Goodlaxson, Warne, & Hickok, 2000; Perkins, 2010). In Perkin's (2010) dissertation on the impact of scientific research experience for teachers, he found that immersion alone influenced subject knowledge and confidence in teaching science inquiry but perceptions of science remained similar.

NOS tenets and SI need to be taught explicitly along with some reflections on current views and instructional philosophy. The explicit-reflective model for teaching NOS is grounded in the literature (Abd-El-Khalick & Lederman, 2000; Khishfe & Abd-El-Khalick, 2002; Lederman, 2006). Recently, studies on teacher preparation in science have included both explicit-reflective instruction of NOS and some level of experience with SI (e.g. Akerson & Volrich, 2006). Results from this approach to teaching pedagogical content were encouraging. For example, Morrison, et al. (2007) conducted a study on teacher perceptions after providing explicit instruction of NOS principles, opportunities for partnerships with scientists, collaboration with a scientific research community and transferring these experiences into the classroom along with reflections. In their study, they analyzed interview data. When asked about their understanding of science, one teacher responded:

> My definition of science has changed a lot. I would never have thought about a meaning of (as) being a part of it (science). It was always just do this experiment or learn about this content area and…now, I am really thinking about it (science) as exploring the environment and looking around and asking questions about why things are the way they are (p. 394).

Bianchini and Colburn (2000) and Schwartz, Lederman, and Crawford (2004) found that preservice teachers having the opportunity to experience inquiry along with explicit instruction in NOS impacted how teachers perceived of scientists. And the presence of these components in addition to collaboration with scientists and discussion on the connections of NOS principles produced positive results as well (Bell, et al., 2003).

In summary, NOS tenets and SI are infrequently addressed in teacher preparation. Naive views and experience with SI are carried into classroom applications. In an effort to improve these views, researchers have attempted multiple approaches in science teacher preparation. The results of several research studies suggest that preparation in science include implicit experience and explicit reflective instruction.

Science in Deaf Education

Current issues in science education are similar in deaf education. Knowledge of science among preservice educators of the deaf is limited and the subject is complex to most teachers (Mangrubang, 2005). Teachers of the DHH have expressed concerns about preparing science lessons due to time constraints, overemphasis on language development, and lack of support and irrelevance from school-wide training (Easterbrooks, Stephenson, & Mertens, 2006). As a result, teachers abstain from evidence based instructional practice, funnel to didactic, teacher-directed instruction and concentrate on low level skills (e.g. science vocabulary, scientific concepts) (Hagevik, Woolsey, & Graham, 2011; Lane-Outlaw, 2009).

In Lane-Outlaw's (2009) dissertation, she found that middle and high school science teachers in bilingual programs used effective strategies such as relating to students' personal experiences and using real life applications; however, instruction targeted attributes of language, e.g. vocabulary. Most teachers used knowledge-based expository teaching and a limited assortment of discursive practices, use of multiple writing strategies, reading, and doing science. Further, science instruction did not always meet the time allocation in elementary schools for the DHH (Hagevik, et al., 2011). From the overall observations of science instruction in this study, researchers found that students *watched* science (e.g. passively attend to a lecture or video) for an average of 54% of the time in comparison to other instructional strategies (*doing* science – 13%; *reading* about science – 13%; and *writing* about science – 8%).

Research in science education for DHH individuals is centered on teaching strategies and student learning. Some examples of recently published literature from 30 years of research in science in deaf education include bilingual practices (Andrews & Cocke, 2005; Andrews, Cocke, & Nichols, 2004), science literacy practices (Lang & Albertini, 2001; Molander, Hallden, & Lindahl, 2010; Roald & Mikalsen, 2001), adaptations in mainstreamed environments (Gillespie, 1997), accommodations for science standardized assessments (Cawthon, 2010), evaluations of science programs (Lang, et al., 2002, Winter; Mertens, 1991), role modeling of deaf scientists (Lang, 2004), science signs (Lang, et al., 2007), and student attitudes of science (Lang & Meath-Lang, 1985). In summary, science education for DHH individuals should look like a learning environment that is rich with visual organizers and centered on content vocabulary development, a place for students to engage in experimentation with multiple tools including technology and other science tasks that are hands-on and minds-on, authentic, and problem solving oriented. Teachers need to hold high expectations and excellent communication skills to engage in scientific discourse. Examples of these characteristics of a science learning environment are also explicated in Easterbrooks, Stephenson, & Mertens (2006), Antia, Jones, Reed, & Kreimeyer (2009), Lang (2006), and McIntosh & et al. (1994).

Most of the literature continues to focus on essential practices in the classroom; however, it is unclear whether the authors considered “science concepts” as topic-orientation or philosophical-orientation. For example, did the researchers include history and principles of science, focus on developing skills in scientific processes and inquiry, reasoning, discursive activities, critical thinking, and transfer of knowledge in context? To what extent were high level science tasks utilized? In a survey on science and math literacy practices, teachers reported putting effort toward planning high level science instruction but due to varying functional levels of students in one class, these types of tasks are generally assigned as homework.

To date, only one study was identified that is related to science preparation for deaf education majors. Mangrubang (2004) conducted this study investigating the impact of a kit-based curriculum on deaf education preservice teachers' skills in developing inquiry-based science lessons. He reported positive results in improving preservice teachers' pedagogical skills. With regard to NOS, it is unclear whether the researcher provided preservice teachers with opportunity to conduct their own scientific investigation, addressed SI and NOS. There is no known study on addressing perceptions of scientific practices and science pedagogy among deaf education teachers.

Chapter 3

Research Methodology

The purpose of this dissertation was to highlight preservice teachers' perceptions of the inquiry process in scientific fields and science teaching to deaf and hard of hearing students. Two research questions were formulated for this study: 1) What are deaf education preservice teachers' perceptions of scientific inquiry? and 2) What are deaf education preservice teachers' perceptions of science teaching and learning among deaf and hard of hearing students? This chapter describes the theoretical lens of the dissertation study, research context and design and approaches to data collection and analysis.

Theoretical Framework

Pragmatism, unlike other worldviews in social research, is not bound to one system, where specific rules apply for strategies of inquiry. This problem-centered and real world practice perspective allows for the researcher to use multiple measures and research methodologies (Patton, 1990). In other words, "researchers are free to choose the methods, techniques, and procedures of research that best meet their needs and purposes" (Creswell, 2009, p. 11). Mixed-methods are common practices in pragmatism; however, due to the nature of the research questions and line of inquiry, the present study utilized qualitative research strategies.

The qualitative researcher as a data collection instrument and participant observer acts as facilitator, discussing and reflecting on participants' perspectives and preconceived ideas, encouraging professional growth, and co-constructing new perceptions. The participation of the researcher may potentially influence interpretations; however, this is appropriate within any qualitative methodology. Knowledge is abstract and the elucidation of individual interpretations of new information cannot be measured or described without language, thus making it difficult for the researcher to remain objective (Hatch, 2002).

The assumptions of subjectivity make generalizations difficult based on potentially diverse backgrounds and beliefs. The researcher understands that everything is relative and responses from each participant are mutually exclusive. The researcher assumes each individual constitutes a unique structure of knowledge with a scaffold of prior experience, hence, the lack of uniformity. When the researcher and participants create new understanding of a phenomenon, the goal is to capture that process and increase each individual's aptitude of perceptions of science and science teaching.

Research Context

The deaf education majors in this study enrolled in a graduate level course on curriculum and instruction specific to DHH students during their professional internship year. At this time participants were assigned at their first of three placements. Elementary teachers at this school did not teach science as part of their everyday routine. Due to departmentalization in the elementary school, only one teacher was assigned to teach science to all grades. Participants in this study were placed with other elementary teachers.

This graduate course was framed to address curricular methods, content area pedagogy, second language teaching strategies, dialogic inquiry, expressions of content-related concepts in ASL, and adaptations of lesson plans and assessments and divided into four segments to incorporate content areas. In addressing science methods centering on scientific practices, the instructor employed implicit and explicit reflective pedagogy as suggested from the literature. Two NOS tenets (observations and inferences; subjectivity, social and cultural context in science) were addressed. Lederman and Abd-El-Khalick (1998) explained that explicit instruction does not mean providing participants with a list of tenets but rather to embed the principles in the context, as well as reflect on what is known about science and its relation to scientific practices. In support of providing explicit instruction, participants completed a scientific investigation throughout the semester. The purpose of this implicit task was to provide participants with experience of common scientific practices. Reflective questions were assigned for tasks related to scientific practices and ideas of experimentation in the classroom. See Appendix C and D for examples of reflective questions. All course documents and reflections were collected for the study.

Methodology

Due to the nature of the research question and context, the researcher utilized instrumental case study criteria to guide the design of this dissertation. Case study in education is the "study of the particularity and complexity of a single case, coming to understand its activity within important circumstances" (Stake, 1995, p. xi). Instrumental case study was selected because the researcher was interested in "providing insight into an issue or refinement of a theory" (Stake, 1998, p. 88). Description of this case would present grounds for further inquiry related to perceptions of scientific inquiry and instructional practices in science and ideas for deaf education preparation. To provide a multi-dimensional profile for this case, the researcher incorporated multiple data sources including interviews, surveys, and artifacts. Multiple data instruments or sources will help the researcher present an comprehensive description of the case study (Baxter & Jack, 2008; Yin, 2003).

Selection of Participants and Participant Profiles

Through purposive sampling (Patton, 1990), all participants enrolled in the course were invited to participate in the study. Due to the role of the researcher as the course instructor, the researcher's program advisor met with participants a few weeks before the conclusion of the course and introduced the dissertation study, described the contents in the project information sheet (Appendix H) and informed consent form (Appendix I), including protection and rights as participants. Upon receiving these documents, participants were encouraged to ask any questions and express concerns. Participants were asked to provide a response to consent along with their signatures if they wished to participate. These forms were collected, sealed in a manila envelope, and retained by the advisor until final grades were submitted, to reduce the possibility that students would feel coerced into participation.

Four participants agreed to take part in this study. Pseudonyms are Dawn, Sonya, Penny and Kerri. Their academic preparation in science and methods varied. All individuals completed at least one science content course (biology). Two that completed two courses either selected geology or chemistry. One completed two additional courses: earth science and life science. Each individual completed one science methods course.

Three completed methods inclusive of all contents (e.g. social studies, mathematics), one completed a science-only methods course. Participants reported learning about the inquiry process including generating predictions and conducting experiments from this methods course. One participant explained her experience with conducting her own scientific inquiry project and how this implicit experience influenced her understanding of effective practices. Another participant expressed needing more experience on the practice of SI. They also understand that the learning environment needs to be interactive, engaging, and compatible to literacy tools. Finally, when asked about their content preferences, three of the four selected language arts as their first choice with science as their 3rd, 4th, or 5th preference. The fourth participant selected science as her first choice. Table 2 includes these responses to the first survey including demographic information.

Data Sources

Surveys, course artifacts, and interviews were collected and conducted for this study. The researcher developed a survey including a set of demographic-related questions (Appendix A) and compiled a second survey with 7 open-ended questions (Appendix B) derived from several instruments (VOSI-270A, VNOS-B, and a survey on language use in science). Views of Nature of Scientific Inquiry (VOSI-270A) was developed specifically to assess understanding of scientific processes and version 270A was most appropriate for preservice teachers (Schwartz, Lederman, & Lederman, 2008). Of the 7 open-ended questions in this survey, the researcher selected question number 1 to explicate preservice teachers' understanding of investigative practices (see question number 1 in Appendix B). The second survey reviewed, Views of Nature of Science

(VNOS-B), was constructed to explore views of NOS principles (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002) and version B has been widely used for preservice elementary and secondary science teachers (e.g. Akerson, Abd-El-Khalick, & Lederman, 2000; Morrison, et al., 2007). Of the 6 open-ended questions on this instrument, the researcher selected question number 5 (see question number 2 in Appendix B). Finally the third survey developed by Stoddart, Pinal, Latzke, and Canaday (2002) focusing on teaching science to diverse student populations was reviewed. Two questions from this survey were selected and slightly revised due to the nature of the student population of this study (see question numbers 4 and 5 in Appendix B). In summary, the second survey for this study contains 7 questions; four of which were derived from three sources.

