The Co-Construction of Mathematics Identities Among d/Deaf and Hard of Hearing Middle Grade Students

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DISSERTATION

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This dissertation is dedicated to the memory of my dear mentor and colleague, Dr. Louis DiBello. Albert Einstein said that "Education is what remains after one has forgotten what one has learned in school." Your kindness, integrity, and love of learning will remain with me forever. It was an honor to know you and to work with you. You will be missed.

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LIST OF ABBREVIATIONS

DHH	d/Deaf and Hard of Hearing
WV	Water View Elementary School (pseudonym)
TC	Total Communication
IEP	Individualized Education Plan
LRE	Least Restrictive Environment
IDEA	Individuals with Disabilities Education Act
UIC	University of Illinois at Chicago
ASL	American Sign Language
CCSS-M	Common Core State Standards in Mathematics
NCTM	National Council of Teachers of Mathematics
CAEP	Council for the Accreditation for Teacher Preparation

SUMMARY

Research in mathematics education among d/Deaf and hard of hearing (DHH) learners has documented that DHH students lag behind their hearing peers on measures of mathematics achievement (e.g., Kritzer, 2008; Nunes & Moreno, 2002; Swanwick, Oddy, & Roper, 2005). Research in the areas of mathematics identity, agency, and socialization has great potential for advancing our understanding of mathematics teaching and learning among DHH learners. In this study, I examine the mathematics learning experiences of four d/Deaf and hard of hearing (DHH) middle grade students in a self-contained DHH classroom. Through in-depth analyses of narrative identities and identities-in-practice, I explore the co-construction of DHH students' mathematics identities: what a DHH student believes about himself or herself as a learner of mathematics and how others position the individual.

Based on my analyses of classroom observations, teacher interviews, and student interviews, my findings focus on rich descriptions of the general and specifically mathematical obligations and the characterizations of competence in this classroom. The general and mathematical obligations that emerged in this classroom involved expectations of compliant behaviors and procedural fluency in the context of low-level activities. The characterizations of competence and of being a competent learner are based, in part, on these jointly constructed expectations in the classroom. I present within-case analyses of two students to illustrate how the obligations and characterizations of competence in this classroom, coupled with the students' and others' narratives and experiences, shape how these two students see themselves and are seen by others as DHH learners and as doers of mathematics. While complying with the obligations may position a DHH student as competent in this classroom, ultimately, it may not align with the larger mathematics community's characterizations of proficiency in mathematics.

Furthermore, students' abilities to positively align their DHH and mathematics identities are influenced by classroom practices and structures. Several new and related questions emerged from this study that could have implications for further research and practice.

CHAPTER 1 STATEMENT OF PROBLEM AND BACKGROUND

1.1 Statement of the Problem and Research Questions

This dissertation work is motivated and inspired by my own experiences as a mathematics teacher of the d/Deaf and Hard of Hearing[1] (DHH), and the relationships I have built with DHH peers. In high school, I studied American Sign Language and developed a passion for Deaf culture. The more involved I became in the Deaf community, the greater my appreciation grew for Deaf culture and its unique community. After receiving two Master's degrees in Mathematics Education and Deaf and Hard of Hearing Education, I relocated to Chicago for a full-time position as a mathematics teacher of DHH students.

I taught mathematics in elementary and middle school for five years. As a teacher in both DHH self-contained and mainstream classrooms, the disparate mathematics instruction and student proficiencies in the two classroom settings were starkly apparent. The teachers in the DHH Department asserted that they followed the same mathematics curriculum as that of the mainstream neighborhood department, albeit modified in language and in scope. However, the eighth-grade mainstream classrooms were studying pre-algebra and algebra while the majority of DHH classrooms practiced basic computational operations, including multiplication with multi-digit numbers, subtraction with regrouping, and long division. In addition, the underlying curricular approaches, which form the foundations of these mainstream and self-contained mathematics curricula, are fundamentally different. The DHH Department used Saxon Math (Hake & Saxon, 2004), "a modern prototype of the skills approach" (Baroody & Dowker, 2003),

[1]Lowercase deaf refers to "the audiological condition of not hearing" and uppercase Deaf refers to "a group of people who share a language of American Sign Language (ASL) and Deaf culture" (Padden & Humphries, 1988, p. 2). Since individuals identify as audiologically deaf, culturally Deaf, and bicultural (Bat-Chava, 2000), d/Deaf and Hard of Hearing and d/Deafness is written as lowercase "d" slash uppercase "D", d/Deaf (abbreviated DHH), throughout this thesis.

while the primary grades in the neighborhood department used various texts that are less skill-based and followed conceptual or problem-solving approaches, such as *Think Math* (Education Development Center, Inc., 2008) and *Everyday Mathematics* (Bell, M., et al., 2007).

More generally, research on DHH learners' performance in mathematics claims that DHH students lag considerably behind their hearing peers in mathematics (Kritzer, 2008; Nunes & Moreno, 2002; Swanwick, Oddy, & Roper, 2005). It has also been reported that DHH children perform at lower levels on mathematics assessments, and graduate high school at significantly lower levels in mathematics (Nunes & Moreno, 2002). In fact, the median score of computational skills of DHH high school graduates on the Stanford Achievement Test is comparable to sixth grade hearing students, and the median score of problem-solving skills of DHH high school graduates is comparable to fifth grade hearing students (Traxler, 2000).

The discrepancy between DHH and hearing students in mathematics is not attributed to lower intellect of DHH individuals (Gallaudet Research Institute, 2003). Though some DHH children also have cognitive and learning disabilities, d/Deafness itself has no effect on intellect (Gallaudet Research Institute, 2003). In addition, achievement in mathematics has no correlation with the degree of hearing loss (Nunes & Moreno, 1998), and the gap between achievement levels of DHH and hearing students is attributed to multiple factors (Marschark, 2001; Moores, 2001; Pagliaro & Kritzer, 2005; Ray, S., 1979; Swanwick, Oddy, & Roper, 2005; Zarfaty, Nunes, & Bryant, 2004). For example, research about mathematics teaching and learning suggests that many DHH educators tend to focus on concrete mathematics, and neglect most abstract concepts which would establish a better foundation for future mathematics learning (Pagliaro & Kritzer, 2005). Moreover, teaching DHH students to merely "function" in the outside world, and at a very basic level at best, often replaces the development of basic mathematical comprehension and mathematical competence. These findings, coupled with my own observations and experiences while teaching mathematics, motivated me to pursue a Ph.D. to develop mathematics curricula specifically designed for the DHH population in order to improve mathematics learning among DHH learners.

As a doctoral student, my understandings of curriculum design and mathematics instruction shifted as I developed a deeper understanding of curriculum studies, and as I studied research in the area of critical mathematics education, particularly in relation to issues of socialization and identity construction and policy (e.g., Anderson, 2007; Berry, 2008; Diversity in Mathematics Education, 2007; Esmonde, 2009; Grant, Crompton, & Ford, 2015; Jackson, 2009; Kollosche, 2017; McGee & Martin, 2011; Martin 2000, 2002, 2006, 2007a, 2008, 2009; Nasir, 2002, Nasir & Shah, 2011; Spencer, J., 2009; Stinson, D., 2008; Terry 2011; Terry & McGee, 2012). Studying issues in curriculum studies led me to develop deeper considerations of identity and policy. As I reflected on my own teaching practices and experiences, I thought deeply about research on issues of identity, negotiating between my teacher-driven perspectives and research-driven perspectives. For instance, I began to consider whether views of d/Deafness and DHH students' abilities in mathematics impact curricular decisions, such as the decision to implement a skills-based curriculum (e.g., Saxon Math) in DHH classrooms. Moreover, I was interested in investigating how these curricular decisions influence a DHH individual's mathematics experiences. I realized that the experiences of DHH learners, how a DHH student comes to understand what it means to do mathematics, as well as the extent to which a DHH individual identifies with particular mathematics, should inform instructional design and teaching for DHH learners. Presently, little, if any, work takes up issues of mathematics identity, agency, and socialization among DHH learners, though it is an area of research that has great potential for advancing our understanding of mathematics teaching and learning among DHH learners.

Studies that "take up student-centered and identity-related questions…provide insight into how students exhibit agency to resist their marginalization, assert their own identities, and experience mathematics learning and participation" (Martin, 2009, p. 327). However, while the current research in DHH mathematics education cites assessment results, highlights the number of factors that hinder DHH students' success in mathematics, and illuminates the potential for improvement in mathematics education of DHH (i.e., through early intervention), research in mathematics education of DHH has yet to investigate the mathematics experiences of DHH learners in mathematics classrooms (Swanwick, Oddy, & Roper, 2005). That is, what it means to be a DHH student in the context of learning mathematics, and what it means to be a learner and doer of mathematics in the context of being a DHH student.

In my dissertation research, I explore the nature of DHH students' experiences in a mathematics classroom and how the mathematics identities of DHH students, as learners and doers of mathematics, are co-constructed by an individual, peers, and others. Through in-depth analyses of narratives and classroom behaviors, I explore the co-construction of DHH students' mathematics identities: how a DHH student sees him/herself as a learner of mathematics and how others view and position the individual.

My research focuses on the co-construction of DHH learners' mathematics identities in the context of a middle school mathematics classroom. Through this study, I seek to understand the mathematics experiences of the learners, and how mathematics identities develop among a group of DHH learners in a self-contained mathematics classroom. I explore the ways that DHH students experience learning mathematics in relation to the classroom practices and activity structures. Specifically, I seek to better understand the following questions:

- How do particular DHH learners narrate what it means to be DHH in the context of mathematics learning? And how do these same students narrate what it means to be a learner and doer of mathematics in the context of being DHH?
- How do these DHH students perceive and co-construct their mathematics identities in a self-contained classroom, particularly in relation to the normative mathematics identity in their classroom?
- In the contexts of narrating and performing their DHH and mathematics identities and within the affordances and constraints of their classroom practices and structures, what forms of agency emerge among these students?

I study identity through a phenomenological lens, to examine the experiences of a group of DHH students in a self-contained classroom, and I utilize narrative case study to examine specific student cases of the phenomenon. Phenomenology emphasizes the direct observation of phenomena (Husserl, 2012; Schutz, 1967). "In phenomenology, perception is regarded as the primary source of knowledge, the source that cannot be doubted" (Moustakas 1994, p. 52). By examining identity through a phenomenological lens, I relied upon the participants' interpretations of their own experiences as learners and doers of mathematics as well as their interpretations of each other's experiences in a self-contained DHH mathematics classroom. The participants in the study narrate, through speech and sign, their mathematics learning experiences and narrate what it means to be a mathematics learner in relation to the classroom obligations and characterizations of competence in the classroom. I observe and document the DHH students' experiences in the mathematics classroom in order to understand how these students' mathematics identities are co-constructed by themselves and others in their particular classroom, through mathematics activities and classroom discussions and interactions. By employing a phenomenological approach, the perceptions and experiences of each participant are both essential and valued.

1.2 Significance of the Study

This work extends current literature in the field of DHH mathematics education by providing an analytic lens for understanding the complexities in DHH mathematics education and exploring the actual experiences of the DHH learners. It has potential for advancing our understanding of mathematics teaching and learning among DHH learners. Furthermore, this work provides a new context for applying theory of mathematics identities, which is critical for students who have experienced less access to high quality mathematics (Larnell, 2016). Theoretically, this work begins to explore how to coordinate two complementary interpretive schemes for analyzing mathematics identities, identities-as-narratives and identities-in-practice. Finally, on a personal level, researching DHH learners' mathematical learning experiences will contribute my ultimate goal of developing mathematics curricula and instruction, specifically designed for DHH learners.

Before the research community can begin to propose changes to DHH education, suggest modifications to improve mathematics instruction among DHH learners, and advocate for more appropriate policy and educational initiatives, it is essential to understand how DHH individuals narrate their identities and how they interpret their experiences as DHH learners in the mathematics classroom. Classrooms, lessons, and curricula that are not adapted to the population they serve become a hindrance rather than a gateway to a successful mathematics education.

1.3 Key Findings

In this classroom, the general and mathematical obligations involve expectations of compliant behaviors and fluency of low-level mathematics activities. Furthermore, the authority to determine the reasonableness and legitimacy of the mathematics responses is primarily distributed to the teacher, and as a result, there are limited opportunities for the students to exercise agency. Competence in mathematics is determined by a student's accuracy and using established solution methods to complete the assigned practice problems. Thus, competence in mathematics, as defined in this study, is situational and based upon what it means to do mathematics in this particular classroom setting.

Specifically, the general classroom obligations that emerged from analyses of the teacher and student interview data are *completing practice problems in class*, *following directions*, and *completing and reviewing homework problems* and the mathematical obligations are *using established solution methods* and *developing fluency in procedures*. Multiple data sources, including the field notes and classroom observation video data, were triangulated to corroborate the classroom and mathematical obligations. For example, time segmentation of the video data revealed that, on average, roughly 77% of the class time each day is spent on the general obligation of *completing practice problems*.

As the students engage in mathematics in this classroom, they develop identities of competent learners based on the classroom's characterizations of what it means to be a competent learner and a doer of mathematics. Three of the four students in this class come to see themselves as competent mathematics learners when they accurately complete the assigned problems. Analysis of the mathematics activities reveal that the activities are predominantly low-level. Thus, students may be developing identities of competent mathematics learners based on their performance on low-level mathematics activities.

In-depth case studies of two students examined *how* and *why* these individual students take up the obligations and identities of competence in the classroom. Both students are positioned by others as competent mathematics learners. However, they internalize the classroom obligations and describe their own competence in mathematics differently. Findings from the case study analyses reveal that views of d/Deafness, as well as the ways these students interpreted and internalized the classroom obligations and their prior classroom experiences, relate to how they see themselves as learners and doers of mathematics in this classroom setting.

Documenting the classroom norms and obligations from the perspectives of the participants provides a critical context for understanding how these DHH students narrate and perceive their mathematics experiences in a particular classroom. Findings from this work highlight the importance of paying close attention to the ways teachers and students describe the specific practices, behaviors, and activity structures in the classroom when examining how DHH learners' mathematics identities are co-constructed. In this classroom, the mathematics activities and classroom structures afforded and/or restricted opportunities for DHH learners to participate in the mathematics classroom. Additionally, if students take up identities of competent mathematics learners, but the classroom obligations emphasize procedures and repetition and the mathematics activities involve low-level mathematics, the students may be developing misleading senses of what it means to be competent mathematics learners outside the walls of this classroom. Based on the findings of this dissertation work, I emphasize that mathematics classroom must provide DHH learners opportunities to engage in high level mathematics *and* create learning environments that foster the development of strong mathematics identities.

1.4 Limitations of the Study

The first set of limitations of the study is related to recruitment. I planned to study DHH high school students. The age range of the student subjects was later modified to include middle school DHH students, since limited schools in this Midwestern metropolitan area have DHH students and classrooms. The research goals and the design of this study are focused on DHH adolescents, so including middle school students served to broaden the potential population of eligible student participants without threatening the goals of the research. Working with middle school students did not pose a greater risk to the participants, since the middle school students were able to understand their role in the study and decide whether or not they choose to participate in the study. That said, middle grades students may not be as expressive about their experiences as older students.

In the Midwestern city where this study takes place, DHH high school classrooms are situated within the Public School system. Since access to the public schools as research sites is restrictive, I included private schools into the site recruitment, and ultimately decided to conduct this study at a private school. Consequently, the school is not bound by state standards and protocols. The administrator of the school (pseudonym Ms. Clark), however, asserts that the school chooses to follow state standards whenever possible (Ms. Clark, personal communication, February 25, 2015).

Additionally, I aimed to observe DHH students in two settings: a self-contained classroom and a mainstream classroom. At the participating school site, however, no middle school students were mainstreamed for mathematics at the time of this study. Therefore, this study only includes a self-contained classroom. As I searched for potential school sites, I found a very limited number of mainstreamed students. In fact, in one of the largest High School Deaf programs in the public school system, at most one student is mainstreamed at each grade level in mathematics. Including only a self-contained classroom did not alter my research questions, although it did impact the scope of the study. I still explored the DHH students' experiences in mathematics and how DHH learners' mathematics identities are co-constructed in a self-contained classroom but was unable to examine how DHH learners' mathematics identities are co-constructed in a mainstream classroom setting.

Finally, the teacher in this classroom was new to teaching and was not certified in mathematics nor DHH education. The original seventh and eighth grade teacher left the school in the middle of the school year, and the current teacher replaced her for the remainder of the year. Since this is a private school, the teacher was not required to be state certified to teach the mathematics class.

In addition to limitations related to recruitment, the design of this study has two limitations. In this study, I focus on the mathematics experiences of four DHH student participants. This is a small number of cases, and the findings are not intended to be generalizable to the larger DHH population. That said, the findings from this study may be relevant to other classrooms and DHH learners. As Boaler (2008), states, "qualitative case studies can provide highly generalizable findings, not by showing something repeated across cases but by providing the depth of observation and analysis that enables readers to understand a connection or phenomenon clearly and judge its applicability to other cases (p. 592)." Secondly, I did not include parents and community members in the study. Since identities are co-constructed by peers, teachers, community members, families and others, the perspectives of the students' families and community members could be incredibly valuable. This, however, is beyond the scope of this study.

1.5 Organization of the Dissertation

This dissertation is organized into seven chapters:

Chapter 2 provides a review of policy and research related to DHH mathematics education. A brief review of policy and legal frameworks, as well as a discussion of school and classroom contexts, situates this study of DHH learners' experiences in a mathematics classroom. Next, I describe literature in general mathematics education as it relates to DHH learners, as well as DHH education literature as it relates to mathematics education. I then discuss an emerging area in mathematics education research that studies learners' mathematics experiences, and I explain how these frameworks are applicable to DHH mathematics education research.

Chapter 3 describes the research methods and analysis for this dissertation work. I describe data collection, the school and classroom setting, and the teacher and student participants. Subsequently, I describe coding and analysis.

Chapters 4 through 6 discuss several findings from the analyses. Chapter 4 provides an overview of the narratives about classroom behaviors and practices. This includes an examination of the salient norms and obligations in the classroom, as narrated by the students and teacher, and illustrated through the classroom observation data. I then examine how the obligations established in this classroom are consequential to identity development. Finally, I discuss the salience of d/Deafness in the students' practice-based narratives. Chapter 5 explores, in-depth, characterizations of competence as well as how specific students take on identities of competent learners, given the obligations established in this classroom. I examine what it means to be a competent learner in this classroom, who is positioned as competent, and potential consequences of such characterizations of competence. In the final findings chapter, Chapter 6, I provide case studies of two students, to illustrate how these two students take up the obligations and characterizations of competence in the classroom differently.

In Chapter 7, I provide a summary and discussion of the findings and discuss potential implications and recommendations for research, practice, and policy.

CHAPTER 2 REVIEW OF THE LITERATURE

My research focuses on the co-construction of mathematics identities among four DHH students in a self-contained DHH classroom. Mathematics identities refers to students' beliefs and dispositions about their ability to participate in mathematics, and the importance and value of mathematical learning in their lives. They are negotiations between how individuals view themselves as learners of mathematics, and how others construct them as learners of mathematics. Thus, mathematics identities are co-constructed, are not static, and are always evolving.

Research on identity development in mathematics education entails a focus on the mathematics experiences of learners within broader contexts. To contextualize the educational experiences of DHH learners, I will begin by briefly reviewing policy and legal frameworks, including how DHH learners and DHH education are defined. Following an overview of federal policy and initiatives and categorizations of d/Deafness, I will describe the school and classroom contexts, including a discussion of the organization of DHH education and classroom instruction, such as classroom placement, and mode(s) of communication. An overview of select DHH educational structures and instruction within DHH school and classroom contexts, in conjunction with a review of educational policy as it relates to d/Deafness, will illuminate the complexities of DHH education, as well as the need to further investigate the unique experiences of DHH learners. Moreover, this framing situates the mathematics experiences of the participants within the classroom, school, and historical contexts, while also considering policy and legal frameworks that impact DHH education (e.g., Hand & Gresalfi, 2015).

Subsequently, I review current literature in the field of mathematics education as it relates (or not) to DHH learners and in the field of DHH education as it relates to mathematics learning.

A broad review of mathematics education literature reveals that studies involving DHH learners is absent in the literature. Furthermore, research in DHH education related to mathematics, while extensive and informative, has yet to explore issues of mathematics socialization, identity, and agency among DHH learners. I will, therefore, describe an emerging area in mathematics education research that focuses on the experiences of learners in mathematics, which has great potential for the field of DHH mathematics education.

2.1 <u>Policy and Categorizations of d/Deafness</u>

During the past few decades, there have been numerous legislative initiatives augmented by technological advances and a growing social awareness and sensitivity directed towards adapting the physical environment to pluralistic needs. Despite such great advances and increased cultural awareness, current research states that DHH students continue to lag behind their hearing peers academically (Allen, 1995).

I will review various federal legislation, initiatives, and examples of case law, to examine how DHH individuals are defined in this broader context and to examine resources and services provided to DHH individuals in general and educational settings. Policy impacts educational decisions, such as classroom placement and the rights and services afforded to DHH students, and thus impacts DHH students' educational experiences.

2.1.1 <u>Legislation for the Protection of People with "Disabilities".</u> Since the United States Constitution does not state that education is the responsibility of the Federal Government, the structure of education and educational regulations are generally determined by the states. The Federal Government, however, maintains control in the area of civil rights. Therefore, the Federal Government, through its commitment to civil rights, is responsible for equal access to education, but not the education itself. The Civil Rights and Women's Rights Movements of the

1960s impacted U.S. views of the civil and basic human rights of individuals, including DHH individuals. Laws implemented in the 1970s sought to provide basic human rights to disabled people, similar to the protection of minority groups under Title VI of the 1964 Civil Rights Act and women under Title IX of the Education Amendment of 1972. Although these laws are not necessarily ones specifically written for the benefit of the DHH, they nevertheless include DHH individuals under the "disabled" umbrella.

Policy often defines DHH students at a broader level, and rides on the coattails of a broader definition of d/Deafness as a "handicap/disability." "Disability" is a statutory definition for the purposes of federal legislation. DHH individuals are protected under this identification because they are considered to have a permanent medical condition, which produces "an activity limitation (inability to understand conversational speech through the ear alone…) in education, employment, and independent living" (Bowe, 1994).

A number of important pieces of federal legislation have been established specifically for the protection of all "individuals with disabilities." Several laws were passed that intended to provide greater accessibility to people with disabilities. The 1973 Rehabilitation Act (PL 93-112) sought to provide accessibility in the workplace, including calls for "affirmative action" and "program accessibility." The "program accessibility" requirement of Section 504 requires programs that receive federal financial assistance to provide DHH individuals with interpreters or other auxiliary aids, when necessary. Whether state vocational rehabilitation agencies or colleges are legally liable for full coverage of interpreter costs when DHH individuals attend college is still debated. Additionally, in 1990, The Americans with Disabilities Act (ADA, PL 101-336) was enacted to provide opportunities for people with disabilities to participate in programs and activities. It is broken into five parts that: (1) prohibit discrimination in recruitment, hiring, discharge, compensation, and other job related elements; (2) mandate all jurisdictions to make services accessible to individuals with disabilities at the state and local level; (3) require that any privately operated establishments that are open to the public be physically accessible (ramps, elevators, etc.) and provide equal opportunity for people with disabilities, be they customers, visitors, employees, or clients; (4) require telephone companies to provide both local and long distance telecommunication, TTY/voice relay services; and (5) establish other miscellaneous provisions. Under the Americans with Disabilities Act, "disability" is defined as "a physical or mental impairment that substantially limits one or more of the major life activities of such individuals, a record of such impairment, or being regarded as having such an impairment."

In addition to the laws enacted to protect equal civil rights for individuals in general, federal laws and initiatives were established to provide all disabled students with equal education. The Education for All Handicapped Children Act (PL 94-142) was passed by the United States Congress in 1975 to protect children's right to free and public education. It went through a series of amendments, additions, and name changes [PL 94-142 EAHCA (1975) →EHA (PL 99-457) (1986)→ FDEA (PL 101-476) (1990) → IDEA 97 (PL 105-17)], and was ultimately renamed the Individuals with Disabilities Education Act (IDEA) in 1997. Under IDEA, the Federal Government assumed what was previously primarily the states' responsibility for education, and thus became responsible for defining "appropriate education" for children with disabilities. DHH children may be eligible for special education and related service programming under the categories of "hearing impairment" and "deafness[2] ." Hearing impairment is defined as "an impairment in hearing, whether permanent or fluctuating, that

[2] IDEA refers to *d/Deaf* individuals as *deaf*. Therefore, I use *deaf* and *deafness* to be consistent with the law.

adversely affects a child's educational performance but that is not included under the definition of deafness in this section." Deafness is defined as "a hearing impairment that is so severe that the child is impaired in processing linguistic information through hearing, with or without amplification that adversely affects a child's educational performance." In other words, a child who is deaf cannot receive sound, while a child with a hearing loss can generally respond to auditory stimuli. These definitions categorize DHH learners on the basis of their spoken language abilities, and how the hearing loss is likely to impact the learner's ability to *speak* and develop *verbal* language.

The Individuals with Disabilities Education Act stipulates that each and every child with a disability, no matter how severe, is entitled to free appropriate public education. The legislation also establishes that parents must be duly informed, give consent, be able to have their child independently tested free of charge, and have due process in an arbitration hearing. All expenses for programs must be paid for by the local school or on a district level. Additionally, the IDEA requires that every child with a disability have an Individualized Education Plan (IEP), which specifies the individual services agreed upon by the parents, teachers, school, and school district. Students must be provided with free appropriate public education in the "Least Restrictive Environment" (LRE). The LRE means that a student with a disability should be educated with non-disabled students unless, "the severity of the disability of a child is such that education in regular classes with the use of supplementary aids and services cannot be achieved satisfactorily" (IDEA, Section 5A). As I will discuss later, determination of the least restrictive environment by the educational team has a great impact on the classroom placement, curricular goals, mode of communication, and thus, the overall educational experiences of a DHH learner.

2.1.2 <u>Case Law Related to People with "Disabilities."</u> The nature of the U.S. legal system is structured so that laws are interpreted and fine-tuned by court precedence. Several important legal cases have both positively and negatively impacted the rights of the "handicapped/disabled" and the DHH through the court's interpretation, legislation of the constitution and amendments, and the aforementioned laws.

Several of the cases brought before the United States Supreme Court relied upon the Fourteenth Amendment which addresses the Federal umbrella over the states' obligations to provide "due process of law" and "equal protection." Such cases as Brown versus Board of Education (1954), Pennsylvania Association for Retarded Children (1971), and Mills versus Washington, D.C. (1970) underscore the Amendment's breadth. For example, PARC versus Penn (1971) found there was a violation of the Fourteenth Amendment when students who were "mentally deficient" were rejected from general education. The students were entitled to a free and appropriate education. In Mills versus Board of Education (1972), the court found that when students' services had not been provided to children with handicaps, it too violated the Fourteenth Amendment. In this case, the court also felt that funding cannot be selective, and that a student not only has a right to fair and appropriate education, but in the least restrictive environment as well.

On the other hand, in such cases as Amy Rowley versus Board of Education (1982), the Supreme Court imposed limitations to a school district's obligations. Amy Rowley was a 10-year-old DHH student whose school refused to provide a sign language interpreter since Amy received passing grades without one. The Supreme Court agreed with the school and the state, and did not feel that a DHH student who could perform adequately without an interpreter was entitled to an interpreter. In this case, the current legal/political framework imposed a fixed identification on a DHH individual in educational settings. The school and Supreme Court rejected Amy's right to an interpreter because her characteristics did not meet the school's characterization of d/Deafness as a disability. This ruling limited the services provided to Amy, based on a determination that receiving passing grades indicates adequate success in school. By refusing to provide Amy with an interpreter, the school did not provide Amy equal access to information in the classroom. Although she may have been receiving passing grades, and was promoted each year to the next grade level, she may not have been provided the services necessary to reach her potential in school.

At the time of this study, the Supreme Court is hearing the Endrew F. versus Douglas County School District case, which challenges the level of educational services that schools are required to provide to students with disabilities under the IDEA. The ruling by the Supreme Court could have a great impact on education for students with disabilities, as it may require schools to raise the standards of services provided to students with disabilities.

2.1.3 Categorizations of d/Deafness. As the identifications and categorizations of DHH individuals have changed and developed, a tension has emerged between a need for categorization for the sake of efficiency and the consequential classifications of DHH individuals. For example, the federal and legal categorizations of DHH individuals described above emphasize functional characteristics of DHH individuals and determine the appropriate educational services to be provided to DHH learners based upon specific categorizations of d/Deafness. Rosen (2003) distinguishes between various categorizations related to DHH individuals and d/Deafness: (1) medical and audiological categorizations (e.g., congenitally deaf, profound hearing loss), (2) demographic, educational, and legal categorizations (e.g., hearing impairment, prelingual deafness), and (3) humanist categorizations, which are grounded in sociological and anthropological perspectives and look at the community and culture of the Deaf community (e.g., Deaf, deaf).

