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Science Fair: Is It Worth the Work? A Qualitative Study on Deaf Students' Perceptions and Experiences Regarding Science Fair in Primary and Secondary School

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SCIENCE FAIR: IS IT WORTH THE WORK? A QUALITATIVE STUDY ON DEAF STUDENTS' PERCEPTIONS AND EXPERIENCES REGARDING SCIENCE FAIR IN PRIMARY AND SECONDARY SCHOOL

by

Vivian Lee Smith

Abstract of a Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
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ABSTRACT

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Science fairs have a long history in American education. They play an important role for establishing inquiry-based experiences in a science classroom. Students may be more motivated to learn science content when they are allowed to choose their own science fair topics. The purpose of this study was to examine Deaf college students' perceptions and experiences regarding science fair participation during primary and/or secondary school and determine the influence of science fair involvement on the development of language skills, writing skills, and higher order thinking skills as well as its impact on choice of a STEM major.

This study examined responses from Deaf students attending Gallaudet University and National Technical Institute for the Deaf (NTID) majoring in a Science, Technology, Engineering, or Math (STEM) field. An electronic questionnaire and a semi-structured interview were used to collect data. The electronic questionnaire was divided into two strands: *demographics* and *science fair experience*. Twenty-one respondents participated in the questionnaire and ten participants were interviewed.

A cross-case analysis revealed communication was the key to a successful science fair experience. Findings showed the educational background of participants influenced their perspective regarding the experience of a science fair. When communicating

through American Sign Language, the science fair experience was more positive. When communicating through an interpreter or having no interpreter at all, the science fair experience was viewed in a negative light. The use of science fairs to enhance language development, writing skills, and higher order thinking skills was supported. Teachers and parents were strong influences for Deaf students participating in a science fair. Participation in a science fair did influence students to choose a STEM major but there were other considerations as well.

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DEDICATION

It may take a village to raise a child but it certainly takes a community to produce a dissertation. I am grateful to *my* community. The role you played might have been large or small but definitely significant towards helping me set and accomplish my goal of a doctoral degree. Allen and Kitty Graham, I may not be able to award you an honorary PhD like Marlee Matlin got from Gallaudet University, but you have my utmost gratitude for the pages and pages of transcriptions you read for ASL translation accuracy that the voices of my Deaf respondents might be heard. To my husband, I.V. Smith, for his patience and support and countless Saturdays that the house didn't get cleaned and the countless meals he prepared and to too many trips to What-a-Burger before that August 21st heart attack. For all the times I had fresh, clean clothes because *he* did the laundry while I was studying and to all the fish recipes he endured until we found the right ones. Robin Roberts, co-anchor of *Good Morning, America!* and previous resident of Pass Christian, Mississippi, credited her mother in Guidepost magazine (August 2012) for her philosophy of gratitude. Mrs. Lucimarian Tolliver Roberts said, "We never do it just on our own. There are all those people behind us, our teachers, coaches, pastors, mentors" (p.38). She wanted to thank everybody in her acknowledgements in her book *My Story, My Song*. I, too, want to thank everybody! My God, my professors, my family, teacher candidates, colleagues, students at the Mississippi School for the Deaf, my church friends, my massage therapist, all who believe in the power of prayer and have encouraged me, you have my deepest gratitude. My life motto as been, "How do you eat an elephant? One bite at a time." Here's to the next buffet. My older sister fondly says, “A journey of a thousand miles begins with the first step!” Here’s to many more challenging journeys of life! Hear, hear! My last remarks? I’m still having fun!

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CHAPTER I

INTRODUCTION

Many teachers across our nation use science fair projects as a way to immerse students into science. Because students have the opportunity to choose topics that interest them, students may be more motivated to learn science content. When students conduct a science fair experiment, they are doing *real science* as a scientist might do by using their powers of observation, keeping a log, making a hypothesis, conducting an experiment, analyzing data and making conclusions. Science fairs have been part of American education for quite some time as evidenced by its history. *Science Service* was established in 1921 for keeping the public informed of scientific achievements. Now known as the *Society for Science & the Public (SSP),* this nonprofit organization uses science research and science education for public appreciation as one of its primary goals today as well as a recruitment tool for students pursuing science, technology, engineering, and math (STEM) careers (Society for Science & the Public, 2013). In 1928, the American Institute of Science and Technology (AIST) included student work in their exhibits for the first time. This set a trend that continues to this day. In 1942, SSP partnered with Westinghouse to sponsor the Science Talent Search, a contest for high school seniors. In 1950, the International Science and Engineering Fair (ISEF), sponsored by SSP offered monetary incentives for high school winners. Today SSP owns and administers the Intel ISEF which is “the largest pre-college scientific research event in the world” (Society for Science & the Public, 2013). The Intel Corporation became title sponsor for ISEF in 1997 and awards students in grades 9-12 for their excellence in research. There are opportunities for students to pursue their interests in science by participating in science competitions with the beginning of it often happening in primary and secondary schools with an in house science fair. It is here that students execute the principles of the scientific method and the processes of observation, data collection, and determining results of experimentations.

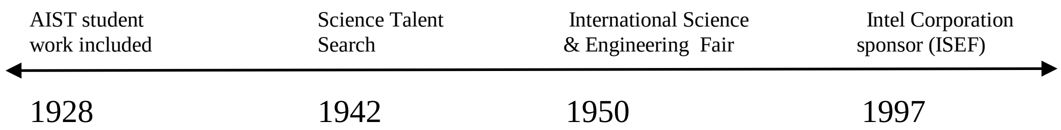

Figure 1. Timeline of the History of Science Fair.

The United States is desperate to recruit students into STEM fields if she is to retain her leadership in science and technology (Subotnik, Tai, Rickoff, & Almarode, 2012; Zhe, Doverspike, Zhao, Lam, & Menzemer, 2010). With a shortage of college students studying and preparing for STEM careers (Baker & Finn, 2008; Kendricks & Arment, 2011) participating in a science fair competition may guide pupils toward choosing a STEM career (Olson, 1985). Other influencing factors such as early exposure to science may help students choose STEM careers. Support from family, school, friends and social outlets are characteristics of successful students as well as their own intrinsic motivation (Hassenger & Plourde, 2005; Reyes, 2007). Many educators believe when students are involved in science fair projects, their attitudes, science skills and science content knowledge are enhanced and help them become more successful as students (Czerniak, 1996). Deaf students can do this, also. Science fairs are an integral part of science education in many elementary, middle, and high schools; however, there is very little empirical research to show its use in classrooms of children with special needs. In one of the few studies on the benefits of participation in science fairs by special needs students, Ricketts (2011) found that English language learners (ELLs) were benefited from the participation in science fairs. Rosebery, Warren, and Conant (1992) added the learning of English can be expedited by using inquiry which also aids reasoning skills and scientific thinking. Since Deaf students are considered ELL, they would also benefit from participating in science fairs.

Deafness can be viewed two different ways: clinical versus cultural. Someone who views deafness from a clinical perspective tends to focus on sensory deprivation and deficiencies or deviations from the norm. The term *deafness* refers to an audiological condition of hearing loss (Reagan, 2006). Preventing and curing deafness is a priority when viewed through the lens of the clinical perspective (Paul & Moores, 2010). In contrast, deafness is not viewed as a deficit or a disability by the Deaf community (Coryell & Holcomb, 1997; Enns, 2009; Lane, 1992; Reagan, 2006; Simms & Thumann, 2007). Paul and Moores (2010) wrote that members of the Deaf community view deafness as "a natural or ethnic condition" as reported by others (DeClerck, 2010; DeLana, Gentry & Andrews, 2007; Evans, 2004; Evans, Zimmer & Murrah, 1994; Miller, 2010; Ramsey & Padden, 1998; Saylor, 1992). When writing about peoples or cultures who are African American, Hispanic, or Native American upper-case letters are employed; however, a person can be deaf without being Deaf (Reagan, 2006). For example, an elderly person who has acquired a profound hearing loss does have a sensory deprivation, but has no cultural or ethnic connection or identity with members of the Deaf community; thus the term *deaf* is appropriate. In contrast, a hearing person can be part of the Deaf community if they are a child of Deaf parents or an interpreter, by the use of ASL (Saylor, 1992). Saylor acknowledged it is a matter of language, identity, and shared experience, not hearing loss. Child First Campaign (2012) declared, "Being deaf is not what disables a child-it is language deprivation that results from diminished exposure and access to meaningful language and communication" (p. 2). Language is not equated with English or speech; therefore, if a Deaf child is deprived of English, receptively and thus expressively, there will be the diminished results mentioned (Enns, 2009; Hickok, Bellugi, & Klima, 2001). Exposure to the fullness of American Sign Language actually is the opposite of language deprivation. Reagan (2006) addressed the issue of linguistic human rights in education particularly for the Deaf child and supported an empowerment approach which advocated for recognition of a cultural and linguistic minority. American Sign Language (ASL) is recognized as a Deaf child's native language and English is learned as a second language (Hermans, Knoors, Ormel, & Verhoeven, 2008; Lane, 1992; Padden & Ramsey, 2000) and has its own unique phonology, semantics, syntax, pragmatics, and morphology (DeClerck, 2010; Enns, 2009; Haptonstall-Nykaza & Schick, 2007; Hickok et al., 2001; Padden, 1980; Padden & Humphries, 2005; Stokoe, Casterline, & Croneberg, 1965; Valli & Lucas, 2000; Valli, Lucas, & Mulrooney, 2005). ASL is a visual-spatial language and is the primary language used by the Deaf community in America and Canada (Enns, 2009).

The establishment of ASL/English bilingual educational programs promotes the cultural perspective (Delana et al., 2007; Enns, 2009; Paul & Moores, 2010). The use of a bilingual Deaf education philosophy can help Deaf students reach their potential as successful students (Enns, 2009; Evans et al., 1994; Schimmel, Edwards, & Prickett, 1999). Features in an ASL/English bilingual educational program include 1) valuing equally both ASL and English as distinct, separate languages; 2) fostering a proud Deaf identity; 3) having Deaf role models; 4) being culturally sensitive with conflicts and issues; and 5) learning written English using ASL (Enns, 2009; Evans et al., 1994.) By understanding and using a bilingual strategy, teachers can help their students improve their ASL skills, English skills, and in their content knowledge of science when it is applied to a science fair project.

Persons in the Deaf community do not always feel respected but, like other minorities, may feel marginalized. In 1975, Tom Humphries created the term *audism* to identify an attitude of superiority by those who hear and speak English (Berke, 2011). This negative or oppressive attitude towards Deaf people can occur by other deaf people and by hearing people. Berke mentioned refusing to sign in the presence of a Deaf person as an example of *audism*. The term *hearing-impaired* is considered an audist label and promotes the clinical perspective of deafness (Lane, 1992). I am using the term *Deaf* throughout my study in respect for the Deaf community, thus supporting the cultural view.

Nancy Rourke, a Deaf artist, often uses audism as a subject of her painting. Nancy Rourke is a proponent of De'VIA (Deaf View/Image Art) which was established in 1989. Historically, members of the Deaf community kept their anger and frustration at a low profile; however, topics such as Deafhood, Deaf culture, audism, Deaf history, Deaf politics, American Sign Language and bilingualism are now being addressed (Rourke, 2013). Rourke's work focuses on resistance, affirmation, and liberation by using blue tape on the fingers and hands of her subjects representing audists' disapproval of American Sign Language as a means of communication.

As an educator of Deaf students for over 25 years, I am constantly looking for innovative ways to meet the educational needs of my students. Could the use of science fairs be a pedagogical strategy that would enhance scientific concepts as well as English learning skills of Deaf students? In my study, all my subjects were college students who participated in science fairs while they were elementary students and/or high schools students. They were asked to share their experiences and perceptions with me, in an attempt to determine whether Deaf students perceived science fairs as having an impact on language development, writing skills and higher order thinking skills and whether their experiences had an impact on their choice of a major in college. I also attempted to determine the person or persons who provided the most meaningful support during their participation in a science fair. Deaf children can also be successful (Luckner & Muir, 2001) and the same support and motivation are important for their success. I believe Deaf students can be successful participating in a science fair if given appropriate opportunities to develop their language and communication skills.

Purpose of the Study

The literature is relatively silent regarding the use of science fairs with students who are Deaf. More empirical research is needed in the fields of science and deaf education; therefore, the purpose of this study was to examine Deaf college students' perceptions and experiences regarding science fair participation during primary and/or secondary school and determine the influence of science fair involvement on the development of language skills, writing skills, and higher order thinking skills as well as its impact on choice of a STEM major.

Research Questions

I proposed the following research questions for my study in order to provide data that were directly related to the subject of Deaf students participating in science fairs:

1. What are Deaf students' experiences while participating in science fairs in primary and/or secondary schools?
2. What are Deaf students' perceptions on the impact of participating in a science fair regarding language development, writing skills, and higher order thinking skills?
3. Which people, and to what extent, are reported as helpful for Deaf students while participating in science fairs?
4. In what ways do Deaf students perceive participating in science fairs as influencing their choice in a STEM major?

Conceptual Framework

The conceptual framework for my study was based upon two ideas: 1) students who conduct hands-on learning and are actively engaged learn more in science as well as developing higher order thinking skills and 2) having a mentor influences the decision to stay in a Science, Technology, Engineering, and Math (STEM) major or career. The teaching of science is changing and evolving to become more learner-centered, allowing students to construct their own knowledge from previous experiences and building from the known to the unknown. It appears that many of today's classrooms are embracing the constructivist learning theory that promotes student-centered teaching strategies (Bergman & Olson, 2011; Brown, Cobbs, Neale, & Wilson, 1999; Foxx, 2001). Constructing one's own knowledge through authentic learning activities is the premise on which constructivism is based (Bednar, Cunningham, Duffy, & Perry; 1992). Collins (1994) supported hands-on experiences because of the multi-sensory aspect of learning through the senses which helped students gain information and access to the world of learning then this personal, constructivist view of the world is the student's own epistemology and is in a continuous process of evolution and adaptation (Miller, 2010). C.T. Fosnot (1989) suggested:

> [a] constructivist takes the position that the learner must have experience with hypothesizing and predicting, manipulating objects, posing questions, researching answers, imagining, investigating, and inventing, in order for new constructions to be developed. From this perspective, the teacher cannot insure that learners acquire knowledge just by having the teacher dispense it; a learner-centered, active instructional model is mandated. The learner must construct knowledge; the teacher serves as a creative mediator of the process. (p. 20)

Components of constructivist theory include inquiry-based learning and inquiry-based teaching as well as hands-on activities, manipulatives and problem-based learning (Jones, 1996). In a constructivist classroom, there is an abundance of activities that offer opportunities for interactions, especially problem-solving investigations in which mental conflicts of previous concepts can arise. Students then work through these conflicts with the guidance of a teacher or peer in order to develop a deeper understanding based on inquiry-centered activities (Easterbrooks & Scheetz, 2004). Several best practices in the classroom involve students' doing science by questioning and discovering via hands-on inquiry wherein students' investigative skills can be developed. A teacher merely covering material is not enough (Cook, 2003). Newton and Newton (2011) reported that children learn better when they are actively engaged in science. Newton and Newton (2011) also advocate teacher enthusiasm, a non-threatening environment, and the use of strategies that support learning and create interest in science. They conducted a study using pre-service teachers with a focus on how science lessons engage students. The pre-service teachers participated in a variety of science activities and rated each. The hands-on activities were considered the most effective means for student engagement. In action-oriented science classrooms, the use of manipulatives and hands-on materials provides an active approach to learning (Lang & Albertini, 2001). This participative learning style and academic achievement were shown to have a positive correlation on course grades in Deaf college students (Lang, Stinson, Basile, Liu, & Kavanagh, 1999). Hands-on activities are ideal for struggling readers and English Language Learners (ELL) because they afford opportunities for students to develop reading and writing skills as well as vocabulary along with key concepts (Capraro & Slough, 2008; Wallace, Hand, & Prain, 2004). Collaboration and repetition provide meaningful avenues for development of verbal skills (Slough & Rupley, 2010). Selco, Bruno, and Chan (2012) also found hands-on, minds-on inquiry experiences were beneficial in generating interest, not only in science content, but in science as a possible career choice. Wang (2011) drew from her research on the limited bank of information and concluded that, as stated, hands on inquiry-based instruction provided optimal learning opportunities and were successful with Deaf students; therefore, the use of a science fair project seems to be the way to make the connection between hands-on and minds-on involvement.

A second component of my conceptual framework is the idea that hands-on, inquiry-based science can promote higher order thinking skills in Deaf students. For effective inquiry lessons students must not only have a hands-on opportunity, but students' minds must also be engaged (Bergman & Olson, 2011). Learning important process skills and understanding how scientists do science are indispensable. If science fair projects are considered hands-on, inquiry-based instruction, benefits would necessarily include an increase in factual knowledge retention, student motivation, problem solving creativity, and critical thinking according to the conclusions drawn by Lord and Orkwiszewski, (2006). Science fair projects offer students the chance to make deductions from hypotheses and to offer solutions to a problem with a follow-up investigation, in other words, to do science as scientists do (Bergman & Olson, 2011). Determining variables, predicting outcomes, and estimating results help to develop logical thought processes (Mann, 2002). Meaningful science must "aim to develop thinking, problem solving, and attitudes of curiosity, healthy skepticism, and openness to modify explanations" (Cook, 2003, p. 47).

One tool used in today's educational system to determine the level of thinking skills is the *Taxonomy of Educational Objectives*, commonly known as Bloom's Taxonomy, established in 1956. Benjamin Bloom and a team of theorists developed six learning levels to identify and categorize questions used in examinations based on difficulty. Bloom, Eglehart, Furst, Hill, and Krathwohl (1956) categorized learning into three domains of behavior: cognitive, affective, and psychomotor. This instrument was designed to assist instructors to evaluate their courses and testing outcomes (Halawi, McCarthy, & Pires, 2009). It is often visualized as a triangle in a hierarchical pattern where the first level assists understanding of the second level and so forth. Each level of thought advances to the next. Lord and Baviskar (2007) explained the levels as follows. The first level, *Knowledge*, involves recalling facts. The second level, *Comprehension*, involves rewording and explaining something learned. The third level, *Application*, requires students to apply concepts learned to a new situation. *Analysis* is the fourth level and requires breaking down ideas into parts while the fifth level, *Synthesis,* requires students to put things together in new, original ways. The sixth level, *Evaluation*, requires students to make judgments about what they have learned and relate to real world problems.

The original taxonomy was reevaluated and revised by Anderson and Krathwohl in 2001 and is currently called the *Revised Bloom's Taxonomy*. Terminology, structure, and emphasis were addressed (Halawi et al., 2009) with stress on promoting knowledge transfer. Four types of knowledge were identified as: *factual, conceptual, procedural, and metacognitive* (Anderson et al., 2001). Student learning was the focus for the *Revised Bloom's Taxonomy* (Su & Osisek, 2011) where learners transfer knowledge to actual practice. Krathwohl (2002) explained, "[t]hree categories were renamed, the order of two was interchanged, and those category names retained were changed to verb form" (p. 214). The six categories now in use are: *Remember, Understand, Apply, Analyze, Evaluate,* and *Create*. Krathwohl (2002) clarified "*Synthesis* changed places with *Evaluation* and was renamed *Create*" (p. 214). Another change advocated in the *Revised Bloom's Taxonomy* was accepting an overlap or merging of the cognitive levels instead of a strict hierarchical order.

Educators today use this design to help students move from factual content knowledge to understanding. It has recently been used to aid in designing online courses (Chyung, 2003) as well as evaluating student achievement of online simulations and traditional courses (Boyd & Murphrey, 2002). Verbs classified using Bloom's taxonomy, are often used to ensure discussion questions address all levels of cognitive thought (Halawi et al., 2009). I used the *Revised Bloom's Taxonomy* to determine if each of the six levels of cognitive thought processes were used during science fair participation.

Social interactions and active learning result in better learning; therefore, to develop cognitive abilities and world knowledge, early unrestricted access to language is critical (Gardner & Gardner, 1980; Kegl, 2002; Slobin, 1985). Easterbrooks and Baker (2002) proclaimed, “Pedagogies should be designed to support language and cognitive growth” (p. 3). In a bilingual-bicultural educational setting, language and cognitive growth is accomplished through ASL as a first language (Andrews, Ferguson, Roberts, & Hodges, 1997; Enns, 2009; Hermans et al., 2008; Horn-Marsh & Horn-Marsh, 2009; Padden & Ramsey, 2000). Wang (2011) further advocated that “integration of inquiry science with linguistic and metacognitive analyses serves to promote the development of higher-order thinking skills in students who are deaf or hard of hearing” (p. 242).

The writing component is another higher order thinking skill that applies to a science fair project. Not only does the hypothesis and purpose have to be written in proper English, but also the procedures, results, conclusion and a research paper. There is a writing/thinking connection that occurs. Simply put, “writing influences thought” (Lang & Albertini, 2001, p. 259). Students must have the language base to put their thoughts into writing. This language base is ultimately the result of the use of American Sign Language as a first language for the Deaf child (Andrews, 2002; Rusher, 2012; Simms, Rusher, Andrews, & Coryell, 2008).

A third component of my conceptual framework is the notion that students, including Deaf students, who have a STEM mentor are more likely to choose a STEM degree and stay in a STEM career (Eagan et al., 2011; Holland, Major, & Orvis, 2012). There are several benefits that promote undergraduate students conducting real world scientific research with faculty members (Cole & Espinoza, 2008). Experiencing hands-on training with their faculty mentor afforded conversations for future career planning and consideration of higher degrees in a STEM field (Espinosa, 2009; Hunter, Laursen, & Seymour, 2006; Laursen, Seymour, Hunter, Thiry, & Melton, 2010; Seymour, Hunter, Laursen, & Deantoni, 2004). In Wilberforce, Ohio, at Central State University, Kendricks and Arment (2011) found that faculty mentors helped with course registration advice, study tips, and research opportunity information. They also provided a nurturing environment where students felt safe and supported.

Traditional mentoring usually occurred with a more experienced veteran aiding a less seasoned protégé (Holland et al., 2012); however, peer mentoring also held its place of importance and was beneficial in providing career guidance, learning, encouragement, and social support (Kram, 1983). Several other benefits noted by recipients of peer mentoring were satisfaction, commitment and more involvement in their STEM major and a willingness to be future peer mentors themselves (Holland et al., 2012). These college students found a comfortable learning environment with friends and classmates and were able to network with one another via study groups, collaborative class assignments, and "active encouragement of mentoring" (p. 351).

Based on the conceptual framework, I proposed the participation in science fair projects provides Deaf students with an opportunity to learn science via a hands-on investigation and provides an opportunity to develop higher order thinking skills. By working with a volunteer or mentor as they complete a science investigation, this relationship influences students to possibly choose a STEM major and to stay in STEM careers.

Delimitations

Some delimitations of the proposed study include the following.

1. The number of participants was limited to those who answered an electronic questionnaire and chose to participate further by sharing their stories during the interview.
2. Only students from National Technical Institute for the Deaf (NTID) and from Gallaudet University who were majoring in a field of science were asked to participate.
3. The use of a semi-structured interview, have inhibited those who wished to participate due to the length of time required.

Assumptions

Participants in the questionnaire and interview were asked to recall answers based on their perceptions and experiences regarding science fair participation in retrospect. Perceptions and memories may be inaccurate and may change over time as students mature and are exposed to other science experiences. I assumed the students being surveyed and interviewed honestly answered the questions posed.

Justification

There is a lack of information regarding the use of science fair projects by Deaf students. By conducting my study, it was hoped that other teachers who work with Deaf students would find using science fair projects a worthy endeavor for promoting learner - centered, hands-on development of higher order thinking skills. An additional benefit through my study might show evidence that science fair competition was one influence for Deaf students choosing a career in one of the fields of science.