Table 2. Participant Profiles

Information	Dawn	Sonya	Penny	Kerri
Gender	F	F	F	F
ASL skills	Advanced	Intermediate	Intermediate	Advanced
Science coursework	Biology	Biology Geology	Biology Chemistry	Biology Chemistry Earth Science Life Science
Methods coursework	Methods course (all contents)	Methods course (all contents)	Methods course (science only)	Methods course (all contents)
Subject preference	Reading Math Science (4^{th})	Language Arts Science (3^{rd}) Math (5^{th})	Language Arts Math (3^{rd}) Science (5^{th})	Science Math (6^{th})

Additionally, four artifacts from course activity were collected: science inquiry reflections, lesson plan reflections, and peer review and analysis of presentation of inquiry-based science lesson. Participants were asked to conduct a scientific inquiry project and provide a 10-minute PowerPoint presentation on their progress and reflections on implementing inquiry-based science in deaf education. Seven questions were developed as a guide for this presentation (Appendix C). In addition to the scientific inquiry project, participants were asked to construct an inquiry-based lesson plan for deaf elementary students. Two drafts were requested to allow for the instructor to provide feedback and participants to reflect on these changes. For the final copy of this lesson plan, participants were asked to respond to four reflection questions focusing on inquiry-based science and its practice in a deaf education classroom (Appendix D).

For the third task, participants were asked to present an inquiry-based science lesson in class. This presentation was limited to 15-20 minutes. A peer review form was developed for participants to provide constructive feedback for each presentation (Appendix E). This form was divided into 6 sections: level of inquiry, scientifically oriented questions, investigative practices, explanation of science concepts, communication skills, and dialogue skills. Communication skills are focused on sign language expressive and receptive skills; whereas, dialogue skills are centered on specific questioning strategies and communication prompts. For the last task, participants were asked to analyze their lesson presentation video and provide evidence and reflections of their lesson content and delivery. A form was developed based on the 5 principles of scientific inquiry derived from National Research Council (2000) and provided to participants in a rubric form to use as a guide (Appendix F).

An interview protocol developed by the researcher included two broad questions on perceptions of scientific practices and science teaching in deaf education (Appendix G). These questions were constructed based on quick overview of survey responses and course artifacts in an effort to clarify perceptions. Data sources and instruments listed with the associated research questions are provided in Table 3.

Data Collection

In the beginning of the course the researcher administered the demographics survey, which required approximately 20 minutes of class time. The second survey was posted on Blackboard for participants to complete outside of class, before the third class meeting. Completion of survey two required approximately 30 minutes. All course documents and student presentations during the science portion of the class were videotaped and/or collected. The researcher reviewed drafts, provided feedback and requested revisions. These revisions were therein gathered. At the conclusion of this course, a research assistant conducted a 10-minute post-course interview with an audio-recorder. A second research assistant transcribed the recordings. The researcher reviewed the confidentiality agreement form (Appendix J) with both research assistants. A timeline listing course topics and data collection with abbreviated codes for each source is provided in Tables 4 and 5.

Data Analysis

The researcher used suggested steps for thematic analysis provided by Braun and Clark (2006) and Creswell (2009). Inductive coding procedures were drawn from suggestions by Fereday and Muir-Cochrane (2006) and Boyatzis (1998). The first step into analysis was the review of all documents and transcripts. The goal was to immerse into the data and become familiar with the content and identify potential codes. As the researcher began coding each line, sentence, and paragraph, a post-it note was used to list all the codes and reference information within a section and posted at that location (See Figure 1). The process was repeated until all transcripts and course documents were coded.

Table 3. Data Sources

Research Questions	Instrument & Source
1) What are deaf education preservice teachers' perceptions of scientific inquiry?	Survey (questions 1-2) Science inquiry reflection Interview
2) What are deaf education preservice teachers' perceptions of teaching and learning among deaf and hard of hearing students?	Survey (questions 3-6) Science inquiry reflection Lesson plan reflection Peer review of lesson presentation Analysis of lesson presentation Interview

Table 4. Project Timeline

Date	Timeline of science methods course activities	Assignment schedule
Week 1	Demographics survey *(Appendix A)*	
Week 3		Select science/math inquiry project topic

Table 4. Continued

Date	Timeline of science methods course activities	Assignment schedule
Week 7	Discuss readings and responses to guiding questions focusing on exemplary practices in science	Complete survey online *(Appendix B)* Read from text & articles on ELL, science signs, and science writing Blog - identify 2 ideas for teaching science & justify with examples of exemplary practices
Week 8	Demonstration of inquiry-based lesson & discussion of 5Es	Read articles on inquiry science and 5Es
Week 9	Discuss readings and responses to guiding questions focusing on dialogic inquiry strategies	Present science/math inquiry reflection with PPT *(Appendix C)*
Week 10		Submit inquiry-based science lesson, first draft
Week 12		Presentation of inquiry-based lesson Complete peer review form *(Appendix E)*
Week 13		Submit inquiry-based science lesson, final draft and responses to reflection questions *(Appendix D)*
Week 15		Submit analysis & reflection of inquiry-based science lesson presentation *(Appendix F)* Complete survey online *(Appendix B)*
	Interview	

Table 5. Timeline for Data Collection

Data Source (code)	Appendix	Timeline
Survey (PS/PTS)	B	Pre/Post
Science inquiry reflection (I)	C	Concurrent
Lesson plan reflection (LP)	D	
Peer review of lesson presentation (PR)	E	
Analysis of presentation (A)	F	
Interview (IV)	G	Post

A table was created with columns for data sources and rows for participants (Table 6). All codes and reference information from the post-it notes were transferred into this table. This visual representation or *data display* allowed for the researcher to visually present codes to make patterns of initial codes transparent. Viewing the data in this manner "helps us to understand what is happening and to do something – either analyze further or take action – based on that understanding" (Miles & Huberman, 1994, p. 11). All initial codes were reviewed again to ensure accuracy of codes and reference information. Redundant or duplicate codes within each cell were grouped together. A code manual with three columns for code labels, descriptions, and reference information was constructed and completed (Weber, 1990). The researcher referred back to this manual for clarification of codes or categories.

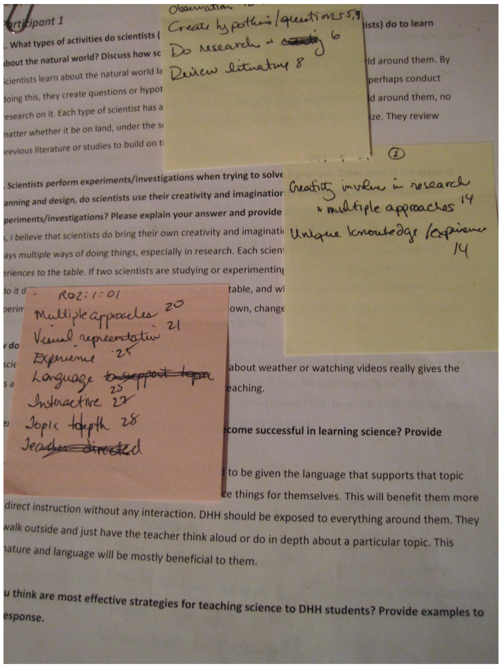

Figure 1. Initial coding procedures

Table 6. Table Format for Data Display

	PS	I	LP	PR	A	PTS	IV
Dawn							
Sonja							
Penny							
Kerri							

The researcher sought patterns and commonalities among codes through an iterative process across data sources and participants. Codes were grouped together into categories and renamed. As patterns became more transparent, categories were summarized and assigned to preliminary themes. The table displaying codes across participants and data sources were re-visited and re-defined when needed. Review of the final revisions of this table was necessary to ensure that data were sufficient and themes were well represented. When themes and sub-themes were corroborated, the researcher referred back to the transcripts to select data across participants and data sources that supported each theme and sub-theme. Themes with selected excerpts from the data were rearranged into coherent manner. The researcher provided a rich, thick description of the themes and sub-themes (Guba & Lincoln, 1998).

Trustworthiness

The researcher utilized qualitative analysis approaches grounded in the literature to ensure quality of the findings, which was a threefold task: credibility, transferability, and confirmability. Credibility relates to internal validity in quantitative line of inquiry (Shenton, 2004). Several options are available to justify data collection approaches and research questions (Lincoln & Guba, 1985). Triangulation of data collecting methods were selected based on two reasons: 1) the ability to address potential gaps across participants and 2) incorporating multiple participants. The data collecting approaches included surveys, course documents, and interviews. Some of the survey questions were derived from instruments that have been frequently used in this area of research. Four course artifacts were collected, all of which include various types of responses ranging from reflections to lesson planning. Interview questions were semi-structured and constructed to allow for the participants to expand on responses from the survey. Finally, codes that were related to the research questions were entered in a table to allow for the researcher to identify patterns. See Tables 7 – 10 for examples of triangulation procedures.

Table 7. Display of Themes and Associated Data Sources for Research Question 1

Themes	PS	I	PTS	IV
Theme 1: Nature of scientific inquiry				
Procedural & linear	X	X	X	X
Purpose of inquiry	X		X	X
Theme 2: Literacy tools				
Obtaining information	X	X	X	X
Documenting data	X	X	X	X
Sharing findings	X	X	X	X
Theme 3: Practices & creativity fall in physical engagement				
Methodology	X	X	X	X
Creative nature	X	X	X	X

Table 8. Triangulation of Codes for Research Question 1

Nature of scientific inquiry		
Procedural & linear	*Purpose of inquiry*	
PS-1; PS-5; PS-15; PS-20; I-1; I-8; I-13; PTS-1; PTS-4; PTS-9; PTS-11; IV-1; IV-5; IV-12	PS-8; PS-18; PS-23; PTS-8; PTS-13; IV-6; IV-14	
Literacy tools		
Getting information	*Documenting/data*	*Sharing findings*
PS-3; PS-9; I-16; PTS-14 IV-10; IV-16	PS-12; PS-14; I-6; I-12; PTS-16; IV-9; IV-17	PS-25; I-18; PTS-17; IV-4; IV-11; IV-15
Practices & creativity fall in physical engagement		
Method/data	*Creative nature*	
PS-2; PS-6; PS-11; PS-13; PS-16; PS-21; PS-22; I-2; I-4; I-9; I-11; I-14; I-17; PTS-2; PTS-5; PTS-7; PTS-12; IV-2; IV-7; IV-13	PS-4; PS-7; PS-10; PS-17; PS-19; PS-24; PS-26; PS-27; I-3; I-5; I-7; I-10; I-15; PTS-3; PTS-6; PTS-10; PTS-15; IV-3; IV-8	

Table 9. Display of Themes and Associated Data Sources for Research Question 2

Themes	**PS**	**I**	**LP**	**PR**	**A**	**PTS**	**IV**
Theme 1: Content pedagogy & student learning							
Student learning & strategies for engagement	X	X	X	X	X	X	X
Content pedagogy & teacher role	X	X	X	X	X	X	X
Aims/Issues	X	X	X	X		X	X
Theme 2: Scientific practices							
Physical & cognitive practices	X	X	X	X	X	X	X
Social practices	X	X	X	X	X	X	X

Table 10. Triangulation of Codes for Research Question 2

Content pedagogy and student learning		
Student learning *Strategies for engagement*	*Content pedagogy & teacher role*	*Issues* *Aims*
PS-1; PS-6; PS-10; PS-14	PS-3; PS-7; PS-15	PS-12
I-1; I-5; I-9; I-12	I-2; I-6; I-10; I-13	I-8
LP-3; LP-9; LP-10; LP-16;	LP-4; LP-7; LP-12; LP-17;	LP-22
LP-18; LP-25; LP-27	LP-20; LP-23; LP-28	PR-3
PR-1; PR-4; PR-7; PR-10	PR-2; PR-6; PR-8; PR-11	PTS-4
A-3; A-6; A-10; A-15; A-18	A-1; A-5; A-7; A-9; A-11;	IV-4; IV-14
PTS-1; PTS-5; PTS-11;	A-16; A-19; A-21	
PTS-15	PTS-2; PTS-6; PTS-14;	PS-4; PS-12
IV-1; IV-6; IV-11	PTS-18	I-4; I-8
	IV-2; IV-7; IV-12	LP-5; LP-31
PS-2; PS-11		PR-3; PR-13
LP-6; LP-19; LP-26; LP-29		PTS-4; PTS-7; PTS-13;
PR-5; PR-9; PR-12		PTS-17
A-13; A-20		IV-4; IV-9; IV-14
PTS-8; PTS-12; PTS-16		

Table 10. Continued

Scientific practices	
Physical & cognitive practices	*Social practices: Communication Writing Reading*
PS-5; PS-8; PS-13; PS-17	PS-9; PS-16
I-3; I-11; I-14	I-7
LP-1; LP-11; LP-14	LP-2; LP-5; LP-8; LP-13;
A-2; A-4; A-12; A-17; A-22	LP-15; LP-21; LP-24; LP-30
PTS-3; PTS-19	PR-14
IV-3; IV-8; IV-13	A-8; A-14; A-23
	PTS-9
	IV-5; IV-10
	LP-5
	IV-5; IV-10; IV-15
	LP-8
	IV-5; IV-10; IV-15

The second approach to improving credibility included peer debriefing with an individual in a faculty position who is experienced in teaching and carrying out qualitative research. Peer debriefing ensures "external checks on the inquiry process" (Lincoln & Guba, 1985, p. 301) and can act as a "sounding board for the investigator to test his or her developing ideas and interpretations, and probing from others may help the research to recognize his or her own biases and preferences" (Shenton, 2004, p. 67). Peer debriefs included discussion and review of iterative coding process and interpretations. The researchers reached consensus on these processes, codes, and themes.