Lane, Hoffmeister, & Bahan (1996) argue that categorizations and subcategorizations have been shamefully used for expediency regarding employment and allocation of resources, and that it is consistent with the construction of d/Deafness as a defect and a disorder. Their framework for classifying DHH individuals narrows the population into two paradigms: pathological and cultural. Those who view deafness in pathological terms define the DHH from the outside, in terms of their physical defects (Lane, Hoffmeister, & Bahan, 1996). The cultural paradigm, on the other hand, views d/Deafness from "within", as a cultural construct with one community, language, and cultural perspective. In this framework, lowercase "d" deaf refers to audiological hearing loss while uppercase "D" Deaf refers to members of the Deaf culture, who share American Sign Language (Padden & Humphries, 1988). Other researchers have advocated for a shift from this dichotomous view of d/Deafness, which defines individuals as either culturally hearing or culturally Deaf, to include bicultural identities of deafness (Bat-Chava, 2000, Ladd 2003, McIlroy & Storbeck, 2011).

2.2 The School and Classroom Contexts: Factors that Impact DHH Education

Federal legislation, initiatives, and case law have influenced the structure and organization of DHH public education and impacted instruction within DHH education. Specifically, the Individuals with Disabilities Education Act [IDEA] (1997, PL 94-142) influenced a major shift in DHH education by determining that all educational decisions must aim to provide a student with an education in the *least restrictive environment* (LRE, or what is perceived to be the LRE, PL 94-142). Educational decisions for a DHH child are determined by each student's educational team, which includes parents, educators, speech therapists, audiologists, and others. Therefore, the various educational approaches are bound by federal and legal policy, and interpreted by the student's parents and educational team.

The decisions made by the educational team are multifaceted and influenced by many factors, and can have a great impact on a child's education (Mitchell & Karchmer, 2006). A DHH individual's identity, and the collective identities of a group, are shaped by the school contexts (Martin, 2000, 2002, 2006, 2007a, 2009). Presently, a variety of school settings are available for DHH learners, such as mainstream classrooms in hearing schools, self-contained DHH classrooms in hearing schools, and schools for DHH. Moreover, within schools and academic programs, there are a variety of modes of communication and pedagogical approaches, including manual approaches (i.e., signing or other manual cues in various forms including SimCom, Total Communication, and Cued Speech) and oral/aural approaches. Since only ten percent of DHH children are born to DHH parents, communicational and educational decisions are often based upon the perspectives of the educational and medical professionals the parents and DHH child(ren) encounter (Kravitz & Selekman, 1992; Lane, Hoffmeister, & Bahan, 1996; Marschark, 2001). Educational teams determine the most appropriate communication mode, school setting, and living environment. Parents are intended to be an integral part of the educational team, and to be involved in making decisions regarding medical and educational interventions for their child(ren). Researchers have found that many parents are satisfied with their level of participation, yet some feel that their participation and access are restricted (Wagner, Newman, Cameto, Javitz & Valdes, 2012).

With a multitude of educational decisions, DHH students are exposed to a wide range of educational experiences. In this review of the literature, I focus on two instructional factors: (1) mode(s) of communication, and (2) classroom setting. According to current research, as well as my own experiences as a teacher of DHH in New York City and Chicago, these factors have a great impact on DHH learners' educational experiences (e.g., Angelides & Aravi, 2007; Bernstein & Auer, 2003; Bowe, 1994; Karchmer & Mitchell, 2003; Kluwin & Stinson, M., 1993; Stinson, M. & Liu, 1999).

2.2.1 <u>Mode of Communication.</u> Communicational decisions for DHH children are often influenced by perspectives of d/Deafness. Members of the Deaf culture, who identify as "Deaf", extensively use American Sign Language [ASL] (Padden & Humphries, 1988). DHH adults who are members of the Deaf community strongly advocate for ASL as the primary mode of communication. Alternatively, most medical professionals and proponents of oral/aural and cued speech programs support the development of speech and oral communication skills to enable DHH learners to assimilate in the hearing community. Consequently, instruction ranges from completely oral/aural to completely manual methods, and many systems of communication which fall somewhere in the middle. DHH learners must navigate between the perspectives of their (often hearing) parents, medical professionals, educational professionals, and members of the Deaf community.

Manual Programs. Manual programs use hand, facial, and body movements as a means of communication. American Sign Language (ASL) is a language in and of itself, with its own syntax/grammar and lexical/semantics structure, and is not based on English grammar/syntax. Aside from ASL, other manual approaches to language and communication include signed (not spoken) communication such as Sign Exact English (SEE) and Pigeon Sign English (PSE). Such manual approaches are representations of spoken language, and therefore are not themselves a language. Cued speech is a multisensory oral approach, and is a visual communication system of hand shapes (cues) that represent different groups of consonants and vowels. Cued Speech enables a child to differentiate between sounds that appear the same on the lips. It has been found to be effective for students who have trouble with traditional oral/aural approaches (Nicholls & Ling, 1982).

Oral/Aural Programs. Oral/aural programs make use of the child's residual hearing through use of amplification. In oral/aural programs, students use hearing aids, cochlear implants, and FM systems to utilize their residual hearing, and work with speech therapists, audiologists among other specialists. Since oral/aural programs strive to create speech and communication skills to function in the hearing community, manual communication is often discouraged in the classroom setting. Parents are expected to incorporate ongoing training by making hearing a meaningful part of all the child's experiences.

Amplification and cochlear implantation can help DHH students make use of auditory sounds. Assisted listening devices, such as hearing aids, magnify sound so that DHH will be able to take advantage of the available acoustic cues. If a child is eligible, the parents decide whether or not their DHH child(ren) should receive a cochlear implant. Cochlear implantation is a two to four-hour surgery, in which an electronic medical device is surgically implanted in a DHH individual's inner ear to stimulate the remaining cochlear neural ganglia and eighth nerve to send signals to the brain to be interpreted as sound.

Cochlear implantation is controversial not only because it is an invasive surgery, but also because it can potentially ostracize the implanted individual from other members of the DHH community. Critics of oral/aural educational approaches and cochlear implantation argue that oralism and cochlear implantation threaten d/Deafness and can cause DHH children to become confused about their identity (Glickman, 1993; Lane, Hoffmeister, & Bahan, 1996; Marlowe, 1987; Spencer, P. & Marschark, 2003). Some assert that cochlear implantation perpetuates a view of d/Deafness as a disability in need of remediation through technological advances, and thus seeks to "cure" d/Deafness medically (Lane, Hoffmeister, & Bahan, 1996). Moreover, they argue implanting a child's ear emphasizes the importance of spoken language, and has the potential to eliminate Deafness and the Deaf community among youth (Spencer, P. & Marschark, 2003). As more DHH individuals have decided to get cochlear implants, including members of the Deaf community (see *Sound and Fury: Six Years Later*) and a past president of the National Association of the Deaf (NAD), the stigma associated with cochlear implantation appears to be changing. For example, individuals with cochlear implants are now included in the NAD, signaling greater acceptance of DHH individuals with cochlear implants.

Ultimately, whatever approach(es) the educational team of parents, doctors, therapists, educators and others choose, research supports that it is important to be exposed to instructional approaches that are either bona fide language, or a complete representation of a language (Paul, 2001).

2.2.2 Classroom Setting. In the U.S., DHH students may attend schools for the DHH, or "hearing" schools which include mainstream programs and/or self-contained classrooms. In mainstream settings, DHH student(s) are included in regular education classrooms and learn alongside their hearing peers. In self-contained DHH settings, the DHH students are in a separate classroom with their DHH peers. Between 1989 and 2004, the percentage of students in general education public school settings for more than forty percent of the school week increased from 45% to 65%, while attendance at residential schools for DHH decreased from 25% to 15% (Karchmer & Mitchell, 2003). Karchmer and Mitchell (2003) claim that many DHH students are placed in public hearing schools because the interpretation of least restrictive environment (LRE) is often determined by hearing people, who often believe that the LRE is a hearing school. Thus, by enforcing the right to the LRE, DHH students are now integrated more often into mainstream instructional settings.

Current research examines the benefits and drawbacks of mainstream and self-contained programs (Angelides & Aravi, 2007; Angelides & Charalambous, 2005; Bernstein & Auer, 2003; Kluwin & Stinson, M., 1993). Studies regarding school and classroom settings have examined how classroom settings impact students, both socially and academically. Research has found that classroom settings can impact the self-identification and self-esteem of DHH students, and highlight feelings of loneliness and marginalization in mainstream settings (Angelides & Aravi, 2007; Angelides & Charalambous, 2005; Kluwin & Stinson, M., 1993). In other words, DHH students may feel isolated from society and culture due, in part, to their hearing loss, which can hinder communication and participation in an integrated instructional setting (Stewart & Kluwin, 2001). Alternatively, children in self-contained classrooms feel a greater sense of belonging and community (Angelides & Aravi, 2007; Stewart & Kluwin, 2001; Van Gurp, 2001).

Although self-contained classrooms and private schools for the DHH have higher teacher-to-student ratios when compared to mainstream classrooms, students in self-contained classrooms often have fewer opportunities for challenging instruction (Angelides & Aravi, 2007; Stewart & Kluwin, 2001). Angelides and Aravi (2007) conducted interviews with 20 participants in Cyprus between the ages of 19 and 30. The study found that while DHH programs provide more opportunities to socialize, the mainstream programs were more academically challenging. DHH students at schools for the DHH often received worksheets, and felt as though they learned the same material and content year after year. In this study, the researchers selected four individuals for in-depth interviews, two that had been mainstreamed, and two that attended schools for DHH. The individuals who had been mainstreamed expressed feelings of isolation in the mainstream setting. Both attended oral programs and neither individual was provided with a teacher of DHH nor had any DHH classmates. These factors could have a great impact on the social experiences of the learners. Future research is needed to build upon this study to examine DHH students in mainstream setting with other DHH peers and a teacher of DHH.

In mainstream settings, some DHH children still do not receive equal learning opportunities (Angelides & Charalambous, 2005). Stinson, M. and Liu (1999) conducted a study involving field observations and focus groups of forty interpreters, teachers of DHH, and note-takers. Their analysis revealed that accommodations and positive classroom environments, as provided by regular classroom teachers, teachers of DHH, and interpreters, could facilitate participation of DHH students (Stinson, M. & Liu, 1999). In addition, in order for students to be successful in a mainstream environment, DHH children need to be adequately prepared for the general education classroom (Kluwin & Stinson, M., 1993).

When DHH students are placed in more challenging programs and provided with the appropriate services and accommodations, they are more successful in school (Holt & Allen, 1989). That is, given more difficult and challenging instruction, DHH students are capable of rising to the challenge and are more successful academically. However, when programs do not provide the necessary support, students are not able to reach their full potential (Angelides & Charalambous, 2005; Kluwin & Stinson, M., 1993; Stinson, M. & Liu, 1999). In addition, contextual variables such as age of diagnosis, the learning environment, parental support, accessibility, and financial wherewithal may also impact the efficacy of one program over another (Bernstein & Auer, 2003).

2.3 Mathematics Education and DHH Learners

In this section, I review mathematics education research among DHH learners, in light of the complexities of DHH education and the unique experiences of DHH learners. I discuss research in the field of mathematics education, as it pertains to DHH learners, and research in the field of DHH education, as it relates to mathematics learning. Research on d/Deafness and mathematics learning is primarily found in the DHH education literature, and not in the mathematics education literature. Presently, DHH mathematics education literature lacks the appropriate attention of the mathematics education community. In addition, current mathematics education theories concerning mathematics socialization, identity, and agency are absent in the DHH literature related to mathematics education.

2.3.1 Mathematics Education Research and Initiatives and DHH Learners.

Currently, mathematics education research does not include studies involving DHH learners. Consider, for example, the Handbook of Research on Mathematics Teaching and Learning (Grouws, 1992) and its follow-up Second Handbook of Research on Mathematics Teaching and Learning (Lester, 2007), which were intended to provide a comprehensive review of research and developments in mathematics education. Combined, the two handbooks include 60 chapters that explore issues in mathematics education, including theory, perspectives, teachers, instruction, culture, curriculum, and assessments. In fact, the first handbook is "the most referenced single resource book of research on mathematics teaching and learning" (Stinson, D., 2011, p. 1). Both handbooks, however, contain no chapters that specifically discuss mathematics learning and instruction among DHH learners. Similarly, there is no mention of DHH students in the National Council of Teachers of Mathematics (NCTM) *Principles and Standards for School*

Mathematics (NCTM, 2000). Like the handbooks, the *Principles and Standards* do not consider teaching and learning specifically among DHH learners.

The *Common Core State Standards in Mathematics* (CCSS-M) are a set of benchmark standards intended to provide a consistent set of learning goals, to ensure that all students across the U.S. are provided with coherent mathematics instruction and curricula. The standards are built upon research-based learning progressions, i.e., learning trajectories (Confrey, 2007). Learning progressions are informed by extensive research that focuses on the ways that students tend to build increasingly sophisticated understanding of mathematical concepts over time. They are hypothesized based upon research and theory, and require empirical validation (e.g., Clements & Battista, 2000; Clements, Wilson, & Sarama, 2004; Confrey, 2007; Confrey & Maloney, 2010). At the time of this study, thirty-seven states, the District of Columbia, four territories, and the Department of Defense Education Activity have adopted the Common Core State Standards in Mathematics ("Standards in Your State," 2016). As the CCSS-M are fully implemented, they have a direct impact on mathematics instruction and curricula for all of the students, in all of the classrooms, in every state that has adopted the CCSS-M. Limited research, however, empirically validates the appropriateness of the CCSS-M among DHH learners.

Learning trajectories are based upon the "general" population and relate to understanding and reasoning in specific domains such as algebra, measurement, and place value (e.g., Clements & Battista, 2000; Clements, Wilson, & Sarama, 2004; Confrey & Maloney, 2010; Daro, Mosher, & Corcoran, 2011; Fuson, 1998; Griffin, 2009; Lee, Nguyen, & Confrey, 2012; Simon, 1995; Simon & Tzur, 2004). For example, Lee, Nguyen, and Confrey (2012) unpacked the development of the learning trajectories for length, area, and volume. The learning trajectories were based upon research pertaining to the development of conceptual understanding of length

(Clements & Sarama, 2009), area (Outhred & Mitchelmore, 2000), and volume (Curry & Outhred, 2005; Battista, 2007) among the general population.

Not only are these hypothetical learning progressions not based upon research involving DHH students, but at the time of this study, limited research has empirically evaluated the appropriateness of such learning progressions for DHH students who, "by the simple fact that they access the world differently, are unique learners, and this distinctiveness must be taken into consideration in regard to their mathematics development" (Pagliaro, 2015, p182). Pagliaro and Kritzer (2013) found that DHH learners exhibited greater understanding of mathematical concepts involving geometry, and weaker understanding of concepts involving number and operations, specifically measurement and problem solving, when compared to non-DHH learners. In addition, DHH learners who communicate using ASL have different mathematical problem-solving progressions compared to their hearing learners. For example, DHH learners employ counting strategies more often when compared to non-DHH learners (Pagliaro & Ansell, 2012). Specifically, Carpenter asserted that non-DHH learners follow a progression of modeling to counting to fact based (as cited in Pagliaro & Ansell, 2012), while DHH learners were found to follow a counting to modeling/counting to fact based/counting progression (Pagliaro & Ansell, 2012).

These findings reveal potential issues associated with implementing standards based on learning progressions that are not grounded in, nor empirically validated by, research involving DHH learners. The findings also expose the need to conduct further research to examine the DHH learners' experiences in mathematics classrooms. Research is needed to examine in what ways these findings about DHH learners' mathematical development are a function of the DHH learner and in what ways they are a function of the classroom environment, including curricula, instruction, and teacher preparation and expectations. Until more work is done, it is unclear whether the trajectories which form the foundation for the CCSS-M are appropriate for the DHH population. Moreover, it is unknown how implementing standards that are not designed nor empirically validated in consideration of the needs and learning experiences of DHH learners will impact the mathematics learning experiences and the development of mathematics identities among DHH learners. More specifically, it is unknown how DHH learners co-construct their mathematics identities in relation to mathematics activities and classroom structures that are informed by standards which may or may not pertain to DHH learners.

Furthermore, the CCSS-M outlines essential mathematical practices including: constructing viable arguments and reasoning with others, modeling with mathematics, using appropriate tools strategically, and attending to precision. Mathematics educators are expected to promote and cultivate these ways of thinking about mathematics in their students. While it is clear that the CCSS-M was influenced by the five strands in *Adding It Up: Helping Children Learn Mathematics* (National Research Council, 2001)*,* the CCSS-M does not include the strand, "productive disposition" from the report. According to the National Research Council (2001), "*Productive disposition* is the inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy" (p. 116). This statement can be parsed to show three components of the strand: (1) "mathematics as sensible, useful, and worthwhile," (2) "belief in diligence," and (3) "one's own efficacy." Examining this further, it is apparent that seeing mathematics as useful and worthwhile can be mapped on to specific mathematical content goals in CCSS-M, such as "describing their physical world" (Kindergarten), or recognizing "the need for standard units of measurement" (Grade 2). Likewise, the belief in diligence corresponds to the CCSS-M, *Mathematical Practice 1* which emphasizes perseverance. Self-efficacy, however, does not appear to be embedded in the mathematical practices or the content goals. Learners' self-efficacy in mathematics can have a great impact on the way students approach demands and obstacles in the mathematics classroom (Bandura, 1997). As I will expound upon later, emerging research in mathematics education highlights issues of self-efficacy and agency, and discuss the profound impact it can have on mathematics learning, particularly among marginalized groups who have had restricted access to mathematics, such as the DHH (Boaler & Greeno, 2000; Cobb et al., 2009; Foley, 2016; Larnell, 2016; Martin 2000, 2006, 2007a, 2007b, 2012; Stinson, D., 2008). Emphasizing and exploring how DHH students experience mathematics learning, how their perspectives and self-perceptions as learners of mathematics influence how mathematics identities are co-constructed, and the ways they exhibit agency, has potential to inform curricula and instruction, and improve mathematics education of the DHH.

2.3.2 DHH Education Research in Mathematics. Research concerning mathematics education of DHH learners is primarily situated in the DHH education literature. Research in the field of DHH mathematics education reports that DHH children perform at lower levels on mathematics assessments, and graduate high school at significantly lower levels in mathematics compared to their hearing peers (Kritzer, 2008; Nunes & Moreno, 2002; Swanwick, Oddy, & Roper, 2005; Traxler, 2000). Research in the field of mathematics education of the DHH has put forward several explanations for discrepancies between DHH and hearing students, investigated how DHH children learn particular mathematical skills and concepts, and provided evaluations of specific instructional interventions. Although the differences between achievement levels of DHH and hearing students cannot be attributed to a single source (Marschark, 2001), researchers have found that possible explanations for the differences between DHH and hearing students include factors such as: lack of incidental learning, teacher preparation and teacher expectations, and difficulties on word problems due to lower reading levels (Moores, 2001; Swanwick, Oddy, & Roper, 2005; Zarfaty, Nunes, & Bryant, 2004).

Incidental Learning. DHH children have difficulty in mathematics in early years, prior to formal schooling (Kritzer & Pagliaro, 2013; Pagliaro & Kritzer, 2010). Current studies have found that incidental learning is a key factor that impacts DHH students' achievement levels in mathematics (Marschark, 2001; Nunes & Moreno, 1998; Ray, E., 2001). Most DHH children have limited exposure to rich auditory language environments which impacts incidental learning (Marschark, 2001; Nunes & Moreno, 1998; Ray, E., 2001). Because roughly ninety percent of DHH children are born to hearing parents, most DHH children miss out on the frequent, consistent, and accessible communication exchanges that are critical to language development (Marschark, 2001). DHH children's inadequate access to language results in low exposure to pre-math concepts and incidental learning (Ray, E., 2001). For instance, if parents talk about money and time, or use ordinal and cardinal numbers in everyday contexts, a hearing child will pick up on some of the concepts incidentally. DHH children, however, often miss such forms of learning. Due to inadequate access to spoken language, most DHH students' language development lag behind their hearing peers, and they begin elementary school with deficits in reception and expression of spoken language, grammatical skills, and knowledge of the world (Moores, 2001). Moreover, delays in mathematics performance may negatively impact the ways that educators instruct DHH learners. That is, the fact that DHH learners are behind may cause teachers to employ procedural approaches to teaching, in order to move students through the curriculum and "close the gap" (Pagliaro & Ansell, 2012).

Researchers have examined the benefit of intervention programs to address gaps in DHH learners' mathematical proficiency (Kritzer & Pagliaro, 2013; Marshall, Carrano, & Dannels, 2016; Nunes & Moreno, 2002; Nunes, Bryant, Burman, Bell, D., Evans, Hallett, & Montgomery, 2008; Nunes Bryant, Burman, Bell, D., Evans, & Hallett, 2009). For example, in the United Kingdom, Nunes and Moreno (2002) implemented an intervention program in a school for DHH in London, England to explore issues regarding opportunities for incidental learning, and difficulty in making inferences involving time sequences. The study compared 23 students in the intervention to a baseline of 65 students in the same school for DHH. All students in the study attended the UK school for at least one year prior to the intervention, and had taken the standardized test developed by the National Foundation for Educational Research (www.nfer.ac.uk, n.d.) called the NFER-Nelson UK standardized test. The purpose of the intervention program was to build a foundation for DHH children's informal mathematical knowledge to prepare them for the school curriculum. Teachers administered an intervention, which included tasks in four mathematical concept areas: additive composition, additive reasoning, multiplicative reasoning, and ratio and fractions. The four concepts were introduced, and explored through a variety of tasks. The study showed no initial differences between the groups on the NFER-Nelson test. At post-test, those students who participated in the intervention performed better than expected on the basis of their pre-test score (Nunes & Moreno, 2002). Thus, although DHH children often come to the classroom with delays and gaps in mathematics due, in part, to incidental learning, intervention programs have the potential to help build a base of informal knowledge (Kritzer & Pagliaro, 2013; Marshall, Carrano, & Dannels, 2016; Nunes & Moreno, 2002; Nunes et al., 2008; Nunes et al., 2009).

Teacher Preparation, Expectations, and Instruction. Current research pertaining to teachers' content and pedagogical knowledge in mathematics, and teachers' expectation of DHH students looks almost exclusively at DHH (and not mainstream) classrooms. In mathematics classrooms for DHH students, “the tendency of deaf students is to know better how to perform a mathematical operation than when to perform it” (Stone, 1988, p. 67). Often, teachers of DHH still employ traditional teaching techniques (Pagliaro, 1998b), and refrain from teaching concepts they believe to be too for difficult for DHH students (Pagliaro & Kritzer, 2005).

Pagliaro (1998b) found that although some reform techniques are used, DHH educators still employ mainly traditional teaching techniques. Traditional approaches to teaching mathematics do not promote flexibility in thinking mathematically, and may not prepare students for real-world contexts (Boaler, 1998). Pagliaro’s (1998b) study examined the extent that teacher and administrator behaviors and practices in schools of DHH reflect mathematics reform, and the ways the reform is promoted through classroom instruction and school structure. She found that teachers “lacked both the time and the knowledge necessary to incorporate mathematics successfully” (p. 26). She surveyed 54 programs and 141 teachers of the DHH, using a Program Questionnaire and a Teacher Questionnaire. Follow-up interviews were conducted with 5 administrators and 11 teachers. Results showed that teachers in the lower grades were more influenced by the reforms than those in the upper grades. Results also showed minimal planning collaboration and planning among teachers in the upper grades. In terms of instruction, the authors reported that on average, 19% of classrooms were limited to drill and practice, 74% used worksheets frequently, and 65% stressed memorization. Although more than 85% of the teachers used computers, they were primarily used for games or drill and practice. Manipulatives, which are noted as important in math reform, were used in the lower grades to practice, and in the higher grades to model. Tests and quizzes were the main forms of assessment, and increased with grade level. In general, the results of this study showed some features of reform teaching through the use of manipulatives and technology. Classroom instruction, however, followed a traditional model. Recommendations for mathematics education of DHH included: collaboration between administrators and teachers to form a cohesive math program, increased planning time, and increased use of technology.

Pagliaro (1998a) also found that teachers of DHH, instructing students in mathematics, do not have sufficient content preparation in mathematics. When teachers are well-prepared and knowledgeable in the specific subject matter that they are teaching, students not only learn skills and procedures, but also learn concepts and problem-solving (Schoenfeld, 2002). Thus, teachers' mathematical content knowledge has a great impact on instruction and in teaching for conceptual understanding (Hill & Ball, 2009; Hill, Rowan, & Ball, 2005; Hill, Blunk, Charalambous, Lewis, Phelps, Sleep, & Ball, 2008; Manouchehri & Goodman, 1998).

Pagliaro (1998a) surveyed 66 schools for the DHH across the United States, including 54 administrators and 141 K-12 teachers. She sent out two questionnaires to the participants: (1) the "Teacher Questionnaire," which focused on the individual teachers' preparation and professional development, and (2) the "Program Questionnaire," which examined school support for professional development. Semi-structured phone interviews were conducted for necessary clarification. Results indicated that DHH education teachers were not sufficiently prepared to teach mathematics, and that the average teacher at a school for DHH had only taken approximately six courses in math-related studies, including courses related to content, pedagogy, and cognition (Pagliaro, 1998a). In addition, schools for DHH did not encourage nor provide incentives for this specific type of professional development (Pagliaro, 1998a). The results also exposed the "insufficient level of mathematics preparation among deaf education teachers, especially at the high school level" (Pagliaro, 1998a).

In later work, when examining student recall of geometry terms in mathematics, Lang and Pagliaro (2007) found a significant difference in geometry word recall between teachers of the DHH who were certified or had degrees in mathematics education and those who were not certified. Based on their findings, the authors reiterate the importance teacher preparation in mathematics and mathematics education. Still, more research is necessary to assess the content and pedagogical knowledge of mathematics teachers of the DHH, the impact on mathematics instruction, and especially the impact on DHH students' mathematical learning experiences and conceptual understanding in mathematics.

In addition to teacher's pedagogical and content knowledge, teachers' expectations of their students also impact mathematics instruction and DHH students' success in mathematics (Schullo & Alperson, 1998; Pagliaro & Kritzer, 2005). "What happens when we assume that certain children are less than brilliant? Our tendency is to teach less, to teach down, to teach for remediation." (Delpit, 2012, p. 6). Teachers who believe that their students' intelligence and math ability is not a fixed, innate ability tend to have higher performing students (Schullo & Alperson, 1998). Pagliaro and Kritzer (2005) collected survey data from 290 mathematics teachers across 96 K–8 and K–12 schools and programs that serve at least 120 students with hearing loss. They found that teachers did not include discrete mathematics in their curriculum because they believed that the concepts were too complex for DHH students. Teachers must recognize that DHH students, at any level, can do complex mathematics (Pagliaro & Kritzer, 2005).

Mathematics Word Problems. Problem-solving has been classified as "an insight into the learning process and as a tool for teaching" (Pagliaro & Ansell, 2002). Math education of the DHH, however, continues to be focused on skill and computation, and problem solving in

DHH education is often hindered by the children's reading and language level (Pagliaro, 1998b; Pagliaro & Ansell, 2002).

Swanwick, Oddy, and Roper, 2005 (2005) analyzed student work from 14-year olds in the United Kingdom from the National Mathematics tests. The study included 126 test papers from 24 schools for DHH. They found that DHH students differed from hearing students in the following areas: (1) performance mathematics word problems; (2) the interpretation and application of arithmetic and algebraic procedures and concepts; (3) clarity and completeness of written responses; and (4) performance of "difficult-to-teach" items. Often, the work of the DHH students could not be interpreted due to DHH students' clarity of writing. DHH student's inability to express their strategies and processes, however, may not necessarily reflect his or her inability to solve a problem. Moreover, lower performance may be due to the difficulty in teaching a particular concept, rather than a DHH student's inability to comprehend that concept. The authors encouraged follow-up to the research to examine DHH experiences in mathematics to better understand DHH students' interpretation of mathematical concepts and their performance in mathematics (Swanwick, Oddy, & Roper, 2005).[3]

Studies in the U.S. related to DHH students' performance on mathematics word problems have found similar relationships between reading levels and performance on word problems in mathematics. Problem-solving in DHH education is often hindered by the children's reading and language level. Unfortunately, the inability to "verbally" express strategies and processes often is misinterpreted as the inability to solve a problem. Given typical word problems and a

[3] One limitation regarding the applicability of studies conducted in other countries is the differences in sign languages. For example, in British Sign Language, the number 10 is signed using two hands, whereas in ASL the number 10 is signed using only one hand. In addition, the U.S. and other countries do not have the same federal educational regulations and legislation. Thus, the broader political context, as well as the school and classroom contexts, differ.

visual/manipulative puzzle, Mousley and Kelly (1998) implemented problem-solving strategies among first and second year DHH students enrolled in mathematics courses at the National Technical Institute for the Deaf. The study revealed that, (1) students had higher success with higher reading levels; (2) students differed in the ways they articulated the mathematics and in how they behaved; and (3) word problem solving could be enhanced through instructional strategies such as visualization. Although this study relies heavily on literacy and language skills, the results highlight that given the proper instruction, DHH students can learn to solve mathematics word problems and puzzles.