CHAPTER II

REVIEW OF LITERATURE

History of Science Fair

The year 1828 is given credit as the beginning of science expositions for public knowledge (Cook, 2003). It was this year in New York City, New York, the American Institute of Science and Technology sponsored the Science and Technology Exposition, providing displays opened for public viewing (Cook, 2003). Distinguished work was honored by the presentation of medals (Bellipanni & Lilly, 1999). At this time, the focus was upon scientific and technological advances such as Morse's telegraph and Bell's telephone. It was not until 1928 the course of these exhibits would change its focus to include students' efforts when the American Museum of Natural History co-sponsored the first student science fair (Silverman, 1985).

Around 1921, a nonprofit organization by the name of *Science Service* was founded in Washington, D.C., by E.W. Scripps. The main purpose of *Science Service* was to keep the public informed of scientific achievements via an editorial newsletter. Additionally, Science Service, with collaboration of the American Institute of the City of New York, formed science clubs, which exploded from 800 to 25,000 clubs across the United States, Puerto Rico, the Philippines, the British West Indies, Canada and Portugal. G. Edward Ferdrey of the Westinghouse Corporation joined E.W. Scripps to establish the *Westinghouse Science Talent Search* in 1942, a science contest for high school seniors. It was hoped that science clubs and the Science Talent Search would increase the number of students choosing science or engineering as a career, so scholarships were offered for the first time to these high school seniors. The first National Science Fair was held eight years after the Science Talent Search began, when high school finalists from local and regional competitions met in Philadelphia, Pennsylvania. This level of competition is now known as the International Science and Engineering Fair (ISEF). ISEF is the only international science competition for students in grades nine through twelve. The top students at regional and state science fairs are chosen to attend ISEF. One of the perks for being an ISEF finalist is the awarding of large sums of college scholarship monies. More than $3 million in awards and prizes are distributed each year (Society for Science & the Public, 2013). The top award is the Gordon E. Moore Award which amounts to $75,000 for one finalist in *Best in Category* and an award of $50,000 goes to two finalists in the Intel Foundation Young Scientist Award *Best in Category*. Other awards include an all-expense paid trip to Sweden to attend the Stockholm International Youth Science Seminar for three finalists. Not only individual students win monies, but their school can be awarded a $1,000 grant along with those who win $5,000 for *Best in Category.* Grand Awards are given to each of the 17 categories with a top cash award of $3,000 for first place. When Rillero, Zambo, and Haas (2005) questioned finalists at the ISEF in Arizona for an evaluation report, the finalists indicated benefits for participating included an opportunity to win scholarships and awards.

In 1999, Discovery Communications and Elmer's Glue partnered with *Science Service* to focus on science fair winners in grades five through eight. They established the Discovery Channel Young Scientists Challenge (DCYSC) in St. Paul, Minnesota, which promotes middle school students to produce a short video regarding a new invention to help with everyday problems and awards ten students a summer mentorship program working alongside scientists. *Science Service* is still very much involved in promoting science research and technology at all levels (Bellipanni & Lilly, 1999; Cook, 2003; Science Service, 1999). Science fair competitions have been around a long time and are used in many classrooms to promote science concepts. It is time that deaf education look upon science fair projects as a viable teaching strategy with Deaf students as they can compete on the same level as their hearing peers and should be given the opportunity to participate.

Science Fair Components

A science fair is typically a competitive event in which students in elementary, junior high, and high schools display science projects (Bellipanni, 1994) which have seven main parts. They are the title, purpose, hypothesis, procedure, data, results, and conclusion. Wilson, Cordry, and Uline (2004) suggested ten steps to follow once the student has selected a topic.

1. Define the problem by stating the purpose of your experiment.
2. Choose a variable to be tested.
3. Determine a hypothesis.
4. Explain how the variable will be modified.
5. Determine how the results will be appraised.
6. Keep a daily logbook to include measurements, emerging ideas, and photos.
7. Evaluate collected data.
8. Design a chart or graph to represent your data.
9. Determine conclusion.
10. Decide on options for further study. (p. 114)

Wilson et al. (2004) advised students to include printed materials such as books, journals, and magazines as resources and not limit oneself to the Internet. They promote the use of standard print in a font size of 12 and the written report should be double-spaced. The written report which should include the title page, table of contents, problem, hypothesis, procedures, materials, variable, and controls, results, conclusions, discussion, and references should be on display with the student's exhibit during the science fair competition (Wilson et al., 2004). Students will need to complete a display board containing a title that will promote interest in their experiment. The display board should be well organized and have a logical flow of information. Visual graphics such as charts and photographs can be used to further support data (Wilson et al., 2004).

Students have a variety of science fair categories to choose from, which encourages students to focus on an area of interest. Categories include behavioral and social sciences, biochemistry, botany, chemistry, earth, space and environmental sciences, engineering, computers and math, medicine and health, microbiology, physics, and zoology (Somers & Callan, 1999). Projects based on human behavior are considered behavioral and social sciences. Topics on the chemistry of life processes are labeled biochemistry and ideas on the study of plant life fall under botany. Studies related to the nature and composition of matter and the laws governing it are called chemistry. Topics related to the composition of the earth are considered earth science while astronomy and planetary science are called space science. Engineering involves projects dealing directly with applying scientific principles to manufacturing and practical uses. The study of diseases and health of humans and animals falls under medicine and health. The biology of microorganisms is called microbiology. Theories, principles, and laws governing energy and effect of energy on matter are physics. The study of animals is labeled zoology (Science Service, 2008; Somers & Callan, 1999).

Table 1

Science Fair Categories and Topics

Category	Topics
Behavioral and Social Sciences	human and animal behavior, social and community relationships, psychology, sociology, anthropology, archaeology, ethnology, linguistics, learning, perception, urban problems, reading problems, public opinion surveys, education testing
Biochemistry	molecular biology, molecular genetics, enzymes, photosynthesis, blood chemistry, protein chemistry, food chemistry, hormones
Botany	agriculture, agronomy, horticulture, forestry, plant taxonomy, plant physiology, plant pathology, plant genetics, hydroponics, and algae
Chemistry	physical chemistry, organic chemistry, inorganic chemistry, materials, plastics, fuels, pesticides, metallurgy, and soil chemistry
Earth and Space Science	Geology, mineralogy, physiography, oceanography, meteorology, climatology, speleology, seismology, geography, astronomy, planetary science
Engineering	civil, mechanical, aeronautical, chemical, electrical, photographic, sound, automotive, marine, heating and refrigerating, transportation, environmental engineering
Medicine and Health	dentistry, pharmacology, pathology, ophthalmology, nutrition, sanitation, pediatrics, dermatology, allergies, speech and hearing
Microbiology	bacteriology, virology, protozoology, fungi, bacterial genetics, and yeast
Physics	solid state, optics, acoustics, particles, nuclear, atomic, plasma, superconductors, fluid and gas dynamics, thermodynamics, semiconductors, magnetism, quantum mechanics or biophysics
Zoology	animal genetics, ornithology, ichthyology, herpetology, entomology, animal ecology, paleontology, cellular physiology, circadian rhythms, animal husbandry, cytology, histology, animal physiology, invertebrate neurophysiology, or studies of invertebrates

Criteria established at the regional, state, or national science fair competitions are used by judges to evaluate the quality of exhibits. The quality of an exhibit is based on creativity, scientific thought, thoroughness, skill, clarity and teamwork, when two or three students work together. As part of the evaluation process, students are interviewed by judges.

Deaf students may need to learn how to effectively use an interpreter to facilitate communication with the judges. Often, Deaf students see an interpreter on stage at school-wide assemblies or may have some experience of interpreter use in a mainstreamed, public school setting but do not know how to use an interpreter in a one-on-one situation. Deaf students will need to understand the role and responsibility of the interpreter as well as the role and responsibility of the student (DeLana et al., 2007) and should practice with their interpreter, if possible. Wilson et al. (2004) advised students to practice explaining their project to a parent or friend prior to competition in order to build confidence and help them present their information in a smooth and flowing manner on the day of competition.

Interpreters are professionals who have honed their skills to become effective communicators based on criteria established by the Registry of Interpreters for the Deaf (RID) which was established in 1964. RID formalized interpreting as a profession and established the standards for certification-much like the American Medical Association (AMA) establishes standards for medical fields. RID is the only national certifying agency of its kind and offers guidelines for both interpreters and Deaf clients (Napier, 2004). There are strict protocols such as the Code of Professional Conduct that interpreters must follow to maintain the confidentiality of Deaf persons. Interpreters cannot interject their own ideas or opinions into the conversation which means they must remain impartial. The responsibility of the interpreter in the educational setting of a science fair is to sign to the Deaf student what is being said by the judge and voice to the hearing judge what is being signed by the Deaf student, providing the Deaf student does not wish to voice for himself. Deaf students should understand that their interpreter will not advise or counsel them on what to say to the judge about their exhibit (Siple, 1993). Additionally, the interpreter should make it clear to the judge that he or she should speak directly to the Deaf student, not to the interpreter (Phelan & Parkman, 1995).

Participation as judges allows community stakeholders to assist in the development of students. The science fair is benefited by persons outside the school supporting its cause and can enhance public relations (Rice, 1956). Newspaper releases can provide needed publicity and can help the public be aware of the scientific endeavors of its students.

Science Fair and STEM Careers

President Barack Obama supports the emphasis on STEM education in our schools. In 2009, President Obama’s administration launched the *Educate to Innovate* campaign, which identified three main goals: (a) increasing STEM literacy so all students can think critically in these subject areas, (b) improving the quality of math and science teaching in order for American students to no longer be outperformed by those in other nations, and (c) expanding STEM education and career opportunities for underrepresented groups, including women and minorities (Milgram, 2011; Prabhu, 2009).

A good summer enrichment experience for all students can be effective determinants for those interested in STEM (Milgram, 2011). Seymour et al. (2004) conducted a study on student perceptions regarding the benefits of summer research experiences using subjects from four colleges. Seymour et al. found that students' confidence levels increased regarding their ability to do research and to think and work like scientists and they felt their communication skills improved as the result of participating in the summer research opportunities.

Zhe et al. (2010) reported on a 10-week summer program designed to help high school students build interest in STEM careers. These researchers perceived,

> [a]n early research experience is one of the most effective avenues for attracting and retaining talented students in science and engineering careers, including careers in teaching and education research. (p. 61)

The summer program provided inquiry-based science opportunities and highlighted problem-based learning. Students worked in groups facilitated by a faculty member and a graduate student mentor. The summer program was deemed a success as 86% of the participants who were ready to declare a college major, chose a STEM field. While this summer program was designed for hearing students, Deaf students may also benefit from specialized summer programs that focus on STEM development and interests.

Underrepresented minority students were the subject for a study completed by Kendricks and Arment (2011). At Central State University in Wilberforce, Ohio, only 11% of the students were studying for a degree in a STEM emphasis such as biology, chemistry, computer science, engineering, mathematics, and water resources management. Participants revealed they ranked undergraduate research as having the largest impact on professional preparedness for a STEM career. A student-faculty relationship was the strongest indicator of student success which was highly ranked as having an impact on being prepared for a STEM career.

Likewise, participating in a science fair competition may influence students to choose a STEM career (Olson, 1985); however, minimal research on the relationship between STEM careers and science fairs has been conducted. After an intensive online search, only one document identified the possible influence of students' participating in science fair as a useful predictor for obtaining a bachelor degree in a STEM field (Baker & Finn, 2008). More research reveals it is early exposure to science as well as early encouragement of STEM careers that are significant predictors of students' pursuing bachelor degrees in a STEM discipline (Baker & Finn, 2008; Lubinski & Benbow, 2006; Tai, Liu, Maltese, & Fan, 2006). In 2005, an evaluation of the ISEF was conducted and identified about 97% of the teachers surveyed indicated they thought the Intel ISEF motivated their students to pursue a STEM career while the students themselves (75%) stated they were more interested due to their involvement in the ISEF (Rillero et al., 2005). More empirical evidence is needed regarding the various influencing factors of STEM careers and science fair.

Characteristics of a Successful Student

Approximately 83% of Deaf students do not attend a residential school but attend some form of general education setting (Luckner & Muir, 2001; Smith, 2007). Luckner and Muir (2001) conducted a study regarding successful Deaf students who attend school in a general education setting. They identified characteristics that allowed students with a severe-to-profound hearing loss to succeed in this environment. To determine what distinguishes success is subjective; however, Luckner and Muir chose three aspects that appeared in several of the works they studied. Their definition of *success* incorporated constituents of achievement, social skills, and self-perceptions. Through a qualitative study, Luckner and Muir (2001) were able to interview Deaf students and their parents as well as professionals who worked with these students. The Deaf students identified the rationalization for perceiving themselves successful as working hard, family support, friends' support, using specialized equipment and participation in athletics. Specialized equipment used by Deaf students which aided in success included hearing aids, computers, text telephones and closed captioning. When parents were asked why they considered their child successful, six explanations were noted, including: 1) having skilled and caring professionals, 2) family support, 3) early identification and early intervention, 4) extracurricular activities which included sporting events, school newspapers, camps, work and even playing musical instruments, 5) the value of reading and 6) perseverance. In addition to students and their parents, teachers of the Deaf, interpreters, and note takers were interviewed and identified three explanations for their Deaf students being successful: family support, determination and an outgoing personality. General Education teachers added initiative, determination, good social skills and ongoing assistance as characteristics that made the Deaf students successful. Self-advocacy was mentioned by both the Deaf Education teachers and the General Education teachers (Luckner & Muir, 2001). Self-advocacy is a skill needed by Deaf students, because most of them avoid standing up for themselves and remain passive bystanders, allowing others to make decisions for them (Luckner & Muir, 2001). Is it possible, by using an interpreter in a science fair setting, this skill can be developed? Is it possible that these characteristics are needed to be successful in a science fair or, conversely, does participating in a science fair increase the potential for developing successful characteristics?

Hassinger and Plourde (2005) investigated traits of high achieving Hispanic students and found three areas of interests: supportive relationships, student characteristics and family/school factors. The Hispanic students had at least one person in their life that conveyed compassion. Personal attributes were comprised of high self - esteem, internal locus of control and a positive disposition. An *internal locus of control* is the belief that the students are in control of their own destiny, not controlled by others. The most resilient children had at least one caregiver within the family who offered support and attention. Hassinger and Plourde (2005) also noted the importance of school involvement which included participation in sports and/or clubs.

In a similar study with Mexican immigrant youth, Chavkin (2000) identified five key factors of a successful student. Supportive relationships from school personnel and other adults were found to be key factors. Self-esteem, motivation and accepting responsibility were identified as characteristics of successful students. Family factors included concern from parents and involvement with school issues. Community factors included youth programs with sports, clubs and hobbies. School factors were identified through academic success and social training (Chavkin, 2000).

McMillan and Reed (1994) studied factors related to resiliency in at-risk students. *Resiliency* can be viewed as the ability to cope with adversity and to overcome the most challenging circumstances (Hassinger & Plourde, 2005). McMillan and Reed identified four categories of resiliency as individual attributes, positive use of time, family, and school. A positive attitude, high intrinsic motivation and a desire to succeed were noted as *individual attributes*. Hobbies and club activities fell under *use of time*. Needed attention and support came from the bond of a close *family* member. Support at *school* via teachers also played an important role in resilient students (McMillan & Reed, 1994).

From these studies on characteristics of successful students, there was a common thread of support from family, school, friends and social outlets as well as intrinsic motivation from the student. Many educators maintain that when students were involved in science fair projects, their attitudes, science skills and science content knowledge were enhanced and helped them become more successful as students (Czerniak, 1996). The use of science fairs in general education has been well documented (Cook, 2003; Fisanick, 2010; Foxx, 2001; Metz, 2011). Science fair projects offered students the opportunity to construct and solve problems as they worked through the steps involved in the scientific method (Foxx, 2001). Preparing a science fair project was one way students participated in science inquiry and was a positive experience for students at all levels from younger students to older students (Cook, 2003). Content knowledge, self-confidence and poise were all developed from participation in science fairs (Cook, 2003). There were cross-curricular benefits as well as the benefits of having a professional mentor for students (Bernard, 2011). Enthusiasm and interest in science were enhanced for students participating in science fairs as well as the opportunity to practice communication skills (Fisanick, 2010).

Education of Deaf Students

In Deaf Education, there has been an on-going debate regarding the use of oral skills versus manual instruction in classrooms (Easterbrooks, 2001; Miller, 2010) which are the two schools of thought prominent in working with deaf children. The oral method supports the use of oral and auditory skills while the manual method supports use of sign language in some way (Easterbrooks & Baker, 2002; Enns, 2009). The oral method values use of residual hearing and places a strong emphasis on speech production, auditory training, and lipreading. In contrast, the manual method recognizes Deaf people as visual learners and promotes communication and learning, rather than speaking, using American Sign Language (ASL) or English-based signed systems (Easterbrooks & Baker, 2002; Enns, 2009).

A bilingual deaf education framework incorporates a cultural view of Deaf people, visual learning strategies and use of both American Sign Language (ASL) and English (Delana, 2004; Enns, 2009; Geeslin, 2007). Teachers explain content areas in American Sign Language (ASL) then transfer these ideas into a written form of English (Andrews et al., 1997; Chamberlain, Mayberry, & Morford, 2000; Schimmel & Edwards, 2003). There is dual language methodology incorporating ASL and English, currently going through rigorous research both qualitatively and quantitatively (Ausbrooks, 2007; DeLana et al., 2007; Kuntze, 2004).

Lane (1992) promotes the idea that Deaf people are a linguistic and cultural minority where deafness is not viewed as a deficit or a disability by the Deaf community and ASL is recognized as a Deaf child's native language, thus English is learned as a second language. Enns (2009) further explained in her study that the students' knowledge of ASL was used to help them develop their skills in English literacy. The students in her study recognized ASL and English were different and distinct languages, using ASL to express themselves and using English in written form. The teacher in

Enns' study began by introducing a new topic using ASL then using written English, the students read information regarding the topic succeeded by a discussion in ASL and followed up with a written English assignment. Concepts and knowledge the students had plus learning strategies acquired in ASL helped to facilitate English literacy as evidenced in Enns' study.

Markey, Power, and Booker (2003) ascertained "Language is not only a subject within itself. It is an integral part of everything in the education of students who are deaf or hard of hearing" (p. 257). There was no one size fits all remedy and the communication modality must be considered on a case-by-case basis; however, there was strong evidence that Deaf children are visual learners (Easterbrooks & Sheetz, 2004; Holcomb, 2010; Moores, 2010; Wang, 2010) and the use of sign language can enhance communication with persons who have a hearing loss (Garcia, 2009; Keating & Mirus, 2003; Luckner, Slike, & Johnson, 2012; Rittenhouse, Jenkins, & Dancer, 2002). Hearing children experience incidental learning via television, phone conversations, and other avenues; therefore, it is vital that Deaf children be exposed to sign language at all times if they are to be exposed to incidental learning as their hearing peers, the focus being "full, visual access to communication and language" (Holcomb, 2010, p. 474).

Johnson (2004) claimed academic success is linked to instructional effectiveness of teachers. Teachers need to reflect on their own decision-making processes which enable them to determine which teaching strategies and methods they will use in their classrooms to meet objectives outlined in the science curriculum. Teachers need to consider best practices that will benefit the needs of all students and should develop a rationale for selecting the practices they will implement. Wang (2010) advocated educators should be aware of knowledge from research in order to make decisions regarding the material they teach and how they teach it. For a Deaf child, English is a second language. The primary language of Deaf students is American Sign Language (ASL). Deaf students are visual learners and must be taught the grammatical structures and vocabulary of English through strategies different from their hearing peers. Wang (2011) advocated traditional text-based science instruction was not successful with diverse learners who struggle with reading. Language development and higher order thinking skills were vital if Deaf students were to understand basic science concepts. The use of science fair projects allowed Deaf students the opportunity to develop language pertinent to science. Higher order thinking skills were also reinforced through inquiry-based learning. Lang and Albertini (2001) advocated that the use of writing strategies builds metacognitive skills in Deaf students and action-oriented classrooms should provide authentic science inquiry opportunities. Teachers should include their Deaf students in science fair projects in order to promote valuable skills that are needed to build further concepts and learning.

Johnson, Liddell, and Erting (1989), stated directly that deaf education fails in our country due to two reasons: 1) lack of access to curricular content and 2) low expectations of Deaf students' performance. Enns (2009) found that by using the ASL/English bilingual approach with her Deaf students both issues regarding curricular content and low expectations were addressed. Enns (2009) clarified, "The key factor in providing the students with full access to curricular content was the use of a shared language of instruction, ASL" (p. 16). When the teacher was fluent in ASL, shared communication allowed students to be successful as evidenced in class discussions and “meaningful dialogue” (p. 16). Critical issues that helped to inculcate high expectations included establishing a safe and supportive environment where students were willing to risk approximations in their answers, valuing relevant and meaningful lessons that connect to students’ own experiences, and developing trust and respect between student and teacher.

Previous Studies of Inquiry-based Science Instruction

The purpose of the review of literature includes identifying what has already been conducted as well as identifying the gaps that exist in current research (Ryan, 2011). This identification establishes areas that need further research and investigation which includes research on inquiry-based instruction. A science fair project could be considered open inquiry when the student designs the investigation (Bonnstetter, 1998); therefore, I examined the use of inquiry strategies with Deaf students in an effort to determine gaps in current literature. I found there is a need for empirical evidence that inquiry-based science instruction is effective with Deaf students.

One study focusing on inquiry-based science instruction was conducted by Wang (2011) in which she spanned the literature from 1970 to 2011 and found very few results. To qualify for her study, the research had to focus on science instruction, science learning or science performance. Both quantitative and qualitative data on students’ performances could be used. Wang also incorporated research journals and textbooks from the past 40 years and found only 12 articles that met the criteria as scientific inquiry. Of these 12, only five were intervention studies designed to modify scientific teaching in the classroom of deaf and hard of hearing students. From these five, only two have been conducted in the past 30 years (Barman & Stockton, 2002; Lang & Steely, 2003). Wang

(2011) reinforced the idea that print has been the traditional way to present science concepts and suggests there are other ways to help students who are challenged by reading difficulties. She proposed the use of performance literacy which she explained as the use of speaking (oral) or signing literacy mode to present information. Information that is typically presented in print form could be translated into talking books or video books. Many Deaf readers may find performance literacy beneficial when combined with the inquiry approach. The emphasis moves from factual knowledge to practical application of principles. Students are no longer detached observers but become involved performers using science in real world problem solving situations.

Wang (2011) described the various types of inquiry being utilized in today's classrooms which included teacher-controlled inquiry to student-controlled inquiry as well as several levels in between. She cited Bonnstetter (1998) as describing a continuum to help visualize inquiry-based science instruction. On one far side was the teacher choosing the topic, research question, materials, procedures, analysis, results and conclusions. This design, where the teacher made all decisions, was followed by structured science experiences then guided inquiry and on the opposite side of the continuum, student-directed inquiry.

Figure 2. A Continuum of Inquiry.

The assessment tool Wang used to evaluate the research she considered inquiry - based was grounded on the work established by Lederman, Lederman, and Bell (2004).

Lederman et al.'s scale for assessing levels of inquiry practice in classroom was designed on a scale from 0-3. A *Level 0* indicated confirmation of a principle where the results are known in advance. A *Level 1* inquiry involved the teacher providing the problems as well as the procedure and the students determining their own conclusions. *Level 2* required students to design their procedures and conclusions once the problem had been given. Questions, procedures, and conclusions were created by the students in open-ended problems were to be labeled *Level 3*.