Transferability is similar to generalizability in quantitative line of inquiry, in which the readers can use the review the research setting and draw from findings in different context. Lincoln and Guba (1985) suggested providing a rich, thick description of the case, ensuring that "sufficient contextual information about the fieldwork sites is provided to enable the reader to make such a transfer" (Shenton, 2004, p. 70). This study included a detailed description of the research context, participants, and data sources and collection procedures.

Confirmability refers to researcher bias or subjectivity. In addressing confirmability, the role of the researcher and assumptions were described including subjective nature in qualitative research and triangulation of multiple data sources. Another approach is to present an audit-trail (Miles & Huberman, 1994). In this study, the researcher conducted a thorough review of the literature to ensure that the study relates to past studies, which aids in "the researcher to relate his or her findings to an existing body of knowledge" (Silverman, 2000, p. 69). A data-oriented audit trail includes coding procedures, process of identification of patterns and themes, and availability of instrument protocols.

In sum, the researcher sought to understand perceptions of scientific practices and science teaching to DHH students. In this qualitative case study, multiple data sources were considered in effort to thoroughly describe the nature of the case and participant roles and activities. Data sources included surveys, course documents, and interviews. Thematic analysis entailed initial coding procedures, groupings of codes, and identification of commonalities and patterns leading to themes. Trustworthiness and quality of findings were verified.

Chapter 4

Findings

Introduction

The purpose of this study is to describe deaf education preservice teachers' perceptions of teaching science to deaf and hard of hearing students. Research questions are as follows: What are deaf education preservice teachers' perceptions of scientific inquiry? What are deaf education preservice teachers' perceptions of science teaching and learning among deaf and hard of hearing students? The researcher provided inquiry experience with explicit reflective pedagogy for the science methods aspect in curriculum and instruction for deaf education majors. Data collection included surveys, interviews, and course artifacts to elucidate the perceptions of science inquiry and science teaching throughout this course. In this chapter, the researcher described participants' perceptions of scientific inquiry and science teaching to DHH students.

Research question 1

What are deaf education preservice teachers' perceptions of scientific inquiry?

Data sources in support of research question 1 included surveys, science inquiry project reflections, and interviews. Three themes were identified through the iterative coding process; Table 11 provides a visual representative of the development of themes. Preservice teachers of DHH in this study share perceptions about the nature of scientific inquiry, literacy tools, and level of practices and creativity.

Theme 1: Nature of scientific inquiry

Participants described SI as a construct of distinguishing practices in a procedural and linear manner. They perceive that inquiry begins with an observation or question followed by an arrangement of investigative practices and ending with some form of response to the question or a conclusion. Framing questions for inquiry are constructed from background knowledge and experience; however, proceeding with this process is driven by curiosity and motivation. The development of formulating questions entails creativity and reasoning. Questioning is interchangeable with predicting and hypothesis; regardless, this component in SI is the lead for investigative proceedings.

Table 11. Development of Themes for Research Question 1

Nature of scientific inquiry
- Procedural & linear
- Purpose of inquiry

Literacy tools
- Obtaining information
- Documenting observations/data
- Disseminating findings

Level of practices & creativity
- Investigative practices
- Creativity

Participants believe that SI in part constitutes physically engaging exertions, most of which associate with two of the five principles of SI: *conducting investigations* and *collecting data*. Conducting investigations is characterized in participants' responses as implementing diversified skills and tools to follow up on the research questions. Some examples include observations, experiments, “hands-on activities”, and data collection and take place in the natural environment or in artificial setting using treatments and manipulations. In Sonja’s interview, she illustrates the differences in investigative practices, “I think scientists find questions that they want answered, and they observe their natural surroundings to answer those questions or create a method.” Scientific inquiry in this manner is comparable to the “scientific method.” Kerry’s description of the scientific method in her survey follows.

> Scientists use the scientific method to investigate the world. They do experiments and research to find the answers of their questions. To learn about the natural world the scientist observe, manipulate, classify, compare and any other inquiry skills in order to figure out answers.

This pattern exists across participants’ course developments and reflections. A scientific method is characterized as a linear procedure beginning with an observation, issue, or question followed by some form of investigation in which is interchangeable with doing research, science, and experiments.

The concluding component of the inquiry process is the findings; however, when asked to respond to survey or interview questions about the inquiry process, participants described questioning, conducting investigations, and collecting data. Conclusions or findings were discussed separately. An example from Penny’s survey response demonstrates the linear nature concentrating on physical practices: “Scientists learn about the natural world through engaging in meaningful and authentic science activities. These activities could involve investigations, research, data collection, or ‘hands-on’ activities.” The results are not indicated immediately after this statement. Sonja compared her inquiry project to the work of a scientist. Her response centered on predictions, methodology, and documentation. The results or findings are not indicated immediately after the physical practices.

The findings or conclusions and purpose of inquiry are explicitly discussed or implied in course documents and transcripts. Equivalent phrases include “finding answers”, “sharing results”, or “presenting data.” Generally the purpose of inquiry as described by participants is to generate scientific knowledge to satisfy individual curiosity; however, when prompted on how scientists use social practices (e.g. communication) in their field, participants agreed that findings needed to be disseminated to some degree. Dawn replied, “They [scientists] can do it in forms of papers, presentations, projects.” Sonja explained that scientists “collect their data in their notebooks, then they can make their findings known to the university or to whoever’s paying the grant to support their research.”

In summary of theme 1, SI is perceived as a procedural and linear process as one would compare to a scientific method. The first stage is constructing a question or identifying a scientific issue. The second component encompasses physical practices centering on methodology and data collection. The final component, while not frequently discussed immediately after the second component, is devising a conclusion primarily to generate knowledge and for some to disseminate to the community through various forms.

Theme 2: Literacy tools

Participants’ perceptions of SI include the belief that scientists use literacy tools as part of the inquiry process. Some examples include review of literature, documentation of data, and using communication tactics to disseminate findings. Dawn explained that scientists “review previous literature or studies to build on their own.” Kerry’s response in her inquiry reflection indicated the significance of literacy tools to gain information about the issue or extent of interest. Additionally, review of literature adds to current understanding of scientific processes. Penny delineated the use of literature as part of scientific practices.

> Reading is important because if you can’t read what you need to research, then you don’t know what to research, so reading to know where to begin, what to read help you guide you to find out the next step you should take (Interview).

Sonja asserted in her interview that reading is necessary to find out “what’s already known to help you build on your knowledge of the concept you’re trying to find an answer to.” Reading also provides ideas for investigative practices. Kerry explained in her survey that scientists need to “research and look for something that has been done before. Once they find out that they set up their experiment and how they are going to look for answers.”

Writing is another task that is frequently mentioned by participants as being employed throughout the SI process. Participants described the practice of writing tools for recording data and notes from observations and disseminating to distinctive audiences. In Sonja’s interview, she explained, “scientists need to be able to write findings and make it legible for people to understand.” She described that scientists use inscriptions to make more sense of the observed events, for example, drawings, diagrams, documenting images, and field notes.

Participants also explained that communicative practices in science are employed during dissemination of findings. During Kerry's presentation of her research, she reflected on communication tactics to present findings to peers. Penny enumerated communication strategies to meet the needs of distinctive audiences. Communication in the field occurs "with other science professionals, in written form or used for educational purposes, it could communicate with different types of educators." Presenting visual representations of the data analysis (e.g. "charts or graphs") is a way to "communicate what [scientists] have found." Scientists use high-level reasoning and originality in how their information is displayed. During Dawn's interview, she elaborated on the use of communication tactics in science, "creativity comes into a lot, they can do it in forms of papers, presentations, or projects. Depending on the audience, I think it can really vary, like presentations, projects, books, stories, and anything like that."

In sum, theme 2 encompasses beliefs about literacy tools utilized in the sciences. Review of literature is primarily for the purpose of expanding knowledge on an issue and identifying promising methods. Writing is a mechanism for documenting observations of a scientific phenomenon. Originality is essential to distinguish observed events. Additionally, writing contributes to the dissemination of findings and meeting the needs of heterogeneous readers. Communication strategies are employed in the sciences by delivering findings within the science community and to the public.

Theme 3: Level of practices and creativity

As highlighted in themes 1 and 2, participants' beliefs regarding the use of methodology in SI is accentuated across data sources. Participants periodically described the methodology as a physical and cognitive practice. It is what scientists "do" that is primarily representative of their work in the field. Dawn explained, "Scientists learn about the natural world largely through observations. They observe and act on that curiosity." Another example involves "doing research" and "collecting or documenting data." Penny illustrated physical practices including "investigation, research, data collection, or 'hands-on' activities." For her research study, she compared two variables, used treatments systematically, and "took pictures to document [her] results." She believed this was comparable to the work of a scientist. Oftentimes scientists observed the natural surroundings prior to or in place of experimentation. When Kerry designed her research study, she decided on systematic observations but if there were incidents when observations were not possible, she referred to print-based resources. "Doing research" corresponded with manipulations. Sonja explained in her survey that scientists observed things in natural environments or developed protocols or manipulatives.

According to participants, innovations and creativity intertwine fundamentally with physical and cognitive practices in science. Examples of cognitive practices include "classification, comparison, and critique." The creative nature depends on the unique experiences and perspectives of scientists. Participants agree that scientists use imagination and originality in their work. Dawn's description of the creative nature in the experimentation process is as follows.

> There are always multiple ways of doing research. Each scientist brings their own knowledge and experiences to the table. If two scientists are studying or experimenting the same thing, more than likely they will do it differently. They will bring their own ideas to the table, and what they think is best.

Scientists generally construct protocols or treatments. Construction of these protocols or manipulation of variables requires creativity. As part of the participants' scientific inquiry projects, they were asked to reflect on the consequences of their unique experiences and scientific knowledge during their progress. In Dawn's reflection on her inquiry project, she indicated she would add more variables, more time, and more documentation of her observations because she developed more questions at the end of her study. Sonja described the impact of creativity on revisions of methods, "if an experiment fails, scientists need to be "creative to think of what happened and then they need to change it."

> Scientists need to figure out how they want to record their data and make measurements. As the scientists finish their experiment, they must think of ways that they would alter or change their experiment if they were to do it again, which requires a level of creativity to do so.
>
> I strongly believe that the work of a scientist is creative and it takes a 'special' person to take on the responsibilities that come with problem solving, experiments, and investigations. I think a scientist has to use their creative mind and be willing to 'think outside of the box' and to try different things. We know that many things have been discovered/invented through scientists who are willing to try different things as a result of their creative minds.

When asked about the creative nature of inquiry, participants associated high-level reasoning and originality with documenting observations particularly how scientists would describe their experiences. Some examples they gave of scientific inscriptions are unique visual representations including drawings and recording images. Kerry explained that individuality is used in "how they [scientists] record or present data" and Sonja believed "scientists have to use some creativity when they are creating how they will record their information. They may need creativity when it comes to documenting their observations (e.g. drawings)."

To conclude theme 3, participants perceive that the level of practices and creativity in SI are meshed with physical and cognitive practices. The majority of the work involved in science is centered on what scientists physically do particularly during investigations and collecting data. Creativity derived from experiences and unique backgrounds are embedded in these practices as well, e.g. reasoning process, devising methods, reflecting on experimental practices, and approach to documenting data.