Pagliaro and Ansell (2002) studied the nature of problem-solving in DHH education. Their study analyzed questionnaire data to ascertain the frequency of word problems, the mode of communication, and the relationship to teacher preparation and experience. The study included thirty-six kindergarten through third-grade teachers of the DHH at schools for the DHH across the U.S. They found that teachers did not introduce story problems until they felt that the students had the computational and operational skills to solve the problems and that teachers with more teaching experience included word problems more frequently. Furthermore, when introducing word problems, teachers of the DHH often followed traditional teaching approaches. The authors asserted that teacher education programs are an essential component to providing mathematics teachers of the DHH with the theoretical, pedagogical, and content knowledge to shift from traditional instruction of word problems towards high-quality mathematics instruction (e.g., aligned with the NCTM *Principles and Standards*; The *Common Core State Standards in Mathematics*, CCSS-M).

This brief review of studies of DHH students in mathematics education reveals that much of the research involves surveys and interventions, and generally takes place in self-contained settings in schools for the DHH. While the current research examines a number of factors that hinder DHH's success in mathematics, explores cognition and problem solving among DHH learners, and illuminates the potential for improvement in mathematics education of DHH (i.e., through early intervention), minimal research documents the mathematics experiences of DHH learners in the mathematics classroom (Swanwick, Oddy, & Roper, 2005). Researchers in mathematics education among DHH learners should examine how DHH learners, who have not been exposed to pre-mathematics concepts or who may not have teachers that are sufficiently prepared to teach mathematics, perceive and narrate what it means to be a learner and doer of mathematics. Since mathematics identities are co-constructed by teachers and others, it is also important to investigate how teachers of the DHH who are not knowledgeable in mathematics content and pedagogy, and who may not have high expectations of their DHH students, describe and position the DHH learners in their mathematics classrooms. Furthermore, researchers should examine what forms of agency emerge in DHH mathematics classrooms, particularly given that many DHH students have had less access to incidental learning, that instruction of the DHH often follows traditional teaching approaches, and that many teachers do not have training in mathematics education. Taking up issues of mathematics socialization, identity, and agency among DHH learners is essential to understanding the mathematics experiences of DHH learners, as performance and achievement scores do not tell a complete story.

2.4 Emerging Area in Mathematics Education Research: Potential for Research of the DHH

Across both mathematics education research and DHH mathematics education research, the mathematics experiences of DHH students tend to be under-studied. Mathematics education literature does not include studies involving mathematics education among DHH learners (e.g., see Grouws, 2000; Lester, 2007). Research in mathematics education of DHH focuses on teacher preparation, expectations, and content knowledge, experimental interventions, and DHH language and reading skills and the subsequent impact on performance in mathematics (e.g., Booker, Markey, & Power, 2003; Davis & Kelly, 2003; Hyde, Power, & Zevenbergen, 2003; Nunes & Moreno, 2002; Pagliaro, 1998a; Pagliaro & Ansell, 2002). In the past few decades, an emerging area in mathematics education research has made significant advances, particularly in relation to issues of socialization and identity construction (e.g., Bishop, 2012; Boaler, 2002; Boaler & Greeno, 2000; Cobb, Gresalfi, & Hodge, 2009; Esmonde, 2009; Gresalfi, Martin, Hand & Greeno, 2008; Langer-Osuna, 2011; Langer-Osuna, 2015; Martin 2000, 2002, 2006, 2007a, 2007b, 2009; McGee & Martin, 2011; Nasir, 2002; Nasir & Shah, 2011; Spencer, J., 2009; Stinson, D., 2008; Terry, 2011; Wilson-Akubude, 2016). Research focused on mathematics identity and agency seeks to understand how learners experience, perceive and position themselves as learners of mathematics. While researchers in general mathematics education are moving the field forward with this research, DHH mathematics education research has yet to explore DHH learners' mathematics experiences and issues of identity and agency among DHH learners. DHH learners have complex and unique educational experiences, impacted, in part, by policy, as well as educational and cultural factors. Applying theories of mathematics socialization, identity, and agency has potential for exploring the experiences of DHH learners in mathematics and advancing our understanding of mathematics teaching and learning among DHH learners.

Martin (2000, 2002, 2006, 2007a, 2009) explores *mathematics socialization* and the co-construction of racial and *mathematics identities* among African American learners, and highlights the enormous power of the positive mathematics experience and the profound impact it can have on identity. “Mathematics socialization and identity formation…occur as an individual negotiates the contextual forces, opportunities, and constraints that he or she encounters and that come to bear on that individual’s mathematical development” (Martin, 2000, p. 36). *Mathematics socialization* is defined as “the experiences that individuals and groups have within a variety of contexts such as school, family, peer groups, and the workplace and that facilitate, legitimize, or inhibit meaningful participation in mathematics” (Martin, 2006, p. 206). *Mathematics identities* include students’ beliefs about their ability; the importance and value of mathematical learning, limitations and opportunities; and the motivation and approaches to acquire mathematical knowledge. Mathematics identity reflects the negotiation of how a student sees him/herself as a learner of mathematics, and how others position the individual as a learner of mathematics. It is always under construction, and is the negotiation between self-perceptions and the externally imposed identifications (and devaluations) by the larger society (Martin, 2000, 2006). *Individual agency* and perceived self-efficacy, encompass how students “transform and internalize their experiences and respond productively to the forces they encounter” (Martin, 2000, p. 197).

Like Martin, Stinson, D. (2008) studied the experiences of African American learners through narratives. Stinson draws upon three theoretical frameworks: post-structural theory, critical race theory, and critical theory. His research looks specifically at mathematical experiences, then focuses broader to address practices and meanings. As a White male teacher in a predominantly Black school, Stinson conducted participatory inquiry research, which included surveys, autobiographies, math autobiographies, and interviews. He also had the participants respond to manuscripts and the literature in order to reflect on their experiences and confirm the findings. According to Stinson, D. (2008), the stories illuminated the complexities of how

African Americans "negotiate (rather than overcome) specific discourses that surround them as discursive formations" (Stinson, D., 2008, p. 1004). He found that conceptualizations of race as “permanent” and “endemic” components of U.S. society permeated throughout the storytelling. Studying the mathematics experiences of African American learners through the multiple theoretical frameworks, and through the use of storytelling, provided a tool for understanding how African American males who were successful in mathematics “negotiated sociocultural discourses without essentializing their individual and collective counterstories into monolithic sameness” (Stinson, D., 2008, p. 510).

Other researchers studied mathematics identity and agency within particular communities such as classrooms (e.g., Boaler & Greeno, 2000; Cobb, Gresalfi, & Hodge, 2009; Gresalfi, Martin, Hand & Greeno, 2008; Varelas, Tucker-Raymond, & Richards, K., 2015). Wenger (1998) and others assert that mathematics learning involves a student becoming a certain type of person that is accepted or isolated in the mathematics learning community based on their knowledge and understanding of the subject matter (Boaler, 2000; Lampert, 2001). How students are enculturated in mathematics classrooms facilitate how their identity is shaped, how they make meaning, how they function as participants in the mathematics classroom learning community, and their sense of belonging (Wenger, 1998).

Cobb, Gresalfi, & Hodge (2009) draw upon Martin’s (2000) multilevel framework, which includes sociohistorical, community, school, and individual levels, for analyzing mathematics identities among African American learners, and hone in on the school level. Cobb, Gresalfi, & Hodge (2009) focus on what it means to do mathematics in a classroom and how students identify with mathematics activities. They look at classroom behaviors and structures to understand micro-cultures in the classroom: how a classroom is structured, how mathematics is done in the classroom context, and ways that students exercise agency. They argue that in order to explore what it means to be a learner and doer of mathematics, it is important to understand the behaviors that are validated in the specific mathematics classroom(s) under study.

When comparing two classrooms, an algebra class and a self-selected data-based mathematics class, Cobb, Gresalfi, and Hodge (2009) found that students' understandings and valuations of their general classroom obligations differed in the two settings. While the students in the algebra class demonstrated disciplinary agency by listening to the teacher and following the routine, students in the design experiment class demonstrated conceptual agency by asking questions and justifying their mathematical decisions. Moreover, students in the algebra class felt obligations to the teacher, while those in the design experiment class developed a sense of obligations to themselves.

2.4.1 A Conceptual Framework for Applying Theories of Identity to Research on DHH Learners. All students come to the mathematics classroom with beliefs and assumptions about mathematics and experiences that shape their perceptions of mathematics and their mathematics identities (Martin, 2006). DHH children have particularly unique mathematical and social experiences. The current literature in DHH mathematics education has yet to examine what it means for a DHH individual to be a mathematics learner, how s/he views him or herself as a learner of mathematics, and how s/he is positioned by others as a learner of mathematics. Given the ways that DHH students have been defined by policies, others, and by themselves, studying mathematics identity provides an analytic lens for exploring these tensions and the actual mathematics experiences of DHH learners.

This dissertation study has the possibility of moving DHH mathematics education research forward by building upon and adapting theories of mathematics identity in mathematics education to DHH population. I draw upon theories about mathematics socialization (Martin, 2000, 2006, 2007a), and mathematics identity (Cobb, Gresalfi, & Hodge, 2009; Martin, 2000, 2006; Sfard & Prusak, 2005; Wenger, 1998). I apply aspects of Martin's (2000) multilevel framework to explore the mathematics experiences and identities of a select group of DHH students, which entails a focus on the individual mathematics experiences of learners within the broader, school, community and sociohistorical contexts, as well as a focus on individual agency, which emerges from experiences with community forces, school forces, and opposition and resistance to negative influences (Martin, 2000, 2006). Martin's (2000) framework provides a model for understanding the mathematics identities of African American learners, conceptualizations of mathematics identity, and mathematics socialization. Although developed in empirical studies of African American students, it is useful for considering the contextual influences on students' socializing experiences in mathematics, and the mathematics identities that students develop as a result of those experiences. I draw upon Martin's (2000, 2006, 2007a conceptualization of socialization to examine the experiences, messages, and stories of the DHH learners.

My work focuses specifically on the school and individual levels, while taking into account the broader sociohistorical and community contexts, as depicted in Figure 1.

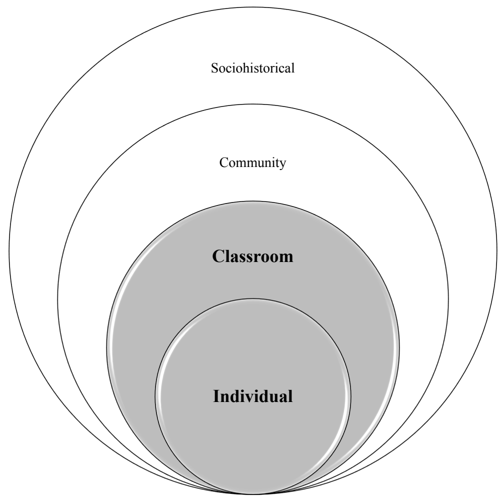


Figure 1. Multilevel Considerations

In this study, I explore the nature of DHH students' experiences in mathematics and the ways that DHH students, as learners and doers of mathematics, co-construct their mathematics identities. While there has been a great deal of growth in research on mathematics identity, especially on African American students in mathematics (e.g., Anderson, 2007; Berry, 2008; Esmonde, 2009; Grant, Crompton, & Ford, 2015; Jackson, 2009; Martin 2000, 2002, 2006, 2007a, 2009; McGee & Martin, 2011; Nasir, 2002; Nasir & Shah, 2011; Spencer, J., 2009; Stinson, D., 2008; Terry, 2011; Terry & McGee, 2012), the mathematics stories and experiences of DHH individuals have yet to be portrayed in educational research. In exploring issues of identity, I simultaneously consider issues of learning (Varelas, Martin, & Kane, 2013). While stories of successes and failures may tend to repeat themselves, learning has the potential to close the gap between the present-tense assertions that one holds about him or herself, and future-tense expectations that have the potential to become part of his or her identity (Sfard & Prusak, 2005). Thus, identities are an important aspect of learning.

I operationalize mathematics identities as both narratives and classroom practices. Through this lens, identities are not static and are always evolving. I explore DHH students' mathematics identities through in-depth analyses of narratives and classroom behaviors: how a DHH student sees him or herself as a learner of mathematics, and how others position the individual. *Figure 2* below depicts my concern with narrative and practice-based identities of the DHH learners.

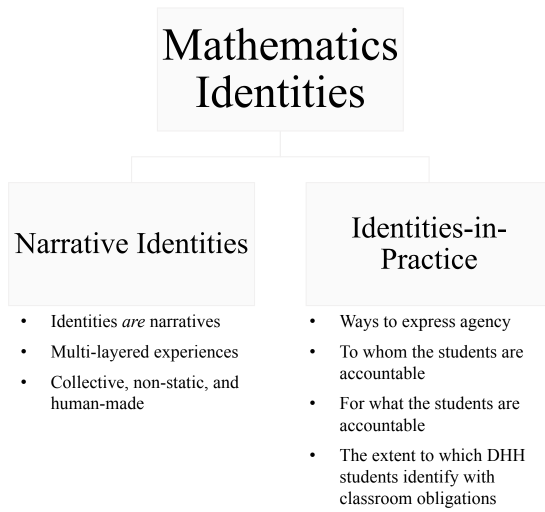


Figure 2. Narrative and Practice-Linked Identities

Identities-as-Narratives. Operationalizing identities as narratives has the potential to develop a rich theory and understanding of DHH and mathematics identities, since "questions about identity can now be translated into queries about the dynamics of narratives, and because the dynamics of narratives are amenable to empirical study" (Sfard & Prusak, 2005, p. 18). Martin (2006) explains that:

> A mathematics identity is expressed in its narrative form as a negotiated self, the results of our own assertions and the sometimes-contested external ascriptions of others. The

development of particular kinds of mathematics identities reflects how mathematics socialization experiences are interpreted and internalized to shape people's beliefs about mathematics and themselves as doers of mathematics (p. 207)

Operationalizing identities as narratives is a way to study DHH learners' mathematics experiences and mathematics identities through the stories and experiences of DHH individuals.

Sfard and Prusak's (2005) operationalize identities as "narratives that are reifying, endorsable, and significant" (p. 16). Narratives that are reifying say something about the individual's state of being. A narrative is endorsable if it "faithfully reflects the state of affairs in the world" (Sfard & Prusak, 2005, p. 16) and is significant if "any change in it is likely to affect the storyteller's feelings about the identified person" (Sfard & Prusak, 2005, p. 16). This view makes identities researchable since they are viewed as collective stories and human-made, rather than innate and God-given (Sfard & Prusak, 2005). At the same time, it emphasizes that stories about an individual may be different from different sources. This approach to understanding identity is "interested in the stories as such, accepting them for what they appear to be: words that are taken seriously and that shape one's actions" (Sfard & Prusak, 2005, p. 21).

Drawing upon Sfard and Prusak's (2005) model, I operationalize mathematical and DHH identities as the collection of the stories and narratives of the DHH individuals. In this study, the DHH participants' share their stories through their preferred mode(s) of communication. Students communicate orally, using sign language, or through a combination of sign and speech. Sfard and Prusak (2005) assert that the "most significant stories are often those that imply one's memberships in, or exclusions from, various communities" (p. 17). Stories where the person addresses him or herself are "likely to have the most immediate impact on our actions," since that is how one sees him or herself (p. 17). Therefore, I focus on the narratives of the individual participants. I analyze their oral and signed stories, specifically looking to see how the participants presently describe themselves and others as DHH learners of mathematics, and how their stories depict their expected or anticipated situations, which may become part of their identities in the future. I look to see what role mathematics and d/Deafness play in the participants' actual or present identities, and how they see mathematics and d/Deafness in their designated, or expected identities. Through this lens, identities are always evolving, and the DHH learners' stories and narratives, in and of themselves, have the potential to shape the learners' actions.

Studying DHH mathematics identities as narratives through this lens also provides a way to study intersectionalities (e.g., race, class, gender, sexual), and to use storytelling to understand the multi-layered experiences of DHH students (Solorzano & Yosso, 2002). Individuals can be members of many different communities simultaneously (Brickhouse, Lowery, & Schultz, 2000). In this study, I primarily focus on how identities are co-constructed in a social sense, as negotiations between individuals' beliefs about themselves as mathematics learners and others' constructions of them as mathematics learners. By studying identities as narratives, I am able to also consider how an individual's mathematics identity is constructed alongside other identities, and particularly the individual's DHH identity.

Identities-in-Practice. In addition to Martin's work, I also draw upon the empirical and theoretical work of Cobb, Gresalfi, and Hodge (2009), who provide an interpretive scheme for analyzing mathematics identities and agency of DHH learners *in-practice.* While Martin's (2000) framework focuses on broader dispositions and beliefs about mathematics, encompassing global issues involved in mathematics learning and participation, Cobb, Gresalfi,

& Hodge (2009) examine mathematics identities and consider issues of agency at the classroom and individual student levels. Cobb, Gresalfi, and Hodge's (2009) framework enables me to explore mathematics identities through the ways that DHH students are positioned and participate in the mathematics classroom.

Cobb, Gresalfi, & Hodge (2009) define two constructs of the interpretive scheme: *normative identity* and *personal identity*. *Normative identity* is defined by the context of the classroom and is determined by the distribution of authority and the ways students can exercise agency, which can be either conceptual or disciplinary:

> Normative identity … comprises both the general and the specifically mathematical obligations that delineate the role of an effective student in a particular classroom. A student would have to identify with these obligations in order to develop an affiliation with classroom mathematical activity and thus with the role of an effective doer of mathematics as they are constituted in the classroom. Normative identity is a collective or communal notion rather than an individualistic notion (Cobb, Gresalfi, & Hodge, 2009, p. 43).

Students have *general classroom obligations* (the types of agency and accountability), and *mathematical obligations* (what students are accountable for mathematically). *Norms* are recurrent actions and activity structures that occur in the classroom and the general and mathematical obligations are the attempt to fulfill or resist the structures in the classroom by conforming to the jointly constructed expectations. Normative identity is how math is done here in the local context. It emerges through the interactions as the normative way of doing mathematics, and thus becomes the way that mathematics is done.

Distribution of authority and ways that students *exercise agency* are described as two aspects of general classroom obligations that are important for exploring normative identities. *Authority* encompasses student "opportunities to be involved in decision-making about the interpretation of tasks, the reasonableness of solution methods, and the legitimacy of solutions" (Cobb, Gresalfi, & Hodge, 2009, p. 44). *Agency* "focuses on the ways in which students can legitimately exercise agency in particular classrooms" (pp. 44-45). Agency is defined as an action with regard to the mathematical content and the general classroom obligations. Conceptual agency involves "choosing methods and developing meanings and relations between concepts and principles." Disciplinary agency involves "using established solution methods" (Cobb et. al, 2009, p. 45).

Personal identity refers to the "extent to which individual students identify with, merely comply with, or resist their classroom obligations, and thus with what it means to know and do mathematics in their classroom" (Cobb, Gresalfi, & Hodge, 2009, p. 44). Studying personal identities gets at *why* students make different valuations of the classroom obligations. In other words, *personal identity* encompasses how a student identifies with an activity as an obligation to herself or himself versus merely cooperating with the teacher, and includes complying with, resisting to, or engaging in mathematical activities. *Identifying* is defined as the association or affiliation with a group and includes three cases: identifying with the activity, trying to please the teacher, and oppositional. It provides a lens for understanding the mathematical obligations that a particular student has to a teacher and the classroom, and the mathematical obligations that a student has to him or herself.

In this study, I draw upon this interpretive scheme to examine DHH students' general classroom and mathematical obligations, how the classroom is structured, how mathematics is performed, and how a student exercises agency. I am especially interested in the ways DHH students contribute to and identify with the normative mathematics identities that are established in their mathematics classrooms (Cobb, Gresalfi, & Hodge, 2009; Gresalfi, Martin, Hand & Greeno, 2008). Applying Cobb, Gresalfi, and Hodge's (2009) interpretive scheme allows me to look at how the DHH students in this study are positioned in the particular mathematics classroom and how their mathematics identities are co-constructed in this classroom by themselves, peers, teachers, and others.

CHAPTER 3 RESEARCH METHODS

Through this study, my goal has been to understand how DHH middle grade learners narrate their mathematics experiences and co-construct their mathematics identities in a self-contained DHH mathematics classroom. Mathematics identities are co-constructed based upon individuals' beliefs about themselves as learners and doers of mathematics and others' constructions of the individual. In this study, I explore the following questions:

- How do these particular DHH learners narrate their identities in this classroom setting? Specifically, what it means to be DHH in the context of mathematics learning and what it means to be a learner and doer of mathematics in the context of being DHH.
- How do these DHH students perceive and co-construct their mathematics identities, particularly in relation to the normative mathematics identity in their classroom and the ways the students are positioned?
- In the contexts of narrating and performing their DHH and mathematics identities and within the affordances and constraints of their classroom practices and structures, what forms of agency emerge among these students?

An investigation of these questions requires a systematic design, which includes the individual narratives and stories of the DHH learners, as well as an in-depth examination of classroom behaviors and practices. I explore these students' mathematics identities through their narrated stories and experiences, recognizing that stories about an individual may be different from different sources. I also examine the students' identities-as-practice, which includes the ways the DHH students are positioned by themselves and others and the ways the DHH students exercise agency in the particular mathematics classroom.

3.1 <u>Phenomenological and Narrative Research</u>

My research is grounded in the belief that qualitative, or interpretive research, focuses on substantive meaning (Erickson, 1986). Qualitative inquiry facilitates the discovery of new insights in the field of DHH mathematics education, particularly given the unique DHH classroom contexts and each DHH student's unique educational experiences. "Even within the deaf community, no two DHH learners will necessarily be the same because their experiences vary widely, given the environments, audiological levels, etiologies, ages of onset, language/communication, and any disabilities (not deafness) that might be present" (Pagliaro, 2015, p. 183). Studying DHH students' mathematics experiences in the classroom requires an understanding of not only the identifications and labels imposed on them as DHH individuals, but more importantly, the views that each DHH learner holds about d/Deafness and mathematics. Thus, exploring questions about meaning for DHH students through qualitative research is vital to advancing educational research in mathematics of DHH: documenting and making visible what is happening and understanding these phenomena through specific and concrete documentation (Erickson, 1986).

I study mathematics identity through a phenomenological lens, to examine the mathematics experiences a group of DHH students in a self-contained classroom and narrative case study inquiry to study specific student cases of the phenomenon. This investigation employs phenomenology to focus on the lived experiences of four DHH learners (Bogdan & Biklen, 2003). Phenomenological research considers the subjective interpretations of the participants and seeks to understand how the participants make meaning of their experiences (Moustakas 1994; Wilson, 2002). In this view, social realities are studied through the meaning that people give to reality (Bernard, 1995). Meaning is socially constructed, and thus phenomenological research provides a way "to interpret and understand how behavioral outcomes and coping strategies are linked to the social experiences and meaning-making processes of humans given their intersubjective and relevant encounters with others" (Spencer, M., 2006, p. 697). In this study, I examine the phenomenon of what it means to be a student in a self-contained DHH classroom. I explore how the students makes meaning of their mathematics experiences, within the context of the classroom behaviors and practices.

I utilize case study within the overall phenomenological approach (Yin, 2003). While phenomenological study examines the meaning of the lived experience for a group of individuals in the mathematics classroom, narrative case study inquiry enables me to study an individual DHH student's experiences and explore how his or her experiences shape his or her perceptions about what it means to be a learner and doer of mathematics (Ballad & Bawalan, 2012). I draw upon Patton's, strategy of intensity sampling, which involves selecting rich cases that represent the phenomenon (as cited in Mertens, D.M, 2010, p. 321). In this study, I collected data from all four DHH students in the classroom and I chose to analyze the cases of Anna and Vivian in greater depth to provide rich examples of how mathematics identities are co-constructed in a DHH self-contained classroom. Both Anna and Vivian are positioned and described by others as competent mathematics learners, yet analyses reveal they internalize the classroom obligations and describe their own competence differently. Anna, on one hand, sees herself as a competent and successful mathematics learner. Vivian, on the other hand, believes that although she may be successful in this classroom context, she is not a competent mathematics learner. Through a case study approach, I explore how Anna and Vivian interpret the obligations in the classroom and how they identify with and take up those obligations. I highlight specific examples of how Anna and Vivian narrate their mathematics experiences in this self-contained classroom. I build upon the examination of what is happening in the classroom, to look closely at how these individual students' views of d/Deafness, current and prior experiences, and valuations of the classroom obligations may be consequential to the development of their mathematics identities.

3.2 Data Collection

Through interviews, observations, and analyses, I provide new insights about how these DHH students experience learning mathematics in this classroom and what it means for these students to be learners and doers of mathematics in this classroom. While this study does not represent the larger DHH population, I believe that researchers and educators will relate to and learn from these students' narratives and classroom experiences, and use this study as a springboard for further research, to improve mathematics teaching and learning among DHH students. Furthermore, I hope that sharing and exploring the mathematics experiences of DHH learners will be empowering to the learners (e.g., Ayers, 1990).

Data was collected during the Spring of 2015. Multiple forms of data were collected: a short interview with the administrator for the DHH program; thirteen semi-structured, open-ended interviews with four DHH students, individually and in groups, and two semi-structured, open-ended interviews with the teacher; classroom observations; and collection of selected student work and journals. The duration was eight weeks long with individual and group interviews, reflections, and one month of daily observations of the mathematics class.

Table II provides a summary of the data collection.

Table I. Timeline for Data Collection

	Data Source(s)	**Participants**	**Data**	**Time**
Consent forms	NA	All participants	4 student and parent consent forms 1 teacher consent form 1 administrator consent form	Week 1
Initial Interviews	Semi-structured interview: Video data and notes	Administrator	1 interview	After consent forms are returned Week 1-2
		Teacher	1 interview	
		Students	4 individual interviews	
Classroom observation	Classroom observation video data	Teacher	17 days of classroom instruction	Daily for one month Weeks 2-6
		Students		
	Classroom observation field notes	Teacher	17 daily field notes	
		Students		
	Interviews: video data	Students	4 group interviews with Vivian, Mario, and Anna 1 individual interview with James	Weekly Weeks 2-6
	Notes, journals, and student work	Students	Photocopied notes from all four students	Collected at the end of the month-long observation[4]
	Informal conversations with teachers	Teacher	Multiple times per week	When possible Weeks 2-6
	Self-reflection memos	Researcher	17 daily memos	Throughout month-long observation Weeks 2-6
Final interviews	Semi-structured interview: Video data and notes	Teacher	1 interview	After the month-long observation is complete Weeks 7-8
		Students	4 individual interviews	

[4] The students did not save any of their class notes and did not utilize the journals. Limited data was collected.

Figure 3 below depicts a logic model of the research design:

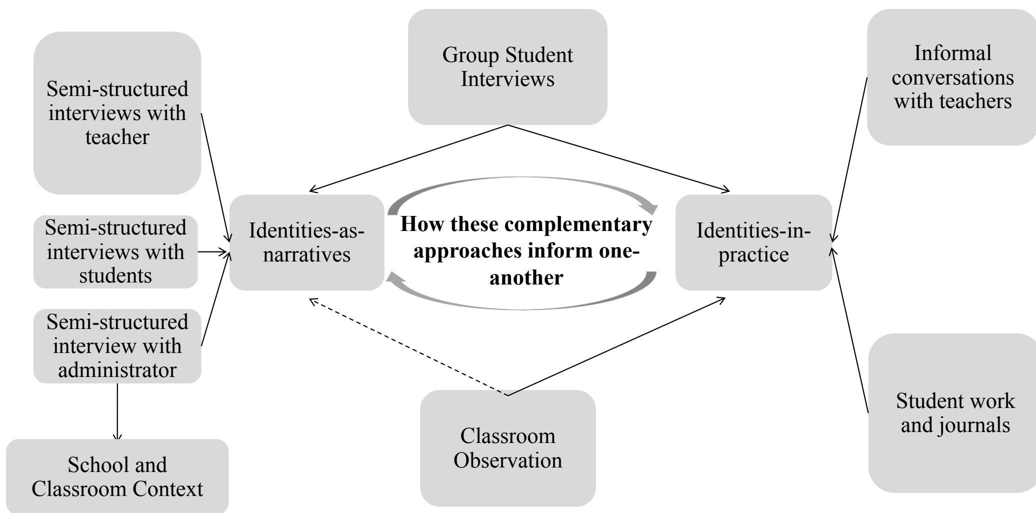


Figure 3. Logic Model of the Research Design

Identities as narratives are explored primarily through collective stories from one-on-one interviews with the students, the teacher, and the administrator. Narratives from multiple sources, including the teacher, administrator, and other students, provide information about how students' mathematics identities are co-constructed in this particular classroom. An interview with the administrator provides information about the students' academic backgrounds, as well as broader information related to the school and classroom. A month-long observation is utilized to examine identities-in-practice in this particular classroom setting. Specifically, I observe the general and mathematical obligations in the classroom: how authority is distributed, opportunities to exercise agency and the ways that the students exercise agency, and what it means to be competent in mathematics. The classroom observations also provide information about the narrative identities. First, during the observations, students may share narratives and stories about their experiences as mathematics learners. Second, the classroom observation data may corroborate or challenge the participants' descriptions in the interviews. During the group interviews, I document the students' understandings of the general and mathematical obligations, their assessments of their own and others' competence, and their beliefs about who determines the legitimacy of the mathematical decisions in the classroom. Students may also draw upon stories and narratives about their mathematics experiences during the group interviews. Informal conversations with teachers clarify any questions that may arise concerning the classroom observation. Student work and journals were intended to be used as artifacts. In addition, while observing and engaging in semi-structured interviews, I wrote memos and reflected on my observations on a regular basis (Corbin & Strauss, 2007; Richards, L., 2005).