Of the five studies Wang (2011) identified as inquiry instruction, one was considered a *Level 3* (Boyd & George, 1973); two were labeled *Level 2* (Borron, 1978; Elefant, 1980); one was included in *Level 1* (Barman & Stockton, 2002), and *Level 0* was given to one study (Lang & Steely, 2003). In the *Level 3* inquiry, the students' investigations were self-initiated and self-controlled. The students used measurement, serialization, timing the rate of activities, prediction and verification to collect data (Boyd & George, 1973). In the *Level 2* investigation the students were presented with a problem but very little formal language was used. The students worked out a solution using their five senses then the desired language constructs were presented (Borron, 1978). The second *Level 2* investigation was a study where demonstrations regarding heat were used to begin each week for eight weeks. The students then experimented on their own, choosing the materials they deemed necessary (Elefant, 1980). In the *Level 1* inquiry the researcher was interested in the students' abilities to find specific information using the Internet. Students used the Science, Observing, and Reporting-High School (SOAR-High) web page and accessed the selected unit. Students could work individually or in teams to evaluate and interpret the data (Barman & Stockton, 2002). The last study's main emphasis was the students' ability to use web-based units from earth science, physical science, and chemistry. Students worked through the multimedia program under the direction of the teacher. The inquiry level was a zero since the lesson was completely teacher directed (Lang & Steely, 2003).

Wang (2011) found higher-order thinking skills in Deaf students were promoted when science inquiry was merged with linguistic and metacognitive analyses. Reading difficulties of Deaf students were addressed by the use of physical manipulation of objects, use of highly pictorial or animated content, simplified English text, additional practice on vocabulary and content graphic organizers as documented by inquiry-based instruction found in Wang's (2011) reviewed literature (Barman & Stockton, 2002; Borron, 1978; Boyd & George, 1973; Diebold & Waldron, 1988; Lang & Steely, 2003; Mertens, 1991; Wang, 2011).

Wang (2011) also noted other recommendations found in the science education literature that could enhance science content knowledge of Deaf students. A thorough discussion of the topic using sign language prior to having students read the textbook for optimum benefit was crucial to student success (Roald, 2002). Scaffolding should be implemented through the use of visual prompts, graphic organizers, and lower-level reading materials (Easterbrooks & Stephenson, 2006). It was best to do an activity first then follow through with vocabulary, reading and writing (Yore, 2000) because when science is taught using inquiry-based strategies, metacognition and meaning-making processes are addressed. Collectively, the comparison of studies revealed students with limited literacy proficiency or language development found physical manipulation of materials and language/reading scaffolding to be advantageous. More research needs to be conducted showing the effects of language acquisition combined with scientific inquiry (Wang, 2011).

There is a scarcity of empirical research on science education and particularly inquiry-based instruction for Deaf students (Moores, Jathro & Creech, 2001; Wang, 2011). According to Easterbrooks and Stephenson (2006), “Researchers in deaf education have much work to do” (p. 395). The use of inquiry in the classroom engages and challenges students mentally; however, little research has been conducted to show evidence that inquiry-based learning makes science accessible to diverse learners, including Deaf students (Wang, 2011).

I conducted an online search from The University of Southern Mississippi’s library using key words “science fair,” “Deaf,” and “ESL/ELL” and implored the guidance of two specialists, a science expert and an education expert to aid in my examination of the literature. After an extensive search was conducted, I concluded that limited research was identified regarding Deaf students and the use of science fair with this marginalized group.

CHAPTER III

METHODOLOGY

The purpose of this study was to examine Deaf college students' perceptions and experiences regarding science fair participation during primary and/or secondary school and determine the influence of science fair involvement on the development of language skills, writing skills, and higher order thinking skills as well as its impact on choice of a STEM major.

In this chapter, I discussed the methods used for my study which included the research questions that drove my study, my research design and a description of participants, followed by data collection, analysis and timeline. The methods used for data collection included a questionnaire used to collect information on demographics and the student's experience of science fair as well as semi-structured interview questions. This chapter concludes with a discussion of the methods for data analysis.

Research Questions

In order to ensure the data was directly related to the use of science fair projects with Deaf students, the following research questions were posed for my study:

1. What are Deaf students' experiences while participating in science fairs in primary and/or secondary schools?
2. What are Deaf students' perceptions on the impact of participating in a science fair regarding language development, writing skills, and higher order thinking skills?
3. Which people, and to what extent, are reported as helpful for Deaf students while participating in science fairs?

4. In what ways do Deaf students perceive participating in science fairs as influencing their choice in a STEM major?

Research Design

A qualitative approach is the most appropriate means of interpreting responses to questions about people's experiences (Patton, 2002); therefore, I chose a qualitative research design for my study in order to assess the responses given by participants regarding their personal experiences with science fair in their primary and secondary schooling. I used a questionnaire featuring two strands: demographics and science fair experiences, and a semi-structured interview followed the questionnaire, to gather data. Analyzing for depth of information is a key component of qualitative research. Detailed information from a small number of cases can provide data (Patton, 2002). I used qualitative data to determine Deaf students' perceptions when participating in a science fair and included if they perceived it as a positive or negative event as well as a detailed description of their experiences. To gather this kind of data I needed in-depth interviews with Deaf students who had a direct experience with science fairs.

Participants

Participants were Deaf college students who attended either the National Technical Institute for the Deaf (NTID), an affiliate of the Rochester Institute of Technology in Rochester, New York, or Gallaudet University (GU) in Washington, D.C., the first liberal arts university in the world designed for Deaf students. All students were majoring in a science field and participated in a science fair during their primary or secondary schooling. Participants from freshman to senior level were included. Gender, race, and level of hearing loss were not factors in choosing the sample for this study. My intended target was approximately 50 respondents for the questionnaire and 20 participants for the interviews in order to provide saturation; however, only 21 students participated in the questionnaire and 10 for the interview. The rationale for this targeted population was that NTID and GU would provide Deaf students who were majoring in a STEM field. Students from all over the United States and worldwide attend NTID and GU which may have given a broader perspective. Descriptive statistics taken from the questionnaire provided the background profiles as follows.

Background Profiles of the Ten Participants from the Semi-Structured Interview

Vickie was an African American female junior majoring in Biology. She was from the central region of the United States and attended a mainstreamed program and a technical high school. She had a moderate (40-69 dB) hearing loss which was discovered between the ages of 2-6. She began using American Sign Language in elementary school. She participated in science fair during upper elementary and in high school. Her career goal was to become a veterinarian.

Barbara was a Caucasian female junior majoring in Lab Science Technology (LST) with an interest in chemistry. She was from the northeastern region of the United States but originally from Brazil. She moved to the United States at the age of 6. Barbara attended an oral residential program until 8th grade and a public high school. She had a profound (90-129 dB) hearing loss which was discovered between birth and 1 year of age. She began using American Sign Language in college. She participated in a science fair during middle school. Her career goal was to get a nursing degree and become a midwife.

Karen was a Caucasian female freshman majoring in Environmental Science. She was from the northeastern region of the United States. Karen attended a residential School for the Deaf. She had a profound (90-129 dB) hearing loss which was discovered between birth and 1 year of age. She has used American Sign Language from birth. She participated in science fair during middle school and high school. Her career goal was to work for the Environmental Protection Agency and become famous.

Brooke was a Caucasian female junior majoring in Biology. She was from the mid-western region of the United States. Brooke attended a mainstreamed program from 1st grade through 9th grade and then a residential School for the Deaf for her remaining high school years. She had a profound (90-129 dB) hearing loss which was discovered between birth and 1 year of age. She preferred using Pidgin Sign Language in an educational setting. She has used sign language since birth. She participated in science fair during elementary school and high school. Her career goal was to work in lab research or become a neurologist.

Charles was an African American male sophomore majoring in Biology. He was originally from Botswana, South Africa and was attending college in the United States. Charles attended a large public high school where he was mainstreamed. He has an unknown level of hearing loss which was discovered between the ages of 2-6. He began using American Sign Language in elementary school. He participated in science fair in upper elementary school. His career goal was to become a dentist and return to his home country of Botswana.

Matt was a Caucasian male junior majoring in Biology. He was from the southeastern region of the United States. Matt attended a residential School for the Deaf.

He had a profound (90-129 dB) hearing loss which was discovered between the ages of 2-6. He began using American Sign Language in elementary school. He participated in science fair in upper elementary school, middle and high school. His career goal was to become a veterinarian.

Maria was a Hispanic female junior majoring in Lab Science Technology (LST) with an interest in chemistry and biology. She was from the mid-western region of the United States. Maria attended a mainstreamed program through middle school then a residential School for the Deaf for her remaining high school years. She had a profound (90-129 dB) hearing loss which was discovered between birth and one year of age. She began using American Sign Language in elementary school. She participated in science fair during upper elementary school and high school. Her career goal was undecided at this time but she has expressed an interest in biomedicine.

Sara was a Caucasian female junior majoring in Biology. She was originally from Canada and was attending college in the United States. Sara attended a residential School for the Deaf for her Elementary school then transferred to a mainstreamed program for middle school. Sara would return to the residential setting for her high school years. She had a profound (90-129 dB) hearing loss which was discovered between birth and one year of age. She has used American Sign Language since birth. She participated in science fair during elementary school and high school. Her career goal was to attend medical school and study neuroscience.

James was a Caucasian male senior majoring in Environmental Science. He was originally from Canada and was attending college in the United States. James attended a residential School for the Deaf. He had a profound (90-129 dB) hearing loss which was discovered between birth and one year of age. He has used American Sign Language since birth. He participated in science fair during middle school and high school. His career goal was to become an overseas teacher perhaps in Australia and work towards Deaf rights in the fight against audism.

Leon was a Caucasian male senior with a double major in Biology and Chemistry. He was from the western region of the United States. Leon attended a residential School for the Deaf since first grade. He had a severe (70-89 dB) hearing loss which was discovered between birth and one year of age. He has used American Sign Language since birth. He participated in science fair during middle school and high school. His career goal was to work in a research lab or attend medical school with a focus on microbiology.

Table 2

Background Profile of Participants

Pseudonym	Ethnicity	Grade Level	Major	Career Goals	Hearing Loss	School Type
Vickie	African American	Junior	Biology	Animal Vet	Moderate	mainstream
Barbara	Caucasian	Junior	LST Chemistry	Midwife	Profound	Oral residential
Karen	Caucasian	Freshman	Enviro Science	EPA	Profound	Residential
Brooke	Caucasian	Junior	Biology	Lab research	Profound	Mainstream Residential
Charles	African American	Sophomore	Biology	Dentist	Unknown	Mainstream

Table 2 (continued).

Matt	Caucasian	Junior	Biology	Animal Vet	Profound	Residential
Maria	Hispanic	Junior	LST	Undecided	Profound	Mainstream Residential
Sara	Caucasian	Junior	Biology	Medical school	Profound	Residential Mainstream Residential
James	Caucasian	Senior	Enviro Science	Overseas teacher	Profound	Residential
Leon	Caucasian	Senior	Biology & Chemistry	Research Lab	Severe	Residential

Data Collection

The data collection instruments I used in my study included a questionnaire and a semi-structured interview. See Appendix A for questionnaire. The 22-item questionnaire was conducted via a password protected survey site. It was divided into two sections. *Strand I* focused on demographics which allowed me to gather background information regarding hearing loss, the grade levels in which students participated in a science fair and type of school attended as well as communication method preferred by the Deaf student. *Strand II* focused on the science fair experience and provided information on the favorite and least favorite parts of the science fair project as well as the type of help received from others. At the end of the questionnaire, the respondents were given an opportunity to decide if they would like to share their personal experiences via a one-on-one interview with me. If the respondent chose to do so, they then provided their contact information. Refer to Appendix B for interview questions.

The purpose for interviewing is to acquire information that cannot be directly observed (Patton, 2002) such as feelings, thoughts, and intentions. Behaviors that took place in the past cannot be presently observed; therefore, another option is needed to gather this important information. My rationale for interviewing was to enter into the Deaf person's perspective. The interview questions used in my study were constructed using information from the four research questions posed for this study. Video phone conferencing was used for the interviews. At the end of the interview, I provided the participant with an opportunity to share any additional information the respondent wanted to add. One benefit of this style of interviewing was the ability to pursue topics or ideas which have not been anticipated (Patton, 2002).

The participants in my study were Deaf; therefore, the interviews were videotaped and answers were translated, using American Sign Language (ASL) into English. Each translation was then transcribed. All names of individuals mentioned in the interview were given a pseudonym to protect the privacy of those involved in the study. All videotapes from interviews were stored in a locked file in a locked file cabinet in my classroom at the Mississippi School for the Deaf at 1253 Eastover Dr. in Jackson, MS. After the study was completed, it was my intent that all tapes/DVDs were to be destroyed using a *Fellowes Powershred* machine after a period of three years. This was the procedure the IRB committee from The University of Southern Mississippi approved; however, when I tried to download on a DVD, the video file was too large and the DVDs were not adequate; therefore, I used two 16 GB flash drives due to insufficient space on the DVDs. The information from the flash drives will be removed after a period of three years.

Timeline for the Study

I began data collection in the spring of 2013, once approval from the Institutional Review Board at The University of Southern Mississippi was achieved. Refer to Appendix C. IRB approval from the National Technical Institute for the Deaf and Gallaudet University was also obtained prior to data collection (Appendixes D and E). My data collection consisted of a 22-item electronic questionnaire to collect background information (Appendix A). An opportunity for students to continue with the research was given at the end of the questionnaire. Those wishing to continue participation in this study were asked to share their perceptions and experiences via a semi-structured interview (Appendix B). I gave a $25 gift card to all participants who completed the questionnaire and interview. A signed consent form (Appendix F) was required of those participating in the study. Gallaudet University required a video release form from their students (Appendix G). Data analysis was conducted during the spring of 2013.

Data Analysis

Data analysis is the process through which qualitative researchers systematically make meaning from collected data (Patton, 2002). The goal of analysis is to organize the data, make meaning from it, and communicate what can be learned from the data (Hatch, 2002). To begin analysis, I reported descriptive statistics in terms of frequency counts using the responses from my electronic questionnaire. I also used information from the questionnaire to create a background profile for each student in order to offer richer data. I translated, transcribed, reviewed, and read all interviews several times for accuracy. I referred repeatedly to my research questions to ensure the analysis answered these questions.

The participants in my study used American Sign Language to respond to interview questions. I reviewed the videotaped sessions and translated their answers into English which I then transcribed. In order to ensure trustworthiness, I requested the assistance of two Deaf native ASL users to review my interview transcripts for translation accuracy. Both of these professionals have worked in Deaf Education for 20 + years and have no connection to the participants. After the interviews were transcribed from ASL into English and were reviewed by the two Deaf translators, I member checked with the participants. Saldana (2013) explained member checking as consulting with the participants themselves "as a way of validating the findings" (p. 35). I emailed four or five participants with other questions or when I needed to clarify information. This occurred up to three times per individual. During analysis I identified commonalities in wording or phrasing as well as similarities, differences, and frequency of events that gave insight into the four research questions that guided my study. I designed an outline from individual cases and place the information in tables in order to identify emerging patterns. I used inductive analysis to evaluate my data and identifying categories, themes, and patterns.

Inspired by *The Coding Manual for Qualitative Researchers* by Saldana (2013), I used nine suggestions to aid in my analysis, beginning with First Cycle Coding then transition followed by Second Cycle Coding. After the interviews, I translated and transcribed the information shared by my participants and included a text box on the right hand side of each page for margin notes and identified codes in capital letters. I began with *Eclectic Coding*, employing a hybrid strategy for a first look at the data in my transcriptions. I used Elemental Methods, Affective Methods and Exploratory Methods to aid in interpreting the data. The purpose of Elemental Methods was to build a foundation for future coding cycles; therefore, I searched for particular elements in the data using *In Vivo* and *Process Coding*. Because *In Vivo* Coding uses the actual words spoken by the participant, I reported the exact words of the Deaf students I interviewed to enhance an understanding of their worldview. *In Vivo Codes* were placed in quotation marks in the text box used for margin writing. *Process Coding* uses <-ing> verbs of action; therefore, I searched for actions and interactions such as judging or winning a science fair competition. At this point, I made use of *Initial Coding* in order to divide the data into smaller pieces and examine the data line by line. This was considered a First Cycle, open-ended approach to coding data recommended for interview transcripts (Saldana, 2013) and was intended as a starting point for further exploration followed by analytic memo writing and recoding. Following *In Vivo* and *Process Coding*, considered Elemental Methods, I employed *Emotion Coding*, an Affective Method. Affective Methods look specifically for emotions, values, conflicts, and judgments so I used *Emotion Coding* to label the feelings of the participants as they recalled their experiences of participating in a science fair and while sharing their educational background. This type of coding “provides deep insight into the participants’ perspectives, worldviews, and life conditions” (Saldana, 2013, p. 106). At this point, I used one more First Cycle Coding called *Holistic Coding*. This coding system was considered an Exploratory Method and concentrates on coding large units of data with a single code to sum up the idea being presented and was used “to ‘chunk’ the text into broad topic areas” (Bazeley, 2007, p. 67). After this initial coding of data, I conducted Analytic Memo Writing to examine my code choices and to reflect on emergent categories and the deeper, complex meanings that were developing. I reflected and wrote on nine different topics from how I related to the participants to my code choices to any ethical dilemmas to emergent patterns. After First Cycle Coding, I engaged in several transitional strategies. Saldana (2013) explained post-coding transitions "examines those shifts after the initial review of the corpus and provides you with additional methods for reorganizing and reconfiguring your transformed work" (p.187). I used *code mapping*, a display strategy, to help organize my observations and to help me continue to progress towards Second Cycle Coding. *Code mapping* allows the researcher to move from the full set of codes to a list of categories and then to central themes. I then used *Code Landscaping*, a visual technique that identifies the most frequently used words and creates a visualization of various sizes depending on the frequency of codes. I used my *Emotion codes* to create a Wordle graphic from www.wordle.net.

Figure 3. Wordle Graphic Using Emotion Coding.

The last transitional strategy I used was *Tabletop* categories. I took copies of all ten transcripts, cut them into sections according to their codes, stapled the piles with the category name on a post-it note and then physically manipulated the paper slips into similar concepts. Interacting with my data in this manner allowed me to analyze deeper and see emerging patterns as I entered into Second Cycle Coding using *Focus Coding*. Saldana (2013) advised, “The primary goal during Second Cycle coding is to develop a sense of categorical, thematic, conceptual, and/or theoretical organization form your array of First Cycle codes” (p. 207). Using *Focus Coding*, I used a tree diagram to identify the most salient categories which allowed me to reorganize and reconfigure my data to fewer, more concise categories with conceptual similarities and prepared me for *Axial Coding* which then helped me to determine the dominant codes. If there were redundant codes, they were identified as synonyms and removed so the best representative codes were selected. I went back to Analytic Memo Writing focusing on four components: context, conditions, interactions, and consequences. The *context* identified the setting in which the action occurred and the *condition* was used to recognize the situations that happen in the context. *Interactions* were specific types of exchanges in the context and condition while *consequences* referred to the outcomes or results. I continued to use diagrams as I worked through the data moving from *Focus Coding* to *Axial Coding* which led to *Theoretical Coding*. The purpose of *Theoretical Coding* was to find the primary theme of my study. This core category identified the major conflict in my research and all other categories became linked with this one concept. Saldana (2013) advocated “post-coding and pre-writing-the transitional analytic processes between coding cycles and the final write-up of your study” (p. 247); therefore, I used the *Top 10* list and concluded with reflections. I chose the ten strongest *In Vivo* codes and typed them on a Word document then cut them apart to arrange them in various orders trying chronologically, hierarchically, telescopically, and from the smallest detail to the big picture for insight to the most salient ideas. Lastly, I went again to my memo writing for reflection on the major outcomes of my study. After I completed the cross-case analysis, I drew conclusions and made recommendations for further study.

Trustworthiness in Qualitative Research

The intent of both qualitative and quantitative research is to "seek honest, meaningful, credible, and empirically supported findings" (Patton, 2002, p. 51). The term *trustworthiness* is of great significance in contemporary qualitative research. In general, trustworthiness was defined according to Saldana (2013) as accountability and "knowledge of acceptable procedures within a field" (p. 255). Expanding upon this definition, Lincoln and Guba (1986) identified four criteria to achieve trustworthiness as: credibility, transferability, dependability and confirmability. *Credibility* is akin to internal validity. Patton (2002) amplified this definition to include the researcher as the instrument for collecting data whereas in quantitative research data collection occurs with measurable tools such as survey questions or test items. The researcher of a qualitative study must show rigor in the field by his expertise, competence and use of criteria. Criteria could include rigorous procedures for collecting data in a systematic manner, cross-checking and cross-validating as well as use of intercoder consistency during theme analysis. Triangulation was another way to establish credibility by gathering different types of data such as observations, interviews, documents, artifacts, recordings, and photographs. One can triangulate observers or analysts, thus reducing bias and promoting trustworthiness instead of the use of one method, one analyst and one perspective (Patton, 2002). The second criterion for determining trustworthiness according to Lincoln and Guba (1986) was *transferability* which could be labeled external validity pertaining to the possibility of generalizing to other situations. Lessons learned that could be applied to other circumstances or the potential applications for future use could be considered evidence of transferability. *Dependability* was the third criterion for determining trustworthiness as reported by Lincoln and Guba (1986) and correlated with reliability and focuses on the process of research and data collection. The reliability of observations corresponds directly to the rigorous preparations and intensive training the researcher has acquired. The researcher must do more than just see (Patton, 2002). He must see not how he imagines things to be, but rather through the eyes of others. Qualitative methods, which help the researcher describe the perspective of others, might include participant observation, depth interviewing, detailed description and case studies. While *dependability* centers on the process, the fourth criterion, *confirmability*, centers on the product or results of the study and is affiliated with objectivity. The researcher wants to "minimize bias, maximize accuracy, and report impartially" (p. 93) regarding the results of his fieldwork. Rigor and integrity must be employed when testing ideas, suggesting patterns and themes, or developing findings. The use of an audit trail can be beneficial in providing evidence of *confirmability* by adding depth and detail to one's findings (Patton, 2002). If trustworthiness is analogous to rigor as supported by Lincoln and Guba (1986) then Saldana (2013) suggested the researcher be

> rigorously ethical with your participants and treat them with respect; rigorously ethical with your data and not ignore or delete those seemingly problematic passages of text; and rigorously ethical with your analysis by maintaining a sense of scholarly integrity and working hard toward the final outcomes. (p. 37)

Qualitative rigor has a direct link to the "quality of the observations made by an evaluator" (Patton, 2002, p. 575). Patton explained that "trustworthiness of the data is tied directly to the trustworthiness of the person who collects and analyzes the data" (p. 570). Researchers should approach their study with no predetermined results to prove but should be open-minded to the analysis and report both confirming and disconfirming evidence (Patton, 2002). The data collection instrument in qualitative research is often the investigator who needs to reflect on:

> (s)ymtematic data collection procedures, rigorous training, multiple data sources, triangulation, external reviews, and other techniques…aimed at producing high-quality qualitative data that are credible, trustworthy, authentic, balanced about the phenomenon under study, and fair to the people studied. (Patton, 2002 p. 51)

Ezzy (2002) used member checking, coding while transcribing interviews and a reflective journal for memo writing as effective tools for conveying trustworthiness. *Member checking* can be defined as consulting with the participants of your study to determine the accuracy of your findings (Creswell, 2009; Saldana, 2013). Creswell (2009) suggested the researcher member check with participants using specific descriptions, themes or the final report not the raw data from interview transcripts. A follow-up interview allows the respondent to add further comments and insights or to support the researcher's findings. The focal point for Ezzy's (2002) second criterion was coding while transcribing.

Rossman and Rallis (1998) defined coding as "the process of organizing the material into chunks or segments of text before bringing meaning to information" (p. 171). The sentences or paragraphs of your interview transcriptions are placed into categories then later labeled often using an *in vivo* term, the actual language of the participant in quotation marks (Creswell, 2009; Saldana, 2013). Saldana (2013) offered this advice, "Be wary of relying on your memory for future writing. Get your thoughts, however fleeting, documented in some way" (p. 20). He suggested you do not wait until your fieldwork is completed to get started on data analysis; therefore, it is imperative to note any preliminary words, phrases, or ideas you may want to consider using as codes. Saldana (2013) also supported the use of memo writing in a research journal, Ezzy's (2002) third criterion for establishing trustworthiness. Saldana (2013) suggested:

> (t)he purposes of analytic memo writing are to document and reflect on: your coding processes and code choices; how the process of inquiry is taking shape; and the emergent patterns, categories and subcategories, themes, and concepts in your data. (p. 41)

Creswell (2009) advocated the researcher writing thoughts in the margins of transcriptions as they are being read and evaluated which will later be used to make topics then abbreviated into codes. Saldana (2013) recommended inserting a text box to the right hand side of your transcription pages if you are using a Microsoft Word document. In this space the researcher can align codes with the data.