Research question 2

What are deaf education preservice teachers' perceptions of science teaching and learning among deaf and hard of hearing students?

In additions to the surveys, science inquiry project reflections, and interviews used to inform research question 1, additional data sources were included in response to research question 2. These included inquiry-based lesson plans and reflections, peer-instruction analyses and reflections, and peer reviews of peer-instruction. As a result of the thematic analysis, two themes with associated sub themes were identified: 1) Content pedagogy and student learning (student learning and strategies for engagement, content pedagogy and teacher role, and issues and goals for learning); and 2) Scientific practices (physical and cognitive practices, and social practices). Table 12 includes a visual display of the themes and sub themes.

Theme 1: Content pedagogy and student learning

Sub theme 1a: Student learning and strategies for engagement

Participants placed great importance on student learning and the uniqueness of learning of DHH individuals, considering visual representations and tactile experiences, incorporating concrete ideas and examples in instruction that are meaningful and authentic to students. DHH students are "visual learners" and seeing things promote comprehension of scientific ideas. Dawn explained, "seeing something in front of them will help them [students] grasp the idea better than an abstract concept that they cannot visualize." She also explained that abstract ideas are difficult if one cannot associate to concrete objects through visual or tactile experience.

Table 12. Development of Themes for Research Question 2

Content pedagogy and student learning • Student learning & strategies for engagement • Content pedagogy & teacher role • Issues and goals for learning
Scientific practices • Physical and cognitive practices • Social practices

> It is harder to focus on that and really understand it if they don't have something to look at it. If they've never seen whatever you're talking about before, they're not going to be able to really make much sense out of it.

> Students have opportunities to actually see and to create something; they are likely to understand it better.

Participants also expressed that students need experiences with everyday activities in their natural surroundings. An excerpt from Penny's transcript is as follows.

> Deaf and hard of hearing student would also need experiences in his or her environment. A lot of science can be done in one's own backyard. If a child already knows a lot about his or her own environment, they would have a better chance at being successful in learning science because they can build on what they know.

Visual representations and experiences were taken into consideration in participants' lesson plans and peer-instruction. In Penny's peer instruction analysis, she reflected on ways to improve the visual nature of her lesson. One example she explained is to project the research question so that students can refer back to text throughout an investigation or lesson. She also reflected on providing more visual tools to reinforce her explanation. Sonja explained that she developed her lesson with special attention to visual tools because of the nature of learning of DHH students. She noted the importance of students actually seeing scientific events.

Hands-on activities or tactile experiences are perceived to be essential in the science classroom for DHH students. Participants agree that students need to be physically and cognitively engaged and apply their senses. Kerry stated that students "need to see and feel and touch (use all senses) in order to comprehend scientific concepts." Sonja believes that tactile experiences should be provided for all students and to moderate lectures because "lecturing is not really the most effective way of teaching; having them figure it out for themselves and use the materials to find things is more effective for anyone." From the post course interview, Penny disclosed that tactile strategies "require students to dig in using their minds and help them understand and figure out what they are learning."

Further, science needs to be meaningful, authentic and related to student's lives to facilitate motivation and activate prior knowledge. An excerpt from Dawn's transcript is as follows.

> Related to student's everyday lives if possible. Students can observe the natural world around them and decide on a question on something they would like to know. They can make a prediction and then conduct an experiment to figure it out. If students experiment about something they physically see or think of themselves, it will be more meaningful to them and they will understand than if it were a foreign abstract concept to them.

Participants shared that preconceived ideas of scientific concepts can be augmented if science is familiar and presented in context. This fosters transfer of scientific knowledge into other disciplines and situations. Sonja provided an example, "I think that as students are able to make connections with experiences that they have had, they are able to recall and generalize the information in a more efficient and comprehensive manner." Kerry explained, "they need things that are related to their real lives, this helps them grasp new concepts and understand. They can build new schemas this way."

To effectively prepare a science lesson, participants agree that science teachers of DHH students consider incorporating visual tools and opportunities for more experience to support learning. Some examples of visual tools include videos/media, graphic organizers and other print-based materials. Dawn described, "reading a book about scientific current events or watching videos really give students a visual representation of what they are learning." Other examples of visual tools include using a poster paper or board to document predictions, data, or reflections. Dawn and Penny reflected on using these materials to document student's predictions, suggestions, or ideas not only for visual purposes but also to demonstrate scientific practices, e.g. the process of documenting data. Kerry and Sonja explained that PowerPoint is a valuable visual tool that can incorporate images and videos and relate to student's prior knowledge or everyday lives.

Experimentation is a strategy favored by participants to help students understand scientific phenomena. In effort to draw in student's prior knowledge Kerry believes, "it is important to start every week with an experiment" because this will help them get interested in new topics which they are able to relate based on prior knowledge. In Dawn's lesson plan reflection, she suggested introducing a new lesson with a setting, hook or demonstration.

> I believe that teachers need to make scientific inquiry meaningful to students by making it relatable. They need to first begin simple with something that students

> are familiar with, and then they can build on that and expand to more complex ideas. For example, in my inquiry project, I first began with a familiar object. I made sure students knew what it was and what it was used for. Then I proposed a question and we conducted an experiment. By doing this, I was able to discuss scientific reasoning with students.

In addition to student learning, participants frequently discussed various strategies for engagement. All participants indicated that science for DHH students needs to be exciting to spark their interest and curiosity into learning about science. Sonja believes that "students become really motivated to find answers when they are curious." Additionally, an innovative and exciting learning environment facilitates engagement, exploration, and interaction. When Penny selected her inquiry lesson, she considered the level of engagement for all students in promoting collaboration and teamwork. She believes that each person should have a part in an investigation. In her survey response, she stated that when given "the opportunity to interact with what they are learning about, they [students] are likely to gain more from the lesson and to actually remember what they are being taught." Interaction is not limited to individuals but objects. She explained, "students will learn best in situations that allow them to interact with things. For example, instead of having students read information about a scientific idea or phenomenon from a textbook, why not have the students mimic the event" or participate in outdoor field studies or field trips. For her peer instruction assignment, she reflected on the level of engagement and on ways to improve interaction among students.

> While I conducted a lesson that was engaging for students and that was guided by one single question, I realize that I should have varied my question types so that I could get more information from students. I caught myself telling the students what to do or why something happened instead of allowing them to fully express themselves through experimentation and answering.

She also felt that she did not give students enough time to investigate their question throughout the lessons. If she were to teach this lesson again, she "would give students more time at the beginning of the investigation to explore."

Kerry designed her lesson with collaboration in consideration. In her reflection, she stated that inquiry-based science encourages engagement and collaboration and included a response to how her lesson was considered "exemplary" for DHH students.

> The students will be working in groups and then at the end of the lesson the students will be asked to share what they feel that they could have done differently. The students will be working in teams and they will need to communicate with each other to figure out the best design. The students will also have to share results and different ideas.

For her lesson demonstration, "she did not give students the answer" but explained that she should "have let the students come up with the procedures instead of [her] giving them to students. This is a hard step away and the students find their own way to what you want to teach."

Sub theme 1b: Content pedagogy and teacher role

In the literature content pedagogy is described as the orientation of substance and instruction. Participants expressed the need to use multiple strategies including inquiry-based instruction and focus on content and vocabulary development. Participants concur that an assortment of engagement strategies and instruction are essential to successful learning of science, as well as the incorporation of scientific practices. An excerpt from Sonja's survey about inquiry follows.

> I think that one of the most effective strategies for teaching students science. The inquiry approach allows students to pose a question and find an answer through their own research. I think that this process motivates students and allows for them to discover science in a way that makes sense them. An example of inquiry-

> based science would be for students to come up with a problem or question that they face and to come up with a way to solve the problem or question.

The goal for learning is also centered on content knowledge and vocabulary development. Some assertions from participants on integrating approaches to vocabulary development are as follows.

> I think that they also need the exposure to English and the language that they use in science (terminology). This way they are able to understand later in the upper grades (Kerry).

> I think that there's a lot of vocabulary with science not just necessarily scientific vocabulary, academic vocabulary so that they can learn, they can learn a lot of vocabulary from discussing science. Vocabulary is essential if introduced in a natural way (Sonja).

In addition to content knowledge and vocabulary development, teaching science as described by participants can be cross disciplinary to allow for more depth. Various ways to do this exists, whether it is incorporating a variety of materials, content, or scientific practices. Penny explained in her interview that inquiry is interdisciplinary in terms of social practices with respect to writing. By incorporating writing tasks, "we'd be writing our data, we could write a story, we could write about what we did in science." She also shared her views on mathematical applications as interdisciplinary. She explained, "students will be applying math in this experiment. Since we would be using measurements, the students would be exercising their math brains." Dawn's reflections agree, "it is real world experience, it can be applied to different disciplines. It includes math as well as science (measurements)."

Inquiry and the nature of interdisciplinary instruction are perceived to allow for depth on a topic or issue. From Kerry's reflection on integrating inquiry in the classroom, she explained with time, “they will learn more in depth about scientific events and see clear relationships and interrelationships among broad and lifelong concepts.” She described the importance of depth in her lesson plan and reflection and survey.

> I will be using depth of understanding. The students will not just be touching on a topic, they will be working to create something. We will not just briefly touch on the topic, we will focus on it so that students understand. This also creates a clear relationship among lifelong concepts. The students will need to know this basic information when they get into higher sciences.

Participants discussed facilitation of cognitive engagement using dialogic strategies. Inquiry-oriented lessons were supported with guided instruction tactics (questions, explanations, modeling, facilitating reasoning). Dialogic and questioning tactics were discussed throughout the course and in participant’s course assignments for the purpose of engaging students and facilitating high-level reasoning and prompting for more content from student’s responses. Dawn used this approach during peer instruction to encourage students to think of reasons for their results, “I asked the students why they think this occurred and encouraged students to give me reasons based on their ideas.” In Penny’s survey, she explained her approach to facilitating high-level reasoning and questioning.

> I think it would be helpful to remind deaf and hard of hearing students to constantly ask themselves “why” when completing/engaging with scientific inquiry. I think that “why” questions allow an inquiry to progress. During my own inquiry projects, I constantly asked myself “why” – for example “Why did this happen?”

In her peer instruction analysis and reflection, she realized that she did not consider asking students “why” throughout her lesson.

> I should have varied question types so that she could get more information from the students. I caught myself telling the students what to do or why something

> happened instead of allowing them to fully express themselves through experimentation and answering.

Participants believe that specialized communication tactics are essential to facilitating cognitive practices and engagement. Sonja explained, "lecturing is not really the most effective way of teaching; having them figure it out for themselves and use the materials to find things is more effective for anyone." Penny's interview response corresponds with Sonja's explanation. Science is not only hands-on but also minds-on, where students "kind of dig in using their minds." Based on peer instruction analysis, Sonja considered the creative nature in experimentation; she wanted students to "think of unique ways to solve the problem based on everyday materials." Kerry also acknowledged this in her peer instruction analysis centering on "having students develop their own procedures." Participants agree that hands-on and minds-on science should include students "creating something and taking charge of their own learning" and using critical thinking and reasoning skills.

Despite class discussion on the creative nature of inquiry and autonomy, participants expressed the need to provide guidance, particularly being that their work was with elementary students and considering the variety of issues that exist in deaf education literature. Guided instruction tactics were frequently discussed throughout the course, ranging from posing a question to providing assistance with methods to providing a thorough explanation of a scientific concept. All participants posed scientific questions for their peer instruction and inquiry-based lesson, although, in their reflections, there was some discussion on allowing students to generate their own questions by preparing an innovative learning environment. Discussion on creativity or exploration occurred primarily during the investigative process. In Kerry's peer instruction reflection and analysis, she felt she succeeded in "allowing students to discover answers for themselves." Sonja encouraged her students to decide on method options and provided assistance during the investigation.

There were some consistencies in how new knowledge of scientific concepts was introduced or facilitated. Participants took on the lead to provide explanation but this occurred either before or after exploration. From Dawn's interview, she discussed scientific laws after presenting a demonstration and facilitated predictions. She used the 5E learning cycle to help design her lesson to ensure the inquiry orientation and introduction of new concepts. Two participants provided feedback on peer instruction stating that "more explanation is needed" to help students understand scientific concepts that were associated with the lesson. There seems to be some confusion among participants about in the nature of scientific inquiry and teaching science. From Penny's analysis of her peer instruction, she felt that she should have "directly explained to students why these events occurred." She felt that she "left it more open-ended and did not provide a straight answer to the question." In her lesson plan, she provided the explanation before students could explore with the question or predictions. She believed that providing background knowledge was necessary for students to proceed with the investigation.