3.2.1 Interviews. Studying the co-construction of mathematics and DHH identities through narratives and experiences requires an understanding of the beliefs that the DHH individuals hold about d/Deafness and mathematics as well as their perceptions as learners of mathematics. Individual and group semi-structured interviews with teachers and students were conducted to help me understand how DHH students describe themselves, and how they are described by others as learners and doers of mathematics through the stories they share. Additionally, the interviews provided an opportunity to reflect on classroom experiences to better understand how students perceive and internalize their classroom experiences and identify with the mathematics. I explore the students' interpretations and valuations of the obligations of the classroom and how, when, and the ways they exercise agency. Moreover, I investigate when and why students identify with specific mathematics activities, as well as the mathematical obligations that a student has to a teacher and the classroom, and the mathematical obligations that a student has to him or herself.

Administrator and teacher participants were interviewed privately, and on an individual basis. Students were interviewed individually and in groups. Through semi-structured interviews, I document the stories and experiences that the participants share (Creswell, 2008). The purpose of the interviews is to understand the students' perceptions of their experiences as mathematics learners (e.g., Ayers, 1990). Interviews were constructed to help me understand the backgrounds and experiences of the learners and teacher in the study. Although I foreground the DHH and mathematics identities, I am aware of other points of intersectionality, such as racial, ethnic, and sexual identities.

Through extensive experience researching mathematics socialization and identities, Martin (2000, 2006, 2006, 2007a, 2008, 2012) has generated a question bank appropriate for exploring questions about mathematics identities. Many of the interview questions for this study, particularly for the student and teacher interviews, were adapted from Martin's interview protocol question bank. These questions served as a starting point to open the conversations, but were adapted based on the responses of the participants. Prior to the interviews, interview questions were peer-reviewed to evaluate whether the questions adequately addressed my research inquiries.

All interviews were videotaped with a stationary camera in a private location. The camera faced towards the participant, and I voiced my questions so that they were heard on the video. Positioning the camera to show both the participant and myself would have limited the visibility of the participant's hands and signs, and hindered my ability to transcribe the interviews. One major limitation is that I was not able to evaluate my own signing on camera, to determine whether my questions were clear and comprehensible. To ensure that the participants understood my signing, I asked them to repeat and re-word my questions, when necessary.

Interview with the Administrator of the DHH program. The administrator interview was conducted to gather general information to provide a context for understanding the school and classroom settings, as well as the students' educational backgrounds. The school administrator that manages the DHH program was asked to provide information, such as:

- How many DHH students attend the school? What grades?
- How many DHH students are mainstreamed? How many DHH students are mainstreamed for mathematics?
- How is mainstream/self-contained determined?

Teacher interviews. Although the focus of my research is the individual students, mathematics identities are co-constructed. As such, it is imperative to understand how the teacher describes the students, her beliefs about students' abilities, and her beliefs about her students' opportunities and limitations in the context of mathematics learning.

I conducted two interviews with the teacher: an initial interview at the beginning of the study, and a final interview at the end of the study. In addition, I took advantage of opportunities to engage with her throughout the month-long classroom observation. This included short, informal conversations and clarifications on any questions that arose. During the interviews, the teacher was given an opportunity to explain how her experiences have shaped her perceptions of these DHH students' abilities and success in mathematics. To evaluate how she perceives her DHH students as learners and doers of mathematics, she was asked to provide brief descriptions of each student in the study in order to explore her views of each individual student.

To make the teacher feel comfortable, I shared my research questions with her and did periodic member checks to make sure that her responses were represented as their intended meanings.

Initial semi-structured interview. The initial interview occurred during the first week of the study, before the month-long classroom observation. The purpose of the initial interview was to: (a) gather basic background information about the teacher, (b) understand the broader federal and district policies and initiatives that impact mathematics instruction in this DHH self-contained classroom, and (c) understand her general beliefs about the DHH students' abilities and success in mathematics. The primary focus of the initial interview was to obtain information about the teacher's broad perceptions of mathematics learning and instruction among DHH learners.

First, the teacher was asked to provide information about her educational and teaching history, including her undergraduate and graduate institutions and degrees, certifications and endorsements, years teaching mathematics, and years teaching DHH students. She was also asked about her preferred language, and mode of communication in the classroom so I could determine whether her preferred mode(s) of communication (sign, oral/aural, etc.) is the same or different than the students' preferred mode(s) of communication.

Next, she was asked to share how the various federal and legal initiatives impact classroom instruction for DHH students. I inquired as to how the adoption of the Common Core State Standards in Mathematics (CCSS-M) has or has not impacted her mathematics curriculum. I also asked what mathematics curriculum she currently uses, and who chooses the curriculum. Finally, I inquired how students are placed in her classroom; specifically, how her classroom was determined to be the least restrictive environment for each student.

In the last part of the interview, I explored the teacher's general views of DHH mathematics learning and instruction. I asked her to describe what it means to be a good mathematics student, and who is considered a good math student. I inquired as to whether there had been a change in her attitude toward teaching mathematics during the course of her teaching experience. I asked whether she believes that any factors prevent or discourage DHH students from taking mathematics, doing well, and sticking with mathematics. Other questions regarding the teacher's views of DHH learning in mathematics included:

- Do you think schools, teachers, and the world send a different message to DHH students than to hearing kids about their ability to do mathematics? How?
- Are DHH students treated any differently than other students? In what ways?
- What do you think schools and teachers should do to encourage students?
- Do you think your DHH students are expected to achieve and do as well in math as other students in the school?

During the initial interview, the teacher was also asked questions about the participating students' (perceived) abilities in mathematics. I asked questions about the grade level of the students, and whether she was satisfied with her math instruction. I also asked about the most difficult and most enjoyable parts of teaching mathematics to this particular group of DHH students. Finally, I asked general questions about each student participant in the study, including:

- How would you describe ____? Why do you say those things?
- How confident are you in ____ math ability? Why?
- How do others describe _____? Why?
- What is your outlook for _____future? Do you think there will be things that will prevent ____ from achieving those goals?

While these questions may have led to broad characterizations of the individual students, they also provided an opportunity for the teacher to offer context-specific characterizations. Identities are fluid, and not static, and the teacher's characterizations of the students are constructed in this classroom within the affordances and constraints of the classroom practices.

Final semi-structured interview. The final interview occurred the week after the classroom observations were completed. I asked the teacher to reflect on the students' performances and abilities, and her own classroom instruction. During this interview, I asked her to share stories and anecdotes to describe her understandings of the students' mathematics experiences over the course of the study. In addition, I brought specific questions I had formulated based upon my classroom observations. For example, I asked her to reflect on her instruction of front-end estimation and to explain whether she believed that the students understood the concepts (Ms. Wilson, personal communication, April 21, 2015).

Student interviews. Multiple interviews with students addressed the students' backgrounds, and classroom stories and experiences. Students were interviewed weekly, including an initial individual interview, four weekly small group interviews, and a final individual interview. Weekly interviews enabled students to reflect every week on the mathematics instruction received. Thus, students were more likely to remember specific experiences in the mathematics classroom.

A DHH student walking into a one-on-one interview may feel intimidated or uncomfortable, especially when being interviewed by an unfamiliar adult. In preparation for the interviews, I practiced American Sign Language with native signers. Fluency and clarity in sign language was essential to reducing stress, and putting the students at ease with me as an interviewer. In addition, I wore solid, non-distracting clothing, so that my signs were easily visible. At the beginning of each interview, I reiterated that the purpose was to understand what it means for DHH individuals to be learners of mathematics in this classroom. I explained to the students that I am interested in understanding how they see themselves as math learners, how they believe they are positioned in the classroom and the larger society, what limitations and opportunities they have had in their lives, and their approaches to gaining knowledge in mathematics. All students provided written consent at the beginning of the study. In addition, before beginning each interview, students were asked again whether they still consented to be interviewed. The interviews were videotaped using a stationary camera.

Initial interviews. Initial interviews were used to gather important background demographic information on the individual participants, including their age, educational backgrounds, and familial backgrounds (e.g., Do you have DHH parents or siblings? What language do you speak/sign at home?), and whether or not they had a cochlear implant (and why). Additionally, students were asked to describe how they see themselves as learners of mathematics, and the identities that others ascribe to them in relation to their DHH status and their mathematics performance. We explored perceptions of mathematics, how the students perceive themselves as learners, and how others position and perceive them as learners. Sample questions included:

Questions about the learner:

- How would you describe yourself as a person? Why do you say those things?
- How do others describe you? Why do you believe they describe you in these ways?

Experiences learning and perceptions of mathematics:

- Who are good math students? Who are not considered good math students?
- What was the highest math course you have completed? What math courses did you take in elementary and middle school? What kinds of grades did you receive?
- Are there any classroom experiences that you can remember in mathematics? Why are those instances most memorable? Did those experiences impact you - positively or negatively?

- Do you know anyone in your family or neighborhood who did mathematics on a regular basis, or whom you would say benefited from mathematics?

What it means to be a DHH learner and doer of mathematics:

- As a DHH student, do you think you were expected to achieve and do as well in math as other students?
- Do you think there are factors that prevent or discourage DHH students from going into mathematics, doing well, and sticking with it? Did any of those factors affect you? How?
- Do you think schools, teachers, and the world send a different message to DHH students than to hearing kids about their ability to do mathematics? How?
- Are DHH students treated any differently than other students? In what ways? What do you think schools and teachers should do to encourage students?
- How do you think DHH students can change these perceptions of DHH students in math classes?
- How can math education be improved?

At the end of the initial interview, the students were provided with blank journals. Students express themselves in a variety of ways. In order to reach different students, the students were told that, if they chose to, they could draw pictures, share their work from class, write stories, make collages, or use any other method to depict their mathematics experiences. At the end of the study, the journals were collected. None of the students in the study, however, used the journals to express their mathematics learning experiences.

Weekly interviews. I conducted weekly interviews with three of the students during their lunch period. The fourth student (James, pseudonym) was unable to attend the weekly group interviews, since he was mainstreamed for all other subjects and his schedule was different than the other three student participants. To accommodate this student's schedule, he participated in an additional individual interview, which addressed the same questions as the weekly group interviews.

The students were interviewed during their lunch period for approximately one hour in their classroom. In addition, at the end of the teacher's final interview, the students entered the classroom and began asking about our discussion. I asked the students if I could continue to record the conversation, and we began an informal conversation, where the students answered some of the questions I had posed to the teacher, including a discussion of their definitions of deaf, Deaf, and hard of hearing.

Although group interviews have limitations, such as revealing the identities of the participants, group interview data can be valuable. In a pilot study researching *personal identities,* Hodge (as cited in Cobb, Gresalfi, & Hodge, 2009, p. 57) found that group interviews elicited more information than individual one-on-one interviews. Drawing upon the group interviews conducted by Cobb, Gresalfi, & Hodge (2009), my group interviews focused on the students' interpretations of the mathematics activities, specifically emphasizing "their understandings and valuations of their general and specifically mathematical obligations, and on their assessments of their own and others' mathematical competence" (Cobb, Gresalfi, & Hodge, 2009, p. 57). The group interviews had four purposes: (1) to check my notes, (2) to understand students' interpretations of participation, behaviors, positioning, and understanding of mathematics, (3) to explore how and why students do, or do not, identify with particular mathematics activities, and (4) to further explore mathematics identities through narratives.

Classroom interactions and experiences in mathematics are interpreted and internalized by the learner. The meanings and interpretations of the learners are of utmost importance, since the individuals act and react based upon their perceptions of the interactions and experiences

(Spencer, M., 2006). As such, I conducted these periodic group interviews to understand the students' interpretations of mathematics instruction, and to document whether my notes and interpretations of the classroom observations were consistent with the participants' interpretations. If our notes were not consistent, I documented how my interpretations differed from student perceptions, and probed to find out why they differed. We discussed specific instances of mathematics instruction and learning, including their perceived understanding of the specific content and the obligations, their assessments of their own and others' competence, strengths, and limitations, their beliefs about who determines the legitimacy of the mathematical decisions in the classroom, and the ways that they exercise agency.

During our discussion, students were encouraged to explain "verbally" (using spoken or sign language), through their journal entries, or through their class work. How do they think they did? Why? Sample questions include:

- How confident are you in your math ability? Why?
- Is it important for you to do well in math? Why or why not? Does doing well in math seem to be important to the other students around you (DHH or hearing)? Why or why not?
- Do you think you could have done better than you did? Do you have a desire to go further?
- Are you satisfied with the math education that you are receiving?
- What are some of the most difficult things about learning math? Most enjoyable things?
- Do you think your teacher believes you can do well in math?

To explore their valuations of particular activities in mathematics, the students and I looked at specific problems that they had completed in class. Students were asked to share activities that were easy or difficult, and activities that they did or did not enjoy learning; they were asked to explain why they thought some activities were easier or harder, and more or less interesting than others. Using specific examples from class and their work, I asked them to explain whether they thought that the mathematics instruction for that week was meaningful and useful in their lives, and to explain why or why not. To understand how they perceived how the teacher positioned them, I asked whether or not they thought the instruction was fair, and if there were any factors that hindered or enhanced their mathematics learning. Students were asked to elaborate on all responses. At the end of each interview, I concluded with open-ended questions, asking the students to share additional thoughts or stories. This provided students with an opportunity to share additional aspects of what it means to be a learner and doer of mathematics.

Final semi-structured interview. After completing the month-long observations, all student participants were interviewed again individually. The protocol for the final interview was similar to the initial semi-structured interview, but was modified and adapted based on prior interviews and classroom observations. I also asked students about their plans for the future. More specifically, I asked if the student plans to take math in high school and college if it is not required, and how important is it to do well in mathematics for his/her goals in life.

Over the course of the study, I established rapport with the teachers and students, by being present in the mathematics classroom every day and engaging in weekly interviews. During the final interviews, the students opened up and initiated discussions, sharing additional stories and experiences. The questions for the final interviews were modified based on individual responses from the previous interviews and classroom observations. Since some students' perceptions may have shifted and changed over the course of the study, I looked for any differences in the narratives.

Throughout the data collection and analysis process, I continuously met with the participants to member-check and clarify any questions that arose. After each interview was complete, I transcribed the interviews. In American Sign Language, a sign can have multiple English meanings. To ensure that the transcriptions were accurate and complete, specifically that the transcribed stories reflected the intended meaning of the oral and signed stories, I checked interview transcriptions with the participants, when necessary.

I reviewed and cross-checked teacher and student interviews for convergence and divergence among teacher and student narratives. I looked to find overlaps and sought to understand discrepancies. If a student described him or herself as a particular type of learner, and this description was inconsistent with the teacher's narrative, I documented the divergence, then probed further to understand why a student's perceived motivation, competence, strengths, or perceptions of mathematics were disconnected from his or her teacher's perceptions.

3.2.2 Classroom Observations. The purpose of observing the mathematics classroom was to explore the normative mathematics identity in this classroom context and how the normative identity in the classrooms is constructed. Normative identity is constructed by students and teachers through interactions as the normative way of doing mathematics. Thus, it is how math is done in this specific classroom context.

Classroom observations occurred daily over the course of one month. During this time, I conducted the periodic interviews discussed in the prior section. I observed the classroom every day so that the students could get used to seeing me in the room. All lessons were videotaped with a stationary camera. The video camera was positioned to best see the students. Since the teacher voiced while she signed, I was able to capture the classroom dialogues, even when the teacher was not visible in the video. Since all students consented to participate in the study, it was not necessary to have the faces of the non-participating student blurred in the video.

I did not participate in classroom discussion. Since the purpose of the observations was to document classroom practices and activity structures, I sat in the back of the classroom, where the teacher determined to be the least disruptive placement for observation. During classroom instruction, I took field notes on my computer. Immediately following each classroom session, I reviewed my notes with the video data while it was fresh in my mind. Throughout the observation period, I also took reflective notes to document my interpretations and potential biases.

3.3 Settings and Participants

In this section, I describe the school and classroom context and the participants for this dissertation study. Information about the school and classroom setting is primarily provided by the school administrator, Ms. Clark and information about the teacher and students is provided by the individual. I will describe the general criteria for enrollment in the DHH program at the school, criteria for placement within the self-contained classroom, teacher qualifications, and the mode(s) of communication at school. As described in the previous chapter, DHH students are exposed to a wide variety of educational experiences, due to factors such as: classroom settings, mode(s) of communication, teacher's pedagogical and content knowledge, and the educational teams' interpretations of the *least restrictive environment* (LRE, 1997, PL 94-142). Detailed descriptions of the context of the school, classroom, and student body are necessary, in order to situate the participants' experiences in this particular mathematics classroom within the larger school context (e.g., Hand & Gresalfi, 2015; Shanahan, 2009). For example, all the students in this study were placed in a self-contained classroom. This means that each student's educational team has determined that education could not be achieved satisfactorily in a mainstream setting for these students. As will be described in the case study of one of the students, Vivian, her perceived inability to be successful in the mainstream classroom impacts her perceptions of her and all DHH learners' competence in mathematics. Even when she is successful in the self-contained classroom, she still sees herself as less competent than her hearing peers, and believes that she is ill-prepared for high school and real-life mathematics.

3.3.1 School Setting. This study was conducted at Water View Elementary School (WV, pseudonym), a K-8 private school located in a large Midwestern city. WV offers a DHH program within a larger, mainstream program. I chose this site because it: (1) offers both mainstream and self-contained classroom settings, (2) provides students with a traditional academic environment, rather than vocational training, and (3) is located in a large Midwestern city (e.g., Creswell, 2012; Patton, 2002 in Mertens, D. M., 2010;). Since d/Deafness is considered to be a "low-incidence disability," meaning that the incidence rate is less than 1% of enrollment (Individuals with Disabilities Education Act, 1997), few schools in this Midwestern school system have DHH programs. Conducting my study at WV enabled me to study multiple DHH students at the same facility, with a full-time, and not itinerant, teacher of the DHH. Moreover, DHH students who attend WV have diverse backgrounds, academically, racially, and economically.

According to the school administrator for the DHH program, Ms. Clark (pseudonym), WV is tuition-based but provides scholarships to all students in need. While the cost of educating each child is approximately $11,800/year, the school only charges $5,000/year tuition with the help of subsidies and scholarships. When DHH students apply to the program, the administrator evaluates the student's IEP to determine if the DHH program at WV would be appropriate. For example, if the student has additional disabilities, the administrator will refer that student to the public school system, since this private school does not have the same resources and services to accommodate additional disabilities. During the time of this study, 222 students were enrolled in the school, 31 of which were enrolled in the DHH program.

Ms. Clark describes the DHH program as “flexible” (Ms. Clark, personal communication, February 25, 2015). Since it is a private school, the school is not restricted by state standards and protocols. Although they are not required to follow all of the state guidelines that public schools are required to adhere to, the school chooses to follow state standards to the best of their ability, such as hiring teachers that are certified and trained in DHH education. Because of the flexibility of the program, DHH students are able to be mainstreamed into the hearing classrooms and hearing students who would benefit from small group instruction or instruction using more visuals and manipulatives are able to be reverse-mainstreamed into the DHH classrooms. Class schedules are organized to allow flexibility to move students between the DHH and hearing programs, when determined to be appropriate.

The school’s philosophy is to communicate through Total Communication (TC). Total Communication utilizes any communication mode/language representation or combination of modes/language representations with children who are DHH. The simultaneous use of speech and sign language, visual and contextual cues, and cochlear implantation and assisted listening devices are encouraged. At WV, some students communicate through sign language and others rely on their residual hearing to communicate orally. Not all mainstreamed students require an interpreter. In fact, many of them mainstream using only an FM system.

In the younger grades, some students are mainstreamed for mathematics. However, at the time of this study, none of the students in the seventh and eighth grade classrooms were mainstreamed. Per Ms. Clark, many factors that play into determining a student's classroom setting (e.g., mainstreaming versus self-contained) at WV, including:

(1) The DHH students' time at the school: DHH students are not mainstreamed immediately, so they are not overwhelmed by the mainstream environment and develop negative associations with mainstreaming;

(2) The mainstream teacher: If the mainstream teacher primarily lectures, it may not be a good classroom setting for DHH students. If, however, the teacher is more hands-on, then the classroom might be an appropriate setting for DHH students. In addition, the mainstream teacher must be open to making modifications for the mainstreamed DHH students;

(3) Grade level and organizational skills: Students are mainstreamed if they are on grade level or very near grade level, are able to work independently, and do not depend too heavily on teacher assistance;

(4) Parents' opinions: Parental support is an important factor for determining classroom setting;

(5) Students' maturity levels: Students are mainstreamed only if they do not disrupt the mainstream classroom; and

(6) Students' hearing loss: Students with profound hearing loss would need to have an interpreter. A student's ability to mainstream also depends on the schedules and availability of the interpreters. (Ms. Clark, personal communication, February 25, 2015)

3.3.2 Classroom Setting. At WV, no middle grade students were mainstreamed for mathematics at the time of the study. Therefore, this study only includes a self-contained classroom. Most research in mathematics education of the DHH focuses on schools exclusively for the DHH. Some research compares and contrasts self-contained DHH and mainstream classrooms (e.g., Angelides & Aravi, 2007). Limited research, however, includes studies of students in schools that offer both mainstream and self-contained classroom settings.

The middle grades mathematics classroom at WV has one teacher and four DHH students[5]. The administrator asserts that the students in the self-contained DHH classrooms are, for the most part, at grade level. The self-contained classroom uses McDougal Littell Course 1 for 6th grade level students and Course 2 for 7th grade level students. (Ms. Clark, personal communication, February 25, 2015)

3.3.3 Participants. This study examines one self-contained DHH mathematics classroom, with one teacher and four seventh and eighth grade students. This mathematics class includes all of the seventh and eighth grade DHH students at WV. At the time of this study, none of the middle grade students were mainstreamed for math. The administrator in charge of the DHH program, the teacher, and all of four DHH students in the class were recruited to participate in this study. The administrator, Ms. Clark (pseudonym), the teacher, Ms. Wilson (pseudonym) and all four DHH mathematics students—Vivian, James, Anna, and Mario (pseudonyms)—consented to participate in the study and thus were included in the study.

In this section, I provide a brief introduction to the teacher and each student, including information about their personal and educational backgrounds. In the findings chapters, I discuss how the DHH students describe themselves as a learners and doers of mathematics and how they are described by the teacher, the administrator, other DHH students, and others. Ms. Wilson is a participant in this study but is not a central unit of analysis. Her educational and professional background, and content and pedagogical knowledge, are discussed to provide a context for the

[5] In addition to the four DHH students in the mathematics class, several days a week, one hearing student sat in the classroom and completed independent work on other subject areas. He consented to being videotaped, but he did not participate in classroom discussions related to mathematics nor did he participate in the individual and group interviews.

study in which the students are the units of the analysis. Furthermore, since mathematics identities are co-constructed by an individual and others, Ms. Wilson's narratives are an essential component to understanding how the DHH learners' mathematics identities are co-constructed in this DHH classroom.

Teacher. Ms. Wilson first began teaching in January and had been teaching for two months when this study began. At the time of this study, Ms. Wilson did not have a teaching certificate. The administrator, Ms. Clark was assisting Ms. Wilson to find online and university programs to become certified in DHH education (Ms. Wilson, personal communication, March 2, 2015). Ms. Wilson learned sign language in elementary school, which had a DHH department and provided American Sign Language (ASL) classes. She signs and voices in English word order (as opposed to ASL).

Ms. Wilson recently graduated college, where she earned her degree in audiology. During her time in college, she was required to enroll in algebra, trigonometry, and statistics (Ms. Wilson, personal communication, March 2, 2015). She states that when she began teaching, she felt that she had forgotten much of the mathematics content (specifically, algebra, perimeter, and area) and re-taught the content herself. Ms. Wilson states that, "they say math stays with you but certain things, not really I would think" (Ms. Wilson, personal communication, April 21, 2015). Although re-teaching herself the skills and content gave her confidence to teach mathematics, she still believes that mathematics is difficult. She states that mathematics is especially hard for DHH students or students with other disabilities. Since concepts in mathematics build upon one another, if a student does not understand a concept, that student will miss everything that follows. (Ms. Wilson, personal communication, April 21, 2015)

Students. The student participants are in seventh and eighth grade. I chose to study middle school students because they typically have more developed receptive and expressive skills and can better understand their role in the study, compared to younger elementary school students at WV. The four student participants consist of two males and two females. Vivian and James are in eighth grade and Anna and Mario are in seventh grade. Vivian, James, and Anna follow the 7th grade mathematics textbook while Mario follows the 6th grade mathematics textbook. Anna is the only student working out of a grade-level text, and Mario is working out a different text than the other three students during mathematics class.

Table II. Student Participants

Name	**Gender**	**Age**	**Grade**	**Grade Level in Mathematics, according to the teacher and administrator**	**Ethnicity**	**Language(s) Spoken at Home**	**DHH Self-characterization**	**Classroom setting**
Vivian	Female	14	Eighth	Seventh	Hispanic	English, Spanish, and Sign Language	hard of hearing	Mainstream and self-contained
James	Male	13*	Eighth	Seventh	African American	English	hard of hearing	Mainstream and self-contained for mathematics only
Anna	Female	13	Seventh	Seventh	Hispanic	English, Spanish, and Sign Language	deaf	Self-contained
Mario	Male	12	Seventh	Sixth	Hispanic	English, Spanish, and (limited) Sign Language	hard of hearing	Self-contained

*James turned 14 during the duration of the study.

Vivian. Vivian is a 14-year-old eighth grader and has attended WV since first grade. Vivian identifies as hard of hearing and Hispanic. She lives alone with her mother and has four half siblings on her father's side. She is the only hard of hearing person in her family. She was born prematurely after a difficult delivery, where both she and her mother nearly died. Her family speaks English and Spanish at home and they know some sign language. Vivian communicates through speech and sign and has hearing aids in both ears. Vivian attends classes in both mainstreamed and self-contained DHH settings. Until last year, she was mainstreamed for mathematics. Due to social issues and minimal support from the mainstream mathematics teacher, she and her mother decided that she would be best in the self-contained classroom for mathematics.

James. James is in eighth grade and turned 14 years old during the time of the study. James is the youngest of four children, one half-brother, and a brother and sister, who are in their mid to late twenties. James is the only person in his family with a hearing loss. He identifies as hard of hearing and African American. He began attending WV in fourth grade. Previously, he attended a residential school for the DHH nearly four hours away. He enrolled in the residential school for the DHH in first grade, when he first began losing his hearing. Since he did not like living so far away from his family and friends, he transferred to WV. James is postlingually hard of hearing and explains that the cause of his hearing loss is unknown, but speculates that it may be related to his asthma[6]. James prefers to communicate orally and aurally with the aid of hearing aids, at home and in school.

James is mainstreamed for the majority of the day and is only in the self-contained classroom during mathematics. Until this year, James was two grade levels below in mathematics. This year, he was moved into the seventh-grade book, skipping sixth grade. James was not able to explain why he skipped a grade level (neither was Ms. Wilson).

[6] While it not uncommon for individuals who have asthma to suffer from temporary bouts of otitis media, it has not been established that there is a direct link between asthma and hearing loss (but are often coincidental).

Anna. Anna is 13 years old and is in the seventh grade. She has been at the school since kindergarten. Anna identifies as Hispanic and deaf, and is the only deaf person in her family. She is an only child and lives at home with her parents and her French Bulldog, and has a large extended family. Although Anna has a cochlear implant, she prefers to communicate through sign and not verbal language and explains that she often chooses not to use the cochlear implant. Both of her parents sign at home. Anna is in the self-contained DHH classroom for the entire day.

Mario. Mario is 12 years old and transferred to WV five years ago at age 7. Mario identifies as Hispanic and hard of hearing. Prior to attending WV, Mario attended a hearing school. Mario has one younger sister, who is also DHH and attends WV. Mario's mother speaks only Spanish, but his father speaks English and signs. Mario was born hard of hearing and is able to hear and communicates orally and aurally with the use of his hearing aids. Mario is in the self-contained DHH classroom all day. In mathematics class, he is the only student using the sixth-grade text.

3.4 Coding and Analysis

Interpretation and analysis of the data through a phenomenological lens relied on the participants' interpretations of their own experiences in the mathematics classroom and their interpretations of each other's experiences, as well as the ways their interpretations have shaped their perceptions of what it means to be a learner and doer of mathematics. The analytical approach was for the participants to share their stories through in-depth interviews and reflections of classroom experiences, in order to understand their perceptions of their mathematics experiences (e.g., Moustakas, 1994; Strauss & Corbin, 1990). The participants in this study narrate their experiences through sign, speech, and combinations of sign and speech.