Researchers strive for neutrality when doing qualitative research in order to make their data analysis nonbiased and more valid. As a counter to bias, according to Scriven (1998), the ideal of objectivity is still worth striving for; however, Lincoln and Guba

(1986) said the term *objectivity* should be replaced with *trustworthiness* and *authenticity*. *Authenticity* can be described as the reflection of one's own perspective, recognizing others' perspectives, and being fair regarding the value of these perspectives (Patton, 2002). Patton clarified "the issue, then, is not really about objectivity in the abstract, but about researcher credibility and trustworthiness, about fairness and balance" (p. 576). To obtain authenticity the researcher should use rigorous methods, be credible, and value qualitative research (Patton, 2002). Rigorous methods would produce "high-quality data that are systematically analyzed with attention to issues of credibility" (p. 571). Patton advocated training in research techniques, expertise, accomplishments, history of experiences, and self-poise all lend to the credibility of the investigator while Creswell (2009) recommended the researcher choose several of the eight strategies he identified to ensure the accuracy of findings. The eight findings he suggested were to triangulate, use member checking, use rich, thick description, clarify researcher bias, present negative or discrepant information, spend prolong time in the field, use peer debriefing, and lastly, use an external auditor. I used Creswell's suggestions to ensure trustworthiness in my study. First, I triangulated my data sources by using a questionnaire and a semi-structured interview. Patton (2002) claimed the use of triangulating, using multiple data collection techniques, adds to one's credibility because "the logic of triangulation is based on the premise that no single method ever adequately solves the problem of rival explanations" (p. 555). Secondly, I used member checking to determine the accuracy of specific descriptions and themes. Member checking was conducted using follow up emails. A third suggestion by Creswell (2009) that I applied was use of rich, thick descriptions so readers could share experiences and perspectives of the participants.

Perhaps the audience found a fuller understanding of the setting being described as well as the emotions and significance of the experience. Denzin (1989) elucidated, "In thick description, the voices, feelings, actions, and meanings of interacting individuals are heard" (p. 83). I applied the fourth suggestion by accounting for my own bias via self-reflection using analytic memo writing throughout the data analysis. Creswell (2009) affirmed a core characteristic of qualitative research was researchers reflecting on their own perspective regarding "how their interpretation of the findings is shaped by their background, such as their gender, culture, history and socioeconomic origin" (p. 192). A fifth suggestion from Creswell was to discuss negative or discrepant information. I supposed that most respondents in my study supported the idea of participating in a science fair; however, not all agreed. I presented both sides of the findings. A sixth idea proposed by Creswell was to spend a prolong time in the field in order to develop "an in-depth understanding of the phenomenon under study" (p. 192). While I am a neophyte at qualitative research, I do have experience regarding the various educational settings offered to Deaf students and I have experience with coordinating science fair competitions. Patton (2002) recognized that the researcher's direct experiences have value and provide insight for data analysis. I have taught in a mainstreamed setting where there were two classes of Deaf students at a public elementary school as well as in a residential setting where all the students were deaf. I have been the science fair coordinator at my school for 17 years at both the primary and secondary levels. I have arranged local science fair competitions from first grade through twelfth grades and have sponsored students at the regional and state level of competition. I have also served as judge for regional competitions and assisted as a special judge at the state level. I feel these experiences lend credibility to my writing and research. The seventh component I used, recommended by Creswell (2009) was peer debriefing. A peer debriefer reviews the study and asks questions for clarification "so that the account will resonate with people other than the researcher" (p 192). I used several peers to review my work as well as my doctoral committee; therefore, the credibility of my study was enhanced by expert reviewers. The eighth recommendation from Creswell (2009) was the use of an external auditor. This person reviews the entire project but is not familiar with the research or the researcher which provides "an objective assessment of the project throughout the process of research or at the conclusion of the study" (p. 192). I did not use the 8th recommendation, which involves the use of an external auditor, in this study.

The researcher should write his findings using a "credible, authoritative, authentic, and trustworthy voice" (Patton, 2002). Techniques such as "rich description, thoughtful sequencing, appropriate use of quotes, and contextual clarity" are helpful for engaging the reader and lend trustworthiness (Patton, 2002, p. 65). Reported facts are labeled as thin description; therefore, a thick description would yield an understanding of the circumstances that surround a particular event, as well as the intention and meaning of the experiential process (Denzin & Lincoln, 1998). In line with this idea, Denzin and Lincoln (1998) expounded that the "intent is to create the conditions that will allow the reader, through the writer, to converse with (and observe) those who have been studied" (p. 324) allowing for a more authentic and deeper understanding. In other words, "authentic understanding is created when readers are able to live their way into an experience that has been described and interpreted" (Denzin & Lincoln, 1998, p. 324). The researcher must make a conscious decision about which messages and voices are featured in the interviews and stories that are disclosed. The researcher keeps all this in mind as he begins the process of coding. Brown et al. (1999) suggested researchers should develop initial codes through successive approximations from the full set of codes, to a selected list of categories, and lastly condense them into central themes. Charmaz (2008), too, advised that detailed line-by-line coding promotes a more trustworthy analysis.

I followed Brown et al.'s (1999) recommendations by moving from codes to categories and lastly, to the central theme and as Saldana (2013) suggested, I chose to be rigorously ethical with my participants, data, and my analysis. From Creswell (2009), I adhered to member checking, thick descriptions, clarifying my bias, presenting both positive and negative information revealed by my participants, and used peer debriefing to maintain authenticity and trustworthiness in my qualitative research design and data collection.

CHAPTER IV

ANALYSIS OF DATA

Introduction

My study examined Deaf students' perceptions and experiences regarding participation in a science fair. An electronic questionnaire and a semi-structured interview were used for data collection (Appendixes A and B). The electronic questionnaire had two components. *Strand I* contained demographic questions while *Strand II* contained questions related to science fair experiences. The electronic questionnaire was sent to 96 students in the science department at the National Technical Institute for the Deaf (NTID) in Rochester, New York and 40 students in the science department at Gallaudet University in Washington, D.C. Twenty-one students responded to the electronic questionnaire. From these 21 respondents, 10 students choose to participate in interviews.

To begin analysis, I reported descriptive statistics in terms of frequency counts using the responses from my electronic questionnaire and followed up with responses from interviews regarding my research questions. I created background profiles on each interviewee. Interviews were videotaped, followed by translation and transcription. Transcriptions were viewed by two Deaf native users of American Sign Language for translation accuracy. I applied nine suggestions from Saldana's *The Coding Manual for Qualitative Researchers* to aid in data analysis. I began with First Cycle Coding then Transitional Coding followed by Second Cycle Coding and Post-Coding. For First Cycle Coding I utilized *Eclectic Coding* for a first look at my data. During the First Cycle Coding, I used three methods: elemental, affective and exploratory. Elemental Methods included *In Vivo Coding* and *Process Coding*. The Affective Method I used was *Emotion Coding* and the Exploratory Method I used was *Holistic Coding*. At this point, I utilized analytic memo writing for further reflection followed by transitional strategies using code mapping, code landscaping, and tabletop categorization. *Focus Coding, Axial Coding*, and *Theoretical Coding* were the approaches used during Second Cycle Coding with analytic memo writing conducted between *Axial* and *Theoretical Coding*. For the Post-coding/Pre-writing activities I used the "top 10" list, reflections, and memo writing.

Major Outcomes of the Study

Audism has been a longstanding battle for Deaf people. Audism is oppression that Deaf people experience because of their deafness and is associated with attitudes of viewing Deaf people as disabled versus having their own culture and language (Berke, 2009). Experiences of discrimination are common by Deaf people in the work place and at schools due to the hearing world's view of deafness as a stigma which makes hearing loss the focal point. Social inequalities and empowerment of Deaf individuals are being addressed as an awareness of audism and its oppression are being recognized (Grant, 2007).

Communication brings a feeling of equity and accomplishment and is vital to bridging the worlds of Deaf people and Hearing people where as a lack of communication causes frustration and a feeling of inadequacy. Enns (2009) clarified, "The greatest obstacle for Deaf people is not their deafness, but that others with normal hearing…are unable to communicate well with them" (p. 3). In the Deaf community, communication through the use of sign is the focal point, not speech. In an ASL/English bilingual education classroom both languages are valued as distinct, separate languages and learning English through the use of ASL is critical. This shared communication through ASL allows the teacher and students to have meaningful dialogues in the classroom. When communication is established through a shared first language, the teacher can address the curricular content of science and decree high expectations of students. One of the outcomes of my study was that communication is the key to a successful science fair experience.

The three major categories constructed from transcript analysis were educational background, pedagogy, and mentorship. All were surrounded by the theme of communication which became the core of my study. The educational background of students attending a residential, mainstreamed class or general education, made a difference regarding their science fair experiences due to the ability or inability to communicate with their teachers and the judges at the science fair competition. The pedagogy strategies of language development, writing skills, and thinking skills hinged on communication. The ability to communicate with teachers through sign language was an asset regarding the improvement of students' skills in these three areas. The decision to major in a STEM area also depended on adequate communication between the Deaf student, his teachers, parents, and peers.

The 21 participants on the questionnaire ranged from college freshmen to seniors with the most frequent academic level being juniors at 47.6%. There were no graduate students involved in the study.

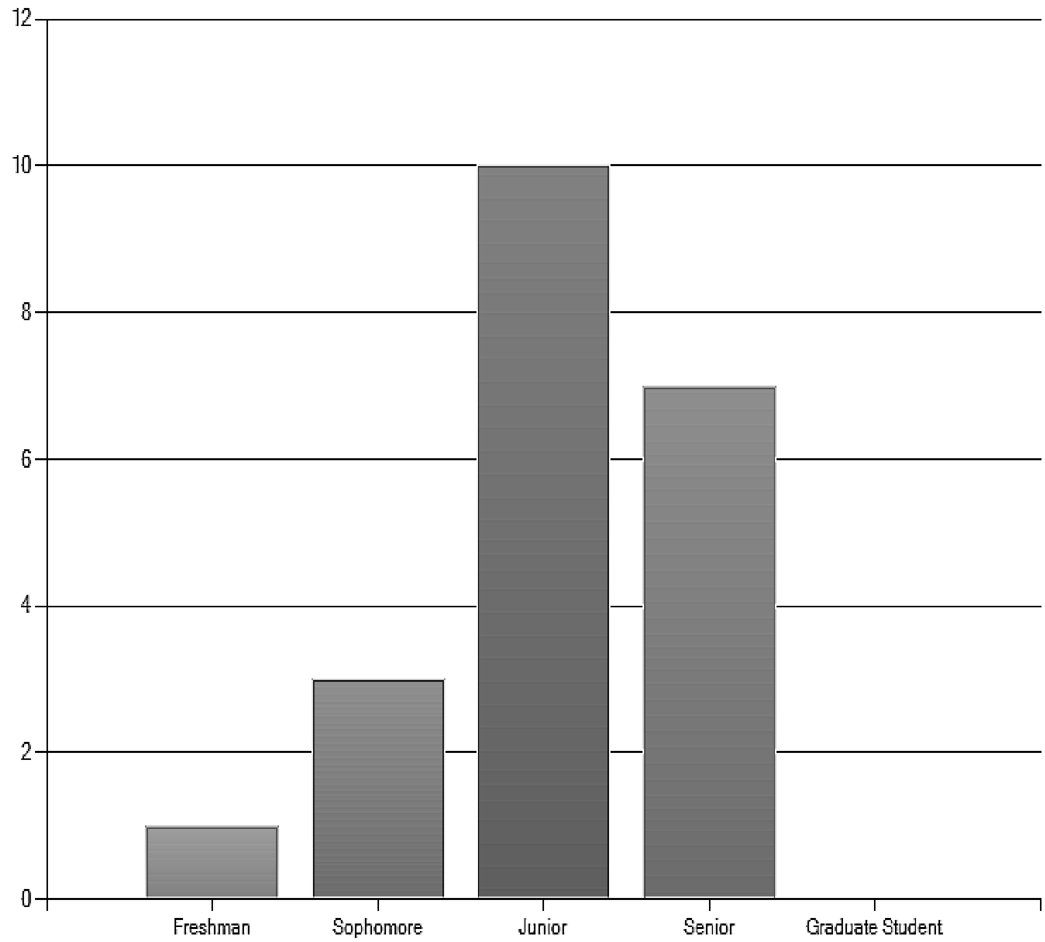

Figure 4. Academic Level of Participants.

Biology was indicated most often as the choice of STEM major at 57.1% followed by chemistry (33.3%) and environmental science (14.3%). These three majors were the only ones represented in my study; therefore, participants in my study were studying life science or earth science. There were no students majoring in physical science or health who participated in the study.

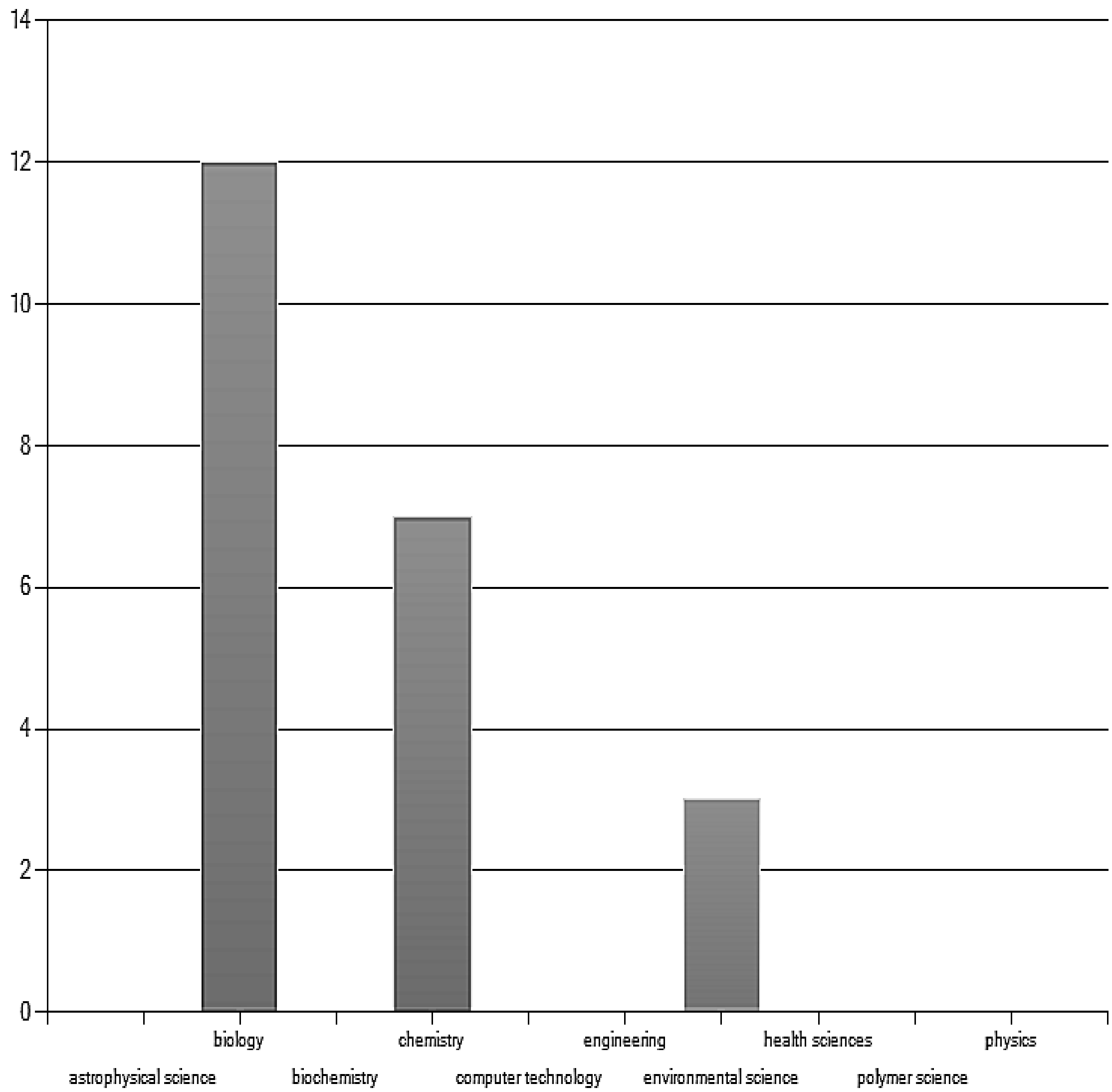

Figure 5. Major in College.

Each region of the United States was represented, as well as three participants from outside the U.S. The Northeast region had the most participants with 42.9% while the Western region had 14.3% participation, as well as other countries at 14.3%, with Brazil, Canada, and Botswana, South Africa being represented.

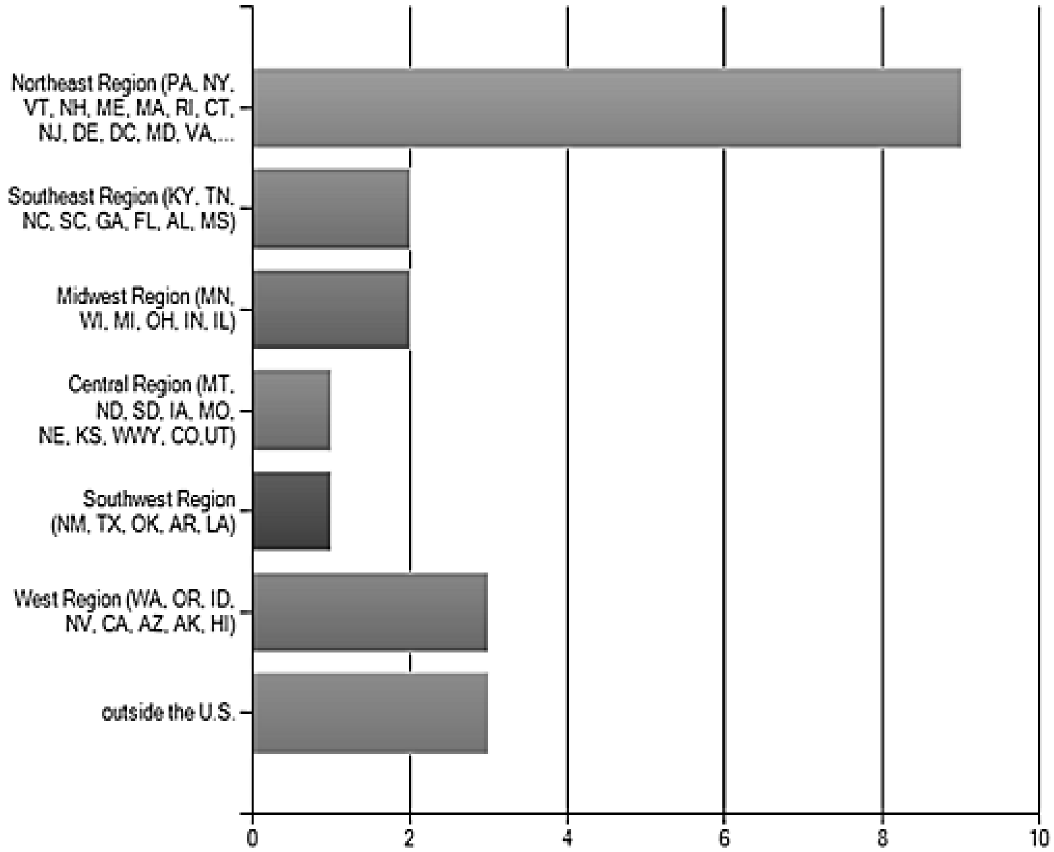

Figure 6. Region of High School Attended.

There was a fairly even distribution regarding type of high school the participants attended. Public school and residential school each accounted for 33.3% with mainstream programs at 28.6%. The question might have caused some confusion as a residential school is also considered a public school. Respondents were only able to choose one option. Public school was chosen by seven persons and residential school was chosen by seven persons while mainstream school was chosen by six persons and charter program by one person. Public school is typically interpreted as a general educational setting whereas a residential school is a school that offers housing to students whose home towns are too far to allow students to commute. A mainstreamed program is typically housed in a nonresidential public school setting with one or more classes designed for Deaf students with a certified teacher for the Deaf. The students return to their homes after school each day whereas at a residential school, students remain on campus in dormitories and go home on the weekend.

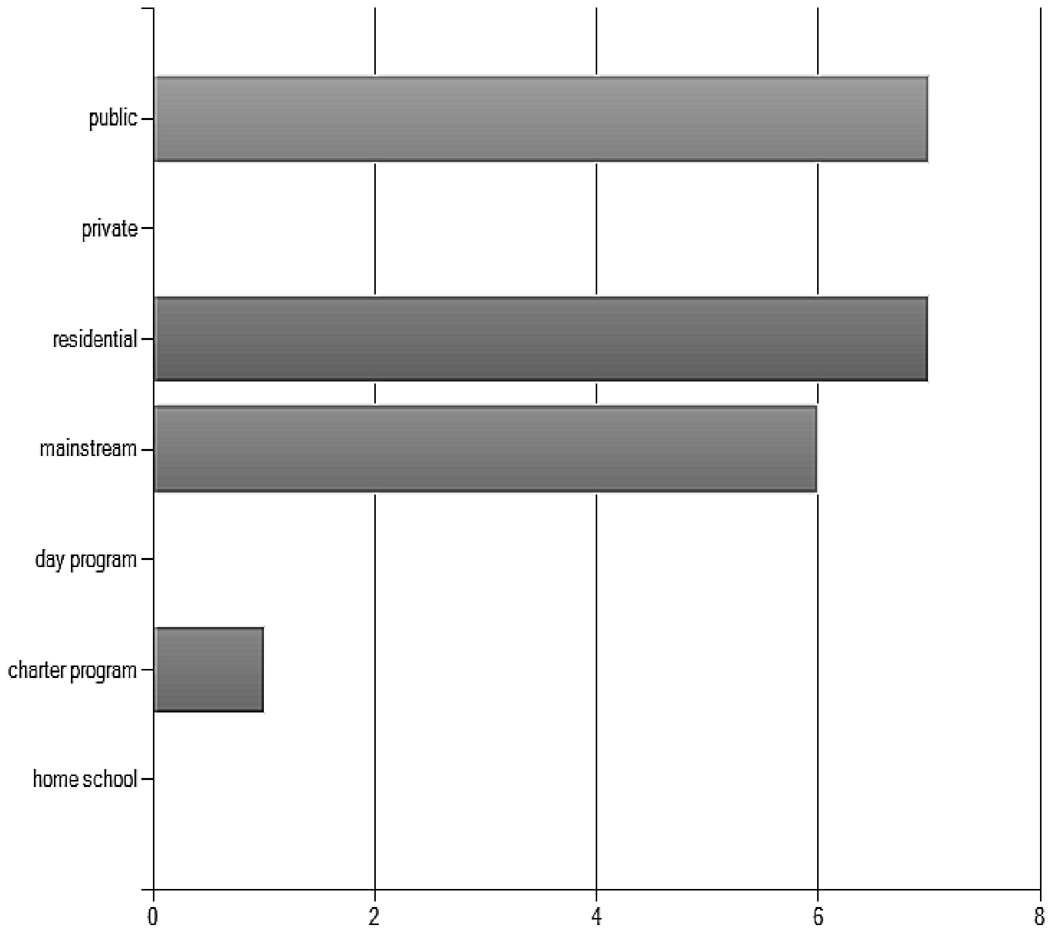

Figure 7. Type of High School Attended.