Sub theme 1c: Issues and goals for learning

Participants expressed issues in respect to DHH student experience and capacity for academic achievement. Some matters discussed include lack of exposure to language impacting reading and writing skills and communication skills and lack of experience in science, as well as issues about teaching science. The lack of experiences of most concern to participants has to do with communication accessibility. These attributes were taken in consideration during course developments whether it be approaches to shared to independent reading or integrating print-based materials in science. Assessing for prior knowledge to contribute to lesson design is considered imperative. Dawn explained in her interview about assessing student's prior knowledge.

> We don't really understand what deaf students already know and don't know, and they don't really have the communication skills to tell us. So I think starting basic relating to something you, some other background knowledge that you already are aware of.

In Sonja response to her inquiry project reflection, she expressed concerns with instructional tools and strategies to address these issues. Insufficient time is allowable for providing inquiry-based instruction and with limited experience among DHH students, she would need to think about the skill levels in scientific practices such as documentation procedures. Further, she expressed that inquiry also requires materials and unfortunately, most schools do not have the resources.

In addressing these issues, participants have highlighted ways they would overcome these challenges to help close the academic gap. Goals for learning they discussed focused on improving language and communication skills to support learning, content knowledge and retaining vocabulary, facilitating high order skills, expanding on prior knowledge, and improving autonomy. Participants agree that students need more experience and exposure to scientific events and concepts. An excerpt from Sonja's post-survey follows.

> I think that experiences within the natural world are necessary for deaf and hard of hearing students to become successful in learning science. I think that students need to have these basic experiences of scientific phenomenon in order to have information to scaffold on to.

Penny responded similarly, “experiences involving the natural world and their environment are necessary for DHH students to become successful in learning science.” In addition to experiences and exposure, they need to be “given the language that supports that topic and those ideas.” Having that language allows for students to generate and ask scientific questions and work collaboratively to complete science-related tasks; students can use language to share their findings and/or project, which facilitate “exposure to receptive and expressive language.” Dawn responded in her interview, “if they [students] can explain it to another person, another student, or to the class, students are getting that receptive skills from the other students but they’re also being able to express themselves.”

Participants believe that DHH students need opportunities to utilize scientific practices encouraging high-level reasoning and that inquiry-oriented science encourages creativity and autonomy. Kerry expressed in her survey that students should “feel that they are in charge of their own learning” and allow for depth on a topic to expand on one’s mental schema. Dawn asserted that if students are “unable to question things for themselves, they will not be able to conduct experiments on their own either.” Based on her description, autonomy allows for depth on topics and for one to follow up on curiosity on an issue or question. Additionally, inquiry should be a place where the goal is for students to follow through with their own questions and establish ownership of the results and new knowledge.

In sum of theme 1, participants perceive that DHH students are visual learners, relying on visual representations and tactile experiences to support learning. Further, science content, experiences, and vocabulary need to be meaningful, authentic, and related to student's everyday lives. Dialogic strategies were frequently discussed to promote high-level reasoning and to overcome issues and challenges that exist in deaf education.

Theme 2: Scientific practices

When asked about teaching science to DHH students, participants discussed the nature of scientific inquiry and use of physical, cognitive, and social practices that are implemented in the field. The nature of scientific inquiry is how one views the process. Participants discussed the inquiry process as linear with some focusing on step-by-step procedures. While the latter is not entirely reflected in the field of science, these attributes are essential in science education and utilized in inquiry. Participants would explain the inquiry process with beginning on the questioning or issues followed by some type of investigation or experimentation with the goal to satisfy the unknown or provide insight on scientific issues. In Dawn's peer-instruction analysis and reflection, she felt that she "should have been clearer with the procedures. I should have told the students step by step what we would be doing with this experiment." Penny responded similarly primarily because of her preferred age group, "since students are younger, I gave them step by step instructions." Kerry reflected on this aspect as well. While she gave her students the procedures, she felt that she should have discussed "why we do the procedures the way we do. I could have let the students make up their own procedures. This was not as unique as it could have been."

Two domains were identified in relation to scientific practices. Physical and cognitive practices are closely associated and will not be separated in this paper. An example of physical practice would be any activity that requires physical capacity such as setting up an investigation, observing, collecting data; whereas cognitive practices would be the use of reasoning skills throughout the process, using mathematical applications (e.g. measurements), analysis of results, or creative nature in methods or data. Social practices, however, distinguish enough from other practices and qualify as its own domain.

Sub theme 2a: Physical and cognitive practices

Physical and cognitive practices are divided by participants into three major aspects of SI: questioning, investigative practices, and findings. Participants used questioning interchangeably with hypothesis and predictions. This is viewed as the "first" step. Sonja explained that the learning environment is essential to encourage students to create and carry out experiments based on questions that they have. For Kerry's inquiry project, she started with a question and needed "collect data to find results." For inquiry-oriented instruction or projects, Sonja explained, "students [will] come up with a problem or question that they face and to come up with a way to solve the problem or question." Observations can occur before questioning or acknowledgement of issues. Dawn explained in her survey that students who are provided with tools to rely on independently can "freely observe anything and make predictions." Her perception is implied through the following: "Students can observe the natural world around them and decide on a question of something they would like to know. They can make a prediction and then conduct an experiment to find out." In the interview, she used hypothesis and questions interchangeably. Penny immediately started with predictions as part of her set. Dawn did the same thing by presenting a demonstration to trigger student's attention and curiosity and facilitated a discussion on their predictions.

The second aspect of this analysis is investigative practices, which are used reciprocally with experimentation, exploration, and research. This phase is assumed by participants to conduct some sort of method to follow up on a question. Specific methods are not frequently discussed, other than "conducting or performing experiment", "exploring", or "making a protocol." Penny compared investigative practice as "follow[ing] procedures and collecting data." Collecting data is discussed as "measuring the amount of" something. There is little discussion on data collection alone and the creative nature of methods. Collecting data is the only approach to gathering data described. Often participants will assign procedures for students to follow. Kerry believes that the scientific method needs to be taught by having students "perform the steps, they need to have multiple opportunities to practice what this means."

Finally, the findings are discussed as an aspect of the SI process. Two attributes include purpose of inquiry and presentation and communication of findings. Participants agree that the purpose of inquiry is primarily to "find the answer", "answer the research question", or "respond to the prediction." There is little discussion on sharing the findings or interpretations or skills required for making sense of data. Dawn designed her lesson so that students would ultimately explain why their results turned out the way they did and share with peers. Penny responded similarly in her lesson plan reflection. Following the documentation of observations, “students will be able to make educated guesses based on their background knowledge.” This shows high-level reasoning that includes student’s prior knowledge and experiences. However, in her assessment or response to the experiment, she would have students respond primarily on what was observed and what was learned from the experiment. This appears appropriate to her being that her preferred age group is in lower elementary students. Another example of high-level reasoning is from Kerry’s peer instruction and reflection. She explained that she would have had students “compare real answers with their guesses. This would have been a great introduction to talking about the causes of scientific events.” Dawn reflected on her inquiry project that if she did her project in the classroom, “students would also present their project to the class” but for the purpose of exposure to receptive and expressive language skills.

An excerpt from Sonja’s survey regarding inquiry process follows.

> I think that it’s important to have an inquiry-based science approach when teaching science because they are able to come up with answers for questions that they may have themselves. I think that this allows students to become motivated to learn and help them really remember and understand information. An example of inquiry-based science would be for the students to come up with a problem or question that they face and to come up with a way to solve the problem or question.

Again, there is little discussion on the creative nature of interpretations or constructing a claim. Sonja and Penny compared their research study to the work of a scientist.

> I think it would be similar because students are finding an answer to a question and having to work either with their teachers or with themselves to find an answer

> to the question, and I think it's different because a lot of the answers are already known, so they're not really expanding upon something that's unknown. It's more of them building knowledge for themselves rather than…I think scientists do it for more general public to learn but scientific inquiry is just student-based, so it's more focused on what they need to know and want to know.

> Would be similar that with an inquiry in the classroom you expect the students in the classroom to take on the scientist's role and you want them to make hypotheses, you want them to follow procedures and collect data and to answer the main question. So I think that a real scientists and science in the classroom is the same; it's very similar

Sub theme 2b: Social practices

In science, the social practice of reading is perceived by participants as important and incorporated to help expand content knowledge to facilitate inquiry. Reading occurs "before" inquiry to help with construction of questions or selecting investigative methods. Reading can also facilitate comprehension of relationships of scientific concepts. Sonja believes integrated reading is essential which allows students to "find information through text" if direct observation is not relevant or possible. Integrating reading also helps students construct questions "based on some background knowledge they learned from books or experiences they have had." Penny explained in her interview that reading is integrated when "reading the instructions, reading what you need to do." Text in science is used to support and prepare students for inquiry.

Writing is another social practice in science. Participants agree that opportunity for writing is an important tool in science. For instance, writing can be used during the inquiry process particularly the investigative stage. Students can use writing to make a "note of their observations or write down what they're learning so that they can look back on it and make conclusions." Dawn explained in her interview about integrating writing in science to build vocabulary skills and content knowledge, reflect on the learning process, and assess on content knowledge.

> It's a good way to have students reflect on it, a good way to build vocabulary. If you have them write the word, not just necessarily sign it, you can understand that they're at least seeing the word and they're kind of relating it back to them. You can also write like a journal about how they feel about science or what they learned or what they're doing.

Penny stated in her interview that she would have students write a "story" about their experiences in science.

> We'd be writing out data throughout, but at the end, we could write a story, make it cross curricular and involve it in our writing lessons, we could write about what we did in science. What we do in writing now is a replay of activities we've done through writing. We could start step-by-step and write a story about what we did in science inquiry.

Writing in science is perceived by participants as a tool that can be applied as social practices including use during the data collection process, reflecting on new knowledge from the findings, and creating a narrative about the science process.

Communication during science is seen as having the purposes of facilitating questioning and dialogue between students, practicing academic language, sharing results, and introducing new science vocabulary. Participants agree that teachers use communication tactics to encourage questioning and reasoning during inquiry and generate new knowledge. An extraction from Sonja's survey follows.

> The most effective strategy for facilitating scientific inquiry for DHH students is by encouraging students to ask questions throughout the lesson. The teacher can pose questions for students and allow students to discuss them, rather than simply providing answers for everything relating to science.

Participants shared that communication tactics can be used during discussions as part of an inquiry approach. In Sonja's peer instruction analysis, she stated, "students were communicating their ideas based on the materials and information."

> I would use communication by having class discussions, a lot of dialogue included within the learning process, so they're not just seeing things happen, they're having a discussion about it, and they're able to learn more about it and they're able to learn from their peers and from their teacher whatever they have to add onto the information they're watching happen.

Dawn explained that communication is a good way to "assess their understanding" and build expressive and receptive skills.

> Communication is a good way to assess whether they're understanding. If they can explain it to another person, another student, or to the class, students are getting that receptive skills from the other student but they're also being able to express themselves. I think that's a great way to incorporate communication.

DHH students may have some gaps in background knowledge about the natural world because "students' parents may be unable to provide them with the language that hearing children may have access to on a daily basis." The following excerpt from Sonja's interview response relates to advantages of using communication tactics to build content knowledge and vocabulary.

> They can learn a lot of vocabulary from discussing science, and just having just any sort of communication helps in the classroom, especially with deaf and hard of hearing students with a teacher who knows sign language and they're maybe not getting that background knowledge at home. It really helps to communicate with them, to build that background knowledge that they might have had a slight understanding of something and when you're able to really explain it and discuss it in class, it helps them improve their understanding of it, whatever the concept it is you're teaching or doing the project on.

Students' inputs and ideas are valuable. Sonja included in her lesson plan reflection that teacher-facilitated discussion encourages questions and responses to predictions, which then "naturally introduces vocabulary."

> This lesson addresses language and communication skills by having each student contribute to the class discussion by commenting on changes they are noticing. This would be a great opportunity for the teacher to introduce a lot of vocabulary in a natural way.