The narratives include verbal and signed stories as well as verbal and signed dialogue among the students, the teacher and students, and myself and the students and/or teacher. To analyze the data, the narratives were transcribed into written form. As I noted earlier, signs may have multiple English translations. Therefore, when necessary, I checked my transcriptions with the participants to confirm that the transcriptions reflect the intended meaning.

The analysis is descriptive and explanatory, and consists of thematic development (Creswell, 2008, p. 477). I used open coding (Strauss & Corbin, 1990) to attend to the participants' perspectives in order to group segments, and to generate common themes (Mertens, D. S., 1990). I drew from and applied two interpretive schemes for studying mathematics identity: identities-as-narratives and identities-in-practice. I began by analyzing the interview data to examine identities as narratives.

3.4.1 Coding and Analyzing the Interview Data. The interview data included one interview with the school administrator, initial and final interviews with the teacher and each of the four student participants, four group interviews with Vivian, Mario, and Anna (Vivian was absent for one of the group interviews), and an additional individual interview with James, who was unable to participate in the group interviews due to scheduling. All interview data was first transcribed in InqScribe then transferred into MAXQDA for coding. Analysis of the interview data was an iterative process and consisted of four stages: (1) read each transcript and code observations; (2) transform codes into emerging themes, (3) cluster the themes and look for patterns, and; (4) create a table of the themes to show the structure of the themes and subthemes.

Initially, there were two purposes for examining the interview data: to code for descriptions of the district, school, and classroom context and to code for identities as narratives. To contextualize the study, I coded for any references to the district, school, and classroom. This information was used to describe the school and classroom setting in the previous section and to situate the learners' experiences in this mathematics classroom. The following codes developed related to the district, school, and classroom contexts: (1) classroom setting; (2) curriculum and instruction; (3) school background; and (4) teacher background. To code for identities as narratives, I engaged in a two-way analysis, applying framings from research involving issues of identity and agency, and also analyzing the data for emergent themes (Glaser & Strauss, 1967).

Coding for Identities as Narratives. One goal of analyzing the interview data was to examine how these DHH learners narrate their identities: what it means to be DHH in the context of mathematics learning, and what it means to be a learner and doer of mathematics in the context of being DHH. Both verbal and signed forms of narrating contribute to identity development. Another goal was to examine how the students interpret and identify with the obligations in this specific classroom context.

Interviews were analyzed to understand the multi-layered experiences of the DHH students in this study. Considering math socialization and identities as a narrative form (Martin, 2006, 2007a, 2009, 2012), I drew upon Sfard and Prusak's (2005) operationalization of identities that identities *are* narratives. Identities are collective stories, are not static, and are human made (Sfard & Prusak, 2005). The stories may be contradictory, but the focus is in the activity of identifying, rather than the endpoint (Sfard & Prusak, 2005). In my analyses, I attended to how the participants presently describe themselves and others in this classroom setting as DHH learners of mathematics, and how their stories describe their anticipated future. While I was primarily focused on the school and individual levels, I also documented narratives at the sociohistorical and community levels, paying close attention for narratives about the DHH community.

During the first stage of the analysis, reading the transcript and coding for observations, I coded each set of interviews for narratives related to mathematics experiences, mathematics identity, d/Deafness, and d/Deafness as it relates to mathematics socialization. Since mathematics identities are multilayered and include different intersectionalities, including racial identities, gender identities, sexual identities, and others, I paid close attention to see if and when, students narrated other identities. Martin (2006) describes mathematics socialization as, "the experiences that individuals and groups have within a variety of contexts that facilitate, legitimize, or inhibit meaningful participation in mathematics" (p. 206). I drew upon his conceptualization of socialization to code all stories and narratives related to present or prior mathematics experiences. Mathematics identities reflect how mathematics socialization experiences are interpreted and internalized to shape people's beliefs about mathematics and about themselves as doers of mathematics. A mathematics identity is always under construction and encompasses a person's *self* understandings as well as how they are constructed by *others*. Since mathematics identities are a negotiation between our own assertions and the external ascriptions of others, I coded relevant narratives about each individual student, including narratives about oneself and narratives from other participants in the study. These narratives enabled me to see how a student perceives and positions him or herself, and how others perceive and position that student.

To examine what it means to be a DHH mathematics learner in this classroom context, I coded narratives that specifically referenced hearing, d/Deafness, or being DHH. This included narratives about prior classroom mathematics experiences, in which students describe specific instances in a DHH classroom, or being DHH in a mainstream classroom. For example, Vivian describes what it was like to be the only DHH student in the mainstream mathematics classroom:

"I didn't like the way [the teacher] talked to me because I'm the only hard of hearing kid in her class …like she would move her mouth like she had never talked to a deaf kid before. That kind of hurt me a little" (Vivian, personal communication, April 15, 2015). In this example, Vivian explains that in the mainstream classroom, the teacher spoke to her differently than the other students. Vivian's segment was coded under "being DHH" and a memo was attached to note that this narrative referenced prior classroom experiences, and specifically being DHH in a hearing mainstream mathematics classroom. I also coded narratives related to perceptions of d/Deafness. For example, James discusses teachers' expectations of DHH students, stating, "I think that teachers and stuff they believe that deaf do the same as the hearing" (James, personal communication, March, 10, 2015). This segment was coded under views of "d/Deafness" and a memo was attached noting that this was James's perception of his teachers' beliefs. Through the process of coding the interview data for narratives related to hearing, d/Deafness, and being DHH, the following codes developed, based upon the descriptive memos: (1) d/Deafness; (2) learning and instruction in mathematics; (3) narratives about prior classroom experiences; (4) the value of mathematics; (5) what it means to be a good math student and what it means to be good at math; (6) descriptions of self; (7) descriptions by others; (8) math performance and ability, and; (9) behaviors and practices in the current mathematics classroom. The interview data was then recoded using these codes. Through the process of coding and recoding, additional sub-codes emerged. For example, "descriptions of self" were sub-categorized to include DHH descriptions, descriptions related to mathematics, and "other" descriptions, such as family. Not all codes applied to every student.

After this iterative stage of the coding process was complete, I looked within and across participants to categorize the codes by common patterns, transform the codes into emerging themes, and create tables to show the structure of the themes and subthemes. First, the coded narratives were uploaded into Excel files and I wrote descriptive memos next to the coded narratives. As I reviewed the memos, I grouped the narratives by the themes that emerged from the memos. Table III below provides examples of codes and themes that emerged across individuals:

Table III. Examples of Student Interview Coding for Narratives Across Students

Code	**Theme**	**Example**
Descriptions by Others	Positioning of Anna as the ideal student	Interviewer: Who do you think is the best math student in the class? Vivian: Anna. (Vivian, personal communication, April 15, 2015)
		Interviewer: Who is the best student in class? Mario: Anna. (Mario, personal communication, April 14, 2015)
		Interviewer: And why do you say Anna is the best math student? Teacher: she takes her time, she makes sure that she understands it, um understands it to the point where she can take it home on her own. (Ms. Wilson, personal communication, April 21, 2015)
Description of Self: Mathematics	One's own competence in mathematics	Interviewer: So before you said your teachers, they told you that you're smart and your parents they tell you you're smart, how else do you know that you're smart? Anna: I do hard math. Interviewer: Ok, and how do you know you do a good job? Anna: Time, good grades. (Anna, personal communication, April 13, 2015)
		Interviewer: do you think that you are expected to do really well in math? James: yeah because I'm really smart so I should be expected to do more. (James, personal communication, March 10, 2015)
Description of Self: d/Deafness	The salience (or not) of d/Deafness in the mathematics classroom.	Interviewer: do you think that the hearing aids and the cochlear implant help you guys in math class? To help you understand math better? Anna: When I hear, math better. Interviewer: When you hear? Ok explain more. Anna: Uhh, I hear and read lips. (Group, personal communication, March 25, 2015)
		Vivian: a hearing person who can understand quickly. a deaf person, it is slower…yes, I do math slowly…to me, a hearing person knows math easier than me. in the mainstream class I was frustrated all of the time. (Vivian, personal communication, March 4, 2015)

In the first row of Table III above, Anna is described by herself and others as the best student in the classroom. Under the code, *Descriptions of Self: Mathematics*, *One's own competence in mathematics* emerged as a theme. To illustrate, Anna states that she is smart because she engages in "hard math" and earns "good grades" (Anna, personal communication, April 13, 2015). In my memos, I documented that that Anna describes herself as a competent and successful student in this mathematics classroom, based upon her belief that she is receiving good grades while engaging in difficult mathematics.

A mathematics identity includes not only an individual's beliefs about him or herself, and his or her own perception of competence, but also the ways that individual is constructed by others. I attended to the descriptions of each DHH student by the teacher and other students. For example, as I wrote descriptive memos, it became evident to me that Anna is described by her teacher and peers as the best student in the class. As shown in Table III above, Ms. Wilson, Mario, and Vivian state that Anna is the best mathematics student in the class (Mario, personal communication, April 14, 2015; Ms. Wilson, personal communication, April 21, 2015; Vivian, personal communication, April 15, 2015). Coding the narratives for "descriptions of self" and "descriptions by others" reveals how Anna views herself, and how others view Anna as a competent mathematics learner.

In addition to looking for themes across individuals, I also looked for patterns within individuals. For example, when examining Vivian's narratives related to d/Deafness and her experiences in this mathematics classroom, she often discussed prior classroom experiences, and noted feeling "embarrassed" (Vivian, personal communication, March 4, 2015), "frustrated" (Vivian, personal communication, March 4, 2015), or like the "slow", or "stupid" kid (Vivian, personal communication, March 4, 2015; Group, personal communication, March 25, 2015), as shown in Table IV below.

Table IV. Example of Interview Coding for Narratives Within a Student: Vivian

Code	Theme	Example
Prior Classroom Experiences	Less competent, compared to hearing students	I think 2 years in 6th grade I had a hearing teacher. She didn't know sign language. I was the only hard of hearing girl in her class. she had an FM system and um never, didn't use it. I don't know why but it was it was a really really hard year for me in math because I was embarrassed. I was frustrated with math problems and I'd get in trouble with the teacher. (Vivian, personal communication, March 4, 2015)
		In 8th grade I did not go [to the mainstream classroom] because I was frustrated with math. I went to the deaf department for math. (Vivian, personal communication, March 4, 2015)
		A hearing person who can understand quickly, a deaf person, it is slower…yes, I do math slowly. To me, a hearing person knows math easier than me. in the mainstream class I was frustrated all of the time. (Vivian, personal communication, March 4, 2015)
		I feel like I'm slow when I'm surrounded by the deaf kids…I feel like a stupid kid. (Group, personal communication, March 25, 2015)
		I mean I've been to her class before and I was her 4th grade student and then she moved up, that year I didn't like the way she talked to me because I'm the only hard of hearing kid in her class and she would say go to the bathroom, like she would move her mouth like she had never talked to a deaf kid before. That kind of hurt me a little…it was like when she talked to me I felt like I was slow or something. (Vivian, personal communication, April 15, 2015)

Vivian's identity of a slower and less competent mathematics learner was unique to her, and this theme did not apply to the other students in the classroom. The other students in the classroom did not share narratives referring to themselves as less competent compared to their hearing peers. Vivian's unique prior experiences in the mainstream mathematics classroom shaped her perceptions of what it means to be a DHH mathematics learner. As shown in Table IV above, Vivian's identity as a DHH mathematics learner begins to emerge through her narratives. The ways that Vivian's prior experiences and her views about d/Deafness influence her views about competence in mathematics and her perceptions of her current experiences in the mathematics classroom, will be discussed in-depth in Chapter 6.

Narratives about Practices and Behaviors. To examine the identities-in-practice in the classroom, I had initially planned to code the classroom observation data for the general and mathematical obligations in the classroom. I then planned to return to the interview data to see how the students interpreted and identified with the classroom obligations. However, as I reflected through the process of coding and analyzing the interview data, I found that many of the narratives referenced specific behaviors and practices in this particular classroom. Although I planned to follow Cobb, Gresalfi, and Hodge's (2009) interpretive scheme and examine the normative identity through the classroom observation data, I decided instead to revisit the interview data and recode the interviews to examine the participants' conceptualizations of the normative identity, looking specifically for narratives related to the norms, obligations, authority, and agency. I coded statements related to what these DHH learners perceive to be the norms of the classroom, how they interpret and co-construct their mathematics identities in relation to the normative mathematics identity, and what forms of agency emerge among these students. The initial codes related to practices and behaviors were broad and included: (1) classroom norms; (2) authority in the classroom; (3) disciplinary and conceptual agency; and (4) identification with the general and mathematical obligations of the classroom. To examine the norms, I coded the students' and teacher's descriptions of actions and activity structures that occur in the classroom. I then documented which norms were mentioned repeatedly, and thus, the most salient. To code for the distribution of authority in the classroom, I documented who or what was responsible for determining the legitimacy of the responses, specifically when a student referenced a mathematical decision, determination of accuracy, or a mathematical contribution. Agency is defined as an action with regard to the mathematics content and the general classroom obligations. When students discussed using established solution methods, those statements were coded as disciplinary agency. When they mentioned choosing methods and developing meaning, it was coded as conceptual agency. Additionally, I coded statements referencing to whom the students are accountable, for what the students are accountable, and how a student identifies with the mathematical obligations. I inserted memos to note when a student described an obligation as an obligation to him or herself and when an obligation was described as an obligation-to-others. I also looked to see if and when students resisted the obligations in the classroom. Furthermore, I coded for evidence of the students' assessment of their own competence and the students' assessments of others' competence. These codes often overlapped with the *Descriptions of Self*, and *Descriptions of Others* codes in the section above.

The next stage of analysis involved clustering the codes into themes to look within and across participants. These themes included: (1) teacher and textbook as the authority, (2) general obligations: completing practice problems in class, following directions, and completing homework problems; (3) mathematical obligations: using established solution methods from the book and developing fluency in procedures; (4) positioning of students and the construction of what it means to be a good math student in this classroom context; (5) competence in mathematics; and (6) d/Deafness, as it relates to the norms and expectations.

Table V below provides select examples of data that was coded under three broader codes: norms, authority, and agency and examples of the themes, and sub-themes that emerged:

Table V. Examples of Student Interview Coding for Practices and Behaviors

Code	Theme	Sub-theme	Example
Norms	General	Completing practice problems in class	Interviewer: What do you do in math class? James: Um, we like we review. We have like tests after the review that we have. Interviewer: So you do review, you have tests, um what other things do you do? James: Um, she gives us problems to do on the board. Um from the book. (James, personal communication, March 26, 2015)
			Interviewer: Teacher says, "math class is staring now". And then what? Anna: Take out your worksheets and your math book and math notebook. Vivian: mm Ms. Wilson will put problems on the board. (Group, personal communication, March 18, 2015)
			Interviewer: What do you think it means to be a good math student? Teacher: ooh, what is means to be a good math student. I think to ask questions when you don't understand so that you don't fall far behind for the next lesson. To take in information on as many notes as possible for you to grasp information as quickly as possible and to just practice, practice as much as you can. I try to get them to practice a lot. We use the iPads for the fun class zone activities because any time you can use iPad's in a classroom it's a good day [laughs] I: Right ha (Ms. Wilson, personal communication, March 2, 2015)
	Mathematical	using established solution methods from the book	Interviewer: Do you think that you're allowed to solve the problems in different ways? Or is there only one way to solve the math problems? Anna: Before, I do it a different way. Interviewer: But now? Anna: Only one way. (Group, personal communication, March 18, 2015)
Authority	Teacher as the authority	Determination of accuracy	Vivian: I will know [I got the right answer] if I show Ms. Wilson and she will say yes. Interviewer: ok Vivian: And if she says no then she'll put it on the board and she'll problem solve it herself or let me solve it. (Group, personal communication, March 25, 2015)
Agency	Disciplinary	N/A	Vivian: Because we always learned it from the book and I always think that's the only way to do it so I'm like ok, so I have to follow. Interviewer: mm hmm Vivian: That's why my math problems is always one way. (Group, personal communication, March 18, 2015)

Normative identity includes the general and mathematical obligations and is founded upon both the teacher's and the students' expectations (Cobb et al., 2009). In Table V above, completing practice problems in the classroom is described recurrently as an activity structure across participants. This obligation is described by all four students and the teacher, showing their mutual understanding of this classroom obligation. In addition, James and Anna explain that in this classroom, Ms. Wilson assigns the practice problems, and the students are expected to complete those problems, and Ms. Wilson emphasizes the importance of practicing problems to be successful in mathematics.

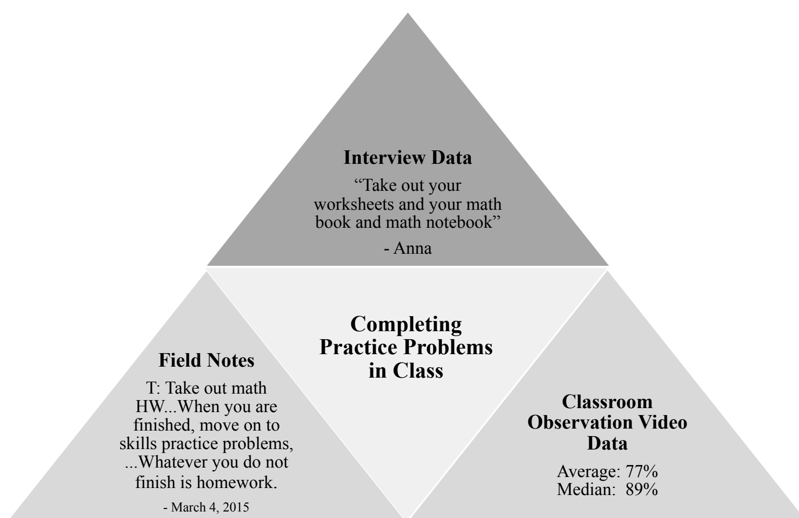
3.4.2 Coding and Analyzing the Classroom Observation Data. Rather than analyzing the classroom observation data and determining the obligations, I approached the observation data based upon the findings from the interview analyses. When I coded the observation data, I had three goals in mind: (1) to substantiate or challenge the narrated descriptions of the norms and obligations in the classroom; (2) to examine specific examples of when the narrated identities and the observed identities do or do not intersect, and; (3) to examine the students' assertions of their own and the other students' competence in mathematics.

My field notes were a primary source for characterizing the dynamics of the classroom context. In coding for important themes, I looked for specific instances to corroborate (or not) conjectures about general and specifically mathematical classroom obligations that emerged from the student interview data. I looked for recurrent patterns of norms in the classroom through teacher/student interactions, both general and mathematical. Specifically, I looked for: (1) occurrences of the teacher or textbook being positioned as the authority (and by whom); (2) evidence of the norms described in the narratives, and, furthermore, evidence of additional norms not described by the students or teacher; (3) evidence of students being positioned by the teacher, themselves, and other students in the mathematics classroom; as well as (4) contexts that allowed students to take on identities of competence and contexts that constrained these opportunities; and (5) contexts that allowed students to take on DHH identities and contexts that constrained these opportunities.

For example, in the interview data, the students narrated that much of their class time is spent completing problems, both from homework and in class. I analyzed the field notes, looking for specific examples to corroborate or refute this finding from the interview data. In addition, I time-segmented the observation video data to determine roughly what percentage of the classroom time was spent on the general classroom obligations of completing practice problems and reviewing homework problems. Time segmenting the video data corroborated that the students spend a large portion of their class-time completing practice problems.

Figure 4 below provides two examples of how I triangulate across multiple sources of data.

Example 1. The norm of *Completing practice problems in class*



Example 2. Anna positioned as the best student.

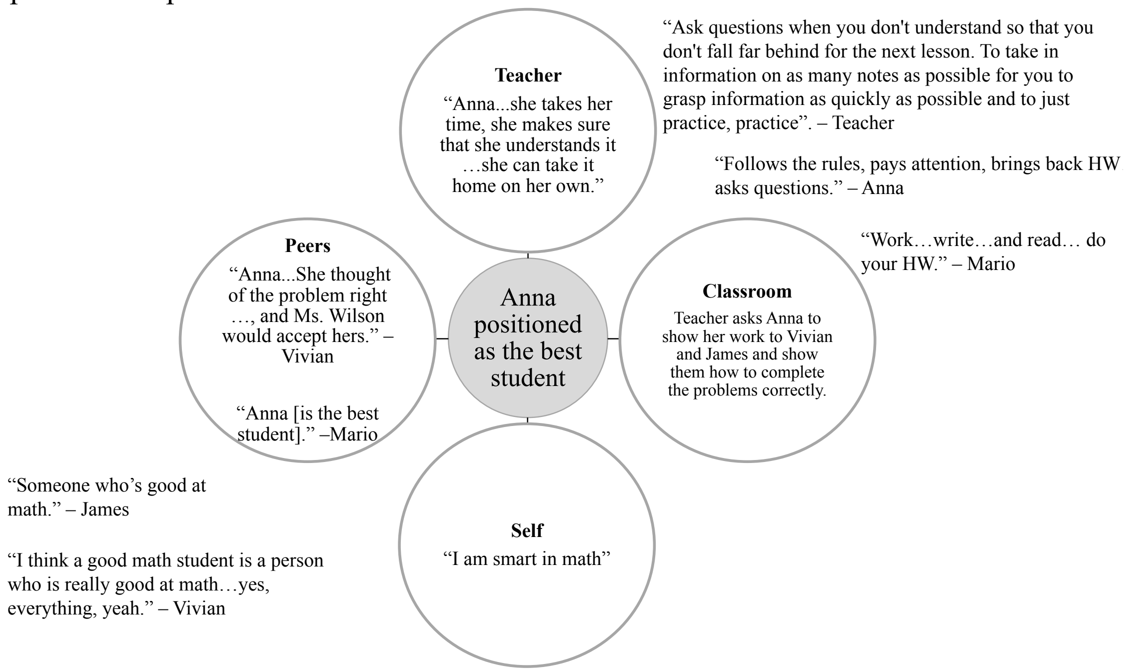


Figure 4. Two Examples of Cross-Data Analysis

As shown in the examples above, the themes that emerged from the interview data were triangulated across multiple data sources. I provide one example from each source of data, although other examples may exist. In Example 1, the obligation of *completing problems* emerged through the interviews, and was corroborated by the field notes and the video data. The three data sources support the conjecture from the narratives that *completing practice problems in clas*s is a salient norm in this classroom.

Example 2 provides a depiction of how is Anna positioned as the best student in the classroom. In the grey circles, I include narratives from Anna, the teacher, and two other students, Mario and Vivian, in which Anna is described as the best student in the class. In the fourth circle, I include evidence from the field notes, whereby Anna's work is modeled to the other students in the classroom. In addition to the data that explicitly references or positions

Anna as the best student in the class, the students describe what it means to be a good student in this classroom. The characteristics of a good math student are situated on the peripheral. James and Vivian assert that being a good math student means that one performs well in mathematics. This is closely tied to Anna's self-description of being "smart" (Anna, personal communication, April 13, 2015) and Vivian's description that Anna "thought of the problem right" (Vivian, personal communication, April 15, 2015). Ms. Wilson, Anna, and Mario describe a good math student as someone who does the work, follows rules, and practices. These characteristics relate to descriptions of Anna from Ms. Wilson's narrative as well as data from the field notes, where Anna is described as diligent and hard-working. In this example, the narratives from Anna, Vivian, Mario and Ms. Wilson, which describe Anna as an exemplary mathematics student, are consistent with the way that Anna is positioned in the classroom, as well as the characterizations of competence in this classroom. However, as I will describe in the findings, this positioning of Anna as a competent mathematics learner may be problematic, since Anna may not be engaging in high-level mathematics.

The students and the teacher characterize competence based upon accurately completing practice problems, but describe obligations that emphasize procedures and repetition. To investigate the students' assertions of their own and the other students' competence in mathematics, I examined the cognitive demands of the mathematics activities. By analyzing the cognitive demands of the mathematics activities, I examine the participants' characterizations of competence, relative to opportunities (or lack thereof) in the classroom to engage in high-level mathematics.

I applied Smith and Stein's (2011) *Task Analysis Guide* framework to evaluate the cognitive demands of the mathematics activities involving: scale factor for Mario and division of decimals for Anna, Vivian, and James. The field notes were segmented into activities, which were marked by shifts in the mathematics content. During classroom instruction, Ms. Wilson circulates around the classroom and works with students individually and in groups. The student-teacher and student-student interactions surround specific mathematics problems and procedures. Each activity segment involves the teacher and/or one or more students either completing a specific mathematics problem, or discussing the rules for solving a particular type of mathematics problem.

To evaluate the cognitive demands of the activities, all segmented activities from the field notes involving scale factor and division with decimals were mapped using the *Task Analysis Guide*, which was developed to analyze mathematics tasks for the task features and cognitive demands. Smith and Stein (2011) focus on mathematics tasks set up by teachers in classrooms, and as implemented by students in classrooms. The *Task Analysis Guide* was intended to help teachers align assessment tasks with their goals for student learning. By utilizing this framework, I categorized the mathematics activities as having low-level and high-level demands, which is further broken down into the following subcategories, low-level: *memorizatio*n and *procedures without connections*, and high-level: *procedures with connections* and *doing mathematics*.

The excerpt below is an example of an activity segment from the field notes. Ms. Wilson is working with Mario on a problem involving scale factor. In the problem, Mario is told that the ratio from the image to the object is 2cm:10cm. The length of the image is 12 cm and Mario is instructed to find the actual length of the object.

> Day 8, March 13, 2015: Scale Factor
> Teacher and Mario
> Teacher: So, Mario, what does it say?
> Teacher rereads the question and tells Mario to do the problem at the board. Mario walks to the board.

Teacher looks at Mario's work and tells Mario to write "the 2 dots" (i.e., the ratio symbol).
On board: 2cm:10cm
Mario: 2 times 12
Teacher: No, it became 12, so 2 times what is 12?
Mario: 6
Teacher asks Mario to compute the object's actual length.
Mario: Times 2
Teacher: Times 2?
Teacher writes on board:

$$\begin{array}{cc} 2cm: & 10cm \\ x6 & x6 \\ = & = \\ 12 & 60 \end{array}$$

The mathematics performed in the activity segment above with Mario is algorithmic, unambiguous, focuses on the correct answer, and does not require any explanation. Thus, it was categorized as a lower level cognitive demand, and, more specifically, an activity segment involving *procedures without connections* (e.g., Smith & Stein, 2011).

In total, thirteen of the fourteen mathematics activities involving scale factor were categorized as low cognitive demand and thirty-three of the thirty-four mathematics activities involving division with decimals were categorized as low cognitive demand using the *Task Analysis Guide.* The findings will be discussed in Chapter 5.

In the next three chapters, I will describe in greater depth the findings from the coding and analyses. I chose to focus my discussion on the classroom obligations: what obligations are identified, how they are interpreted, and the ways the learners identify with the obligations. Additionally, I investigate the characterizations of competence in this classroom and who has the authority to determine the accuracy and legitimacy of mathematical solutions. I look at what the students are accountable for mathematically, and how this may be consequential to their identity development. Subsequently, I describe the findings from the case studies of two students, Vivian and Anna, to examine the extent to which these two DHH students identify with the classroom obligations and the characterizations of competence. These cases provide rich examples of how DHH students perceive and co-construct their mathematics identities in a self-contained classroom, in relation to the normative mathematics identity.

CHAPTER 4 PRACTICE-BASED NARRATIVES

When studying the students' identities as narratives, what emerged was not only stories about oneself and self-doing, but also specific stories and narratives about behaviors and practices situated within the context of a specific classroom setting. The purpose of this chapter is to examine the students' narratives about practice and behaviors, which are embedded in the stories and descriptions these students share about themselves as DHH learners in this particular mathematics classroom context. In this chapter, I highlight the importance of attending to how the students describe the norms, obligations, and behaviors in the classroom, and thus the students' interpretations of the normative identity in the classroom. I will explain how these students take up the obligations, and how this may be consequential to the development of their DHH and mathematics identities. Segments from the classroom observation data serve to corroborate, expand upon, or potentially refute the obligations described by the students.

Through this investigation of the students' narratives about classroom practices, I highlight that attending to the students' interpretations of the obligations is an important component to understanding how these students describe what it means to be a learner and doer of mathematics in relation to their experiences with peers, teachers, and others in this particular classroom setting. Considering the students' beliefs about what it means to do mathematics in this particular classroom exposes complexities of studying mathematics identities in classrooms, as it emphasizes that these students' identities are expressed and manifested in particular ways because of this specific context. That is, the particular situation in the classroom allows the students to narrate their identities in these particular ways.

I will explain some of the classroom practices and behaviors that emerged through the interview data, noting that not every one was described by each student. I will highlight contexts in which the students express particular aspects of their identities and contexts which afford or constrain the students' identity development. For some students, a particular obligation might be an affordance. For others, it might be a constraint or a restriction. Furthermore, the same person might narrate two different, or even seemingly contradictory, aspects of his or her identity.