Ten respondents identified a total student body population of 101-500 students which is 47.6% and the second highest student population was 1,000 + with 19.0%. There were extremes regarding the numbers of Deaf students attending the participant's high school. The largest majority (38.1%) identified the high school they attended as having five or fewer Deaf students which indicated these students attended a general education program or a mainstreamed program while 23.8% identified all the students were Deaf at the high school they attended, which would indicate a residential setting.

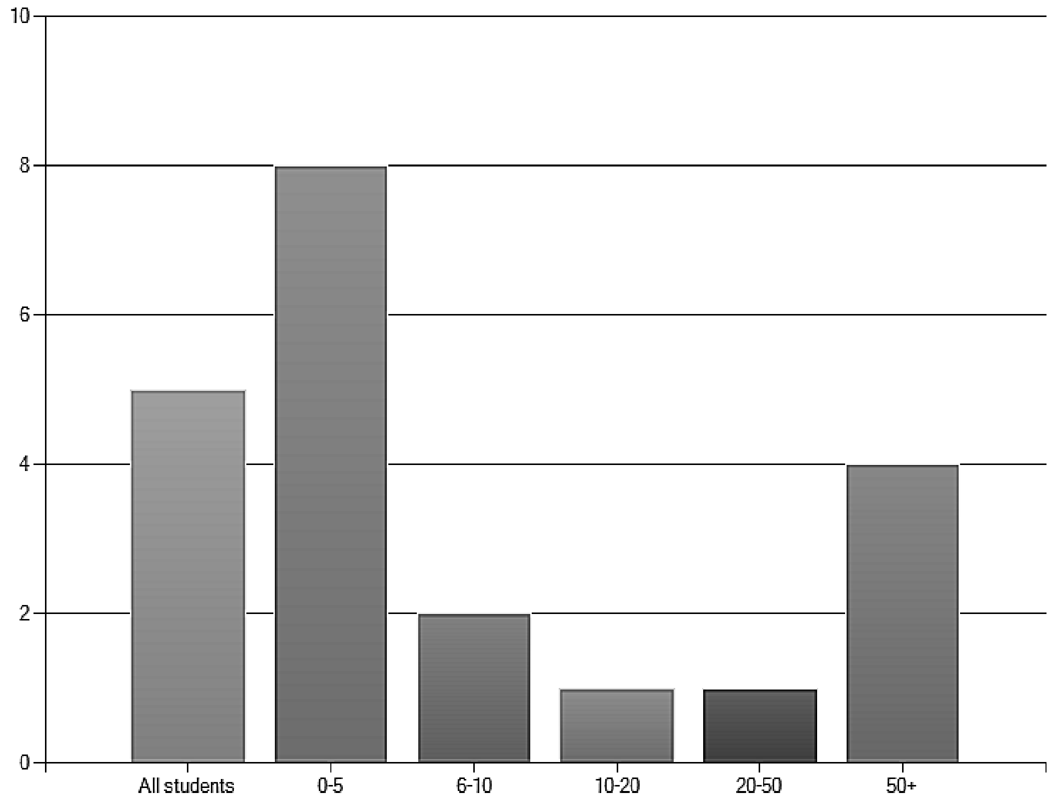

Figure 8. Total Number of Deaf Students.

A large percent of students (66.7%) had their hearing loss identified from birth to one year of age and 33.3% were identified as having a hearing loss from 2-6 years of age. Hearing loss ranged from moderate to profound with the latter category at 71.4% and the moderate category at 14.3%. Most participants started learning and using ASL from birth (55%) and 30% began using ASL during Elementary School while only 15% learned ASL in college.

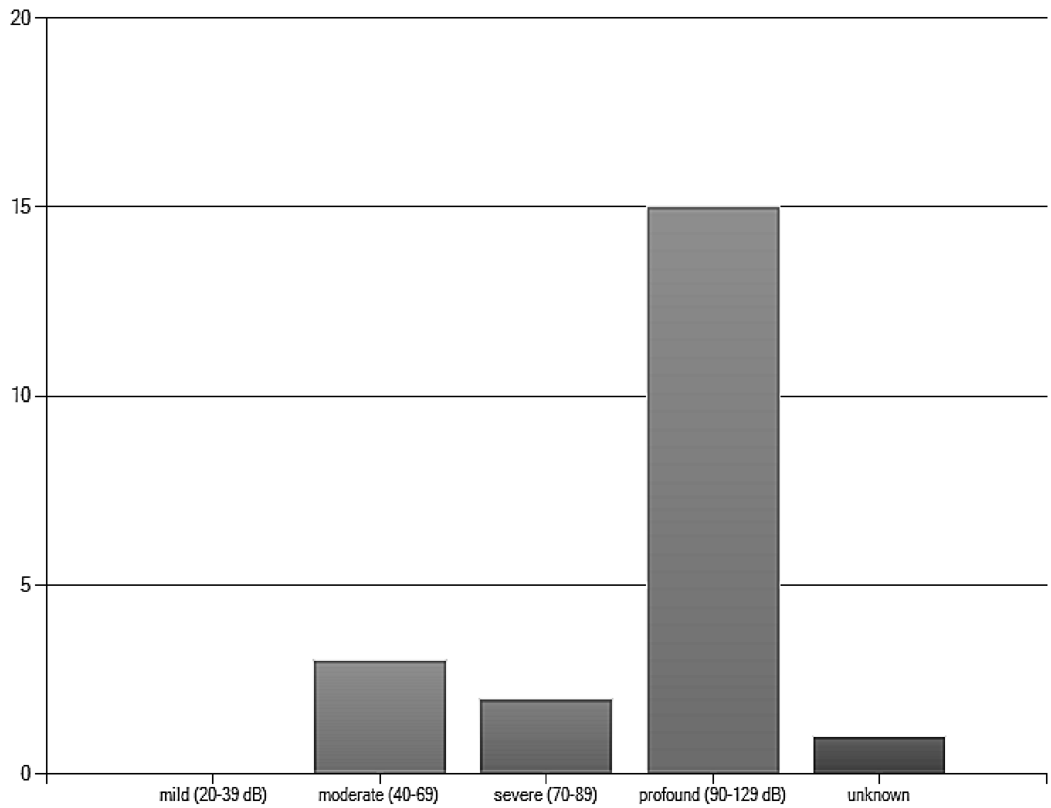

Figure 9. Level of Participants' Hearing Loss.

There was a variety of ethnicities that participated in the questionnaire, notably students identified themselves as Asian, Hispanic, African American and Caucasian. This latter category, Caucasian, had the highest percentage, at 66.7% with 14 participants and three participants identified themselves as Hispanic. Only two African Americans and two Asians participated in the questionnaire.

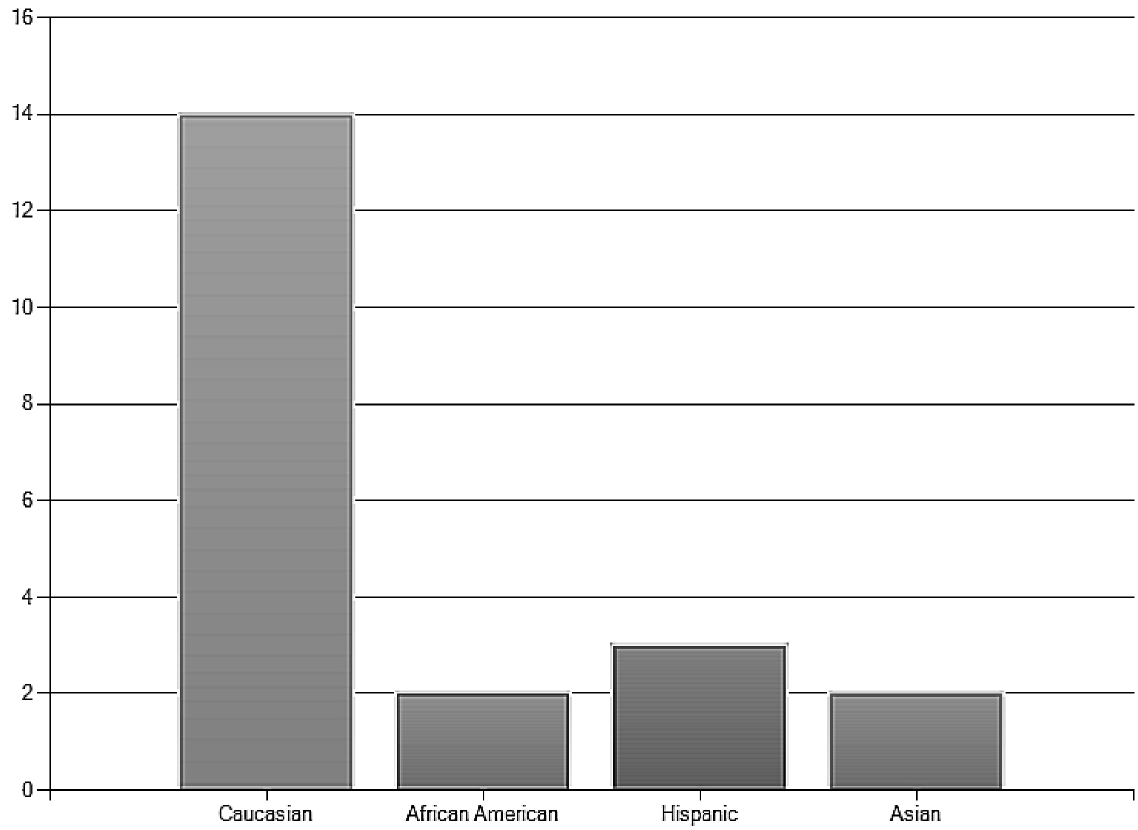

Figure 10. Ethnicity.

When participants were asked if they used American Sign Language, 95.2% indicated they used ASL and 76.2% acknowledged they preferred their professional interpreters to deliver messages using ASL. Some participants (9.5%) expressed they preferred Pidgin Sign Language where the interpreter transitioned from ASL to a more English-like modality and others preferred an oral interpreter for lipreading (9.5%). Only one participant specified Manually Coded English (MCE). When asked whether their science teacher used signed or communicated to their preference, 76.2% answered positively and 23.8% answered negatively.

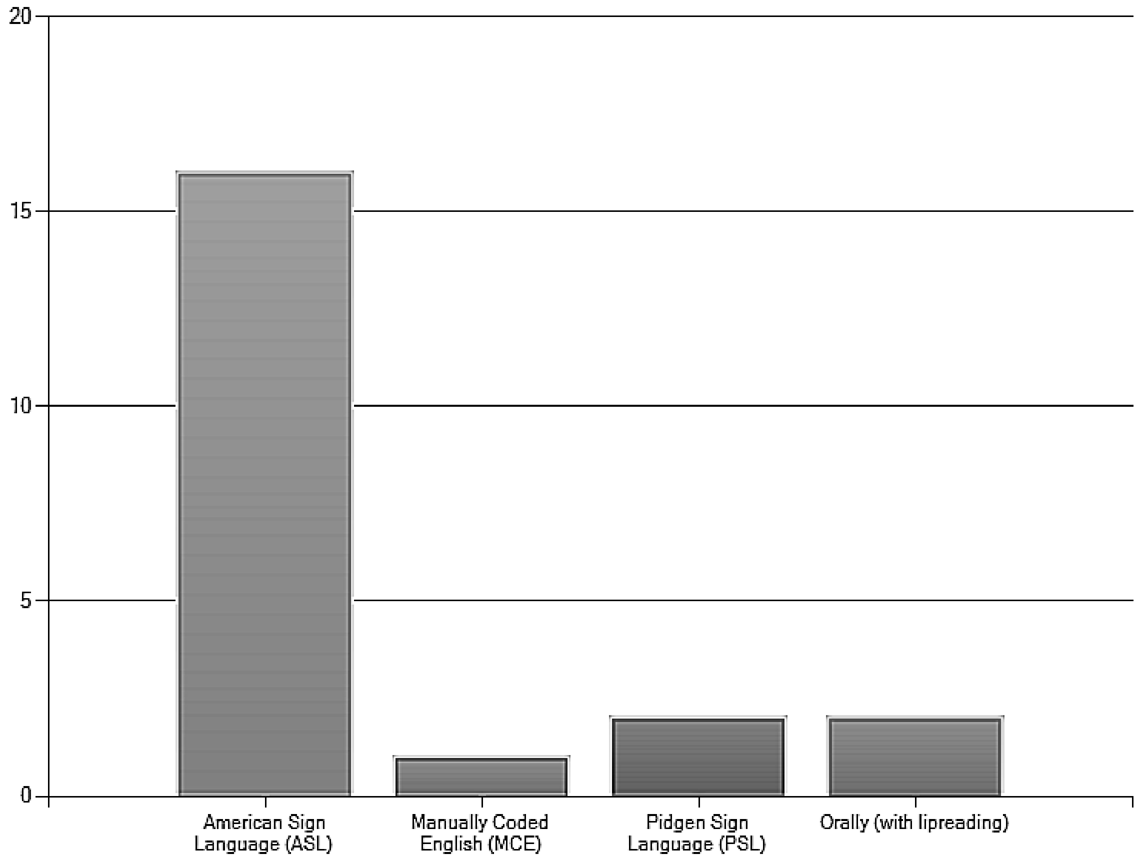

Figure 11. Language Preference Used by Interpreters.

Participants of science fairs are often divided into groups depending on their grade level. Lower Elementary is considered first through third grades; Upper Elementary is considered fourth and fifth grades; Middle school is considered sixth seventh, and eighth grades; and High school is identified as ninth, tenth, eleventh, and twelfth grades. In Lower Elementary, third grade with 25% participation rate, was the grade most questionnaire respondents identified as the grade in which they participated in a science fair. For upper elementary, fifth grade had a participation rate of 31.3%. Most students in middle school participated in a science fair during 7^{th} grade with a percentage of 43.8. In the high school category, tenth grade had the highest participation rate with 50% of the respondents acknowledging science fair participation during this time.

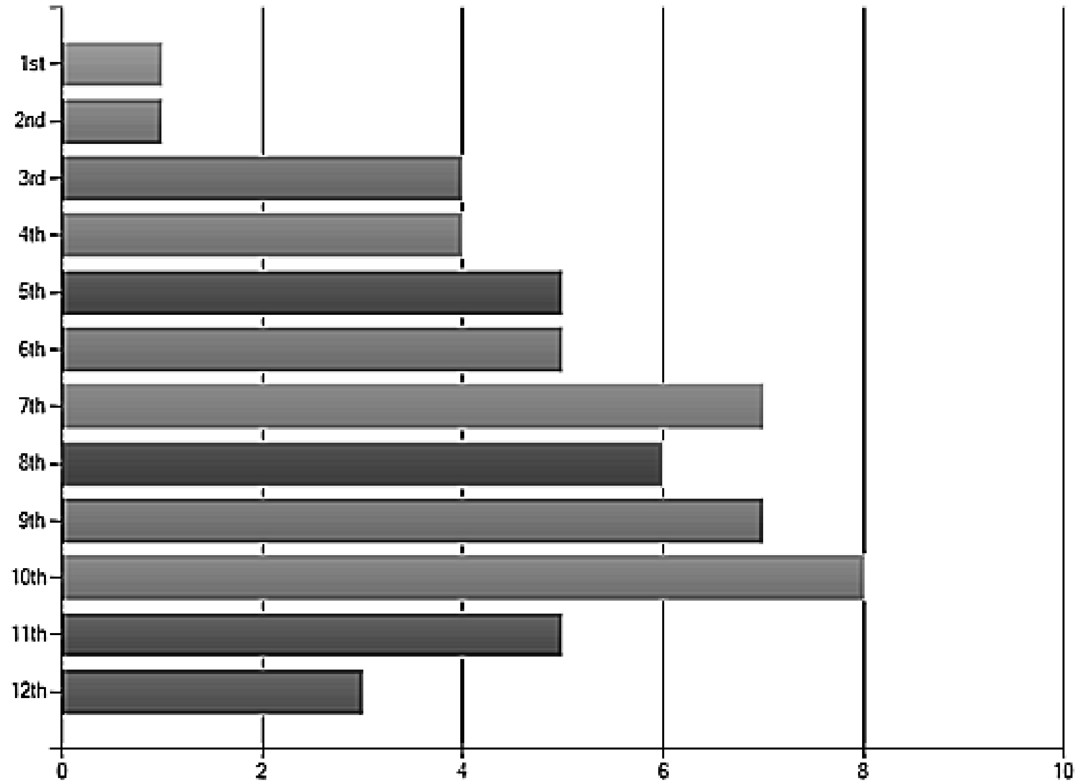

Figure 12. Grades of Science Fair Participation.

Of the 21 participants surveyed, 87.5% indicated they enjoyed *doing the experiment* as their favorite part of the science fair project and the second highest choice at 68.8%, replied *learning/discovering* was their favorite part of a science fair. Other areas that received attention included working with family members, working independently, winning or placing, receiving recognition by others, and making the display board.

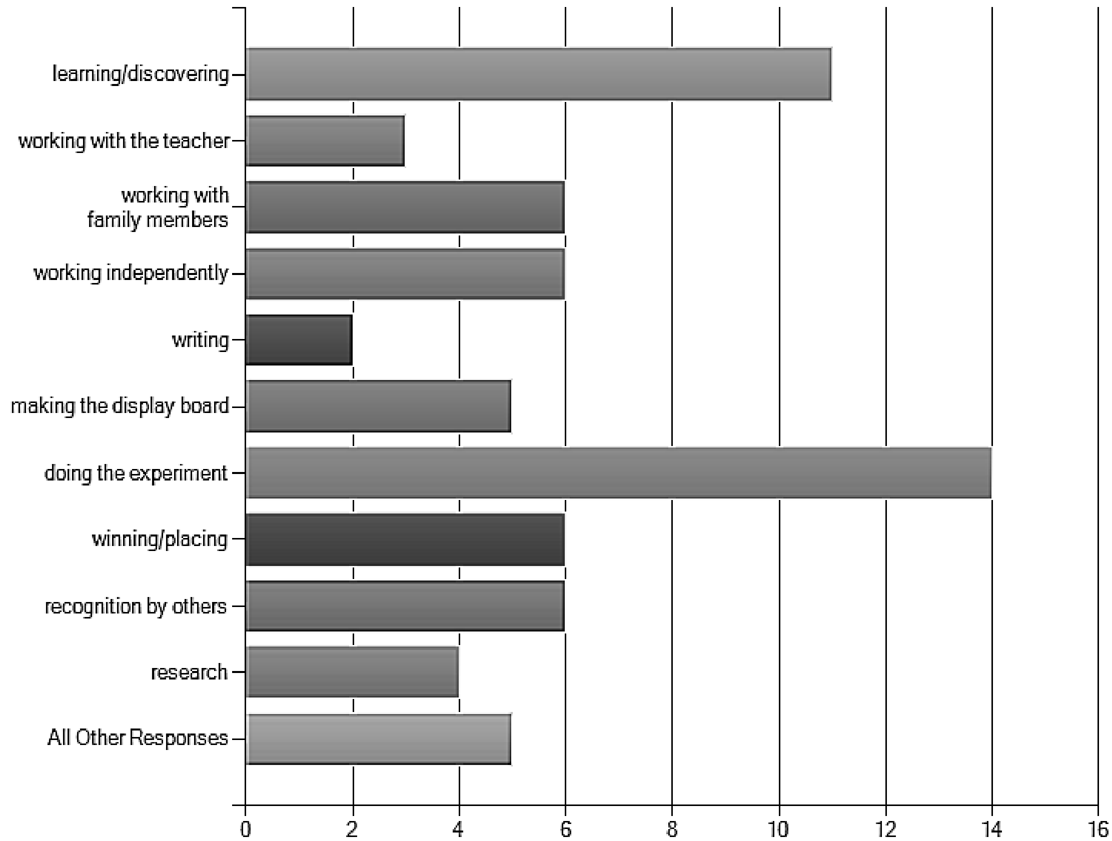

Figure 13. Most Favorite Part of Science Fair Project.

Only 50.0% indicated the writing was their least favorite part of science fair followed by making the display board and research, both at 25%. Other areas that students were unfavorable about included: working independently, working with the teacher, learning/discovering, and going to the next level of competition.

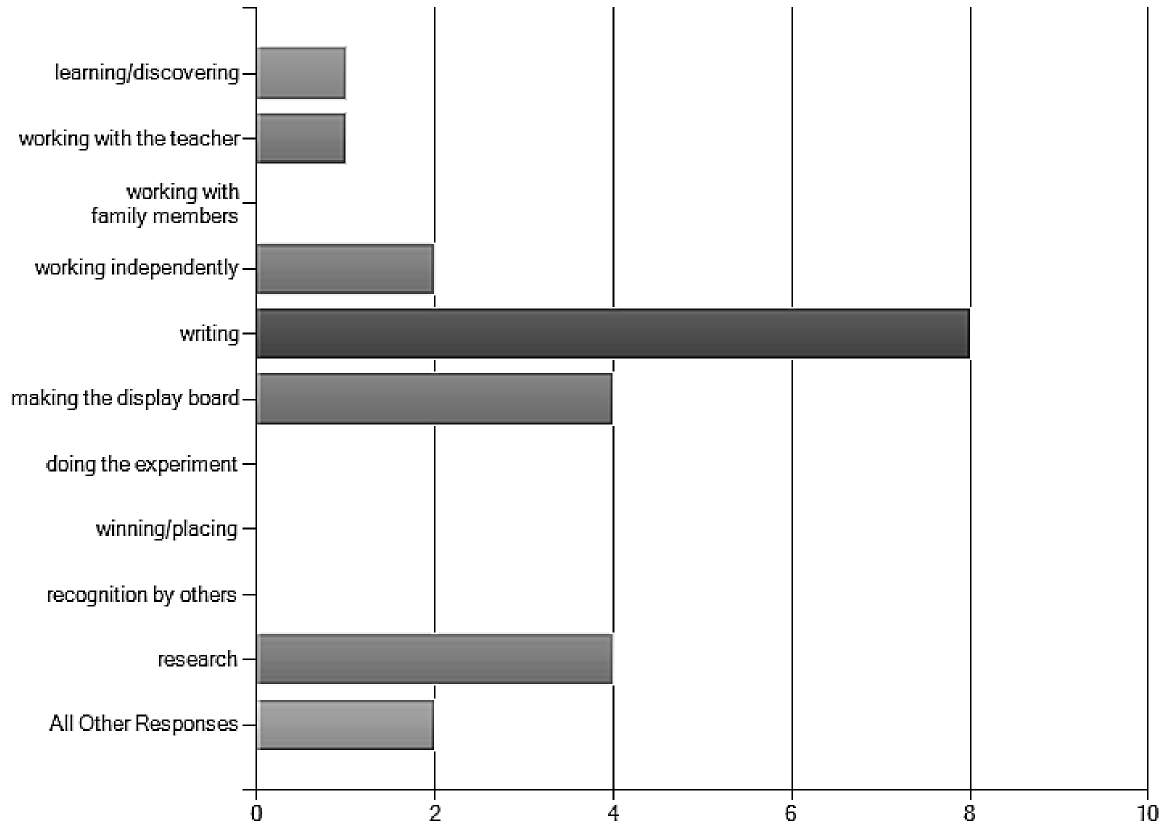

Figure 14. Least Favorite Part of Science Fair Project.

Participants were asked if they received help from their parents or other family members. Help from parents or other family members occurred 56.3% of the time. Participants were also asked if they received help from their teacher and if they received help from professions or students at a nearby university. The results of the survey indicated that 62.5% of those responding received help from their teacher. The participants indicated that they did not receive help from professionals or students at a nearby university.

Participants were also asked about their participation in science fairs. When asked whether they kept a journal notebook, 68.8% of the participants indicated that they did not keep a journal notebook while working on a science fair project. Of those who did keep a journal, 100% mentioned writing both, observations and data/tables, in their log books.

The RIT National Science Fair for Deaf and Hard-of-Hearing Students has been held at the Rochester Institute of Technology's National Technical Institute for the Deaf in Rochester, New York for eight years with a goal to promote STEM interest in students who are deaf or hard of hearing in grades 6th-12th. When asked about involvement in the Rochester Institute of Technology (RIT) National Science Fair for Deaf and Hard of Hearing Students, 80% indicated they had never been involved in any way.