In sum of theme 2, scientific practices were divided into two domains: 1) physical and cognitive practices (e.g. process and creative nature of experimentation); and 2) social practices (literacy tools employed to prepare for and complete the inquiry process for the purpose of disseminating results). Discussion of both domains incorporated attributes of practices as well as approach to teaching and student learning.

To conclude findings in this chapter, three themes associated to perceptions of scientific inquiry are nature of scientific inquiry, literacy tools, and levels of practices and creativity. Participants described the nature of scientific inquiry as procedural and linear, typically comparable to the scientific method. Further, scientists use a variety of literacy tools primarily for increasing knowledge of a scientific issue, documenting observations and other data, and communicating findings. Lastly, the level of practices and creativity in scientific inquiry are meshed with physical and cognitive practices. Two themes linked to research question 2 (perceptions of science teaching to DHH students) are content pedagogy and student learning and scientific practices. Participants discussed the nature of visual learning of DHH students and the significance of incorporating visual representations and providing tactile experiences during science. In this context, science content, experiences, and vocabulary are targeted and need to be relevant to students' lives. Participants discussed the significance of incorporating high-level reasoning prompts primarily to address common issues that exist in deaf education. Moreover, the scientific practices discussed in the data include all aspects of practices; however, physical and cognitive practices were discussed more frequent than attributes of social practices.

Chapter 5

Conclusion and Recommendations

The objective of this case study was to describe deaf education preservice teachers' perceptions of SI and science teaching and learning among DHH students, during a teacher education course incorporating implicit experience and explicit reflective pedagogy considering specialized instruction in deaf education. The design of curriculum and instruction applied to DHH students constitutes recommendations from the literature on science teacher education and NOS, which is to provide preservice teachers with opportunity to engage in SI practices and present explicit instruction and facilitate reflections on SI practices and their implications in the classroom with DHH students. Multiple sources of data were collected, including surveys and interviews. Additionally, participants completed a series of course tasks on the transfer of practices and reflections on this process. Some examples of course tasks include designing, presenting, and critiquing a SI lesson to peers, designing a SI lesson for elementary students, and engaging in dialogue on the transfer of these practices into the classroom. Thematic analysis of the data indicated that preservice teachers' perceptions of SI centered on the nature of scientific inquiry, literacy tools, and levels of practices and creativity. Their views of teaching science to DHH students include attention to content pedagogy and student learning and to scientific practices. This chapter includes conclusions and recommendations for further inquiry and practice.

Conclusions

Response to Research Question 1: Preservice teachers perceive scientific inquiry as procedural and linear, incorporating largely physical and cognitive practices.

The case study findings reported in this dissertation provide readers with insight on the current views of nature of scientific inquiry held by preservice teachers of the DHH. Participants in this study perceive SI as procedural and linear, incorporating largely physical and cognitive practices. Creativity is embedded in these practices. Literacy tools are utilized for various purposes, including reading, writing, and communicating as means to gain knowledge of content, document data, and disseminate findings. Overall understanding of scientific inquiry aligns to contemporary practices with some attributes in need of explanation.

Science as a linear process seems a common assumption among teachers (Akerson, et al., 2009). Solving a problem, equivalent to SI, requires multi-layer, cyclic tasks. This linear practice is analogous to the scientific method. The conception that scientist use the scientific method continues to prevail in science education and older textbooks (McComas, 1996). Reasons for these notions in regards to NOS may be attributed to the formatting of scientific journals and conference presentations. This traditional approach to disseminating findings "makes it appear that scientists follow a standard research plan" (McComas, 1996, p. 4).

Furthermore, participants' described that "doing science" encompasses diverse strategies to solving a problem. SI is viewed as doing research or experiments more than other types of practices, e.g. cognitive skills or acknowledgement of social practices.

Conversely, these practices are not limited to experimental procedures. Scientists use "non-experimental techniques to advance knowledge" (McComas, 1996). An excerpt from Yore, Hand, and Florence (2004) illustrates contemporary views of science:

> The modern view of science proposes that science knowledge is a set of temporary descriptions and explanations that best fits the existing evidence and current understanding of the real world within the limitations of people's sensory and intellectual abilities (p. 342).

Science tasks are influenced by scientist's prior knowledge, experiences, and cultural backgrounds. Creativity, imagination, and innovation fall in all aspects of the practices implemented. Participants in this study associated creativity with conducting research and recording data. In the literature, one of the most fundamental practices of scientists is using their individualized expertise and social perspectives to provide temporary descriptions and explanations of scientific phenomenon, delineate potential reasons why the data occurred the way they did from an investigation and evaluate the evidence and claims associated to this particular study (Dunbar, 2000; McComas, 1996; Yore, et al., 2004). Participants did not discuss the creative nature on these tasks. Referring back to Sam's work with the Hawaiian hawksbill turtles, she was not given a set of guidelines to proceed with her work to delineate feeding trends. Sam needed to use cognitive practices and creativity to construct researchable hypotheses, plan out logistics and investigative measures, determine best approach to recording her process, and evaluate newly developed claims with supporting evidence. Recall from the literature, science tasks and knowledge are the result of human activity; descriptions, inferences, and claims are influenced by cultural backgrounds and social perspectives (Bybee, 2004).

In the article by Yore, Hand, and Florence (2004), their description of the creative nature in science is as follows.

> These temporary descriptions and explanations are influenced by the diverse perspectives and lived experiences of the interpreter; they are expected to change over time and more closely reveal accurate insights about reality; although complete accuracy may not be achieved because of the limitations of the observers (p. 342).

Response to Research Question 2: Preservice teachers privilege content learning and vocabulary and consider the visual nature of the learning environment when teaching science to deaf and hard of hearing students

The second part of the study describes the perceptions preservice teachers of the DHH have of teaching science. They perceive that DHH students are visual learners and rely on meaningful and authentic ‘hands-on’ and ‘minds-on’ opportunities in science. While inquiry inclusive of physical, cognitive, and social practices and dialogic approaches is considered ideal for students; the participants focused on content learning and vocabulary development considering the challenges with English literacy that exist in the deaf education literature. The discussion highlights the level and types of practices described in the findings.

Implementing physical (e.g. hands-on) and cognitive (e.g. minds-on) practices is frequently discussed among participants; however, the two practices are tied closely together but not provided with equal recognition when providing descriptions. For example, participants related hands-on science to observing natural events or manipulated treatments and doing experiments. Minds-on science was often left as is without an explanation. Additionally, discussion of inferences from observed events were not present. The latter is fundamental in science and relates to scientific literacy skills. Oftentimes, SI in the classroom is oversimplified, neglecting essential cognitive skills (Windschitl, Thompson, & Braaten, 2008) and implicit learning is excessive (Holliday, 2001). This perception of hands-on and minds-on science is frequent among preservice teachers or new teachers (e.g. Cady & Rearden, 2007; Finson, 2010).

The second aspect of the discussion is centered on the importance of language and literacy. Participants' discussion on language issues or gaps seemed to determine the strategies for teaching science. Emphasis on vocabulary development and conceptual structures as indicated in the findings are reflective of deaf education preparation, textbooks, and literature (e.g. Moores & Martin, 2006). While these are fundamental aspects of the new generation science teaching framework, they encompass only a third of the standards (NRC, 2011). The other two dimensions are centered on concepts that are applied in inquiry and science practices. The imbalance of these three broad areas in science education is common among inexperienced teachers for whom conceptual structures of science are preferred over others (Brown & Melear, 2006).

Based on Abell and McDonald (2006) and the new science teaching framework (NRC, 2011), science constitutes knowledge, cross cutting concepts and practices, e.g. posing and evaluating questions, designing to conducting investigations, collecting to presenting data, documenting to discussing data, and reading about data and theories/models (Grandy & Duschl, 2007). Language that occurs during these practices are tools for facilitating these tasks but also a scientific practice of its own (Wallace, Hand, & Prain, 2004). There are numerous opportunities to embed literacy tools and with prompts. While participants identified some strategies for incorporating reading, writing, and communication, these practices were not present in their lesson plans or peer-instruction (see example in Appendix L).

Research shows teaching science can be influenced by perceptions of science (Abell, et al., 2010). Further, dependent on the nature of content and teacher preparation, new teachers are typically open to new ideas and have higher chances in applying new approaches and teaching inquiry-oriented lessons (DeHaan, 2005). However, pre-existing views of science are difficult to address considering the frequent use of the scientific method and the imbalance of implicit and explicit learning during teachers' academic experience. Efforts in research and science teacher education have shifted to applying both implicit and explicit teaching (e.g. Cavagnetto, Hand, & Norton-Meier, 2010; Holliday, 2004; NSTA, 2011b).

Additionally, participants were placed in the elementary program at the school, which had recently undergone restructuring. Time allotment for science was removed from individual classes and assigned to one teacher. Mentor teachers no longer taught science; therefore, participants did not have an opportunity to observe science inquiry instruction or apply their knowledge of inquiry science into the classroom. This concern was noted during the design of the dissertation; however, the researcher was aware of the literature on potential factors that contribute to enhanced perceptions of teaching science. For example, Martin (2001) investigated preservice teachers' perceptions of open inquiry after one semester of practicum and student teaching. The researcher found that perceptions towards teaching SI shifted after practicum but did not necessarily transfer to practice due to similar restraints. In another study on views of science with similar concerns, Skamp (2001) identified a relationship between sophisticated views of science to prior academic experience and science methods; however, this was not noted until teachers were in placed in the classroom.

To conclude, preservice teachers' perceive of science as a linear and methodological process constituting physical practices as opposed to practices in the cognitive and social domains. Participants' views of teaching science to deaf and hard of hearing students focus on vocabulary development and the necessity of providing a visually rich learning environment. Inquiry science and language use in science were discussed, but were not as developed in the course artifacts (e.g. lesson plans). These findings suggest that transfer of knowledge occurred primarily from deaf education courses, as opposed to science or science methods courses. This dissertation study provides insight to researchers and teacher educators on the current perceptions of deaf education preservice teachers considering their preparation with emphasis on the needs of DHH students, and recommended practices in science teacher education.

Recommendations

National reforms in science education and science education preparation advocate national standards in guiding content pedagogy to facilitate progression in scientific literacy and 21st century skills. Teaching and research efforts in implementing best practices particularly SI have been underway for over 2 decades. In deaf education, however, efforts in science education preparation and teaching science are hindered due to limited research in content area pedagogy. The body of research on marginalized populations in science education including DHH, generally converges on issues of accessibility to science literacy practices with focus on reading and writing, on science concepts in American Sign Language, and on accommodations for science standardized assessments. Science education at the elementary level is typically disregarded and not maximized to the time allocation but it is far worse in deaf education. Within the community of deaf education educators, only a few with a specialization in content area pedagogy exist, therefore, limiting capacity for research and dissemination of best practices. To contribute to the small body of knowledge on science education and best practices to support teachers, research on science education preparation in deaf education is critical.

Best practices in addressing these factors are well documented in the literature and that is to implement a balance of implicit experience and explicit reflective pedagogy to which NOS tenets are embedded in the curriculum (Schwartz, et al., 2004). While the course incorporated suggestions from the literature, including NSTA (2011b) and NRC (2011), considerations have been discussed, including but not limited to, reflections on past and current teaching, duration, opportunities for professional learning, mentorship, and duration.

As a result of the case study findings, the researcher has identified five recommendations for further research:

1) Explore preservice and inservice teachers' attitudes and beliefs. This area of research is not new in the field, although, literature provides evidence on the intersection and impact of attitudes and beliefs on instruction (Lumpe, Haney, &

Czerniak, 2000; van Driel, Verloop, & de Vos, 1998). In relation to deaf education, some questions to consider: What are the beliefs and attitudes of deaf education preservice and inservice teachers? How do these beliefs and attitudes correlate with implementation of scientific practices?

2) Investigate relationships between academic preparations in science and perceptions of scientific practices. It is believed that perception of science is derived from previous training in science and personal experience (Abd-El-Khalick & Akerson, 2004). From the present study, the researcher identified potential attributes to specific responses to reflections and design of SI lessons. Participants in this study varied in science and science education preparation; however, insufficient data does not allow for the researcher to proceed with additional analysis. The researcher selected this for future research based on some relationship between academic preparation including content and methods and views of best practice (e.g. Skamp, 2001).
3) Examine additional factors that contribute to perceptions on teaching science. In this study, participants discussed the importance of knowledge base content and vocabulary, which is expected due to the nature of deaf education preparation and deaf education textbooks. Teaching science, as well as other content areas, should be from a social cultural learning perspective to which knowledge is generated through language and interaction. Preservice teachers in this study may possess varying epistemological views, traditional or constructivist, on teaching science. Looking closely at these views may contribute to what was learned on current

perceptions of teaching science. In regard to these views, literature suggest that teachers with constructivist views on science teaching implement better practices and engage in dialogue with students (Hasweh, 1996).