4.1 Narratives Related to Classroom Norms, Obligations, and Normative Identity

This section describes the norms, obligations, and expectations that prevail in this classroom, based upon the students' narratives. According to Cobb, Gresalfi, and Hodge (2009) normative identity does not refer to the students' self-descriptions and views; rather normative identity "comprises both the general and the specifically mathematical obligations that delineate the role of an effective student in a particular classroom" (p. 43). Personal identities encompass the degree to which the students identify with the mathematical expectations in the classroom as well as the characterizations of competence in the classroom. In order to examine the extent to which the students identify with the expectations in the classroom, it is critical to examine the students' valuations of the general and mathematical obligations, and the students' assessment of their own competence, as well as their assessment of others' competence.

In their interpretive scheme, Cobb, Gresalfi, and Hodge (2009) document the general and mathematical obligations and the normative identity as a learner and doer of mathematics through classroom observation data. In the current study, descriptions of the classroom norms, expectations, and obligations emerged through my coding and analyses of the student and teacher interviews. I draw upon Cobb et. al's (2009) interpretive scheme to describe the salient norms and obligations in this classroom from the perspectives of the students and teacher, based upon their narratives about the classroom practices and behaviors.

Normative identity is a "communal notion" and reflects both the general and mathematical obligations as they are established, based upon the teacher's and students' expectations in this specific classroom (Cobb et al., 2009, p. 43). Furthermore, the collective expectations in the classroom, which may be interpreted differently across teachers and students, contribute to the norms in the classroom. Norms are actions and activity structures that occur repeatedly in the classroom. The general and specifically mathematical obligations are the attempt to fulfill or resist the structures in the classroom by adhering to the jointly constructed expectations. For example, as will be elaborated upon later in this chapter, students in this classroom are expected to complete a set of practice problems each day. Nearly every day, the students walk into the classroom and fulfill the obligations by checking their homework problems and completing the newly assigned problems. The students and the teacher both describe a competent mathematics student as someone who successfully completes the assigned problems. Thus, the ways that the students identify as mathematics learners and define their competence is founded upon the classroom expectation of completing assigned sets of practice problems. This analysis is not an examination of "specific classroom incidents"; but rather the students' and teacher's collective "appraisals of how the classroom 'works'" (Cobb et al., 2009, p. 64).

I describe the general and mathematical classroom obligations from the perspectives of the students, with specific examples from the classroom to support (or not) the students' descriptions. Subsequently, I discuss the kinds of identities that are made available to the students, given the normative identity in this classroom. Each student interprets and perceives the norms through a unique lens. Furthermore, because of each student's sense of positionality and sense of identity, s/he will take up the norms in different ways. Although the norms in the classroom may shape behaviors, they do not shape the identity in totality. The students' narratives provide insight into the students' identifications of the norms and to whom the students are accountable; to see how the students identify with the obligations. By examining the narratives, norms and obligations are not objectified as a given and careful consideration is given to the fact that each student defines the norms and obligations in different ways.

4.1.1 Authority to Make Mathematical Decisions in this Classroom. When exploring normative identity, the *distribution of authority* in a classroom is an important aspect of general classroom obligations to consider. Examining the students' narratives about who has the authority in the classroom sheds light on the students' perceived role (or lack thereof) in the mathematical decision-making in the classroom, and to whom they are accountable. (Cobb, Gresalfi, & Hodge, 2009)

The student interview data was coded to determine the narrated authority(ies) in the classroom. Each time a student referenced mathematical decision-making, accuracy of solutions, or mathematical contributions, I coded who or what was responsible for determining the legitimacy of the responses. Twenty-one out of twenty-eight references indicated that Ms. Wilson has the authority to determine the legitimacy of the mathematics responses in this classroom. This coding revealed that the teacher is described as the primary authority in the classroom, and is responsible for deciding whether or not the students' responses are acceptable. Mario and Vivian believe that all adults, and thus Ms. Wilson, have knowledge and understanding of mathematics simply because they are adults (Group, personal communication, March 12, 2015; Vivian, personal communication, April 15, 2015). Vivian states that she does not question the teacher, even when she thinks she may have found a different way to solve a problem. Vivian asserts that, "[adults] learn the math that, the math that we're learning they learned it before, they probably understand it more" (Vivian, personal communication, April 15, 2015). Anna believes that a good teacher, "can explain a lot of things, and show examples" (Anna, personal communication, March 5, 2015). That is, a good teacher *shows* the students how to solve problems and *provides* examples and explanations. Ultimately, it is the teacher that establishes what it means to engage in mathematics.

Furthermore, Mario views the teacher as the *only* authority in the classroom. If the teacher is busy, he will either skip a problem, or sit and wait for Ms. Wilson to come to his desk and explain the problem to him (Mario, personal communication, April 14, 2015). This is particularly interesting because the other three students in the classroom are a grade level ahead in mathematics, and presumably, have already learned that mathematics content. However, he never mentions the other students as knowledgeable resources. Table VI provides examples from the student interviews, which illustrate how the students perceive the distribution of authority in the classroom.

Table VI. Examples of Narratives Related to Authority in the Classroom

Authority	Participant	Example from Interview Data	Source
Teacher	Vivian	Vivian: I will know [if I am correct] if I show Ms. Wilson and she will say yes. Interviewer: ok Vivian: And if she says no then she'll put it on the board and she'll problem solve it herself or let me solve it	Group, personal communica-tion, March 25, 2015
	Anna	Interviewer: If Ms. Wilson explains but you still don't understand, what do you do? Anna: I ask about parts Interviewer: So you ask about parts. Who do you ask? Anna: Ms. Wilson	Group, personal communica-tion, March 25, 2015
	Mario	Interviewer: Why do you think it makes it easier to work with Ms. Wilson? Mario: Because she knows it.	Group, personal communica-tion, March 12, 2015
Classmates	James	Interviewer: Yeah? Ok. So do you think that you did a good job in class this week? James: Mm hmm Interviewer: Yeah, how do you know? James: Um working, with, well we're not really working in groups but like working with the kids, we can compare answers and stuff and um. Working with the kids they're um, I guess from like working with the kids and stuff.	James, personal communica-tion, March 26, 2015
	Anna	Anna: First, maybe ask them. Interviewer: Ask your friends? Ok, who would you ask? Anna: Vivian. Interviewer: Vivian? Ok, does Vivian help you? Does Vivian help you understand? Anna: She will.	Anna, personal communicati on, April 13, 2015
Self	James	James: Oh well I kind of, I proved one of the math teachers wrong on a math problem. Interviewer: When? James: This was last, uh the teacher before Ms. Wilson. She said I got all the answers wrong. Then one time I proved her wrong. Interviewer: And how did you feel? James: I was like "yeah". [raises arm]	James, personal communica-tion, March 26, 2015

In the excerpts above, Vivian's statement exemplifies that it is the teacher who determines whether or not a solution is accurate and acceptable. When Ms. Wilson finds that Vivian's solution is not correct, Ms. Wilson either allows Vivian to complete the problem again, or completes the problem for Vivian, thus reinforcing that Ms. Wilson has the authority to determine the legitimacy of a solution (Group, personal communication, March 25, 2015). Anna and Mario state that they defer to Ms. Wilson when they are unable to complete a problem independently, since Ms. Wilson is more knowledgeable (Group, personal communication, March 12, 2015). Specifically, Anna asks Ms. Wilson to break down the problems into smaller parts, to help her attain accuracy. James and Anna also reference other students as knowledgeable and capable of evaluating the legitimacy of a solution. James, for example, states that he compares his work to his peers, to determine his own competence in mathematics (James, personal communication, March 26, 2015) and Anna states that she consults with Vivian (Anna, personal communication, April 13, 2015). Unlike Anna, Mario, and Vivian, James is the only student who sees himself as an authority in the classroom. James cites a time when he proves a teacher wrong, thus positioning himself as worthy of making mathematical decisions and of challenging the authority in the classroom (James, personal communication, March 26, 2015).

Furthermore, analysis of the students' narratives about authority in the classroom reveal that, in this classroom, authority is primarily viewed as the power to determine the accuracy of a solution, and thus how an individual student knows s/he is successful in mathematics. For instance, Mario states, "[I know if I did a good job] because I know the answer" (Group, personal communication, March 25, 2015). As a result, the students base their assessments about themselves as learners of mathematics on their accuracy. James, for example, describes himself as an authority in mathematics when he is able to show a teacher that his solution, and not the teacher's solution, is correct. In this classroom, the legitimacy of the responses is determined by the accuracy of the solutions, which is primarily determined by the teacher.

Based on the narratives, the students are accountable to the teacher, are expected to complete the work assigned by the teacher, and the legitimacy of the solutions is determined by the teacher. As the main authority in the classroom, Ms. Wilson has the power to determine the accuracy of the students' solutions, and, thus determine the legitimacy of the students' responses. However, although Ms. Wilson means well, she lacks content and pedagogical training and preparation in mathematics. This is problematic as the students' construct their perceptions of what it means to do mathematics based upon inaccurate assumptions of the teacher's mathematical knowledge. Ms. Wilson explains that she has difficulty explaining some concepts to the DHH students, such as scale factor. She describes her need to self-teach the mathematics content that she plans to teach the students in school:

> "I felt pretty confident in those skills, it was a lot of me going home and reading before I got to teach it to them because I didn't want to get up and get stuck and say 'I didn't know that was coming up, I didn't know what to do about that'. But I'm not going to lie it was a challenge to go back to the grade school math coming from the statistics, the algebra, the things that got more complicated as I got older and you think perimeter and area, it's easy to learn it and then you look at it and ok it's not that easy anymore, it's things that I have to re-learn and I have obviously and things that I really didn't have much experience with because once they teach it, it kind of sort of goes away. They say math stays with you but certain things, not really, I would think. But then again, yes, it's like a balance between the two, ok area and perimeter I can do that."
>
> (Ms. Wilson, personal communication, April 21, 2015)

The students' qualitative claims about how authority is distributed in the classroom are supported by detailed examples from classroom observation data. The classroom observation data was examined to explore the claim that the teacher is the primary authority in the classroom. Throughout the month-long observation, Ms. Wilson is in control of the mathematical decision making. She determines the accuracy of the solutions by providing answer sheets and correcting the students' responses. In addition, she instructs the students to follow specific procedures to attain correct solutions. Ms. Wilson works diligently and passionately with the students to help them solve problems accurately. However, as will be depicted in the segments below, it is problematic that authority is primarily distributed to the teacher, Ms. Wilson. In this environment, the students are not afforded opportunities to exercise agency. In addition, competence is measured by successfully applying solution methods described by Ms. Wilson, which, at times, are inaccurate.

In the segment below, it does not appear that students understand how to find, and the reason for finding, compatible numbers. The purpose of finding compatible numbers in the assigned problems is to be able to quickly estimate division problems without using long division procedures. For example, if asked to divide 378.5 by 61.8, a student may estimate by dividing two compatible numbers, such as 360 and 60, resulting in a quotient of 6. Below, Ms. Wilson reads the textbook definition of compatible numbers to the students, which states that finding compatible numbers "make calculations easier" (observation, March 25, 2015). In her explanation of the procedures, she instructs the students to round the dividend and divisor to the nearest ten. However, if the students follow this procedure, then per the example above, 378.5

divided by 61.8 would be rounded to 380 and 60, respectively, and the students would still be required to apply long division procedures to compute the quotient.

> Day 15, March 25, 2015: Dividing Decimals and Compatible Numbers
> Example: 122.56/ 2.98
>
> Teacher: We're not moving the decimal. We are changing into compatible number first.
> Vivian: So we're really rounding.
> Teacher: Yeah
> Teacher to Anna: What would you change 2.98 to make it a compatible number?
> Teacher asks if it is closer to 2 or 3.
> Anna: 3
> Teacher asks Anna what 122.56 should change to and Anna says 120. Then Ms. Wilson asks Vivian. Vivian says 120 too.
> Teacher writes on board 120/3 = 40
>
> Vivian begins working independently on the problem 378.5/61.8.
> Vivian tells the teacher that she is confused.
> The teacher tells Vivian to change both numbers so that they end in 0.
> Teacher goes to the board and tells Vivian that she can round up 378.5 to 400 and 61.8 to 60.
> Vivian asks the teacher if she can use a calculator.
> Teacher shows Vivian that the quotient is 6.666.

Since Vivian views Ms. Wilson as the authority, and Vivian does not question or challenge mathematics instruction in the classroom, Vivian accepts that Ms. Wilson's explanation of compatible numbers is legitimate. However, in a group interview following this lesson, Vivian and Anna express that they did not understand compatible numbers.

> Anna: Homework for today was a little hard.
> Interviewer: ok.
> Anna: Don't understand.
> Interviewer: What about you, Vivian?
> Vivian: I did not do the homework yesterday because when I'm in class it's easier for me to do the problems and when I'm at home I forget a little bit.
> Interviewer: What are the problems? What do they look like? Are they division?
> Vivian: Division and compare numbers.
> Interviewer: Compatible numbers?
> Vivian: Yeah, yeah compatible.
> Interviewer: Compatible numbers. Ok. So actually, can we look at your

homework? Can I see it?
Vivian hands Interviewer her homework: I only did 12-14.
Interviewer: So it's using the compatible numbers, ok.
Interviewer: Were you supposed to do the back of the page?
Vivian nods.
Interviewer: Ok

(Group, personal communication, March 25, 2015)

Anna and Vivian both feel that the homework was difficult, and they were unable to complete all of the assigned problems. Neither student questions Ms. Wilson's explanation of compatible numbers. On the contrary, Vivian blames herself for being unable to complete the problems, stating that when she tries to complete the problems at home, she "forget[s] a little bit" (Group, personal communication, March 25, 2015).

Alternatively, James sees himself as successful in mathematics, stating that completing problems involving compatible numbers is easy for him:

James: The easiest thing I learned this week?
Interviewer: Yeah, or in the last two weeks
James: Doing compatible numbers was probably easy.
Interviewer: What does that mean, compatible numbers?
James: Numbers that can make calculations easier.
Interviewer: And what does that mean?
James: When you're doing moving the decimal, you can actually understand it a lot more. It will be like with the decimal in the same place you would divide it, it would be easier to do.

(James, personal communication, March 26, 2015)

When authority in the classroom is not distributed to the students, and the teacher lacks important content knowledge, it may impact the students' beliefs about their abilities as learners of mathematics. In this case, both Vivian and Anna feel that they are not successful in mathematics when, in fact, the mathematics is not taught correctly. James, however, believes that he is successful in mathematics, but his description of compatible numbers is incorrect. The students attach their identities as math learners to “successfully” carrying out procedures and solutions even when the procedures and solutions are inaccurate.

While the students position the teacher as the authority in the classroom, Ms. Wilson relies upon the textbook to determine the legitimacy of the students’ responses and procedures. At the same time, Ms. Wilson asserts that the language and word problems in the textbook are not appropriate nor intended for DHH students (Ms. Wilson, personal communication, April 21, 2015). Exclusively relying on the mathematics procedures from the textbook can also impact the students’ beliefs about what it means to be a learner of mathematics. For example, in the excerpt below Vivian states that she only solves problems the way that they are solved in the book:

> Vivian: I already, I don’t know. I think I’ve always done one way.
> Interviewer: You think that there are different ways?
> Vivian: Yep.
> Interviewer: So why do you think that you only learn one way?
> Vivian: Because we always learned it from the book and I always think that's the only way to do it so I’m like ok, so I have to follow.
> Interviewer: mm hmm.
> Vivian: That's why my math problems is always one way.
>
> (Group, personal communication, March 18, 2015)

Vivian’s beliefs about what it means to be a doer of mathematics, is attached to the instruction and consequently, to the mathematics procedures outlined in the textbook. Although she believes that mathematics problems can be solved in multiple ways, in this classroom context she sees only one acceptable solution method.

The students in this classroom believe that they are expected to follow directions without asking questions. Ms. Wilson has the authority to determine the legitimacy of the students’ solutions and the students have limited opportunities to partake in the mathematical decision making. For example, Vivian and Anna never challenge Ms. Wilson’s explanation of compatible numbers, even though they did not understand the explanation (Group, personal communication, March 25, 2015). On a broader level, Mario never asks the teacher why he is learning out of the sixth grade mathematics book, rather than a seventh grade book (Mario, personal communication, April 14, 2015) and Vivian never inquires about learning more advanced mathematics, even though she feels that she has already learned most of the mathematics they are doing in the classroom (Group, personal communication, March 18, 2015; Group, personal communication, March 25, 2015; Vivian, personal communication, April 15, 2015). In this classroom, the students have limited opportunities to exercise agency.

4.1.2 General Classroom Obligations. When students shared stories about the practices and behaviors in this classroom, they referenced specific practices related to the classroom norms and the general classroom obligations. Based on the coding and analysis of the individual and group semi-structured interviews, the most salient general classroom obligations were *completing practice problems in class*, *following directions*, and *completing and reviewing homework problems*.

The students describe the daily routine as primarily working independently to check their solutions to the homework problems and to complete assigned practice problems. They state that every day, they are assigned a set of problems from the textbook to complete. They work independently on the problems while Ms. Wilson circulates and helps them solve the problems, when necessary. The students' perceptions of what it means to be doers of mathematics in this classroom is inextricably tied to successfully completing mathematics problems from the textbook.

The field notes and classroom observation videos corroborate the students' description of the daily routine, whereby the majority of the time in each class lesson is spent completing and reviewing practice problems. All classroom observation videos were time segmented and coded for the classroom norms, *completing practice problems in class* and *reviewing homework problems*. The percentage of time spent on each of these norms was calculated. As shown in Table VII, the time segmentation of the video data supports the students' narratives about the classroom norms – they spend most of the classroom time completing and reviewing problems. Based on the structure of the classroom, it is not surprising that the students define the authority in the classroom as the individual with the power to determine the accuracy of the solutions to the practice problems, since the majority of each mathematics class is spent completing practice problems.

Table VII. Time Segmentation of the General Classroom Obligations

Day	General Classroom Norm	Percentage of time
Day 1	Complete Practice Problems in Class	88.60%
	Review Homework Problems	11.36%
Day 2	Complete Practice Problems in Class	97.83%
Day 3*	Complete Practice Problems in Class	52.60%
	Review Homework Problems	79.48%
Day 4	Complete Practice Problems in Class	65.08%
	Review Homework Problems	28.29%
Day 5	Complete Practice Problems in Class	98.25%
Day 6	Review Homework Problems	84.96%
Day 7	Review Homework Problems	99.54%
Day 8	Complete Practice Problems in Class	98.29%
Day 9	Complete Practice Problems in Class	98.57%
Day 10	Complete Practice Problems in Class	79.65%
Day 11	Complete Practice Problems in Class	92.52%
Day 12	Complete Practice Problems in Class	61.95%
	Review Homework Problems	32.30%
Day 13	Complete Practice Problems in Class	93.41%
Day 14	Complete Practice Problems in Class	79.49%
Day 15	Complete Practice Problems in Class	91.20%
Day 16	Complete Practice Problems in Class	89.07%
Day 17	Complete Practice Problems in Class	98.44%

*Note that the Day 3 total percentage is greater than 100%. During this class, students took turns checking their homework from the teacher's answer sheet and completing practice problems.

4.1.3 <u>Mathematical Obligations</u>. Two categories related to the specifically mathematical classroom norms emerged from the coding of the teacher and student interview data: *using established solution methods* and *developing fluency in procedures*. To be a competent learner in this classroom, the students must follow the teacher's procedures, which involves the specific solution methods outlined in the textbook. When asked if they are allowed to solve problems in different ways, Anna explains that in prior years she solved problems in different ways, but in this classroom they solve the problems, "only one way" (Group, personal communication, March 18, 2015). This is similar to Vivian's description above, in which she states that she only follows the solution methods from the textbook (Group, personal communication, March 18, 2015).

Since only one solution method is offered in the classroom, some students feel that alternative methods are not acceptable. Interestingly, often the "alternative" methods described by the students, are, in fact, the same method. For example, Vivian explains that she feels like she is not as good of a math student when she solves a problem differently in this classroom. She describes a time when she did not use 0 as a placeholder when dividing 190/4; rather than writing the quotient as 047.5, she wrote 47.5. Although Vivian felt inferior to the other students in the class, her solution was more sophisticated. Yet, Vivian explains that Ms. Wilson accepts Anna's solutions, stating, "[Anna] thought of the problem right but I thought of it differently, and Ms. Wilson would accept hers" (Vivian, personal communication, April 15, 2015).

In this classroom, students complete practice problems in order to develop procedural fluency. When estimating the sum of numbers with decimals, Ms. Wilson tells the students to use front-end estimation. In front-end estimation, instead of rounding to a specific place value, students should round to the number in the "front" (the left-most number). For example, 57,831 + 3,200 would be rounded to 60,000 and 3,000, respectively, and the estimated sum would be 63,000. In the excerpt below, Ms. Wilson tells Vivian to continue to practice, until she understands front-end estimation.

Day 3, March 5, 2015: Addition and subtraction with estimation
Ms. Wilson tells Vivian to work on problems involving front-end estimation until she understands.
Ms. Wilson walks through one problem, stating the procedures (no explanation).
Vivian tells Ms. Wilson that she still does not understand front-end estimation.
Ms. Wilson walks to board.
Ms. Wilson: The front end is everything before the decimal. Everything after the decimal goes away.
Ms. Wilson: It's still the same rounding but stopping at the first number.
Ms. Wilson provides examples.
Vivian: Ahh [understands]
Vivian asks what to do next.
Ms. Wilson looks at the problem and tells Vivian to add. Vivian says she understands and continues to work.

The students are instructed to compute specific calculations in order to attain the correct solution, as depicted above with Vivian. Likewise, when Mario learns about scale factor, he is told to follow a specific set of procedures and calculations.

Day 8, March 13, 2015
Ms. Wilson reads the question to Mario and tells him that the scale is 1in equals 7 ft.
Ms. Wilson: How many do we have there?
Mario: 3
Ms. Wilson: What do we have to do to find out how many feet?
Mario: Multiply.
Ms. Wilson: And what does that equal?

Mario: 21

For each subsequent problem involving scale factor, Ms. Wilson writes the steps in the same format for Mario to follow:

$$\begin{array}{cc} 1\,in : & 7\,ft \\ x3 & x3 \\ = & = \\ 3 & 21 \end{array}$$

Mario believes that each scale factor problem is an independent problem, and thus he needs the teacher to explain each problem to him, even when the problems are isomorphic. When asked if he can solve the problem on his own, Mario states that he needs Ms. Wilson's help because, "the problem[s] [are] hard" (Group, personal communication, March 18, 2015). He believes that each problem is different because Ms. Wilson "change[s] the numbers" (Group, personal communication, March 18, 2015). Thus, Mario states that he is only able to compute the solutions to the problems involving scale factor, when the teacher sets up the procedures and calculations as shown above.

In this classroom, there is a strong emphasis on procedural fluency. When the mathematics is simplified to a set of basic operations and computations, the students view doing mathematics as completing a set of computations. When they know (or are told) which calculations to compute, they feel confident in their knowledge of the mathematics in the classroom. However, when the calculations and operations are not as explicit, they feel less confident in their abilities as mathematics learners.

4.1.4 <u>What It Means to be a Good Math Student in this Classroom.</u> The general and mathematical obligations that are narrated in this classroom are consequential to the students' developments as learners of mathematics. Adhering to these obligations would position a student as a good math student in this classroom. However, this may contribute to problematic conceptions of what it really means to be a good math student. Specifically, broader disciplinary conceptualizations of competence are not aligned with characterizations of competence in this classroom (see, for example, NCTM Standards or CCSS-M).

The teacher's descriptions of what it means to be a good math student in this classroom align with the descriptions of the norms of the classroom. According to Ms. Wilson, "You can be a good math student and not be good at math. You can study all you want and you can do as many practice problems as you want but if you're still not necessarily getting it, then you're still considered good, you're still a good math student" (Ms. Wilson, personal communication, April 21, 2015). Being a good math student does not necessarily mean that the student understands the content, just that the student adheres to the classroom obligations by completing the assigned problems.

Anna and Mario's description of what it means to be a good math student is consistent with the teacher's description (Anna, personal communication, April 13, 2015; Mario, personal communication, April 14, 2015). Anna asserts that a good math student is someone who follows the rules, pays attention, and does their homework (Anna, personal communication, April 13, 2015). Anna describes herself as a good math student, and, given her definition of a good math student, she fits the profile. Anna places great importance on following classroom obligations, such as doing the homework and following the teacher's directions. For example, Anna express frustrations with the classroom norm of completing and reviewing homework. Since the classwork and the homework both consist of completing problems independently, Anna does not see the value in having homework. But, since she believes that students should follow the rules in the classroom, she does not challenge Ms. Wilson (although, as described below, she does ask Ms. Wilson to reduce the number of assigned problems).

Interviewer: Does homework help you to understand?
Anna: I think so. I think so but why can't we do it in class, why at home?
Interviewer: Why do you think?
Anna: Home.
Interviewer: Why at home? Why do teachers give you homework? Why?
Anna: I don't know, to study?
Interviewer: To study?
Anna: Why not in school? Why home? Why house?
Interviewer: So, the work that you do in school, is that the same as the homework?
Anna: Most of the time.
Interviewer: Ok.
Anna: School, why not at school? Why at home? Why at home instead of fun things?
Interviewer: Did you ask Ms. Wilson why?
Anna: No [smirking]
Interviewer: No? Why not?
Anna shuffles around.
Interviewer: Are you embarrassed?
Anna: What?
Interviewer: Embarrassed to ask her?
Anna nods.
Interviewer: Why are you embarrassed?
Anna: Embarrassing, I don't know. [throws up arms smiling]
Interviewer laughs.
Anna laughs.
Anna: I don't know if you should ask teachers about that.
(Anna, personal communication, April 13, 2015)

Similarly, Mario states that good math students "work," "write," "read," and "do your homework" (Mario, personal communication, March 5, 2015). A good math student is someone who listens and follows directions (Mario, personal communication, April 14, 2015). He believes he is a good math student because he pays attention to the teacher and does his homework (Mario, personal communication, April 14, 2015).

Unlike Ms. Wilson, Mario, and Anna, James and Vivian believe that being a good math student and being good at math are synonymous. That is, a good math student *is* someone who is good at math. According to James, a bad math student is someone who is not good at math or only knows a little math (James, personal communication, March 10, 2015). James also states that being a good math student means focusing, putting pride into one's work, and using prior knowledge to figure out problems (James, personal communication, March 26, 2015). Vivian adds that a good math student is someone who is respectful and listens to the teacher. Vivian states that good math students persevere; they do the problem sets even when they make mistakes. Good math students pay attention and try to understand the mathematics (Group, personal communication, March 25, 2015).

The "Ideal" Student and the "Mischievous" Student. Based on the teacher's and students' definitions of what it means to be a good math student in this classroom, Anna is positioned by others as the ideal student, while James is positioned by others as a mischievous student. Anna is described as a good math student by her peers and teacher because her behaviors in the classroom align with the general and specifically mathematical obligations established in the classroom, and because she attains accurate solutions. Anna spends most days working independently, completing the assigned problems correctly. She does not question the teacher, and she successfully follows the mathematics procedures outlined in the textbook. Anna's positioning as the "best" student in the classroom will be discussed in-depth in Chapter 6.

James's beliefs about what it means to be a good math student differs from the teacher's and most of the other students' beliefs in the classroom. The disconnect between the teacher's and students' constructions of James and James's self-construction problematizes the co-construction process. Within the time frame that I observed the classroom (albeit not long), the characterization of James as the mischievous student was never taken up by James and James's self-perceptions of a good mathematics student were never taken up by the teacher and other students in the classroom.

The teacher describes James as “the mischievous one... in the group” (Ms. Wilson, personal communication, March 2, 2015). Ms. Wilson asserts that James often gets distracted and goes off-task, but when she specifically tells him what to do, he will focus on his work. She asserts that James needs help to learn how to focus and that she often needs to explain things to him multiple times. Both James and Ms. Wilson agree that he rushes through his work (James, personal communication, March 26, 2015; Ms. Wilson, personal communication, April 21, 2015). Ms. Wilson states that because James often rushes through his work, he makes many calculation errors (Ms. Wilson, personal communication, April 21, 2015). James agrees that his answers in math class are often incorrect. However, he asserts that this is not because he does not understand, but rather because he goes through the problems too quickly. Although he makes careless mistakes, he still understands the mathematics, which makes him a good math student (James, personal communication, March 26, 2015). Ms. Wilson explains that although James tends to rush through his work, James will stop to ask questions to make sure he understands the content, which she describes as qualities of a good math student (Ms. Wilson, personal communication, April 21, 2015).