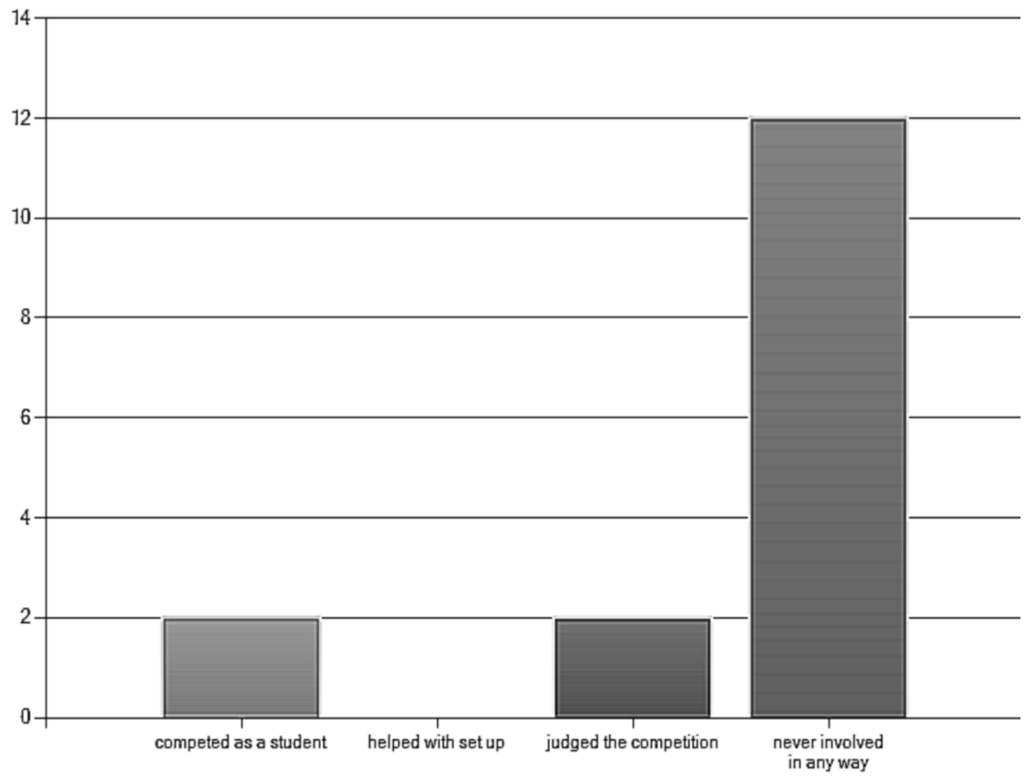

Figure 15. RIT National Science Fair for Deaf and Hard of Hearing.

Only 13.3% had competed as a student and 13.3% had experience judging the competition. When asked if the interviewee had ever had the opportunity to be a science fair judge, an overwhelming 86.7% had never judged a science fair competition.

The last item on the questionnaire asked if the participants would be willing to share their story about their science fair experience one-on-one through Skype or other technology. Of the 21 respondents, 10 chose to participate in the semi-structured interviews. After analyzing the questionnaire for descriptive statistics, I focused on the data taken from the ten interviews. The results of the data analysis are presented under each of the research questions.

Research Question 1: What are Deaf students' experiences while participating in science fairs in primary and/or secondary schools?

After application of *Axial Coding*, there were two major categories identified: educational background and the science fair project. Educational background had a major influence on Deaf students' experiences. Three settings were identified: residential, mainstreamed, and a combination of both. Of those interviewed, five attended a residential school for elementary, middle school and high school. These participants indicated that they had teachers who were both Deaf and Hearing. All hearing teachers of the five participants who attended a residential school could sign and communication was more effective according to James who said, "I could understand them. Most of my hearing teachers were women, but they could sign." Better communication was reported to be the consequence of attending a residential school throughout elementary, middle, and high school.

Of those interviewed, two attended a mainstreamed school for elementary, middle school and high school. Neither signing nor an interpreter was used at Vickie's Elementary school, only the FM system with a microphone and hearing aids; however, in high school she used an interpreter. A FM system uses frequency modulated technology to amplify sounds directly to the Deaf students' ears. A microphone is worn by the teacher and sent wirelessly to a receiver in the hearing aids which bypasses background noises and uses the student's residual hearing. These two students felt isolated being the only deaf person at their school and felt they did not have the support they needed. "No one took notes for me," recalled Charles and, "If the interpreter was out then I just sat there." Lack of communication and frustration were evidenced to be consequences of attending a mainstreamed school throughout elementary, middle, and high school. Charles remembered they did not participate in laboratory exercises but only read about them. He took biology, chemistry, and physics without actually completing one lab activity. Consequences of being the only Deaf student in a class of hearing students were reported to be the feelings of loneliness, frustration and isolation.

Of those interviewed, three attended a combination of a mainstreamed school and a residential school for their educational experience. Brooke was the only Deaf student in her district from 1st grade until 9th grade where she attended a mainstream school with an interpreter. She remembered the interpreter signing and then leaving. She also recalled not have any interactions with her teachers. At the lower Elementary mainstreamed class, Brooke remembered being assigned a science fair topic by her teacher but in 4th grade she was allowed to pick her own topic. For the remainder of her high school (10th-12th grades) she transferred to a residential school where her teachers were Deaf and used ASL. When asked about this, Brooke replied, "It was much better." Maria attended a regional day school program and had 5-10 other Deaf students in the class, but was housed in a public school setting. Maria also remembered being mainstreamed until her high school years when she transferred to a residential school. She reported, "I could understand them. All my science teachers were hearing but they signed, too." She remembered having a science fair with hearing students in 5th grade. She recalled, "It was a public school that had a mainstreamed Deaf program. It was in fifth grade there that I had science fair with hearing students. I felt awkward and unsure of myself. I didn't know the procedures or what to do, the experiment and everything." Sara began at the residential school for her elementary experience then went to a mainstreamed middle school, but returned to the residential facility for her remainder high school years. At the lower Elementary residential class, Sara remembered being assigned a science fair topic by her teacher and remembered working in teams. She credited her elementary years as the time when she was grounded in science and explained, "I had really good science teachers all the way through Elementary school so I became fascinated with science. It didn't matter that my middle school was awful. I loved science." Being the only Deaf student at a public school sometimes took its toll. Sara mentioned her experience, "It was very frustrating being the only one, lack of support, inability to chat with my peers [sic]. It was boring."

An opportunity to take advantage of the best of both worlds was related as one consequence from attending both school settings. Sara and Maria were willing to take science courses at a nearby public school while being enrolled at the Deaf School during their later years in high school. Again the quality of communication was the key. When a top quality interpreter was provided students felt more willing to study and put forth effort because learning was occurring. Maria was willing to ask for tutoring help from her residential teachers in order to understand material presented in her mainstreamed classes. When an incompetent interpreter was used, comprehension of science concepts was limited. Sara recalled, “I didn’t like it because one time the interpreter didn’t really understand the subject matter. So, I would think, ‘Oh! She’s using the wrong signs! Good grief!’ I felt frustrated, annoyed [sic].”

Promoting an awareness of the Deaf community may be considered another consequence from attending both schools. At the mainstreamed classes, Deaf students made friends with their Hearing peers who wanted to learn sign language. Sometimes the teacher was interested in learning some signs as well.

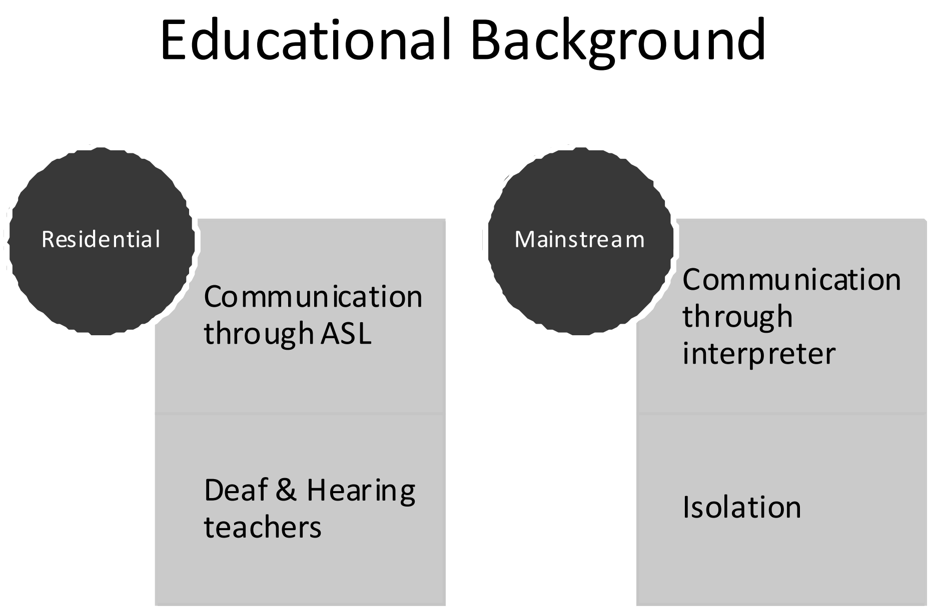

Figure 16. Educational Background.

The second category for answering research question one was the science fair project itself. This category had three themes: opinions, outcomes, and opportunities. Participants were asked their opinions regarding what they liked the most about participating in a science fair and what they liked the least. The results indicated that 50% of the participants thought the experiment was their favorite part. Of the 50% that chose the experiment as their favorite part, 30% also included the analysis or research.

The 50% who identified the experiment as their favorite part did so because it was hands-on or visual. Research and analysis of data were included with the experiment because that is when everything about the experiment, made sense to the students. Students enjoyed analyzing the *why* regarding their experiment. James said, "Because when you analyze the data, you then understand your project." Retention was better with hands-on learning. Leon recounted, "You're doing it and it sticks with you. You remember it, just like the science fair that I did 6 or 7 years ago. It was good." Interactions between student and parent, using the display board as a means of communication and design skill were cited as reasons for the display board being their favorite component of the science fair project. Students felt encouraged and supported when parents helped them with the display board. Students wanted the display board to communicate their efforts. Brooke said, "I'm good at design. Everything I had worked for was there! It showed it all." Barbara said, "I want them to understand what I did."

Socializing with hearing peers (10%) and winning (10%) were the next categories for the participants' favorite part of science fair. Socializing with hearing peers was noted as a favorite according to Charles because, "I was looked at as an equal." Winning and advancement to the next level of competition was mentioned by Matt because, "There, it was even more of the best projects. It made me feel like I was doing something right." The feeling of equity was a result of science fair participation. Inclusion with hearing students at more advanced levels of competition meant your project was one of the best, whether you were Deaf or Hearing.

Participants were also asked to identify their least favorite part of participating in science fair. The results indicated that 40% chose writing as their least favorite part, 30%

chose presentation, 10% chose research, 10% chose display board, and 10% were undecided. Less than half (40%) mentioned some component of writing was disliked. Vickie identified the writing using the scientific method while Brooke pinpointed the lab notebook/journal. Leon disliked composing the research paper and James disliked writing the planner or design of the project.

Part of the difficulty of writing involved understanding, and understanding came from communicating. Vickie had some very challenging schools and teachers to work with. She summed up her whole educational experience like this: “In my opinion, what I didn’t like, really? It was high school…the whole time! The bean and the corn experiment, I just didn’t get it! The teacher forced me to do extra. She forced me to do all this stuff and then wouldn’t help me! I didn’t understand the research method. I didn’t get it. She told me everything that was wrong. She was very negative. Like, the corn and bean experiment was good. It was a good experiment but the writing…the teacher criticized me and my writing and I didn’t understand why she didn’t like it. Honestly, high school helped me with the research method better in relation to college but the teacher never taught me what is the research method, what it means. She didn’t teach it. Really, I hated science.”

Brooke thought the log book was too time-consuming. She stated, “I know it’s important but the time it took. Science fair sometimes requires too much time!” James cited to him the annoying part was writing the planner and having to stick with it and not being able to make changes to the proposal. He also did not like the science fair to be required by the teacher saying that could affect one’s attitude regarding science fair participation.

The presentation was recognized as the second category that was liked the least. The communication barrier between the judges as well as the people viewing the projects was cited by Barbara as the reason for her choice. A second student, Charles, chose the presentation as well because no interpreter was provided at all. Maria chose the presentation because she felt people were staring at her and that made her nervous and uncomfortable. She also admitted she was a shy person and presenting in front of others was difficult for her. Maria stated, "I didn't like the presentation. I didn't like that because I felt like people were staring at me. I felt awkward. I understand that I learn better but the presentation…I didn't like presenting the evidence. I don't know why. Maybe because I'm a shy person. I don't know. I should break that, I know. Now, I'm better but still a little bit shy." The presentation was mentioned as being disliked, specifically by three persons. Lack of communication was identified as the main reason for citing the presentation, as well as being nervous. Leon admitted he just did not like the research paper. Only one student, Matt, acknowledge doing the background work of the research was not his favorite because it was hard when he did not know what the key vocabulary terms were that he needed to look up. Matt felt comfortable with his science teacher and believed he could ask his teacher for help and the teacher would guide him. Karen said the display board was boring because she'd rather focus on the experiment, the part she liked and Sara was undecided.

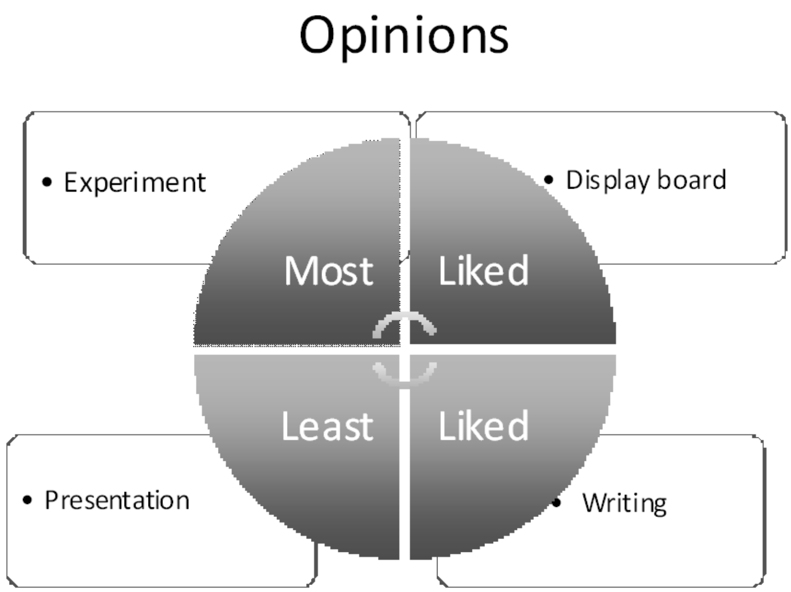

Figure 17. Opinion Regarding Science Fair Participation.

The second theme for the category of the science fair project was the outcomes of the experience regarding benefits and disadvantages. Two main beneficial outcomes from participating in a science fair were affirmed: *equity* and *learning*. Equity was a powerful theme running throughout my study. It was mentioned 11 times as a benefit. Working with hearing people was recognized as an important element. Karen stated, "Well, most of the time, understand my time is spent in the Deaf World. I go to a Deaf School. I'm part of the Deaf community. I'm from a Deaf family. So it's a positive benefit to socialize and work with my hearing peers and learn from them and they have the privilege to learn from me, too. So, that's a positive benefit to me." One student from a mainstream educational setting also recognized access to hearing people as important. Marie said, "Also for a Deaf person in a mainstream setting, it helps them feel like they can compete on the same level as their peers." The consequences of equity resulted in a sense of accomplishment. The *I-can* attitude which promotes self-confidence and self-esteem was articulated as a by-product of equity.

Students felt more confident to meet other people. They felt more confident to express their own opinions and viewpoints. Sara reported, "Most of the time I felt, before, I felt inferior. Do they look at me as inferior or as a friend when it comes to science fair? No, we're peers, equal. That's a positive benefit." Equity simply, "shows Deaf people can do anything," according to Matt. Science fair participation brought a feeling of connectedness. James said, "It helps you feel connected to the Hearing world." He thought it brought diversity to the scientific community as well that Deaf people and hearing people could work side by side and help one another.

Learning was the second most popular answer regarding benefits of a science fair. As a Deaf person, Matt thought his deafness helped him focus on his work because outside noises did not distract him. Learning different topics and learning from each other were considered benefits. Participating in science fair helped students learn in general, but also their knowledge increased regarding a specific target or subject of interest. Perhaps another impetus for self esteem was being allowed to choose the topic for their science fair project. Of those interviewed, 80% were given the ability to choose for themselves what they wanted to study. Critical thinking skills were enhanced according to Brooke. Leon mentioned retention occurred because he thought hands-on worked better than a PowerPoint or lecture. He said, "Hands-on work can help you, us, [sic] visualize what you are doing. Instead of always lecturing or using PowerPoint and it going right on by. With this you *have to* learn. It sticks with you." Learning the scientific method helped prepare Vickie, Matt, and Karen for future college coursework and preparation for future careers.

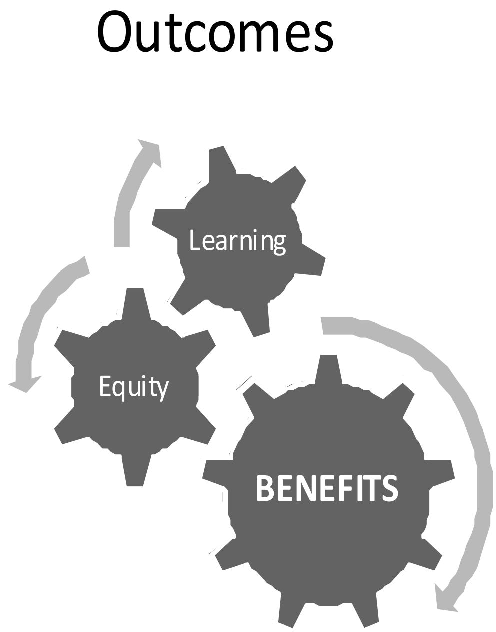

Figure 18. Outcomes: Benefits.

There were two major categories under disadvantages disclosed: *communication* and *inequality* which occurred at both the school and the competition. The communication barrier was mentioned over and over again. The students' own sign language skill as well as their teachers' sign language skill, promoted or inhibited communication. This may have contributed to the Deaf student's skill level in reading and writing. It was mentioned by one participant some Deaf students' ability to understand the science fair project was affected due to poor, underdeveloped skills which was reflected in their display board. Another disadvantage cited was the teacher not teaching the scientific method and assuming her students knew it or was unwilling to take additional time for Deaf students. Misunderstandings occurred between the judge, student and interpreter at the competition. The skill level of the interpreter was cited repeatedly, especially in regard to science concepts and terminology for the competition but also for mainstreamed science courses Deaf students were taking. At the competition Matt noticed his interpreter would break eye contact before he finished signing. He also noticed the interpreter sometimes misunderstood what he said. "I noticed sometimes when I was signing or fingerspelling a word, I might have to repeat a word or phrase for the interpreter before she would tell the judge what I said," clarified Matt. The need to plan ahead of time if an interpreter is needed at the competition and payment for the services needs to be determined in advance was mentioned by James. Also, he recommended that the science fair participant meet with his or her interpreter ahead of time to discuss vocabulary choices and the project. James said, "That's the one day I wish it were a Deaf world, you know." A feeling of inequality was demonstrated by the Hearing to Deaf ratio at a competition when Sara said, "There were too many hearing participants and not an equal opportunity to advance in the competition as a Deaf person." Leon also mentioned the distractions for a visual person at competing in such a large environment.

Lack of communication was affirmed as being the major disadvantage of a Deaf student participating in science fairs. Barbara said, "I have a strong memory about that lack of communication." People could not understand her voice at the oral school which caused her frustration. She said, "I wish we had a signing interpreter and communication to make sure the people understood what my project was about." A feeling of being marginalized by judges occurred to some. Sara remembered the judges' response, "'Oh, She's deaf. Poor thing.' No! Please look at me like I'm a capable equal. Then they're impressed that, Wow! I CAN do this. So, come on! That's a disadvantage. I felt looked down upon." Audism occurred at the competition permeating a sense of inadequacy, but not all students had this viewpoint. No disadvantages were cited if the competition was held at a Deaf school or if a qualified interpreter was provided. Matt said, "I had an equal chance and opportunity to compete so I don't see any disadvantages for me personally."

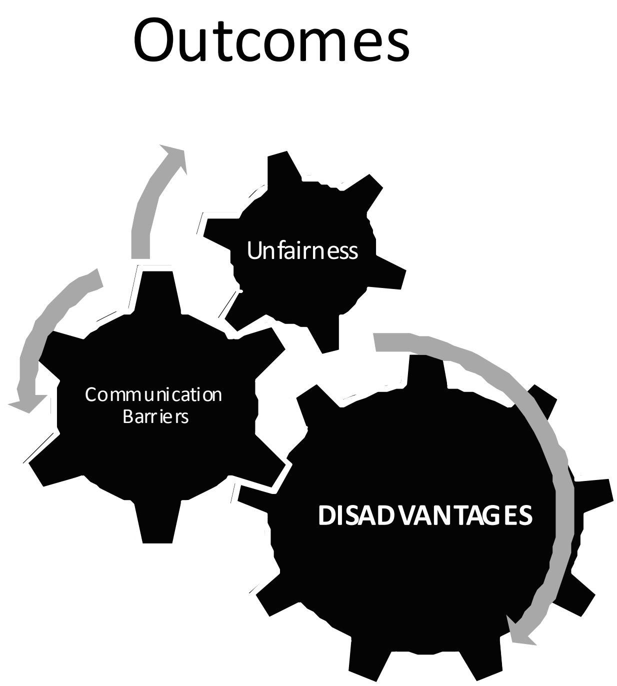

Figure 19. Outcomes: Disadvantages.

The third theme for the category of the science fair project was the opportunities for competition. There were three conditions addressed: judging, winning, and advancing to the next level of competition. There were two components for judging: getting judged and being the judge. Sometimes teachers were used as judges mainly for communication reasons and they were available at the local level where the competition was held at their school. Only a few Deaf students recalled being a science fair judge themselves. They were empathetic with the students and understood their nervousness. Maria remembers asking questions of the middle school students she was judging and did not want her questions to be too hard. She stated her reason, "I didn't want to intimidate them." An interpreter was provided when needed and the Deaf students as judges expressed, “It went smoothly.” Maria remembers fondly when she recalled, “It’s a great memory.” Karen enjoyed the experience, too. She added, “I’ve learning a lot through the years. I’ve learned a lot through judging, too. It was a good experience.”

Winning had a powerful impact on students and promoted excitement, anticipation, and a feeling of equity. Matt recalled, “It was such a positive experience.” Having a local science fair in elementary and/or middle school without the pressure of moving to the next level of competition, was a popular option. Barbara recalled, “It was done for pleasure” and another student said, “In Elementary School, it wasn’t called a competition.” While there was a discrepancy regarding science fair participation in elementary and middle schools, 80% participated in a science fair during their high school years.

A third important experience for science fair participants was moving to the next level of competition after winning a local fair. Of those interviewed, 60% won at their local school and advanced to the next level of competition. Vickie won in elementary school but her teachers did not enroll her into the next level of competition. She did not even realize there were other levels of competition and felt cheated out of this experience. Vickie vented, “Back in 5th grade I won second place and they didn’t say nothing [sic] about that.” Leon remembers when he and his partner won at their local school and advanced to the competition at NTID. He exclaimed, “We made it into the big competition! We didn’t win, but it was a good experience to get to move to that level of science fair competition with Hearing and Deaf students from my school and outside of my school.” Matt enjoyed competing against his hearing peers and sometimes even beating them. Maria credits winning at RIT as her reason for choosing NTID as the college she wanted to attend. Sometimes judges would give the Deaf students feedback, advice or suggestions for improving their projects. Being asked to be a science fair judge promoted self-esteem and value, according to Maria. As a judge, she recalled being given the task to assign specialized certificates. One consequence of winning is summed up by Matt when he pronounced, "It made me feel good about myself."