4) Follow up with participants completing this course. Participants did not have the opportunity to work with mentor teachers who used SI, due to the way the school is departmentalized. This brings up questions about how participants will implement best practices without the experiences during field placement. New teachers working closely with mentor teachers that utilize SI improve on implementation of scientific practices. Science education preservice teachers are typically placed with mentors that teach science; however, deaf education preservice teachers are placed with any teacher in K-12. This presents concerns on the lack of opportunity for mentorship on best practices in science teaching. Preservice teachers that work closely with mentor teachers that implement SI have changed from traditional to constructivist views on teaching science (e.g. Haney & McArthur, 2002; Skamp, 2001).

5) Investigate professional development opportunities and effectiveness in regard to teaching SI to DHH students. Professional development is an opportunity for teachers to learn about current trends in teaching and to immediately apply in the classroom. However, professional development provided by the school or workplace is typically centered on language development and literacy (Rosen, 2005). Teachers may benefit from professional learning opportunities with explicit examples on how to embed language in science and modeling of scientific

practices. A model on interactive writing in deaf education has impacted implementation of writing strategies (Stephenson, Wolbers, Dostal, & Skeritt, 2012) and research could potentially explore this model incorporating literacy practices in science. Additionally, professional development to incorporate opportunities for teachers to experience SI would be beneficial in improving awareness of practices. In a field-study program for science teachers of the deaf, teachers expressed improved views on the various practices used during the research study (Graham, Gabriel, & Hagevik, 2011).

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Appendix

Appendix A: Demographics survey

Name: ____ **Date:** ______________________

Instructions: Please complete the following questions as best as you can.

Part 1: Background Information

1. Rate your American Sign Language skills:

- ❑ No American Sign Language skills
- ❑ Beginner
- ❑ Intermediate
- ❑ Advanced
- ❑ Native

2. Current major (circle all those that apply):

- ❑ Deaf Education
- ❑ Special Education
- ❑ Elementary Education
- ❑ Secondary Education
- ❑ Other (please specify): ____

3. Completed certification/s (circle all those that apply):

- ❑ Deaf Education
- ❑ Special Education
- ❑ Elementary Education
- ❑ Secondary Education
- ❑ Content specialty: _________________________
- ❑ Content specialty: _________________________
- ❑ Content specialty: _________________________
- ❑ Other (please specify): ______________________

4. Projected certification/s (circle all those that apply):

- ❑ Deaf Education
- ❑ Special Education
- ❑ Elementary Education
- ❑ Secondary Education
- ❑ Content specialty: _________________________
- ❑ Content specialty: _________________________
- ❑ Content specialty: _________________________
- ❑ Other (please specify): _____________________

5. Preference in teaching assignment (<u>rank</u> in order starting with 1 for top preference):

____ PreK
____ Kindergarten
____ Grades 1 – 2
____ Grades 3 – 4
____ Grades 5 – 6
____ Middle School (Grades 7 – 8)
____ High School

6. Preference in teaching (rank in order starting with 1 for top preference):

____ Reading	____ Writing
____ Social studies	____ PE/Health
____ Mathematic	____ Other (please specify): ____________________
____ Science	____ Other (please specify): ____________________

Part 2: Preparation in Science & Methods

7. Background in science (circle all those that apply):

- ❑ College courses in science
- ❑ Science education conferences (e.g. NSTA)
- ❑ Professional development or workshops
- ❑ Field study
- ❑ Science camp
- ❑ Other (please specify): ____
- ❑ Other (please specify): ____

8. Completion of college level science courses (circle all those that apply):

❑ Biology	❑ Geology
❑ Environmental science	❑ Life science
❑ Chemistry	❑ Physics
❑ Physical science	❑ Other (please specify): ________________________
❑ Earth science	❑ Other (please specify): ________________________

9. How **many** of these college level science courses were required for general education?

❑ 1 – 2	❑ 7 – 8
❑ 3 – 4	❑ 9 – 10
❑ 5 – 6	

10. How **many** of these college level science courses were required for your education major?

❑ 1 – 2	❑ 7 – 8
❑ 3 – 4	❑ 9 – 10
❑ 5 – 6	

11. What science methods courses have you completed? Please explain the major focus for each course.

Science methods course 1 (major focus): ____

Science methods course 2 (major focus): ____

Science methods course 3 (major focus): ____

12. How many of these science methods courses were required for your education major?

- ❑ 1
- ❑ 2
- ❑ 3

13. Please describe what you learned from these science methods courses.

Appendix B: Survey

Name: ____ Date: _____________________

Instructions: Please complete the following questions as best and thorough as possible.

1. What types of activities do scientists (e.g., biologists, chemists, physicists, earth scientists) do to learn about the natural world? Discuss how scientists do their work?

2. Scientists perform experiments/investigations when trying to solve a problem. Other than in the stage of planning and design, do scientists use their creativity and imagination in the process of performing these experiments/investigations? Please explain your answer and provide appropriate examples.

3. How do you think science should be taught in schools?

4. What experiences are necessary for DHH students to become successful in learning science? Provide examples to support your response.

5. What do you think are most effective strategies for **teaching science** to DHH students? Provide examples to support your response.

6. What do you think are most effective strategies for **facilitating scientific inquiry** to DHH students? Provide examples to support your response.

7. How can you use dialogic approaches with DHH students during scientific inquiry? Give me an example.

Appendix C: Science inquiry reflection questions

Presentation of Science Inquiry Reflection (10 minutes)

Having started your investigation, summarize and reflect on your progress. Use these questions as a guide:

a) Did your topic remain the same from your original idea? Please explain. Did you talk with anyone about your topic? Where are you in the process?

b) Were there any surprises or challenges with your methods? Did you need to revise at any point?

c) Do you have preliminary results yet? If so, were they any surprises or challenges with what you have so far?

d) If you did this investigation again, what would you do differently? Why?

e) Do you think everything you're doing with this project is what scientists do in their field? Please use examples and explain.

f) Explain how this process could apply in the classroom with deaf and hard of hearing students? What would be the benefits? Challenges?

g) Would this be considered exemplary instruction for DHH students? Support your response.

Appendix D: Lesson plan reflection questions

1) Why did you select this lesson for deaf and hard of hearing students?

2) What approaches in this lesson are considered exemplary for deaf and hard of hearing students?

3) What aspect/s of this lesson will address language and communication skills?

4) Identify parts of the lesson that would reflect the 5Es. Refer back to your lesson and add the 5Es to the associated headings (e.g. Set = Engage).

Appendix E: Peer review form of lesson presentation

Peer review form for presentation of inquiry-based science lesson

Tasks	**Evidence/Feedback**
Level of inquiry **0, 1, 2, 3**	
Question	
Investigation	
Explanation	
Communication skills	
Dialogue skills	

Appendix F: Analysis of presentation of inquiry-based science lesson

Instructions: For each category, check rating and complete "Evidence" & "Reflection"

Tasks	**Rating**				
		2	**1**	**0**	
Lesson contents					
1) Level of inquiry	(Circle one) 0 1 2 3				
2) Scientifically oriented question	Present, scientific, valid, authentic				Not present
Evidence:					
Reflection:					
3) Planning investigations	Procedures are discussed and implemented to gather evidence; unique methodology is valued and encouraged				Did not implement any type of investigation
Evidence:					
Reflection:					
4) Data analysis	Teacher-given or student generated; relates to research question				Not present or irrelevant to the research question
Evidence:					
Reflection:					
5) Explanations	Students generate explanations based on evidence, creativity, and background knowledge; explanations relate to the research question				Did not implement
Evidence:					
Reflection:					
6) Communication of scientific ideas	Students share explanations with supporting evidence; high level claims and reasoning are encouraged				Did not implement
Evidence:					

Reflection:					
Demonstration of lesson					
7) Knowledge of inquiry	Demonstrates knowledge of scientific inquiry & inquiry-based instruction				Lacks understanding of scientific inquiry and inquiry-based instruction
Evidence:					
Reflection:					
8) Communication skills	Lesson is facilitated without difficulty; pace is appropriate; information is clear; instructor demonstrates high level sign communication skills				Information is not conveyed clearly; pace is too slow or fast; instructor struggles with sign communication skills
Evidence:					
Reflection:					
9) Dialogue skills	Various questioning strategies and prompts from class discussion on dialogic inquiry are used; wait time is appropriate				Questioning strategies are limited to low-order thinking; wait time is insufficient
Evidence:					
Reflection:					
10) Teacher/student interaction	Instructor is encouraging, provides positive feedback to facilitate learning, uses praise appropriately, ensures all students are engaged				Instructor is not encouraging, feedback and recognition are not given, responses are negative, does not include all students
Evidence:					
Reflection:					
11) Preparation	Materials/media are prepared & instructor demonstrates content knowledge				Materials are not present/prepared; content knowledge is limited
Do not need to provide evidence/reflection for this category.					

Appendix G: Interview protocol

Topic Domain 1: Scientific inquiry

(Covert categories: understanding of science as a process, inquiry in the classroom)

Background:
For Curriculum and Instruction (528), I understand that you reflected on science inquiry, developed an inquiry-based lesson, and demonstrated a brief science lesson to your peers. You also provided a description of what scientists do in their field. For instance, you mentioned that scientists develop questions, maybe construct hypotheses, observe their natural environment, and collect data.

Questions:
Can you tell me more about the scientific inquiry process, in other words, what else do scientists do?
***If not mentioned, ask about communication, reading, and writing*

How would the processes that you described be similar or different to scientific inquiry in the classroom?

Topic Domain 2: Teaching science to DHH students

(Covert categories: language-enriched strategies)

Background:
In one of your responses to the course assignment, you described that teachers teaching science to DHH students need to plan and implement hands-on, minds-on experiences that relate to student's background knowledge and instructional materials need to be supported with visual scaffolds.

Questions:
Can you tell me how these strategies are especially important for DHH students?
***If not mentioned, ask about strategies that would support language skills*

We discussed how scientists use communication, reading, and writing in their field. How would you use communication, reading, and writing in science for DHH students?
***If one or two components are missing, follow up until all components are addressed*

This wraps up our interview. Do you have any additional thoughts or questions for me?

Thank you for your time and your willingness to partake in this interview.

Appendix H: Information sheet

Information Sheet
Preservice teachers' perceptions of science teaching and learning of deaf and hard of hearing students

INTRODUCTION

You are invited to participate in a research study, which is for the purpose of learning about preparation in science among deaf education preservice teachers. The researcher would like to include documents from course activities and videotaped presentations from EDDE 528. At the end of this course, a research assistant will interview you with a recorder for approximately 15 minutes. All video and audio recordings are for transcription purposes only. At the end of this study, all video and audio files will be destroyed.

BENEFITS

There is no direct benefit to you, but you may find it helpful to reflect on your teaching and experiences in science. By participating in this study, your time and involvement will contribute to the body of knowledge in teacher preparation in deaf education and science education.

RISK OF PARTICIPATION

There are no known physical, social, or psychological risks for participating in this study.

CONFIDENTIALITY

Recordings and documents will be strictly available for only the researcher and her advisor. All information will remain confidential. Your name will be replaced with a pseudo-name. Research assistants will assist with interviews and transcription of data. They will be required to sign a confidentiality form. All documents and recordings from this study will be stored in the researcher's laptop with password encryption and in a locked file at the University. When the study is complete, video and audio recordings will be destroyed.

RESULTS

Results from this study will be used for presentations and/or publications.

PARTICIPATION

Your participation is valued and appreciated but also voluntary. If you decide to decline or withdraw at anytime throughout the study, you may do so without penalty. In the event of withdrawal, data will be immediately destroyed.

CONTACT INFORMATION

If you have any questions regarding this research study, you may contact the researcher, Shannon Graham, at sgraha10@utk.edu or her advisor, Colleen Gilrane at cgilrane@utk.edu. You may also contact Brenda Lawson in the Office of Research to clarify your rights as a participant in this study, at blawson@utk.edu or 865-974-3466.