James describes himself as the best student in the class and justifies his assertion by stating that he works hard and thinks of different ways to solve problems in mathematics (James, personal communication, April 14, 2015). However, being able to solve problems in different ways is not a quality aligned with mathematical obligations, as well as the teacher’s and other students’ construction of what it means to be a good math student in this classroom. In addition, James describes himself as someone who pays attention, is a good listener, and is good at solving problems. James says that because he is “really smart,” he is expected to do well in math (James, personal communication, March 10, 2015). Furthermore, James asserts that in order to be good at math, one needs to put pride in his or her work, be focused, and apply prior knowledge to figure out problems (James, personal communication, March 26, 2015). The characterization that a good math student applies prior knowledge also differs from other students' characterizations of a good math student, in which a good math student is someone who pays attention and follows the mathematics procedures in the classroom.

When asked if his teacher and peers believe he is a good math student, James says that he knows other students think he's a good math student if they ask him for help. In this classroom, however, the other students do not ask him for help because they are all doing well and do not need help. Therefore, although the other students do not ask James for help, he still believes that they view him as a good math student (James, personal communication, March 26, 2015). Alternatively, none of the students state that they would ask James for help in mathematics. When asked if he believes that Ms. Wilson thinks he is doing well in math, James says that Ms. Wilson thinks he did well because he "works hard" and "puts in a lot of time" (James, personal communication, March 26, 2015). This explanation *is* consistent with Ms. Wilson's perceptions of what it means to be a good math student, rather than James's characterizations that place more emphasis on mathematical understanding than on classroom behavior, work ethic, and adhering to the norms of the classroom.

Segments from the classroom observation data illustrate how the Anna and James were positioned in the classroom. For example, during the interviews, some of the students express that Ms. Wilson assigns too many problems for homework. Anna explains that when she tells Ms. Wilson that she was assigned too many homework problems, Ms. Wilson tells her to only complete a portion of the problems, "I ask can I do half and teacher told me to do half" (Anna, personal communication, April 13, 2015). Since Anna is positioned as a hard-working and diligent student, Ms. Wilson acknowledges her concern and modifies her homework accordingly. However, when James states that he was assigned too many problems for homework, Ms. Wilson's response to James varies greatly from her response to Anna. To James, Ms. Wilson states, "If you don't do the homework, that's not on me, it's on you" (Observation, March 11, 2015).

The following example shows how both James's peer and his teacher do not position James as a knowledgeable and productive mathematics learner.

> Day 9: March 11, 2015 Multiplying Decimals
>
> James looks at Vivian's work and tells Vivian she completed the problem incorrectly.
> James: This is how you do it.
> Vivian does not look over.
> James calls the teacher over to show his work. Vivian tells the teacher that James is doing the problem a different way.
> James: Look it, look it. Oh my god.
> James: I did it a different way. I don't understand why this is incorrect.
> Teacher: James, I will talk to you about it tomorrow. I will show you how you are supposed to do it.

In this segment, James and Vivian are working independently, when James looks at Vivian's work and tells Vivian that he solved the problem a different way, and that her work was incorrect. Vivian ignores James. When Ms. Wilson approaches, she tells James that she will explain to him how to solve the problem correctly, without ever looking at James's work. Vivian's and the teacher's actions imply that James's work is not valued or valid. Furthermore, Ms. Wilson assumes that James's work is incorrect without looking at his work, and states that she will have to "show" him how to solve the problem correctly, emphasizing that her method is the only acceptable procedure for solving the problem.

In this classroom context, James was more susceptible to be deemed less competent and Anna was positioned as more competent. Anna ascribes to the general and mathematical obligations in the classroom and to an identity of a good mathematics student. However, within the time frame that I conducted this study, the characterization of James as the mischievous student was never taken up by James. James continues to refer to himself as a good student, even though he is not described that way by the teacher or the other students, and even when he is not positioned that way in the classroom. Thus, James does not ascribe to (and may have even been unaware of) the mathematics identities imposed upon him by others.

4.2 d/Deafness and the Practice-Based Narratives

When coding and analyzing the student interview data to understand what it means to be a DHH mathematics learner in this classroom context, it became starkly apparent to me that both the teacher and the students never discuss d/Deafness, if not probed by the interviewer. When specifically asked about d/Deafness and mathematics, the students' explanations of the role of d/Deafness in the mathematics classroom differ greatly and often were connected to their past experiences. That is, prior classroom practices and behaviors influence these students' perceptions of what it means to be DHH in a mathematics classroom.

During the semi-structured group and individual interviews, the students provided both abstract broader descriptions of d/Deafness, as well as individual person-centered views about what it means to be a DHH individual. When asked to describe d/Deafness, all four students provide audiological definitions. The students do not discuss cultural definitions of d/Deafness and when asked specifically about the Deaf community, the students did not have stories or experiences to share (e.g., Initial Interviews). Since all four students have hearing parents, their access to the Deaf community may be limited. The students describe d/Deafness as the inability to hear all sounds, and hard of hearing as the ability to hear some sounds. In addition to categorizing d/Deafness on the basis of hearing, Vivian also describes a DHH person by his or her ability to talk, stating that, “A hard of hearing person is one that can talk but you can't hear, deaf is when you can't talk or hear” (Vivian, personal communication, March 4, 2015). These descriptions of d/Deafness are consistent with characterizations of d/Deafness in current policy and legal frameworks, such as IDEA, in which DHH learners are categorized based upon their verbal language abilities and hearing loss.

Vivian and Anna believe that when they are able to hear the mathematics instruction, they feel more confident in their understanding of the mathematics (Group, personal communication, March 25, 2015). According to Vivian, hearing kids are better at math and have greater content knowledge (Vivian, personal communication, March 4, 2015). Since the hearing students know more mathematics, the pace of the mainstream mathematics classroom is faster. Unlike the mainstream classroom, in the DHH classroom, the teacher needs to explain each step in a mathematics procedure. In hearing class, however, instruction can move faster (Group, personal communication, March 18, 2015).

Vivian’s narratives suggest that the norms of the classroom, such as completing practice problems and developing procedural fluency, are necessary in the DHH classroom, since the students are slower and require more direct instruction on specific mathematics procedures. In other words, Vivian associates the mathematical obligations with the fact that it is a DHH classroom. Vivian does not consider, however, that the DHH students may be “slower” in mathematics because they are not provided with the same instruction, affordances, and opportunities to learn as in the mainstream setting.

The students’ narratives about d/Deafness raises the question as to why, in this self-contained DHH classroom setting, d/Deafness is or is not invoked by the teacher and the students in this classroom. Both Anna and Vivian state that mathematics is easier when they are able to hear the instruction through assisted listening devices. Thus, d/Deafness is perceived as a hindrance to learning mathematics. This view of d/Deafness may be due to the instruction and their mathematics experiences in this classroom. One practice that occurred in the classroom, but was not mentioned by the students, was the teacher's use of the CD-ROM. On multiple occasions, when introducing new content, Ms. Wilson plays the audio from a CD-ROM, which was provided with the textbook. In the following segment, Ms. Wilson plays the CD-ROM, then transcribes the definitions on the board for the students to copy.

Day 10: March 17, 2015: Dividing Decimals

Teacher tells students to write 0.448 ÷ 3.2 in their books, the same way it is written on the board.
James writes on his paper.
Vivian to James: You need to write it like that.
Teacher tells the students to write the problem exactly the same way as it is written on the board.
Teacher reads from the board: When dividing by a decimal we need to rewrite the division problem so that the divisor is a whole number.
Teacher: So which is the divisor?
James: 3.2
Teacher circles 3.2 and writes, "rewrite as whole number"
Teacher plays the CD-ROM which states, "multiply by a power of ten."
Teacher: You need to multiply the divisor by a power of ten.
Teacher goes back to CD-ROM, which states, "multiply by 10".
Teacher writes on board, "To do this, multiply both divisors and dividend by a power of 10 that will make the divisor a whole number."
Anna, Vivian, and James copy from the board.
Teacher walks back to the computer and plays the CD-ROM. The CD-ROM states that students need to multiply by a power of ten before dividing.
James: Can't you just move the decimal?
Teacher: You have to multiply, you can't just move it.
Teacher writes 10 x 32 on board and does standard algorithm for multiplication:

$$\begin{array}{r} 32 \\ \underline{\times 10} \\ 00 \\ \underline{320} \\ 320 \end{array}$$

Vivian: You can move the decimal by 1.
Teacher tells them they are right but that she wants them to understand why.

Teacher plays the CD-ROM. Teacher repeats the CD-ROM.
Teacher multiplies by a power of ten.
Anna asks if they need to show the multiplication. Teacher says that you can show it.
Teacher to Anna: Whatever you do to one number, you need to do to the other.
[Meaning that she must multiply both the divisor and the dividend by the same power of ten.]
Teacher asks James why he multiplied the dividend.
James: To get a whole number.
Teacher: I multiplied this to get a whole number, now I have to do the same to this.
[Teacher is trying to explain to James that the divisor must be a whole number. To change the divisor to a whole number, the students multiply by a power of ten. They must then multiply the dividend by the same power of ten.]
Teacher writes 32 | 4.48 and computes long division.
Teacher plays the CD-ROM
James: Ms. Wilson I got 128. I don't know if that's right.
Teacher brings down the 8 and subtracts. The difference is 128. Teacher gives the students calculators.
Teacher asks for the answer.
Teacher plays the rest of the CD-ROM, which provides the solution.
Anna says she got 14
Teacher tells Anna, ".14 don't forget your decimal"

Ms. Wilson explains that the CD-ROM, "was helpful to [her] to teach the basics and then give [the students] the practice problems from those basics and then step into the book and then actually do the lesson from the book and then give them the practice for it to go along with the book." This instruction, however, relies on the students' residual hearing or on the use of assisted listening devices, in order to be an active participant in the classroom. Such classroom practices may be consequential to the development of DHH identities in the mathematics classroom. Anna and Vivian, for example, believe that hearing is beneficial to becoming a successful mathematics learner. In this classroom, being able to hear the audio from the CD-ROM provides a greater opportunity to understand the mathematics, and thus, to be able to follow the procedures and complete the practice problems successfully.

4.3 Discussion of the Practice-Based Narratives

A primary objective of conducting the student and teacher interviews was to explore issues of mathematics socialization and how mathematics identities are co-constructed among these DHH learners. My goal was to examine individual agency as it emerges from experiences with school and classroom forces (Martin, 2000). Subsequently, I planned to apply Cobb et al.'s (2009) interpretive scheme to independently analyze the classroom observation data to examine the normative identity in the classroom. In-depth analysis of the teacher's and students' narratives revealed that these narratives involve specific references to behaviors and practices, including specific references to the norms, expectations, and obligations in the classroom. Through the teacher's and students' narratives, notions of the normative identity in the classroom emerged, including the behaviors, practices, and activity structures situated within the context of their classroom setting. Consequently, the analysis of the interview data became a springboard into my analysis of the classroom observation data. I looked at the observation data for specific instances to corroborate or reject the students' interpretations of the general and mathematical norms in this classroom.

The students' narratives about the classroom norms and practices are more consequential than just stories. Adhering to these narrated norms makes one a good math student in this classroom. Given the mathematical and general obligations established in this classroom, as narrated by the participants, Anna was positioned as the "ideal" student, and James was positioned as "mischievous." Throughout the duration of the current study, Anna took up an identity of being the best student in the classroom, but James did not take up an identity of a mischievous student. Both Anna and James took on identities as competent mathematics learners in this classroom.

Research on mathematics identities has shown that mathematics learning involves a student becoming a certain type of person within a mathematics learning community, such as a classroom. Based on their knowledge and understanding of the subject matter, a student may be accepted or isolated in the classroom (Boaler, 2000; Lampert, 2001; Wenger, 1998). In this classroom, procedures and computation were valued. The ways the students interpreted the norms in this classroom both enable and restrain students from taking on the identities as competent mathematics learners. "What gets constructed as mathematical competence in the classroom has implications for students' perceptions of their own and their peers' relative capabilities" (Cobb et al., 2009, p. 48). Given the mathematical obligations that emphasize practice and repetition in this classroom – *using established solutions methods* and *developing fluency of procedures* – the students may develop misleading senses of what it means to be a competent mathematics student outside the walls of this classroom. An in-depth exploration of the classroom's constructions of competence as well as how individual students take on identities of competent learners will be further explored in the following chapter.

Furthermore, throughout the students' narratives about the classroom practices, d/Deafness is not invoked by the teacher or students. To the contrary, it appears that the DHH identity development is restricted. By using the CD-ROM and relying upon auditory and oral means for instructing mathematics, Anna and Vivian see hearing as an essential component to success in mathematics. In Chapter 6, I examine two individual students' narratives about their classroom experiences, which provide further insights regarding how DHH and mathematics identities develop simultaneously.

CHAPTER 5 IDENTITIES OF COMPETENCE IN MATHEMATICS

In this chapter, I explore in-depth what it means in this classroom to be a competent mathematics learner. Competence in mathematics, as described in this study, is an identity and an opportunity that may or may not be taken up by the students in the classroom. As discussed in Chapter 4, the obligations established in this classroom afford Anna to be positioned as the "ideal" student. Thus, the classroom context enables, and potentially constrains, students to take on identities of competent learners and doers of mathematics. Following an examination of what it means to be mathematically competent in this classroom, I discuss how students' mathematics identities are fueled by the characterizations of competence in the classroom.

5.1 What Does It Mean to Do Mathematics in this Classroom?

Findings from the analysis of the group and individual interviews revealed that the mathematical obligations in this classroom – *using established solutions methods* and *developing fluency of procedures* – emphasize practice and repetition. Furthermore, when students were asked to describe the mathematics in the classroom, the students provided answers that only described arithmetic operations or procedures. For example, during the first week of instruction, the students completed practice problems involving addition and subtraction of decimals, front-end estimation, and multiplying decimals. However, when asked in a group interview which areas of mathematics the students felt confident, Anna responds that she is, "good at multiplying" and describes multiplying single digits, and not numbers involving decimals. Likewise, Mario, while learning about area and perimeter states, "something like math multiply divide and other is easy harder" (Mario, personal communication, March 5, 2015). That is, multiplying and dividing is easy, but the other work (such as area and perimeter) is difficult. Since the procedures for finding area and perimeter of rectangles involve multiplication, Mario describes the mathematics that he is performing as a set of operations. Similarly, in a subsequent interview, when asked what he was learning in mathematics that week, Mario responds "times, dividing, adding, subtract" (Group, personal communication, March 25, 2015). In fact, Mario was learning about scale factor. However, Mario describes the mathematics as a set of decontextualized arithmetic operations.

To become more proficient in mathematics, students repeatedly practice the procedures. In the excerpt below, James explains how to improve in mathematics:

> Interviewer: So how can you get better at math?
> James: If you practice every day and work on math you get better at it.
> Interviewer: What does that mean to practice? What do you do?
> James: You take a couple of math problems you think of them and you write it down and do it step-by-step over and over again and you will become better by doing it step-by-step over and over again and put work into it and you will be a good math student at anything they ask you to do, you'll already know how to do it and then you can prepare for the next level.
> (James, personal communication, April 14, 2015)

As evident in the segment above, James places great value on and identifies with the obligations of practicing rote, repetitive procedures. Vivian recognizes the emphasis on procedures in this classroom, stating that, "Ms. Wilson doesn't tell us why, but she'll tell us what or how" (Vivian, personal communication, April 15, 2015). When Ms. Wilson was asked how she teaches the students to "understand the *why*", she responds, "When I look at certain things that they do on their homework and I give them the correct answers on the board or after they finish their homework and they got it wrong and if I can see where they got the problem wrong, whether it's a multiplication error or they put the wrong numbers that weren't really in the book for the problem, maybe I'll just look at the problem, see where the mistake is and try and coach them into, 'what does the problem say' or 'try these 2 numbers together' or 'check your work again.' Because I think that's another issue too that they don't really check their work" (Ms. Wilson, personal communication, April 21, 2015). Like the students, Ms. Wilson describes mathematics as a set of calculations and operations, emphasizing the operations necessary to accurately solve a problem.

Classroom observation data corroborates that mathematical concepts are often reduced to a set of procedures and operations and that repetition is valued as an effective way to improve in mathematics. To illustrate, an example from the observation data is provided later in this chapter, whereby Mario is learning about scale factor. In this classroom environment, where students are expected to provide procedures and solutions but not asked to explain and discuss, the students are not provided opportunities to exercise conceptual agency.

5.1.1 What Does It Mean to be Competent in Mathematics in This Classroom?

Gresalfi, Martin, Hand and Greeno (2008) define competence within the context of an activity system, such as a classroom. A student's competence is viewed as an "interaction between the opportunities that a student has to participate competently and the ways that individual takes up those opportunities" (p. 50). Competence is defined by the students and teacher based upon what it means to do mathematics in this specific classroom setting. Moreover, the ways that the students take up the characterizations of competence impacts who is and who is not deemed competent in this classroom. Taken together, these views on competence suggest competence can be conceived of as both an identity and a situational opportunity. Therefore, it becomes important to examine who has the opportunity to access competence as an identity and under what conditions.

Descriptions of competence in this classroom initially emerged through the teacher and student interview data. Ms. Wilson and the students generate dialogue about ability and competence through descriptions of being "good at math" and through narratives about specific classroom experiences. When explicitly asked to describe what it means to be "good at math", all four students and the teacher describe accuracy and procedural fluency. Additionally, the students' and teacher's valuations of competence are embedded within their narratives about the classroom practices and behaviors. Of twenty-two instances when the teacher and students reference being competent in mathematics, eleven reference accuracy of solutions, nine discuss procedures, and only two reference conceptual understanding. Thus, based on analyses of the interview data, competency is primarily viewed in this classroom as (1) accurately completing practice problems, and (2) developing fluency of the procedures.

In Figure 5, the teacher's and students' narratives depict the construction of competence in mathematics in this classroom. In this image, competence is depicted as situational and as the collective construction of the teacher and student participants. In other words, competence is defined at the classroom level and within the context of this specific classroom, among these particular members of the classroom. Since this image represents the classroom level, each individual student's conception of competence may appear differently. Individual students would have some subset of the larger diagram but may not map onto every aspect.

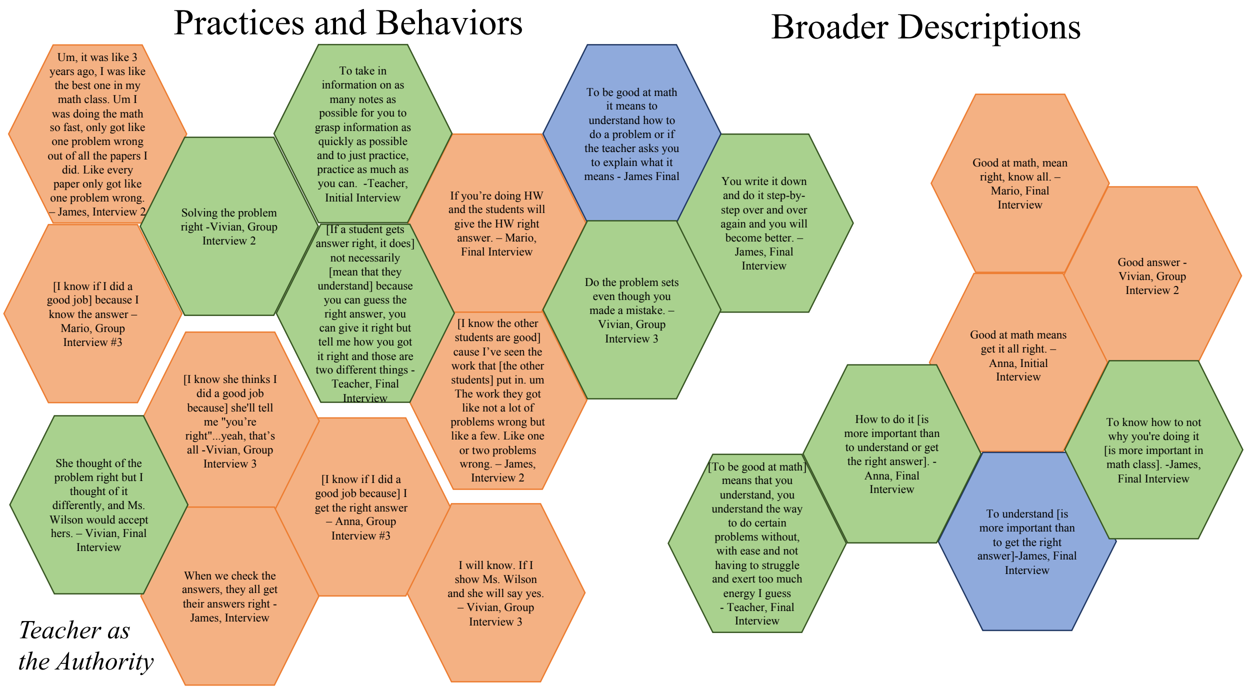


Figure 5. Competency in this Mathematics Classroom

The orange hexagons include narratives that reference accuracy as competence. For example, Mario states, "[I know if I did a good job] because I know the answer" (Mario, personal communication, April 14, 2015; Group, personal communication, March 25, 2015), showing that an accurate solution is an indication of success in this classroom. The green reference procedures and procedural fluency as competence. James asserts that in order to be successful in mathematics, "You write it down and do it step-by-step over and over again and you will become better" (James, personal communication, April 14, 2015). Thus, repetition leads to procedural fluency and success in mathematics. The blue hexagons reference conceptual understanding. James is the only student to reference conceptual understanding as a sign of competence (both blue hexagons). For example, he states, "To be good at math it means to understand how to do a problem or if the teacher asks you to explain what it means" (James, personal communication, April 14, 2015). The hexagons on the left-hand side include references to classroom practices. Within the references to classroom practices, on the bottom are a subset of items that reference the teacher as the authority to determine accuracy of solutions. These statements highlight the importance of attending to who determines competency. The hexagons on the right-hand side are descriptions of what it means to be “good at math.” For example, Anna states, “Good at math means get it all right” (Anna, personal communication, March 5, 2015). As is depicted in Figure 5, most references of competence in mathematics involve accuracy and knowledge of the procedures, and reference specific classroom practices and behaviors.

The perceptions of what it means to be a competent mathematics learner in this classroom are inextricably linked to the obligations in this classroom. The students’ characterization of competence in mathematics, as attaining correct solutions to problems, is aligned with the obligation of *completing practice problems* (see “Table VII Time segmentation of the General Classroom Obligations”). In addition, demonstrating proficiency in operations and procedures to attain accurate solutions aligns with the mathematical obligations of *using established solution methods from the book* and *developing fluency in procedures*. Furthermore, as shown in Figure 5, James and Ms. Wilson narratives reveal that in this classroom, speed is also a sign of competence in mathematics. Ms. Wilson further asserts that if a student is good at math, s/he easily understands the procedures, without great effort (Ms. Wilson, personal communication, April 21, 2015). Since the students are required to complete a given set of problems within the timeframe of a mathematics class, these constructions of competence are consistent with the general classroom obligations.

5.1.2 Who Is Competent in This Classroom? The students’ and teacher’s narratives reveal that knowing how to complete the problems, and completing the problems accurately is an indicator of being competent in mathematics. Based on this characterization of competence, when the students complete the practice problems correctly, the majority of students describe themselves as competent in mathematics in this mathematics classroom. For example, Anna asserts she is “smart in math” because she engages in “hard math” and her answers are typically correct (Anna, personal communication, April 13, 2015). Vivian is the only student who questions her own competence in mathematics, even when she accurately completes the problems.

Mathematics identities of competence not only encompass a student’s self understandings, but also how the student is constructed by others, including peers and the teacher. James, for example, holds that Anna and Vivian are good at math because, “the work they got like not a lot of problems wrong but like a few. Like one or two problems wrong” (James, personal communication, March 26, 2015). This description reinforces accurate solutions as a sign of competence. Examples of Ms. Wilson’s narratives of each student’s competence in mathematics is provided in Table VIII.

Table VIII. Teacher's Descriptions of Competence in Mathematics

Student	Ms. Wilson's description of students
Mario	Teacher: I would say Mario is, I don't want to say a good math student but not good at math because he's good at math when you explain it to him the way he needs it to be explained to him. And I'm still trying to find the balance between how can I word certain things or what's the best way to teach him math because it's, you know, the formality of is it is just more than Mario, I think, at this point can take. (Ms. Wilson, personal communication, April 21, 2015)
Vivian	Teacher: Vivian I would say is good at math. … Interviewer: and who would you say is the best at math? Teacher: best at math...Vivian Interviewer: ok, why Vivian? Teacher: she, she gets the concepts of the math easier and quicker and can apply it in different places. (Ms. Wilson, personal communication, April 21, 2015)
James	Teacher: James, good at math...I want to say he's good at math (Ms. Wilson, personal communication, April 21, 2015)
Anna	Interviewer: and why do you say Anna is the best math student? Teacher: she takes her time, she makes sure that she understands it, um understands it to the point where she can take it home on her own. … Teacher: Anna both [good at math and a good math student]. Diligent math student, diligent, good at math. Interviewer: Do you think she understands the concepts easily also? Teacher: It's, no, I don't think so. It takes her a longer time to get them. So explain it more in different ways is a better way for her to understand it. (Ms. Wilson, personal communication, April 21, 2015)

In the excerpts above, Ms. Wilson states that all of the students are competent in mathematics, but hedges when describing Mario, James, and Anna. Specifically, when describing James, Ms. Wilson states that she "*wants* to say" he is a competent mathematics learner and she explains that Mario and Anna require more explanations.

Identities are not static and the stories may be contradictory (Sfard & Prusak, 2005). At times, Ms. Wilson's narratives about the students' competence appear contradictory or inconsistent. For example, in Table VIII, Ms. Wilson states that she, "want[s] to say [James is] good at math" (Ms. Wilson, personal communication, April 21, 2015), but, as discussed in Chapter 4, she also describes James as "mischievous" and states that he often gets confused in mathematics.

Ms. Wilson's descriptions of Anna also appear inconsistent. Ms. Wilson describes Anna as the best mathematics student in the classroom, but also states that Anna may not understand the concepts and that she requires more time and instruction to understand the mathematics. Thus, Ms. Wilson describes Anna as the best student in the class because she adheres to the obligations and attains the correct solutions, not based upon her understanding of mathematics. This characterization is aligned with the classroom's conceptualizations of what it means to be a good mathematics student and will be further discussed in Chapter 6.

Finally, Ms. Wilson asserts that out of all four students in the classroom, Vivian is the "best at math." She states that Vivian "gets the concepts of the math easier and quicker and can apply it in different places" (Ms. Wilson, personal communication, April 21, 2015). However, when describing what it means to be good at mathematics, Ms. Wilson does not mention conceptual understanding nor the ability to apply mathematics in different contexts. Furthermore, as will be discussed later in this chapter, James is described as "confused" when he attempts to apply mathematical concepts in different contexts. In addition, Ms. Wilson's perceptions of Vivian's competence in mathematics are not consistent with Vivian's perceptions of her own competence. Vivian's and Ms. Wilson's contradictory valuations of Vivian's competence in mathematics will be investigated further in Chapter 6.

5.2 Identities of Competence and the Cognitive Demands of the Activities

The mathematical obligations in this classroom involve practice and repetition and the students describe doing mathematics as performing arithmetic calculations and following procedures. A competent learner in this classroom is one who attains correct solutions using specific procedures. Since the students see themselves as competent when their solutions are correct but describe obligations that emphasize practice and repetition and mathematics as arithmetic operations and procedures, I looked to the classroom observation data to examine the cognitive demands of the mathematics activities. I evaluate the cognitive demands of specific mathematics activities to further investigate the characterizations of competence in this classroom, to see whether they afford students opportunities to develop rich conceptual understanding and whether they push students to think deeply about the content and the mathematics. I selected sets of mathematics activities across two content areas, (a) scale factor for Mario, and (b) division with decimals for Anna, Vivian, and James. Both content areas were referenced repeatedly by the students during the student interviews and are reflective of the content taught, based on an indexing of the mathematics content in the classroom observation data (see Table IX). Mario spent five out of the sixteen lessons completing problems involving scale factor. For Anna, Vivian, and James, eight of the seventeen lessons involved division with decimals.

Table IX. Mathematics Content During the Month-Long Observation

Date	Mathematics Content during Classroom Observation	
	Mario	***Anna, Vivian, and James***
3/3/15	Perimeter and area of squares and rectangles	Addition and subtraction with estimation
3/4/15	Perimeter and area of squares and rectangles	Addition and subtraction with estimation
3/5/15	Perimeter and area of squares and rectangles	Addition and subtraction with estimation
3/9/15	Perimeter and area of squares and rectangles	Multiplying decimals
3/10/15	Perimeter and area of squares and rectangles	Multiplying decimals
3/11/15	Mario absent	Multiplying decimals
3/12/15	Perimeter and area of squares and rectangles; Scale factor	Multiplying decimals
3/13/15	Scale factor	Multiplying decimals
3/16/15	Scale factor	Multiplying decimals
3/17/15	Scale factor	Dividing decimals
3/18/15	Scale factor	Dividing decimals
3/19/15	Interpreting data	Dividing decimals
3/20/15	Interpreting data	Dividing decimals
3/24/15	Interpreting data	Dividing decimals and compatible numbers
3/25/15	Mixed review	Dividing decimals and compatible numbers
3/26/15	Interpreting data	Dividing decimals
3/31/15	Interpreting data	Dividing decimals

As described in the coding and analysis section in Chapter 3, I applied Smith and Stein's (2011) *Task Analysis Guide* framework to examine the cognitive demands of the mathematics activities involving scale factor and division of decimals. Fourteen activity segments involving scale factor with Mario were mapped and all fourteen of the mathematics activity segments were categorized as low cognitive demand. Thirty-four activity segments involving division of decimals with Anna, Vivian, and James were mapped. Of those activities, thirty-three involved lower level tasks, *procedures without connections*. One activity involved higher-level demands, *procedures with connections*. In this activity, the teacher utilizes the CD-ROM from the textbook to scaffold instruction (note that a longer transcript is provided in Chapter 4, where I discuss d/Deafness and the use of the CD-ROM).