Figure 20. Science Fair Opportunities.

A recap of the results of data analysis for *research question one* regarding the science fair experiences embraced opinions, outcomes and opportunities.

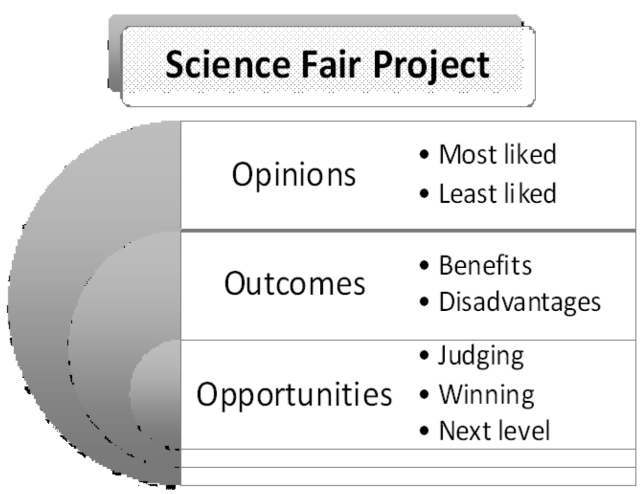

Figure 21. Science Fair Project.

Research Question 2: What are Deaf students' perceptions regarding the impact of participating in a science fair on language development, writing skills, and higher order thinking skills?

After application of *Theoretical Coding*, the major theme identified was pedagogy. Using *Axial Coding*, three categories were acknowledged: language, writing, and thinking skills. The main idea regarding language was to improve communication through vocabulary and application. The development of language skills occurred prior to and during the science fair project. It occurred prior to the science fair project if the teacher taught the concepts of what the scientific method meant and how it could be used. Language development occurred if the teacher introduced new vocabulary terms and explained their meanings and usage. This sometimes occurred on an individual basis if the teacher helped a student one-on-one. It might have occurred if the teacher gave a group lesson. If the teacher taught the scientific method then the interaction would be the student's ability to determine what the six steps were, then apply that knowledge to their own project. Leon felt the ability to pick the "right" words to express himself, was improved. Interactions occurred between the student and teacher; between the student and parents; and between the student and other team members. Perhaps one advantage was learning to proofread each other's research paper.

Better communication appeared to be the consequence of improved language development. The ability to apply vocabulary to "real-life" was improved according to Barbara as well as the ability to "develop words for the board" was mentioned. Conveying the project into words was necessary which meant that an improved vocabulary improved learning. "Once I learned the vocabulary, then I learned more quickly," Maria stated. Vocabulary improved knowledge and provided a vocabulary foundation for learning larger, more complex words and concepts later. Vocabulary was applied to what students were doing in college now, both for the scientific method and reading scientific reports.

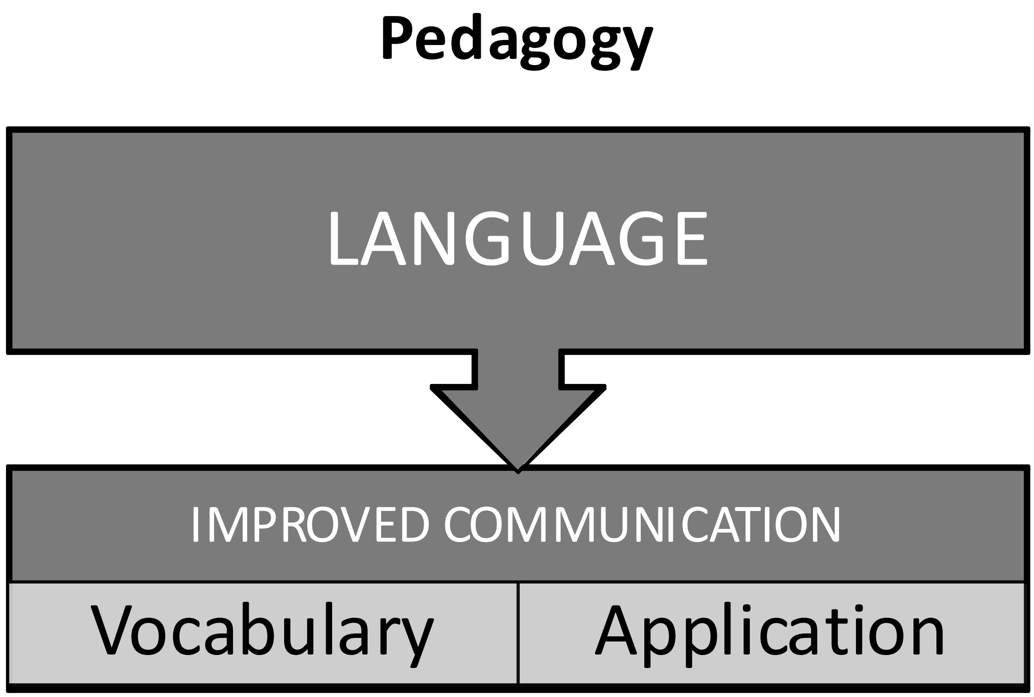

Figure 22. Pedagogy: Language Skills.

The two components brought out regarding the benefits of writing were: grammar structure and the many parts of the project that required writing skills. The development of writing skills occurred during the science fair project since writing occurred project. Components requiring writing skills were identified as the design/planner, the display board, note cards for research and display board, the research paper itself, lab notes during the experiment and a lab journal or log book. A judge's folder was also required. If the teacher required drafts then students proofread and edited their work resulting in improved understanding and use of the scientific method.

Students interacted with the rules and grammar of English, getting the word order and word choices in the right place on the display board and in the research paper. Writing in a log and keeping records helped with interpreting results. James advised, “You should be documenting everything from beginning to end.”

Better communication was described as the consequence of improved writing skills. Writing improved writing according to Brooke when she recounted, “Writing more always helps your writing skills improve.” Karen added, “My writing improved. It was more complex than before. I was able to expand my writing.” Writing drafts helped proofreading and editing skills and gave students confidence in their writing skills. Using writing as a form of communicating information on the display board helped to share the students’ thoughts regarding their science fair project. Journal notes made the data dependable. One consequence was learning to write better in science, using science terminology which then made it easier in college. An incentive for keeping a journal log during the science fair was application to college classes which required a log book. The science fair journal prepared James for future work in his major of environmental science.

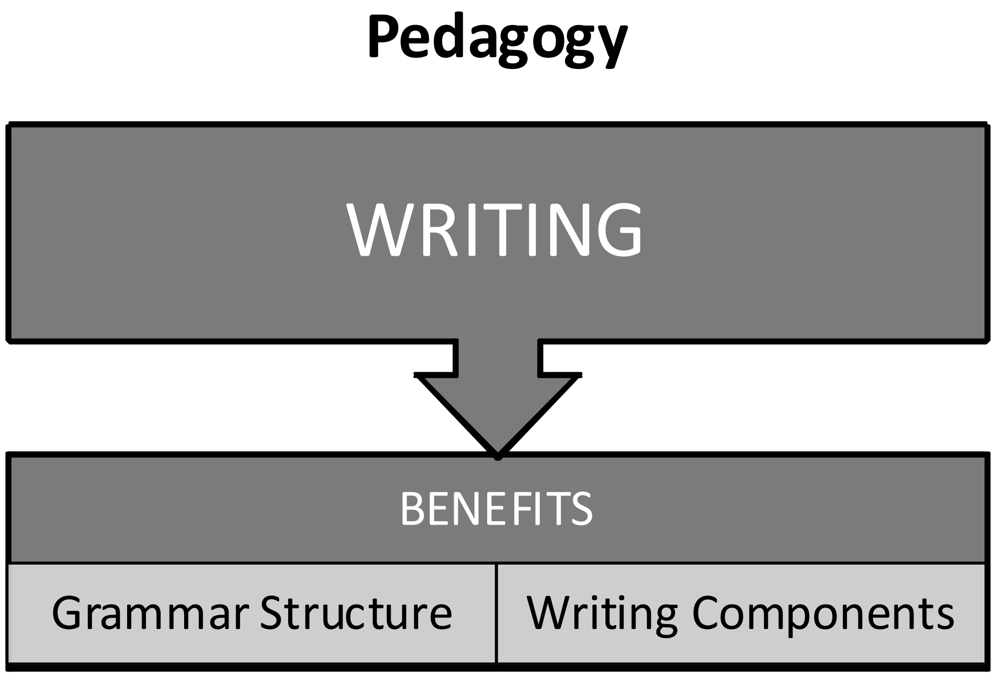

Figure 23. Pedagogy: Writing Skills.

The third category under pedagogy was higher order thinking skills. Using Bloom's Taxonomy, there were six codes that applied: *Analyze, Evaluate, Create, Apply, Understand,* and *Remember*. Each of these levels of higher order thinking skills was recognized by participants during the process of developing a science fair project. The development of thinking skills occurred prior to, during and after the science fair project. Participants needed to consider the scientific method: the purpose, hypothesis, procedure, results, conclusion and how to communicate to others regarding the science fair project. Students needed to follow procedures in the lab, which required thinking skills as well as collecting data. Determining what was necessary for the research paper was identified as use of higher order thinking skills.

Students considered the science fair project they wanted to do long before they began working on the project. Researching information and applying key vocabulary required thinking skills and a hypothesis was created. Students wondered why the experiment worked which caused them to think deeper, analyzing their data, and analyzing the whole project thus promoting higher order thinking skills. Students figured out what to do if the experiment did not work. Was their hypothesis right or wrong and why? "You had to think why that hypothesis worked or what was wrong with it. I had to think a lot," admitted Karen. Students were determining results of their experiment and if they were accurate. James asked himself questions like: "Was the method I set up, be satisfactory? Was it dependable? Was it trustworthy?" Putting your display board together, deciding placement, what goes on the left side versus the right side required thinking skills according to Leon. Students used their observational skills for data collection and analyzing the experiment results. Students recalled grammar structure when writing results or preparing information for the display board.

Better communication was proclaimed to be the consequence of better thinking skills. Barbara, Brooke, Maria, and Leon thought they learned more on a deeper level. Students learned perseverance and Brooke admitted, "I had never before had to start from scratch to a completed project so yes, that (thinking skills) helped me all along the way. It helped me apply thinking process skills from start to end." Students developed problem solving skills. Charles and James thought students learned to be more open-minded. The ability to relate their science fair project to chemistry or biology or everyday life was enhanced according to Maria. Understanding your research was a consequence of thinking about it and analyzing it according to Barbara, Charles, Matt, and Maria. James deduced presenting your project in a manner that was understandable to others occurred because you yourself had to have a better understanding. Ability to follow experimental procedures improved and ability to identify outliers and key vocabulary words also improved.

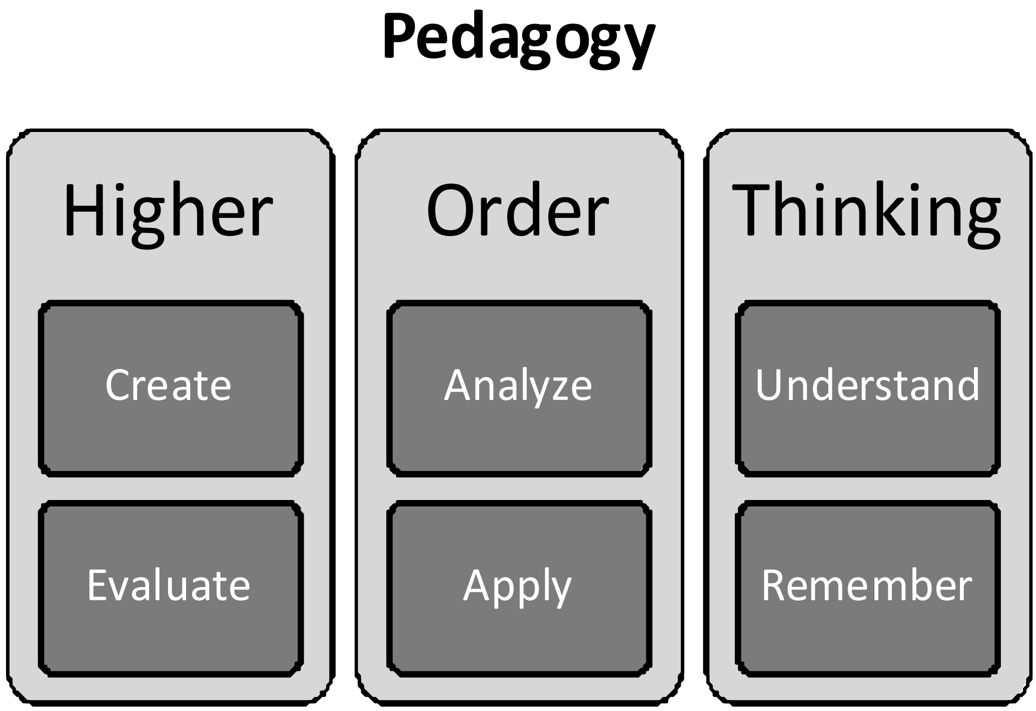

Figure 24. Pedagogy: Higher Order Thinking Skills.

Research Question 3: Which people, and to what extent, are reported as helpful for Deaf students while participating in science fairs?

The third theme identified using Theoretical Coding was mentorship. Two groups of people were recognized as being helpful or influential: parents and teachers. Of the participants interviewed, 50% mentioned one or both parents' helping them in some manner. Influence of parents helping occurred throughout the science fair project. It appeared parents provided help to their child during science fair in three distinct ways: physically, emotionally, and mentally. Interactions between parents and child seemed to occur prior to the science fair as suggestions and ideas were discussed. Parents bought materials and found equipment. Interactions also occurred during the experimentation as procedures were read and followed. Some parents took notes during the experiment and sent them to school for the teacher to see. One mother helped her daughter with the writing and the daughter copied the information onto her display board. For Brooke, there was no communication with her teacher so her father, being a biology teacher himself, became her source for information and feedback. Karen believed that her parents were not knowledgeable enough to help with the information or the experiment but they were willing to get materials and to encourage her.

Better communication was noted as the consequence of parents helping. Bonding with parents, a sense of pride and accomplishment at completing the project were all results from having someone help them. A stronger interest in science was cited. "When I think back, I think if my Daddy wasn't so interested in science I probably would not be either because there was really no communication with the teacher. I went to class, yes, but my interest in science did not come from that teacher. It came from my Daddy," acknowledged Brooke. Due to parental involvement, winning could be a possible outcome.

The second group identified as helpful to students was their teacher. Of the participants interviewed, 100% mentioned their teacher as being helpful or influential, all be it from a wide continuum. Some helped only minimally or with the experiment only, where other teachers were available for help throughout the entire science fair project. Three domains were identified where the teacher helped: guidance, providing materials, and specific teaching. Most students felt they could ask for help from their teachers. Interactions occurred between student and teacher prior to the science fair as ideas and considerations for project topics were discussed. Sometimes the teacher provided a list of topics for students to choose from, but most of the time teachers allowed their students to pick a topic of interest. If the teacher signed and could communicate, students were more satisfied with the science fair experience and learning process. The teacher supervised experiments at school in order to stress lab safety rules and provided access to lab equipment. The teacher simplified and explained details as needed. “The teacher helped me at school” was stated by 60% of the interviewees. Some students remembered the teacher provided guidance and checked the experiment and display board as well as helped to correct English typing. Leon added, “I could always ask my science teacher” regarding procedures, correct wording, grammar, experiment, and feedback. James evidenced that the teacher provided class time for students to practice their presentations to one another. Regarding the presentation to classmates James said, “It did help me improve how I did the presentation, but not my nervous level.” Other teachers only provided limited help, particularly with the experiment. One student said, “My teacher helped me with the experiment. That’s it.”

Better communication was expressed as the consequence of teachers helping. Sara remarked, “She could explain directly to me.” Less frustration and feelings of inadequacy, on the part of the student, occurred when the teacher could sign and communicate. Understanding of the experimental process occurred more frequently when the teacher helped. Students felt willing to ask for assistance knowing the teacher would help to “put it in the correct order, use correct grammar, figure out the placement for the display,” as Leon relayed. The teacher promoted an interest in science for some.

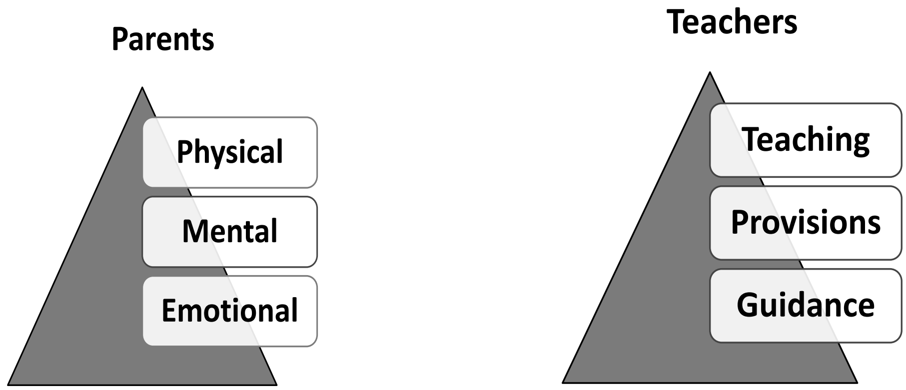

Figure 25. Mentorship by Parents and Teachers.

Research Question 4: In what ways do Deaf students perceive participating in science fairs as influencing their choice in a STEM major?

The influence of Science Fair participation affecting their STEM major choice was acknowledged. When students were engaged in a positive science experience, students reflected their science interest increased. Participating in science fair all through her schooling had a direct impact on Sara's major choice of Biology. Interactions between Deaf and Hearing peers were cited over and over as was equity with their hearing peers. Watching her older sister in 4th grade doing a science fair project when she was in 1st grade had an impact on Brooke. Anticipating the time when she could pick out her own project was a strong emotional memory. Matt also had a strong reaction when he admitted, "All I can say is, if it wasn't for science fair it's a possibility that I would not be a biology major now. Science fair made me focus on what I am doing now." Science fair helped with writing science reports explained James. "In my science major there are so many reports required! So, everything helps from the science fair," he expounded. By doing science fair reports James felt prepared to write reports in his STEM major.

Science fair participation was given credit for an increase in science interest by Barbara and Maria. Karen agreed participating in her Elementary science fair helped her become more interested in science, too. In high school, her confidence level developed. She could challenge her Hearing peers and herself. Karen summarized, “What I recognized is that I am equal to hearing students.” Participating in science fairs all through her schooling had a direct impact on Brooke. She shared, “In elementary school, both were biology-related projects and then…hmm, all of them were. I never realized that! In elementary school it was a botany experiment so that’s biology related and then in high school, I did one related to biology. I enjoyed that one and then the other one I did was chemistry. I didn’t like that one. I remember thinking, ‘Oh my gosh! Why did I pick this one?!’ And I did NOT major in chemistry for a reason!”

When the influence of Science Fair participation did not affect STEM major choice, it was identified that something or someone else did. When no help was perceived as being available at school, there were other influences to promote an interest in a STEM major or career. Interactions between a girl and her dog as they watched *Animal Planet* together would help one begin an interest in science. This same student would see a flyer in subway and attend a lecture about the veterinary program they offered in St. Kitts. Coupled with encouragement from her high school teacher, Vickie would decide to study biology at Gallaudet University. Encouragement from a teacher proved monumental. Attending a veterinarian technological school (South Technology High School) was a major turn-around for Vickie. Originally, at the technology high school she attended, she was told that as a Deaf student she couldn't be a veterinarian but once she explained the need and desire for more Deaf people in this field her teacher understood and encouraged her to go to Gallaudet University. Her GPA in public school was a 2.7 and since attending the technological school, it improved to a 4.0 which Vickie credited as her motivation. Charles would be influenced by a group of people (missionaries) who came to his village in Botswana, South Africa, to offer medical aid. He was told he would make a fine dentist if he wanted. The idea that he could become a dentist was what made him decide to study biology with an intention to attend medical school and study dentistry. The consequence of someone believing a Deaf person could become a dentist was the motivation for Charles. For Leon, deciding to get a double major in biology and chemistry did not come from a direct influence of participating in a science fair. He acknowledged "the best teacher" came from his community college biology class and was responsible for his decision to study in a STEM major. The ability to explain science concepts clearly had a major impact on Leon.

Parents were also identified as an influential factor. Barbara came from a family of doctors and nurses, so she acknowledged that had an impact in her interest in a STEM major. Brooke and James believed the influence came because their fathers were Biology teachers and were able to explain the scientific method to them.

Figure 26. Mentorship.

CHAPTER V

SUMMARY

Conclusions

Is science fair worth the work? According to the perceptions and experiences of ten college students attending the National Technological Institute for the Deaf in New York and Gallaudet University in Washington, D.C., the resounding answer is “YES!”

Science fairs have been part of American education for quite some time as evidenced by its history beginning in 1828 with the American Institute of Science and Technology in New York City, New York until present day with Intel Corporation as title sponsor for International Science and Engineering Fair (ISEF) since 1997. With constructivist learning theory and inquiry-based teaching strategies gaining more attention, it was worthwhile to consider the use of science fair participation as a pedagogical tool in today’s science classroom. Students, who conducted hands-on learning and were actively engaged, learned more in science, as well as developed language, writing skills, and higher order thinking skills and having a mentor influenced the decision for college students to choose a Science, Technology, Engineering, and Math (STEM) major.

The purpose of this study was to examine Deaf college students’ perceptions and experiences regarding science fair participation during primary and/or secondary school and determine the influence of science fair involvement on the development of language skills, writing skills, and higher order thinking skills as well as its impact on the participant’s choice of a STEM major.

I chose a qualitative research design for my study in order to assess the responses given by participants regarding their personal experiences with science fair during their primary and secondary schooling. Qualitative research must establish trustworthiness; therefore, in order to accomplish this, I used Creswell's (2009) suggestions. One of Creswell's suggestions was the use of triangulation. My data was triangulated by the use of a questionnaire and a semi-structured interview as well as member checking using follow up emails. Another component of qualitative research is the use of rich, thick descriptions which I used so readers could share the experiences and perspectives of Deaf college students regarding their participation in science fairs. Additionally, I recognized the need to account for any self-bias that may be present. I accomplished this by using self reflection through analytic memo writing. Still following Creswell's suggestions, I recognized and discussed the participants' positive as well as their negative science fair experiences. I have spent a prolong time in the field and experiential research is a valid component for data collection and analysis. Patton (2002) explains, "Qualitative inquiry depends on, uses, and enhances the researcher's direct experiences in the world and insights about those experiences" (p. 51). I have five years experience at a regional day school program where I taught Deaf students in a public school setting and 25 years at a residential school for the Deaf, which helps me understand the viewpoints of participants from these particular educational backgrounds. I have been involved in science fairs for 17 years which aids my comprehension of Deaf students sharing their experiences and perceptions while participating in a science fair. Continuing with Creswell's advice, I used several peers to review my work as well as my doctoral committee; therefore, the credibility of my study was enhanced by expert reviewers.

There were four research questions that formed the basis of my study. Descriptive statistics were taken from an electronic questionnaire and in depth data analysis was compiled from semi-structured interviews. The process of analyzing qualitative data involved several cycles of reading and coding interview transcriptions in order to identify patterns as well as cross analysis between the ten interviewees to determine similarities and differences.

Research Question Result Analysis

Research Question 1

What are Deaf students' experiences while participating in science fairs in primary and/or secondary schools?