Appendix I: Informed consent statement

Consent Form
Preservice teachers' perceptions of science teaching and learning of deaf and hard of hearing students

I understand that the purpose of this study is to provide the researcher with information on effective practices of addressing preconceived views of science teaching and learning and inform teacher preparation in deaf education If I consent, my participation will include being interviewed by a research assistant, and allowing Shannon Graham to use the following course materials from EDDE 528 as data for her study:

demographic data
pre/post survey results
videotaped instruction and course activity
other course materials about science
notes of class discussions

I understand that my participation is voluntary and I may withdraw at any time by telling Shannon Graham or her advisor Colleen Gilrane. I understand that Shannon will not know whether or not I agree to participate until after grades are turned in for EDDE 528.

CONSENT
(Check one)

______ I have read the above information and **I AGREE** to participate in this study.

______ I have read the above information and **I DO NOT AGREE** to participate in this study.

______________________________ ______________

Name of participant (print) Date

____

Participant's signature

CONSENT TO USE VIDEOTAPE

I understand that all video recordings are confidential, used for transcription purposes only and will be destroyed after this study.
(Check one)

______ **I GIVE** permission for my videotapes to be used.

______ **I DO NOT GIVE** permission for my videotapes to be used.

____
Participant's signature

Appendix J: Confidentiality agreement form

Confidentiality Agreement for Research Assistants/Transcribers/Translators

Project Title: Perceptions and Practices of Science Among Deaf Education Preservice Teachers

Principal Investigator: Shannon C. Graham

I, ____(print name) understand that all materials or activity including interviewing participants, administering surveys, and transcribing (or translating) videos and documents are confidential. I agree that all contents from this study can only be discussed with the principal investigator. I will not keep hard or electronic copies of any materials associated to this project.

____

Signature

____

Date

Appendix K: Institutional Review Board application

THE UNIVERSITY OF TENNESSEE

Application for Review of Research Involving Human Subjects

I. IDENTIFICATION OF PROJECT

Principal Investigator:
Shannon C. Graham, **Doctoral candidate**
College of Education, Health, and Human Sciences
Department of Theory and Practice in Teacher Education
A226 Jane and David Bailey Education Complex
1122 Volunteer Boulevard
Knoxville, TN 37996
Email: sgraha10@utk.edu
Phone: (866) 743-7338

Faculty Advisor:
Dr. Colleen P. Gilrane, Associate Professor
College of Education, Health, and Human Sciences
Department of Theory and Practice in Teacher Education
A223 Jane and David Bailey Education Complex
1122 Volunteer Boulevard
Knoxville, TN 37996
Email: cgilrane@utk.edu
Phone: (865) 974-5448

Department: Theory and Practice in Teacher Education

2. **Project Classification: Dissertation**

3. **Title of Project:**
Preservice teachers' perceptions of science teaching and learning of deaf and hard of hearing students

4. **Starting Date:**
Upon IRB approval

5. **Estimated Completion Date:**
   August 1, 2012

6. **External Funding** *(if any):* N/A

II. PROJECT OBJECTIVES

The purpose of this project is to describe the impact of investigative practices and instruction on scientific and dialogic inquiry during a methods course on deaf education preservice teachers' views of teaching science to deaf and hard of hearing students. The study will provide the researcher with information on effective practices of addressing preconceived views of science teaching and learning and inform teacher preparation in deaf education.

III. DESCRIPTION AND SOURCE OF RESEARCH PARTICIPANTS

Four elementary education preservice teachers are enrolled in EDDE 528 this fall. All students will be invited to participate in this study. A person outside of this course will present a brief description of the study and collect signed informed consent forms. Identity of study participants will not be shared with the instructor until grades have been submitted.

IV. METHODS AND PROCEDURES

Shannon Graham is the instructor for EDDE 528 and will provide instruction on scientific and dialogic inquiry. As part of this course, students will be assigned to complete several tasks including science lessons, scientific inquiry project, and analysis of lesson presentations. Shannon would like to use course artifacts for this study to describe the impact of these tasks on students' views of science teaching and learning. Sources of data are described below:

Demographic data
The PI will provide a survey that includes a set of closed and open-ended questions regarding to participants' experiences and training in science and science methods. This will be administered during class prior to instruction on science pedagogy.

Pre/Post survey
Open-ended questions on views of science learning and teaching for deaf and hard of hearing students, scientific inquiry, and dialogic inquiry will be administered before instruction on science pedagogy and at the end of the semester.

Post interviews
A research assistant outside of this course will interview participants regarding their views of science teaching and learning as well as dialogic practices during mock instruction and in their field placements. Each interview will be audio or video recorded,

depending on the language use (e.g. sign language or spoken English). Both recordings will be used only for transcription purposes. Each interview will take approximately 15 minutes.

Videotaped instruction and course activity
The PI and/or research assistant will use a video recorder to document class activity and tasks, including demonstrations of a science lesson in class, discussions, presentations.

Course artifacts
Course documents relevant to science methods will be collected.

Field notes
The PI will keep a detailed record of notes from observations of class activity.

V. SPECIFIC RISKS AND PROTECTION MEASURES

Participants in this study are students of EDDE 528. There are no known physical, social, or psychological risks for participating in this study, however, students may feel coerced or become concerned about confidentiality issues. To address this issue, someone outside of the course will explain the study to participants and collect signed informed consent forms (Appendix I). Participants will be ensured that these forms will not be revealed to the researcher until grades have been submitted.

The researcher will ensure confidentiality of participants by replacing names with pseudo-names, asking research assistants to sign a confidentiality agreement form (Appendix J), and storing all transcripts, videotapes, and course documents in the researcher's laptop with password encryption and in a locked file at the University. When the study is complete, the researcher will keep course documents and transcripts but all videotapes will be erased.

Course documents, video recordings, and transcripts from participants who do not agree to participate in this study will not be included in the analysis.

VI. BENEFITS

There are no direct benefits to students as a result of participating in this study. The benefits of this study can further expand the body of knowledge in teacher preparation in deaf education and science education.

VII. METHODS FOR OBTAINING "INFORMED CONSENT" FROM PARTICIPANTS

Shannon's advisor, Colleen Gilrane, will visit the class and will explain the nature of this study, participant involvement, research procedures, and option to withdraw from the study at any time without penalty. Each student will be given two copies of the information sheet/consent form printed front and back. If they agree to participate, they will return one signed and dated and keep the other for their records. Signed informed consent forms will be collected, sealed in an envelope, and stored in a locked cabinet in A

223 Bailey Education Complex.. The researcher will not have access to these forms until course grades have been submitted.

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

Shannon C. Graham is a doctoral student of science education in the Department of Theory and Practice in Teacher Education. She has an M.A. in deaf education and an M.S. in conservation biology and environmental science. She has taught science to deaf and hearing students for 10 years. She has completed several research methods courses at UT, received training in ethics of research including human participants, and has experience with some quantitative and qualitative research techniques.

Colleen P. Gilrane is an associate professor in the Department of Theory and Practice in Teacher Education and is experienced in the teaching and conduct of qualitative research. An alternate member of the University of Tennessee IRB, she is knowledgeable about the ethical conduct of research involving human participants, and experienced in supervising graduate student research.

Two research assistants will help in data collection for this study. A graduate student in science education will conduct interviews with those students who give consent following the end of the semester. He has taken graduate courses in research methods and is familiar with research ethics. He will sign the attached confidentiality agreement.

An undergraduate student in deaf education and science education will transcribe the interviews. She will be instructed in research ethics by the PI and will sign the attached confidentiality form.

IX. FACILITIES AND EQUIPMENT TO BE USED IN THE RESEARCH

The study will take place in a classroom at the University. A digital audio recorder and video recorder from TPTE department will be borrowed. The researcher will purchase all videotapes and use her personal computer for field notes and data analysis.

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

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

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

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

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

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

XI. SIGNATURES

Principal Investigator: Shannon C. Graham

Signature: ______________________________ Date: ________________

Ph.D. Advisor: Colleen P. Gilrane, Ph.D.

Signature: ______________________________ Date: ________________

XII. DEPARTMENT REVIEW AND APPROVAL

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

[X] Expedited Review -- Category(s): 6 & 7

Chair, DRC: Dr. Richard Allington, Theory and Practice in Teacher Education

Signature: _______________________________ Date: _______________

Department Head: Dr. Sherry M. Bell, Theory and Practice in Teacher Education

Signature: _______________________________ Date: _______________

Protocol sent to Research Compliance Services for final approval on (Date): ________________

Approved:
Research Compliance Services
Office of Research
1534 White Avenue

Signature: _______________________________ Date: _______________

Appendix L: Sample Lesson Plan

Students: 5th Grade

Unit Goals: ***Using STEM standards
GLE: 0507.Inq.1 Explore different scientific phenomena by asking questions, making logical predictions, planning investigations and recording data.
GLE: 0507.Inq.6 Compare the results of an investigation with what scientists already accept about this question.
GLE: 0507.12.1 Recognize that the earth attracts objects without directly touching them.

Behavioral Objectives:
Given an egg and supplies students will be able to design and implement an experiment that will test a structure to keep the egg from being broken during the forty-five minute class with visual prompts, class review and partial to no assistance.

Given the experiment the students will be able explain gravity in their own words and give at least one example in a picture at the end of a forty-five minuet class with visual prompts, class review and partial to no assistance.

Rationale: The students will learn how to work in teams to design an experiment to successfully. This relates to space because we are dealing with gravity. Gravity is the force that attracts a body toward the center of the earth, or toward any other physical body having mass. In this experiment it would be the egg towards the ground.

I can statement: I can design an experiment.

Set: (ENGAGE) The teacher will get the attention of the class by dropping an egg on the floor (there will be a container or a trash bag down) or dropping it out the window. The teacher will ask the students what happened? The teacher will then pass out the supplies to the teams. Each team gets an egg, tape, cotton balls, toilet paper, socks and straws.

Procedures:

1. Tell the students that in groups they need to design an experiment to make something that will protect the egg from hitting the ground.
2. **(EXPLORE)** Give the students time to brainstorm, come up with a construction plan, create a data sheet and construct the device.
3. The teacher will walk around and let the students work in groups to set up and experiment to test the egg “holder” they make.
4. After the students have completed their projects you will have them show and explain what they made and why this will work.
5. The students will then perform the experiment and let the eggs drop. We will see which ones were successful and which ones were not.
6. The ones that were not we will talk about as a class what could be successful and why.
7. **(EXPLAIN)** I will ask the students if they know what gravity is. I will explain that this is the force that attracts things to the earth, and this is the force that attracts the egg to the ground.
8. I will show a power point about gravity; this way the students can see images to get a better visual of gravity and its definition.

Closure: (ELABORATE) the student's will watch a power point that will help to explain the force of gravity in a more visual way. I will have the students discuss what they would change with their design if they did this again, and why they think that this would work next time.

Remedial Activities: This activity is designed to be on the students level, but if they needed more explanation I could change this from a guided inquiry where I give the question and then allow the students to create the procedures to a more structured inquiry where they are given the materials, procedure and problem to investigate but not told the outcome.

Enrichment Activities: The class can come back together as a team to come up with one design using the same materials that can with stand at least three different drops. This way they have to work together and blend ideas for not only one drop but also three drops.

Evaluation: (EVALUATE) Teacher evaluation of the students completed project. The students will have an exit ticket telling the teacher what gravity is and providing one example of gravity in a picture.

Materials List: power point about gravity, exit tickets, eggs, cotton balls, straws, tape, toilet paper and socks.

Deaf Role Models: Dr. Keith Watt- He is the assistant professor of the Mars education program at Arizona State University. http://marsed.mars.asu.edu/msip-home. This is a man that studies about space and the planets.

Webliography: http://www.csun.edu/~sb4310/The%20Amazing%20Egg%20Drop.htm

Vita

Shannon C. Graham earned degrees in biology and deaf education from Gallaudet University in Washington, DC and a graduate degree in conservation biology and environmental science from the University of Hawai`i-Hilo. She has taught secondary science, math, and technology to deaf and hard of hearing students for ten years. Her research centers on marine conservation, science education, and deaf education. Some of her recent studies include feeding behaviors of endangered Hawaiian hawksbill turtles, environmental field study experiences and views of scientific inquiry of teachers of the deaf, language use in content area instruction, and retention of deaf people in science, technology, engineering, and mathematics (STEM).