The educational setting and the science fair project itself were the two strongest categories with the theme of communication modality interweaving all aspects of the experience. Students who attended a residential school expressed they could communicate well with their teachers using American Sign Language. Students who attended a mainstream program often mentioned a lack of communication unless the interpreter was qualified and knowledgeable of science terminology; however, there was less interaction with the teacher. A feeling of isolation was addressed when the student was the only Deaf student in a class of hearing peers. Participants in the study shared their opinions regarding their favorite and least favorite parts of the science fair experience and why they chose these aspects of the science fair project. The favorite part of the science fair project was the experiment because it was hands-on and the least favorite was the writing of the science fair components. The participants shared the outcomes as what they perceived regarding benefits and disadvantages of participating in a science fair as a Deaf student. Benefits included equity and increased learning while disadvantages involved the communication barrier and some aspects of unfairness. Regarding the opportunities of competition, respondents shared their experiences encompassing judging, winning, and moving to the next level of competition.

Research Question 2

What are Deaf students' perceptions regarding the impact of participating in a science fair on language development, writing skills, and higher order thinking skills?

The respondents of my study were overwhelmingly supportive regarding the use of science fair projects as a pedagogical strategy to enhance language development, writing skills, and higher order thinking skills. In terms of language development, 80% supported the idea that science fair did indeed increase vocabulary as well as communication skills and language learned during that time was now being applied in their college courses. Improved writing skills were noted by 100% of the participants, particularly grammar structure and following the scientific method protocol. All six components of Bloom's taxonomy for higher order thinking skills were addressed and 90% of participants felt their thinking skills were improved because of the science fair experience.

Research Question 3

Which people, and to what extent, are reported as helpful for Deaf students while participating in science fairs?

Two categories were identified as being helpful or influential for Deaf students while participating in science fairs: parents and teachers. Of the participants interviewed, 50% felt their parents were helpful by providing mental, emotional and physical help because parents often helped with the writing component and to understand the scientific method and procedures of the experiment or spent time discussing the project and encouraging them. Parents were also willing to purchase materials and help with the display board. The students who did not acknowledge their parents as being helpful were asked to explain further and many of these students did not ask their parents for help or wanted to do it independently. Some students felt their parents did not have the knowledge while others were unavailable for help. Teachers were cited as helpful by 100% of the students interviewed; however, it ranged from minimally to full support depending on communication access. Teachers provided guidance with feedback and proofreading of written components, provisions in the way of materials and equipment, and teaching of science content and the scientific method.

Research Question 4

In what ways do Deaf students perceive participating in science fairs as influencing their choice in a STEM major?

When Deaf students were engaged in a positive science experience that promoted communication between themselves, their parents, and their teachers it was cited science interest increased and of the participants interviewed, 50% acknowledged a direct correlation between conducting science fair investigations and their desire to major in a STEM area. When no help was perceived as being available at school, there were other influences to promote an interest in a STEM major or career such as a love for animals, an excellent teacher at the community college level and even a television program.

Limitations

There were only a small sample for the questionnaire (21) and semi-structured interviews (10). The population surveyed was predominately Caucasian students. There might have been some confusion regarding question four from the questionnaire which asked about the type of high school attended where the choices consisted of: public, private, residential, mainstream, day program, charter program, and home school. Both public and residential schools had equal rankings of 33.3% and participants were limited to one choice for this question. The confusion might have been the idea that a residential school is also considered a public school.

Recommendations for Practice

Instructional effectiveness is vital to academic success (Johnson, 2004) and teachers should determine teaching strategies and methods that will meet the objectives outlined in the science curriculum. Through reflection and knowledge presented in research, teachers can address curricular content and establish high expectations of all students through the use of best practices and incorporating hands-on inquiry opportunities such as a science fair project. The use of science fair projects increases an interest in science and often encourages students to consider majoring in a STEM field during college.

Participation in a science fair has valuable benefits for Deaf students and hearing students alike and teachers want all students to succeed in science, not just those who like science and/or would be willing to do an extra credit project. Teachers should reflect on how much help should be offered to students and whether the project should be done at school or at home as well as which components could be done at school such as the experiment where the teacher can reinforce safety regulations in the science laboratory and which could be accomplished at home or in the residential dormitories. Teachers should reflect on how best to involve parents and other family members as well as community stakeholders or persons in the scientific community. Teachers should determine if a deeper explanation of the six steps of the scientific method is needed and if the students understand the purpose for the process. One recommendation to assist in comprehension of the scientific method is to allow each student to theoretically choose a science project and go through the six steps then identify the purpose of the other projects or determine what the control group might be. Using each others' imaginary projects, students could reinforce concepts such as identifying a valid conclusion. Once students have worked through a pretend project they could possibly conduct the project "for real" since they have completed most of the work, at least mentally. From this exercise, it is predicted that understanding will increase and perhaps students will feel more confident and more prepared to tackle a science fair project for competition.

Through the results of my study, it is recommend the use of science fair projects as a pedagogical strategy in the classroom which will enhance language, writing, and higher order thinking skills. To involve students at the elementary, middle school and high school levels, all students campus-wide should be invited to view the exhibits on the day of competition after the judging. It is possible prior to competition secondary students could explain their exhibits to the elementary students. This would give the older students an opportunity to practice what they will say to the judges and help build their confidence. At the same time it would engage the younger students and encourage them to participate in a science fair when they get older. It might be possible for older, more experienced high school students to mentor the lower elementary students in team projects and the upper elementary students in individual projects. Junior and senior students could be trained and serve as judges for the Elementary exhibits. At the elementary level, it is recommended the exhibits not be a competition, but a sharing experience and leave it limited to a local science fair and not advance to regional competition.

Teachers of the Deaf should consider how students receive training in the use of interpreting services. Deaf students should be aware of and know about the Code of Professional Conduct, which dictates what an interpreter can say and do. It is recommended to invite an interpreter to be a guest speaker to explain the role of an interpreter and to role play possible scenarios that may occur at a science fair competition.

Recommendations for Future Research

Additional contributions from further study might include the following:

1. Survey Deaf Education teachers in public schools regarding the value of a science fair and identify school systems which require science fair participation and those that simply encourage it and if teachers give an extra credit option to their students. Analyze the perspective of parents whose Deaf child participates in a science fair as well as the perspective of the interpreter involved and how all the parties mentioned interact with one another. Determine if communication is satisfactory with all participants and in the same study, ask the same questions of Science teachers at residential schools followed by a comparison.

2. Survey Deaf high school seniors and ask them about their science experiences. Classifications for comparisons could include: science fair participants vs. non-participants; residential vs. public school; shared language with mentor vs. no shared language; required to participate vs. volunteered to participate; given extra credit vs. no extra credit; already loved science vs. nonchalant attitude; interest in a science major for college vs. other major interests. A companion study regarding teachers of Deaf seniors would enhance the results of the first study.

3. Use surveys to draw links between Science scores on mandated state science tests and science fair participation. Draw a link between science fair success and language scores of the SAT-HI. Study the outliers who did well on the science fair project but not on the Language portion of the SAT-HI. Determine the relationship between thinking skills and self-confidence and the relationship to level of ASL expertise as well as interactions with interpreters.

4. Survey Deaf Education teacher training programs (Comprehensive and Bilingual) to see how pre-service teachers are prepared to teach science to Deaf students. Determine if a manual language is being used and what type. A companion study with Interpreter Training Programs could be conducted regarding educational interpreting, particularly in science. Identify the evaluation tools currently being used for teachers and interpreters and identify if there a science component to these tools. Investigate staff development for Science teachers offered at residential school, in terms of Science vocabulary in ASL and the use of classifiers.

APPENDIX A

ELECTRONIC QUESTIONNAIRE

Strand I: Demographics

1) Your current academic level:
   freshman sophomore junior senior graduate student

2) Your major: astrophysical science biology biochemistry chemistry computer technology engineering environmental science health sciences polymer science physics other_______

3) Region of your high school:

   Northeast Region (PA, NY, VT, NH, ME, MA, RI, CT, NJ, DE, DC, MD, VA, WV)

   Southeast Region (KY, TN, NC, SC, GA, FL, AL, MS)

   Midwest Region (MN, WI, MI, OH, IN, IL)

   Central Region (MT, ND, SD, IA, MO, NE, KS, WWY, CO, UT)

   Southwest Region (NM, TX, OK, AR, LA)

   West Region (WA, OR, ID, NV, CA, AZ, AK, HI)

   outside the U.S.

4) Type of high school: public private residential mainstream day program charter program home school

5) Size of school (student body population total):
   0-50 51-100 101-500 501 – 1000 1,000+

6) Number of D/HH (Deaf and Hard of Hearing) students attending your high school:
   All students 0-5 6-10 10-20 20-50 50+

7) Age when hearing loss was discovered:
   Birth to 1 yrs. 2-6 yrs. 7-13 14+

8) The level of your hearing loss:
   mild (20-39 dB) moderate (40-69) severe (70-89) profound (90-129 dB)

9) Ethnicity: Caucasian African American Hispanic Asian Other___

10) Do you use ASL? Yes No
If yes, when did you start learning/using ASL?
From birth Elementary school Middle school High school In college
What is your skill level? No sign Minimal Fair Good Excellent Native signer

11) How do you prefer your professional interpreters to deliver messages?
American Sign Language (ASL)
Manually Coded English (MCE)
Pidgin Sign Language (PSL)
Orally (with lipreading)

Strand II: Science Experiences

1) Did your Science teacher(s) sign or communicate to your preference in your
elementary? Yes No
middle school? Yes No
high school? Yes No

2) Did you participate in a Science Fair in elementary school? Yes No
If yes, in which grades? (Check all that apply.)
1st grade 2nd grade 3rd grade 4th grade 5th grade
In middle school? Yes No
If yes, in which grades? (Check all that apply.)
6th grade 7th grade 8th grade
In high school ? Yes No
If yes, in which grades? (Check all that apply.)
9th grade 10th grade 11th grade 12th grade
Undergraduate research in college? Yes No

3) Your favorite part of the science fair experience:
learning/discovering working with the teacher working with family members
working independently writing making the display board
doing the experiment winning/placing recognition by others
research going to next level of competition other_______

4) Your least favorite part of the science fair experience:
learning/discovering working with the teacher working with family members
working independently writing making the display board
doing the experiment winning/placing recognition by others
research going to next level of competition other_______

5) Did you receive help from your parents or other family members with your science fair project? Yes No

6) Did you receive help from your teacher with your science fair project? Yes No

7) Did you receive help from professionals or students at a nearby university with your science fair project? Yes No

8) Did you keep a journal notebook while working on your science fair project?
Yes No
What kinds of things did you write in your journal?
Observations data/table general thoughts pictures/drawing
other______

9) Have you ever been involved in the RIT National Science Fair for Deaf and Hard of Hearing Students? competed as a student helped with set up judged the competition never involved in any way

10) Have you ever been a judge at a science fair competition? Yes No
If yes, at which level did you judge? elementary school middle school high school

11) Would you be willing to tell me your story one-on-one through Skype or other technology? Please write your email address below.

APPENDIX B

INTERVIEW QUESTIONS

1. Tell me about your experiences with science fairs.
2. What type of sign language did your teacher use and did s/he effectively communicate with you in the classroom? ASL (American Sign Language); PSL (Pidgin Sign Language); MCE (Manually Coded English)
3. How did participating in a science fair help your language development?
4. How did participating in a science fair help your writing skills?
5. How did participating in a science fair help your higher order thinking skills?
6. What did you like most about science fair participation and why?
7. What did you like least and why?
8. Was your science fair project completed at home or at school? Tell me about that.
9. What are the benefits of participating in a science fair, as a Deaf student?
10. In your opinion, as a Deaf student, what were the disadvantages of participating in a science fair?
11. Looking back at your experiences (elementary, middle school, high school) **who** or what influenced your science fair research over the years?
    a. Anyone in the community and professional scientific world?
    b. your science teacher?
    c. your parents or other family members?
    d. professionals or students at a nearby university?
12. Explain your experience using an interpreter during the science fair competition.
13. Tell me about your science major.
14. Tell me about your career goals.
15. What part did science fair participation have in these plans?
16. What should I have asked that I didn't think to ask?

APPENDIX C

IRB APPROVAL LETTER FROM THE UNIVERSITY OF SOUTHERN MISSISSIPPI

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.6820 | Fax: 601.266.4377 | www.usm.edu/irb

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **13010804**
PROJECT TITLE: **Science Fair: Is it Worth the Work? A Qualitative Study of Deaf Students' Perceptions & Experiences Regarding Science Fair in Primary or Secondary School**
PROJECT TYPE: **Dissertation**
RESEARCHER(S): **Vivian Lee Smith**
COLLEGE/DIVISION: **College of Science & Technology**
DEPARTMENT: **Center for Science & Math Education**
FUNDING AGENCY/SPONSOR: **N/A**
IRB COMMITTEE ACTION: **Expedited Review Approval**
PERIOD OF APPROVAL: **02/04/2013 to 02/03/2014**

Lawrence A. Hosman, Ph.D.
Institutional Review Board

APPENDIX D

IRB APPROVAL LETTER FROM

NATIONAL TECHNICAL INSTITUTE FOR THE DEAF

R·I·T

Rochester Institute of Technology

RIT Institutional Review Board for the
Protection of Human Subjects in Research
141 Lomb Memorial Drive
Rochester, New York 14623-5604
Phone: 585-475-7673
Fax: 585-475-7990
Email: hmfsrs@rit.edu

Form C
IRB Decision Form

TO: Vivian Smith; Christopher Kurz

FROM: RIT Institutional Review Board

DATE: **March 26, 2013**

RE: **Decision of the RIT Institutional Review Board**

Project Title – Science Fair: Is it worth the work? A qualitative study on Deaf students' perceptions and experiences regarding science fair in primary and secondary school

The Institutional Review Board (IRB) has taken the following action on your project named above.

☒ Exempt 46.101 (b) (1)

Now that your project is approved, you may proceed as you described in the Form A.

You are required to submit to the IRB any:
- **Proposed** modifications and wait for approval before implementing them,
- Unanticipated risks, and
- Actual injury to human subjects.

Heather Foti
Heather Foti, MPH
Associate Director
Office of Human Subjects Research

Revised 10-18-06

APPENDIX E

IRB APPROVAL LETTER FROM GALLAUDET UNIVERSITY

GALLAUDET G UNIVERSITY

INSTITUTIONAL REVIEW BOARD
FOR THE PROTECTION OF HUMAN SUBJECTS
(866) 948-3126 (VP)
(202) 651-5295 (FAX)

KENDALL GREEN
800 FLORIDA AVENUE, NE
WASHINGTON, DC 20002-3695

MEMORANDUM

DATE: March 4, 2013

TO: Vivian Smith
Gallaudet University
335 Bounds St
Jackson, MS 39206

FROM: Carolyn A. Corbett, Ph.D., Chairperson
Institutional Review Board (IRB)

RE: **Proposal #: 2225**
"Science Fair: Is it Worth the Work? A Qualitative Study on Deaf Students' Perceptions and Experiences"

After an expedited review, the IRB has approved your above-named research project on **3/2/2013**.

The IRB considers only the issue of research risk to subjects and approval is solely a declaration of the absence of, or adequate control of, research risk. Approval does not guarantee either the quality of the research or access to subjects.

Please notify the Board if your research project changes in any way human subjects are utilized. Subject recruitment materials, including advertisements, fliers, and e-mail messages must be approved by the IRB prior to being utilized. Researchers are also required by federal regulations to have yearly renewal of the IRB approval for continuing projects. Please make timely submission of request for renewal or prompt notification of project termination.

Please add a statement to all recruitment materials indicating that your project has been approved by the Gallaudet Institutional Review Board.

If you have any questions regarding this project, contact the IRB Office at irb@gallaudet.edu, VP 202-250-2615 or Voice 202-651 5649; Dr. Carolyn A. Corbett, IRB Chairperson, at irb.chair@gallaudet.edu; or Carlene Thumann-Prezioso, IRB Coordinator, at carlene.thumann-prezioso@Gallaudet.edu or through VP at 202-250-2753.

APPENDIX F

INFORMED CONSENT FORM FOR INTERVIEW PARTICIPANTS

Purpose

The purpose of this study is to examine the self-reported impact of science fairs upon a population of deaf and hard of hearing youth to validate the use of science fair as a pedagogical strategy with Deaf students. I will be asking questions related to your perceptions and experiences with the use of science fair in primary and/or secondary school.

Description

Participation in this study includes an electric questionnaire and an interview. I will be videotaping the interviews via Skype, Purple 3 or other equivalent technology. Each interview will last approximately 45 minutes to one hour. After the interview, I will translate the answers posed in American Sign Language into English. I will then transcribe the interview and analyze the data to address research questions.

Risks

There are no foreseeable psychological or physical risks expected as a result of participating in this study, and participants may withdraw from the study at any time during the process without penalty. Participants have the right to refuse to answer questions. In the event of loss of confidentiality or other unforeseeable injury, The University of Southern Mississippi has no mechanism to provide compensation for subjects who may incur injuries as a result of participating in research projects. However, efforts will be made to make available the facilities and professional skills at the University.

Confidentiality Alternative Procedures

You are guaranteed confidentiality by the use of pseudonyms. The researcher will not identify any participant by name in reports written about the discussion. In order to insure confidentiality and safe keeping all written notes, videotapes, and transcribed taped information will be stored in a locked file in a locked file cabinet in the researcher's classroom at the Mississippi School for the Deaf at 1253 Eastover Dr. in Jackson, MS. Only the researcher and researcher advisors will be able to see the original transcripts. No personal information will be presented at scientific meetings and /or published in journals. After the study is completed the video-taped interviews, original interview transcriptions, and written notes will be destroyed. After the three year retention period all video tapes/DVDs will be destroyed using a heavy duty *Fellowes Powershred* machine kept in the conference room at the Mississippi School for the Deaf in Jackson, MS.

Subjects Assurance

Your participation in this study is entirely voluntary. You may decline to answer any questions that make you uncomfortable, and you may withdraw at any time without penalty. The information gathered will be kept confidential along with your identity (with the exception identified above). All information will be destroyed when the study is completed.

Contact Persons

Questions concerning the research should be directed to the investigator, Mrs. Vivian Smith at 601.540.8358 or via email at: vismith@mde.k12.ms.us. The project and consent form have been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research subject should be directed to the Administrator, Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406, (601) 266-6820.

Legal Rights and Signature

You will receive a copy of this consent form. You are not waiving any legal rights by signing this consent form. Your signature below indicates that you agree to participate in this study.

____________________________ _______________

Signature of the Research Subject Date

____________________________ _______________

Signature of the Person Explaining the Study Date

APPENDIX G

VIDEO RELEASE FORM

I. Acknowledgement of Video Recording

I, ____ , agree to be video recorded as part

Participant's Name

of my participation in the study, ***Science Fair: Is it Worth the Work? A Qualitative Study on Deaf Students' Perceptions & Experiences Regarding Science Fair in Primary and Secondary School***, conducted by Vivian Smith.

II. Confidentiality and Storage

All written notes, videotapes, and transcribed taped information will be stored in a locked file in a locked file cabinet in the researcher's classroom at the Mississippi School for the Deaf at 1253 Eastover Dr. in Jackson, MS. After the three year retention period all video tapes/DVDs will be destroyed using a heavy duty *Fellowes Powershred* machine kept in the conference room at the Mississippi School for the Deaf in Jackson, MS.

III. Access and Dissemination

I understand that access to the video will be limited to the principal investigator, Vivian Smith, and her dissertation advisors.

____ ______________

Name Date

____ ______________

Signature Date

APPENDIX H

INFORMED CONSENT FORM FOR INTERVIEW PARTICIPANTS FROM NTID

Purpose

The purpose of this study is to examine the self-reported impact of science fairs upon a population of deaf and hard of hearing youth to validate the use of science fair as an educational strategy with Deaf students. I will be asking questions related to your perceptions and experiences with the use of science fair in primary and/or secondary school.

Description

Participation in this study includes an electronic questionnaire and an opportunity to participate in an interview if desired. The electronic questionnaire will take about 15 minutes to complete. The electronic questionnaire asks demographic questions and questions about science fair experiences. At the end of the questionnaire you will be asked if you'd like to participate in a one-on-one interview to share more about your science fair experiences. I will be videotaping the interviews via Skype, Purple 3 or other equivalent technology. Each interview will last approximately 45 minutes to one hour. After the interview, I will translate the answers posed in American Sign Language into English. I will then transcribe the interview and analyze the data to address research questions.

Risks

There are no foreseeable psychological or physical risks expected as a result of participating in this study, and participants may withdraw from the study at any time during the process without penalty. Participants have the right to refuse to answer questions.

Confidentiality Alternative Procedures

You are guaranteed confidentiality by the use of pseudonyms. The researcher will not identify any participant by name in reports written about the discussion. In order to insure confidentiality and safe keeping all written notes, videotapes, and transcribed taped information will be stored in a locked file in a locked file cabinet in the researcher's classroom at the Mississippi School for the Deaf at 1253 Eastover Dr. in Jackson, MS. Only the researcher and researcher advisors will be able to see the original transcripts. No personal information will be presented at scientific meetings and / or published in journals. After the study is completed the video-taped interviews, original interview transcriptions, and written notes will be destroyed. After the three year retention period all video tapes / DVDs will be destroyed using a heavy duty *Fellowes Powershred* machine kept in the conference room at the Mississippi School for the Deaf in Jackson, MS.

Subjects Assurance

Your participation in this study is entirely voluntary. You may decline to answer any questions that make you uncomfortable, and you may withdraw at any time without penalty. The information gathered will be kept confidential along with your identity (with the exception identified above). All information will be destroyed when the study is completed.

Contact Persons

Questions concerning the research should be directed to the investigator, Mrs. Vivian Smith at (601) 540-8358 or via email at: vismith@mde.k12.ms.us. The project and consent form have been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights and welfare as a research subject should be directed to the Administrator, Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406, (601) 266-6820 or you may contact Rochester Institute of Technology NTID Institutional Review Board at (585) 475-2167 or www.research.rit.edu/hsro or hsro@rit.edu. Dr. Christopher Kurz is the faculty sponsor for Mrs. Vivian Smith and he can be reached at (585) 286-4611 or caknsp@rit.ed.

Legal Rights and Signature

You will receive a copy of this consent form. You are not waiving any legal rights by signing this consent form. Your signature below indicates that you agree to participate in this study.

_____________________________ _______________

Signature of the Research Subject Date

_____________________________ _______________

Signature of the Person Explaining the Study Date

APPENDIX I

COVER LETTER TO SUBJECTS FROM NTID

Hello. My name is Vivian Smith and I'm conducting research on Deaf students' experiences regarding participation in a science fair. Participation in this study includes an electronic questionnaire and an opportunity for you to participate in an interview if desired. The electronic questionnaire will take about 15 minutes to complete. The electronic questionnaire asks demographic questions and questions about science fair experiences. At the end of the questionnaire you will be asked if you'd like to participate in a one-on-one interview to share more about your science fair experiences. The interview will last approximately 45 minutes to an hour. By exploring the factors related to the experiences of students participating in science fairs during primary or secondary school, I am seeking to develop information that could be used by other educational professionals seeking to improve inquiry-based science instruction in Mississippi classrooms. In appreciation for your time spent on the questionnaire and interview, I will send you a gift card for $25.

There are no foreseeable psychological or physical risks expected as a result of participating in this project. You may voluntarily withdraw from the project at anytime during the process without penalty, and questions that make you uncomfortable do not have to be answered. No sensitive data will be requested, and all data will be kept strictly confidential. I will not identify any participant by name. All videotapes from interviews will be stored in a locked file in a locked file cabinet in my classroom at the Mississippi School for the Deaf at 1253 Eastover Dr. in Jackson, MS. After the study is completed, all tapes/DVDs will be destroyed using a *Fellowes Powershred* machine after a period of three years.

The project has been reviewed by the Human Subjects Protection Review Committee, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about your rights and welfare as a research subject should be directed to the chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS, 39406-0001, (601) 266-6820. You may also contact the Rochester Institute of Technology NTID Institutional Review Board at (585) 475-2167 or email www.research.rit.edu/hsro or hsro@rit.edu. Dr. Christopher Kurz is my faculty sponsor and can be reached at (585)475-2167 or email at caknsp@rit.edu.

Thank you very much!

__________________________________ _________________

Signature of person giving presentation Date

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