Day 10: March 17, 2015: Dividing Decimals

Teacher tells students to write 0.448 ÷ 3.2 in their books, the same way it is written on the board.
James writes on his paper.
Vivian to James: You need to write it like that.
Teacher tells the students to write the problem exactly the same way as it is written on the board.
Teacher reads from the board: When dividing by a decimal we need to rewrite the division problem so that the divisor is a whole number.
Teacher: So which is the divisor?
James: 3.2
Teacher circles 3.2 and writes, "rewrite as whole number".
Teacher plays the CD-ROM which states, "multiply by a power of ten."
Teacher: You need to multiply the divisor by a power of ten.
Teacher goes back to CD-ROM, which states, "multiply by 10".
Teacher writes on board, "To do this, multiply both divisors and dividend by a power of 10 that will make the divisor a whole number."
Anna, Vivian, and James copy from the board.

In this excerpt, the CD-ROM presents a pathway to the conceptual idea (Smith & Stein, 2011). Rather than merely telling the students to move the decimal place of the divisor, the CD-ROM instructs the students to multiply the dividend and divisor by powers of ten in order to have a whole number divisor. Thus, I categorized instruction of this activity as *procedures with connections*. Subsequent instruction of isomorphic problems involving division of decimals were algorithmic, and so it is unclear whether the students developed conceptual understanding of the procedure of multiplying by powers of ten.

Although this segment was categorized as higher demand because it calls attention to the purpose of the procedure of moving the decimal when dividing numbers involving decimals, the use of the audio from a CD-ROM in a classroom with DHH students is not an appropriate modality for instruction. Since the students in the classroom are DHH, not all students are able to hear the instruction in the CD-ROM. Thus, this activity segment, which is the only example of an activity segment which involved *procedures with connections,* a higher-level demand, was delivered to the students through an unsuitable medium and was not further addressed during classroom instruction.

In this classroom, the majority of the mathematics activities are low-level and the students are not required to explain the procedures nor the underlying concepts. When we discussed specific mathematics activities during the interviews, the students frequently performed arithmetic calculations accurately, but often did not explain the procedures and concepts accurately. For example, on Day 14 of the classroom observations, March 24, 2015, the teacher writes the following patterns involving division of multiples of 10, from the textbook:

$6 / 3 = 2$

$60 / 30 = 2$

$600 / 300 = 2$

$6000 / 3000 = 2$

The textbook displays this sequence of calculations of division of multiples of ten in order to help students develop conceptual understanding of the procedures involved in long division with decimals. If students understand that 6.2 / .2 = 62 / 2, they should ultimately understand the shorthand procedure of "moving the decimals" in the dividend and the divisor when performing long division with decimals. However, when James is asked to explain the patterns above, he states that "if you have 3 and you add a zero that means you have 30. So, it makes it, it changes the number because so that the numbers can keep going, you add zero to bring them down"

(James, personal communication, March 26, 2015). James describes a procedure for long division, "adding zeros" and "bringing them down". When asked to explain the procedure he responds, "um I have no idea" (James, personal communication, March 26, 2015). James does not describe the place value concepts in the items involving division of multiples of ten above, and inaccurately describes long division procedures. Specifically, James states that if you add a zero to 3, it will become 30 so that one is able to continue dividing. This description is inaccurate (and his language "add a zero" is mathematically incorrect as well since 3 + 0 = 3, not 30). When dividing with decimals, if there is a remainder, one may move to the next decimal place in the dividend. If there is no digit in the next decimal place, one may write in a zero to hold the place, and the dividend will remain equal (since, e.g., 3.75 = 3.750). Although in the mathematics classroom James is able to "move the decimal" to accurately complete long division problems, he cannot explain place value patterns or long division procedures.

Similarly, both Vivian and Anna are described by Ms. Wilson and their peers as competent mathematics learners when they compute correct solutions using the instructed solution method, yet are also unable to explain the patterns above. Anna and Vivian recognize that the quotients are the same in each calculation, but when asked why Ms. Wilson showed these patterns, Vivian asks, "to make it look like it's a hard problem?" (Group, personal communication, March 25, 2015). Thus James, Anna and Vivian have basic knowledge of the procedures but have not developed understanding of the underlying place value concepts.

5.3 How are these Characterizations of Competence Consequential to Mathematics Identity Development?

The dialogue generated about ability and competence reference practice-based performances, including repetition, textbook definitions, and arithmetic calculations. At the same time, students share stories about being good math students and their successes in math. Since most students describe themselves as competent mathematics learners in this classroom as they reference arithmetic procedures and repetition, and engage in low-level mathematics activities, I examine whether the characterizations of competence in this classroom are fueling math identities in a productive way. The students' perceptions of their competence may be aligned with the mathematical obligations in the classroom, and the students may develop identities of competent mathematics learners in this classroom setting, even when they are not engaging in high-level mathematics. If the students believe that accurate performance on practice problems is a sign of competence in mathematics, are they building stories about themselves based on problematic valuations of their practice-related behaviors? Furthermore, do the mathematics activities afford identities of competence to some students but constrain identities of competence for others?

Across the two sets of mathematics activities (scale factor and division of decimals), all but one activity consists of low cognitive demand activities (and even that activity is questionable). Based on the findings from the students' and teacher's narratives, as well as the results of the analysis of the cognitive demands of the activities in this classroom, the learners are not afforded opportunities to exercise conceptual agency. Analysis of the students' narratives reveal that the students are required to complete specific calculations in order to follow established solution methods, and that mathematics competence is measured in this classroom based on accurate responses. Since the students are not provided opportunities to choose methods and develop meaning in this environment, they do not have opportunities to exercise conceptual agency. Moreover, it is debatable whether students are even afforded opportunities to exercise disciplinary agency. In this classroom, the students are told to do specific calculations, step-by-step, and the solutions are shown as disconnected calculations. Important components of knowledge remain disconnected and the students do not know when to perform certain calculations and how the calculations link to the procedures.

It is important to examine how and what kinds of DHH and mathematics identities can develop in this classroom and how different students take up identities of competence, given the low-level demands of the mathematics and the minimal opportunities to exercise agency. Furthermore, these findings raise more general questions about the overall influence of mathematics instruction on identity development. To explore the potential consequences of the low-level cognitive demand tasks and the classroom characterizations of competence in mathematics, I present a constellation of activity segments across time and days. This constellation of activity segments involving Mario is an example of the kinds of tasks that are valued and normative in this classroom. The sample of a constellation of activity segments illustrates how Mario interprets his experiences as a learner and doer of mathematics. Later, I revisit the case of James. Just as James does not take up an identity of a mischievous student, he does not take up all aspects of the jointly constructed characterizations of competence in mathematics in this classroom.

5.3.1 Mario as a Competent Mathematics Learner. When Ms. Wilson first introduces scale factor, she utilizes the CD-ROM. Since Mario is hard of hearing and has some residual hearing, he is able to hear the CD-ROM when Ms. Wilson plays it on a high volume. The CD-ROM offers a series of definitions and procedural instructions.

Day 7, March 12, 2015: Scale Factor
Teacher writes on board:
M: to use scale drawings to find the actual length.
Teacher tells Mario that he will be learning lesson 2.3, Scaled Drawings.
Teacher: You will use scale drawings to find actual lengths. Ok?

Teacher turns on the CD-ROM home tutor: The model of a building has a scale of 2 inches to 15 feet.
Teacher takes away Mario's calculator and tells Mario to pay attention to the CD-ROM home tutor.
Teacher: I want you to draw for me what he says. It says, the model of a building has a scale of 2 inches to 15 feet.
Teacher writes on board 2 in:15 ft
That means what? 2 inches to 15 feet. What does that mean?
Mario: I don't know.
Teacher: Let me tell you. It means, in the picture, for every 2 inches on the pictures, in real life that equals 15 feet.
Teacher draws 4 in on the board.
Teacher: So if that says 4 in on the picture, how many feet is that in real life?
Mario: 4 in
Teacher: In real life, how many feet? If 2 inches equals 15, how many does 4 inches equal?
Mario: 4 in
Teacher: Ok, how do you get from 2 inches to 4 inches? Multiply 2 by what?
Mario: uh [shakes his head]
Teacher: 2 times what gives you 4?
Teacher writes on board: 2 x __ = 4
Mario: 2 times 4?
Teacher: 2 times what gives you 4?
No answer from M
Teacher: What number am I going to put there to make that true? To make it true? 2 times what?
Mario: Oh 2
Teacher: ok, times 2 all right, what do I need to do to that number?
Mario: 5 times
Teacher: 15 times what?
No answer from Mario.
Teacher: I need you to do the same. If I multiply this times 2, I need to do the same for here. What do I do?
Teacher writes 15 x 2 on board.
Mario: Times
Teacher: What does that equal?
Mario smiles and Teacher gets Mario a calculator.
Mario: 15 times 2 equals
Mario types into calculator.
Mario: 30
Teacher: 30 what?
Mario: 30 feet.
Teacher: right. Now if the model is 6 inches high, what is the real height? Using this. Now it's 6 inches. How does that get from 2 to 6? What did I multiply by?
Teacher writes 6 in = 45 ft on the board

Mario: add to.
Teacher: I didn't add. Two times what? Two times what equal 6?
Mario: 3
Teacher: Right so if I multiply by 3, what do I need to do here?
Mario: 3
Teacher: What is that?
Mario: 35?
Teacher: Do 15 times 3 on the calculator.
Mario: 45
Teacher: Let's see if he says you're right.
Teacher turns on the CD-ROM and begins working with James while M listens to the CD-ROM: If the model is 6 inches high what is the actual height of the building? To find the height of the building, we find the relationship between the known height of the model and the scale. The scale of model to actual is 2 inches to 15 feet. We know that the height of the model is 6 inches. We are looking for the actual height. We ask, 2 times what number equal 6? Because 2 times 3 equals 6, you multiply by 3 to find the height of the building. 15 feet times 3 equals 45 feet. So the actual height of the building is 45 feet.
Teacher: Did he say the same answer?
Mario: Yeah.
Teacher: Now they want you to do this problem.
Teacher moves on to the next problem.

In the instruction above, Ms. Wilson presents a problem involving scale factor. Ms. Wilson uses the CD-ROM to instruct Mario on the calculations needed to complete the problem accurately. When Mario finishes with the problem, Ms. Wilson plays the answer on the CD-ROM, to verify that Mario arrives at the correct solution. As is evident in the excerpt above, scale factor is instructed as a series of multiplication calculations. Mario is asked to find a missing factor, then asked to use that factor as a multiplier. It cannot be determined if Mario understands the reasons for performing these calculations.

In the instruction that follows, the mathematics problems involving scale factor continue to be simplified to a series of naked, decontextualized multiplication and division problems where Ms. Wilson merely tells Mario the calculation steps, as depicted in the excerpt below.

Day 7, March 12, 2015: Scale Factor

> Teacher: Now, they want you to do this problem. The scale is what Mario? Put your glasses on. What is the scale?
> Teacher writes on the board: 1in = 50 mi
> Mario: 1, 50. Wait 1 inch equal 50 miles
> Teacher: What does that mean?
> Mario: I have to times 1.
> Teacher: by what?
> Mario: 8
> Teacher: Ok, if I multiply by 8 to get 8 inches, now what?
> Mario: 50 times 8. [M types in his calculator].
> Teacher: what does that equal?
> Mario: 400
> Teacher: 400 what?
> Mario: Miles.
> Teacher: Mario look, are you right?
> Teacher shows the solution on the CD-ROM home tutor.
> Teacher: Same?

The following day, Ms. Wilson assigns Mario a set of problems involving scale factor. For each problem, Ms. Wilson reads and signs simultaneously, then writes the problem in the following format:

$$\begin{array}{cc} a\,in : & b\,ft \\ x\,c & x\,c \\ = & = \\ ac & bc \end{array}$$

The ratio symbol is referred to as the "two dots" or "colon" and the meaning of the symbol is absent from discussion. As Mario continues to work through practice problems, each item is set up in the same format, and are once again simplified to a series of mathematical calculations.

Day 8, March 13, 2015: Scale Factor

> Teacher and Mario are working at the board.
> Teacher: You are building a model boat with a scale of 5 inches to 7 feet. The actual boat is 70 feet.
> Mario: Do I have to times?

Teacher: You'll see. Put the information they gave you like that [Teacher points to the board]
Teacher: What information d they give you? Write what you know.
Mario: 5 inches, 7 feet.
Teacher: It says the actual boat s 70 feet. So which side do you put that one? Feet? 7 feet turned into 70, which side? Is it going to be on the inches side or the feet side?
Mario: Feet.
Teacher: Ok so put 70 here...ft. How did you get from 7 feet to 70 feet? What did you do?
Mario: Times.
Teacher: By what number?
Mario: Times equal.
Teacher: No no no, this is already equal, 7 times what equals 70?
Mario: What?
Teacher: 7 times what number equals 70?
Mario: Oooh.
Teacher: Ok, so times 10. what do you need to multiply this number by?
Mario: 2
Teacher: No.
Teacher: We need 70 in the end, right? What do we multiply that number by to get 70. Times what?
Mario: 10
Teacher: So put the 10 there. Equals 70.
Mario: Oh.
Teacher: mm hmm.
Teacher: 5 times...put it in there and let's see if it's right.

On board:
$5\,in : \ 7\,ft$
$x10 \quad x10$
$= \quad =$
$50 \quad 70$

In the days that followed, Mario continues to rely on Ms. Wilson to read the problems, and set up the arithmetic calculations. As is evident in the example below, days later Mario has yet to show deeper conceptual understanding. He merely completes a series of calculations. In this excerpt, Ms. Wilson reads Mario a problem where the scale is 1 inch to 16 feet. He is asked to find the length of the model in inches for the given actual length.

Day 10, March 17, 2015: Scale Factor

Teacher: So, write what you have. You have that right [points to book]. Good you have that.
Teacher takes pencil and erases Mario's work.
Teacher: They give you 32 feet. How do you get from 16 feet to 32 feet?
Mario: 32 feet. Get to 32 feet?
Teacher: What times 16 is 32 feet?
Mario: Can I sharpen my pencil?
Teacher: Use this, then I will sharpen it.
Teacher: Tell me what times 16 equals 32?
Teacher walks to desk to sharpen pencil.]
Mario sits and looks at the book, then says: 32
Teacher: What times 16...
Mario starts writing.
Teacher: No no no don't multiply 16 by 32.
Teacher walks to board.
Teacher: Mario [Teacher directs Mario's attention to the board, where she wrote 16x__=32]
Mario: Can I have a calculator?
Teacher gives Mario a calculator.
Mario: 16 times 2.
Teacher: Ok, so multiply by 2. So what do you do over there? So how many inches?
Mario: 2
Teacher: So, put 2 inches. Put a box around the answer please.

In the final lesson involving scale factor, Mario completes an online assessment of scale factor on an iPad, which includes isomorphic mathematics problems involving scale factor. During the assessment, Mario, once again, calls upon the teacher, who directs him to compute specific calculations to solve the problem correctly.

Day 11, March 18, 2015: Scale Factor

Mario is completing an assessment on the iPad.
Teacher reads the problem.
Mario writes on paper.
Teacher points to paper and says: two, like this, those two dots.
Teacher points to Mario's work again and says: It's 1 foot, 1 foot, not 2.
Teacher: Now, how do you get from 1 foot to 80 feet? Multiply by what number?
Mario starts writing.
Teacher: No no no, how many?
Mario writes.

Teacher: Uh huh
Mario: Just 80
Teacher: times 80, times 80, do it there [points to page]. And then that equals 80, right. And then times 80 [point s to paper] and what does that equal?
Mario continues to work on the iPad.

Following the online assessment, Mario moves on to the next topic: interpreting data. Since Mario attains the correct solutions to the assigned problems, albeit with guided step-by-step instructions from the teacher, he has completed the necessary requirements to proceed to the next topic. For all instruction involving scale factor, Mario does not complete one problem independently. Rather, he relies on the teacher to prompt which arithmetic operations should be performed to arrive at the correct answer. Although he eventually completes each problem successfully, he is merely practicing arithmetic and not engaging in high-level mathematics activities. The excerpts from these four instances across instruction of scale factor continue to reify the general classroom obligation of *completing practice problems*, and the mathematical obligations of *using established solution methods from the book* and *developing fluency in procedures* (although not independently in this case). Furthermore, examining this constellation of activity segments across time reinforces the classroom's perceptions of competence in mathematics as merely attaining accurate solutions.

Given this set of activity segments in the classroom, I examined Mario's perceptions of what it means to do mathematics, and more specifically, his understanding of scale factor. Mario complies with the obligations of the classroom. Every day, he completes the practice problems, as assigned by the teacher. Mario describes mathematics as a set of computations and equates success with obtaining correct solutions to the assigned problems. When he knows which calculations to compute, he feels confident in his understanding of the mathematics. However, when the calculations and operations are not explicit, or when he is required to determine which operations to perform, he is less confident in his abilities as a mathematics learner. Mario describes himself as a good mathematics learner, specifically when he discusses mathematics as a set of operations and computations. Yet, when asked to describe specific concepts, such as scale factor, Mario states that he does not want to answer the question, or defers to other students. In addition, as discussed in the previous chapter, Mario sees each problem as an independent mathematics problem, requiring specific instruction. This may be attributed to Mario's insufficient understanding of the underlying mathematical concepts of scale factor.

In this classroom, Mario is provided with step-by-step guidance as to which procedures to calculate, and consequently, achieves correct solutions. When Ms. Wilson simplifies the problems to a series of calculations, Mario sees himself as a capable and competent mathematics learner. This is aligned with the students' characterization that being good at mathematics means attaining the correct solutions to a set of practice problems. Ms. Wilson reinforces Mario's perceptions of himself as a good mathematics student through positive reinforcement:

> "Like, when Mario, oh I was so proud. The first test I gave Mario like he really really got the information and I was really kinda on edge about it to see whether or not he would get it. And when he got the test, he says to me all the time he says, 'oh I failed I failed'. I said, 'no you didn't'. He has a, he wants a boost of confidence and I realized that and I really like to see the smile on his face when he gets something. And he's like, 'Can you put a smiley face on it so I can show my mom?' And I'm like, 'yeah.'" (Ms. Wilson, personal communication, March 2, 2015)

This constellation of tightly connected smaller instances of activities across lessons and time reveal how Mario's perceptions of his competence in mathematics develops as he engages in specific mathematics in this particular classroom setting. While it is important that Mario develop a strong sense of self and a positive mathematics identity, he must also engage in high-level mathematics. Ms. Wilson provides positive reinforcement and encourages Mario to be confident in his performance in mathematics. However, in a classroom where problems are simplified to a series of calculations, and competence is linked to correct solutions, Mario may be developing a problematic sense of himself as a mathematics learner. In addition, he may be developing a problematic sense of what it means to be a doer of mathematics outside of this classroom. This example highlights potential consequences to identity development for a student who complies with the general and mathematical obligations of this classroom. Mario sees mathematics as a series of calculations. He sees himself as a good mathematics learner when he is only required to perform basic calculations. On one hand, adhering to the obligations in this classroom promotes an identity of competence for Mario. On the other hand, this identity is based upon Mario's perceptions of mathematics as a set of procedures and operations.

5.3.2 James's Identity of Competence in Mathematics. In the previous chapter I discussed how James did not take up an identity of a mischievous student. In this section, I will discuss how he does not always take up the classroom's characterizations of competence in mathematics. James is the only student in the classroom to refer to himself as an authority in the classroom. In addition, James's definitions of what it means to be a good student differs from the teacher's and students' definitions. As a result, James's construction of himself as a competent learner and doer or mathematics differs from the teacher's and other students' construction of James.

James’s perceptions of his own performance and Ms. Wilson’s and the students’ perceptions of his performance are not always aligned. Consequently, in certain instances, James may see himself as competent, when Ms. Wilson and his peers do not. James states, “If the teacher asks me, asks us to work together I try to help them figure out like a better way to do the math problem and good like working together and basically helping them” (James, personal communication, April 14, 2015). However, finding alternative methods to solving problems is not valued in this classroom. Moreover, none of the other students state that they turn to James for help. In addition, James asserts that a good math student applies prior knowledge to the current work, stating, “If you know something that you can use to help you with it, you use it, um, use your knowledge to, um, help you through it” (James, personal communication, March 26, 2015). Ms. Wilson states that James, “understands after I tell him, then sometimes he gets confused. Two things confused, like one thing from another class he had he brings to this class and he's like, ‘no that's not what I learned’ and I’m like, ‘this is different’” (Ms. Wilson, personal communication, March 2, 2015). Based on this statement, it appears that Ms. Wilson interprets James’s actions as confusing the current mathematics with topics he previously learned in mathematics or is currently learning in other subject areas. Thus, attempting to apply prior knowledge to novel situations (albeit not always accurately) is perceived as a strength to James, but, in this case, is interpreted as a weakness by the teacher.

The students and teacher equate competence with accurate performance on the assigned problems. When asked about each student’s abilities in mathematics, Ms. Wilson emphasizes that James often makes calculation errors. Due to these errors, she often needs to explain the mathematics multiple times. Although Ms. Wilson equates James’scompetence and ability with accuracy of responses, James does not view his inaccuracies as a reflection of his competence.

To James, getting incorrect solutions is not necessarily a sign of being less competent. He attributes incorrect solutions to carelessness rather than his knowledge of mathematics, and thus these inaccuracies are not a sign of being less competent in mathematics. James says that he answers questions incorrectly not because he does not understand the content or the procedures, but rather because he goes through the problems too quickly, and so even if he makes mistakes, he still understands the mathematics (James, personal communication, March 26, 2015).

While James does not view inaccuracy as incompetence, like Mario and the other students in the class, he agrees that accuracy is an indicator of proficiency in mathematics. In the segment below, which occurs towards the end of the month-long observation, James attempts to work through a problem to make sense of compatible numbers. Ms. Wilson provides James with "the answer."[7]

> Day 17, March 31, 2015: Dividing Decimals
> Teacher sits with James.
> James tells the teacher that he does not understand compatible numbers
> Teacher: What is the question?
> James reads the question, which asks students to find two compatible numbers to estimate 54.2/6.7
> Teacher: They're not asking you to solve.
> James: Oh ok
> Teacher: They're asking you, remember the meaning for compatible numbers?
> James: Numbers that make calculations easier.
> Teacher: Ok, so now, what two numbers besides these two decimal numbers could you estimate, use to estimate the answer?
> Teacher: 54.2 is close to what number?
> Teacher tells James to think about making each of the numbers a whole number.
> Teacher: 54.2 is close to what number?
> James: Hundred.
> Teacher: Mm mm. 54 divided by
> James: Wait what?
> Teacher: Find the numbers that you have 54.2 divided by 6.7. Ok now, what number did you say you have to change 54.2 into? 54. Ok, so put that down. Now think about what number to change 6.7 into to make it easier for you to divide.
> James: Times 10.

[7] When finding compatible numbers, students can select different numbers. There is not one correct answer.

Teacher: We're not timesing. We're rounding. Up or down.
James: Oh.
Teacher: 54 divided.
James: 7
Teacher: Not 7, 6. Not 7
James: Don't I have to round up?
Teacher: Round up, that's 7, but what's easier to divide 54 by? 6 or 7? What times 6 gives you 54?
James: Oh 9.
Teacher: mm hmm. So now, if you divide by 9, it'll be easier to divide.
James: So 54 divided by 9?
Teacher: 6 because of that number.
Teacher: I think I'm confusing you. You're changing these numbers into compatible numbers to make it easier to estimate the quotient. 54.2 changed to 54.
James: So 54 divided by 6

In this example, Ms. Wilson leads James to obtain a correct solution and, as a result, James describes himself as competent. As discussed in the previous chapter, in a subsequent interview, James states that the topic of compatible numbers is the easiest thing he learned in class in the prior weeks. Yet when asked to describe compatible numbers, he provides an inaccurate explanation, stating, "When you're doing moving the decimal, you can actually understand it a lot more. It will be like with the decimal in the same place you would divide it, it would be easier to do" (James, personal communication, March 26, 2015).

Analysis of James's perceptions of competence in this mathematics classroom reveals two important aspects of how James interprets and internalizes his experiences in the mathematics classroom: (1) his perceptions of himself as a good and competent mathematics learner is based on his own beliefs about competence, and not always aligned with that of the teacher's and other students' perceptions of competence. Thus, he views himself as a competent mathematics doer and learner despite others' perceptions of him; and (2) James, like Mario, sees accurate performance as an indicator of competence. Since accuracy is valued in this classroom, correct solutions are a sign of competence even when the student lacks conceptual understanding and the teacher provides step-by-step directions to obtain the answer.

The case of James provides another example of problemetizing the co-construction process. The classroom's and James's constructions of competence are not aligned. James's interpretation of his competence is not corroborated by the classroom's perceptions of his competence in mathematics. The qualities James values and attributes to his competence in mathematics, such as applying prior knowledge and finding alternative solution methods, are not recognized by the other members of the classroom. Furthermore, like Mario, James may be overstating what he is actually doing.

5.4 Discussion of Competence in Mathematics and d/Deafness

When asked to discuss what it means to be a DHH learner in the mathematics classroom, Mario's asks, "Are we talking about DHH or math?" His question is quite interesting, as it highlights a belief that no relationship exists between d/Deafness and mathematics. On a surface level, the role of d/Deafness as it relates to the classroom's construction of competence appears absent from this chapter. However, through a closer examination of the characterizations of competence and the mathematical obligations in this classroom, it is evident that the classroom context, and more specifically, aspects of curriculum and instruction in a DHH self-contained mathematics classroom, are overarching. Since the students reference practices related to instruction as they narrate their identities, I examine the classroom context in light of the broader educational literature involving mathematics education of DHH learners. Instruction in this classroom is consistent with the broader literature related to DHH mathematics education. Studies of DHH mathematics educators has reported that DHH educators often lack mathematical knowledge as well as mathematical knowledge as it relates to DHH learners, and

DHH educators tend to focus on concrete mathematics (Pagliaro, 1998a; Pagliaro & Kritzer, 2005). In addition, teachers may be “encouraging, if not outwardly teaching, the use of procedures for all mathematics (computation as well as problem solving) without first establishing a conceptual understanding of mathematics concepts such as number” (Pagliaro & Ansell, 2012, p. 455).

Findings from the analyses of the interview and classroom observation data corroborate that this mathematics classroom consists of textbook definitions, repetition, and memorization. Furthermore, accurate completion of mathematics problems in the allotted time and fluency in procedures are indicators of competence in mathematics. Students are applauded for correct solutions and procedures, and able to move on to subsequent problems, but are required to repeat problems if a solution is incorrect. Thus, success in this classroom and competence in mathematics are measured by accuracy on repetitive concrete tasks.

Hill et. al (2008) found that “a lack of MKT (mathematical knowledge for teaching) leaves teachers unable to navigate common and necessary elements of even very basic instruction” (p.468). In DHH self-contained mathematics classrooms, many teachers of the DHH lack expertise in mathematics (Pagliaro, 1998a). Although she has the best intentions, Ms. Wilson does not have training in mathematics content and pedagogy and, thus, relies upon textbook definitions and procedures for instruction (e.g., Pagliaro, 1998a). Instruction tends to focus on rote, concrete concepts, rather than abstract higher level mathematics learning (e.g., Pagliaro & Kritzer, 2005). After finishing a unit on perimeter and area of rectangles, Ms. Wilson reflects on Mario’s mathematical understanding:

> “Area and perimeter I would like to go back over that with him only because I think memorizing the formula will be beneficial for him to know area of a square is this, area

of a rectangle is the L= length, W= width which is why we're going to invest in some of those types of benchmark things so it can be in the classroom so that he can see all the time posters that have the information that have him learning. Like those, like measurement length times width equals that. I think him seeing it more times and imagining math class and the book would help him memorize it better. If I ask him now he's probably going to be like ‘what's the formula for the length or the area of a rectangle?’. I don't think he would be able to tell me.

(Ms. Wilson, personal communication, April 21, 2015)

Ms. Wilson’s reflection reveals that she believes that Mario will become more successful with practice and repetition. Like many other DHH students, the students in this classroom often learn *how* to compute an operation, rather than understand *when* it is appropriate to perform an operation (e.g., Stone, 1988).

In addition to relying upon textbook definitions and repetitive practice problems for instruction, Ms. Wilson does not have the training and professional support needed to explain mathematical concepts in multiple ways. For example, when discussing instruction of scale factor, Ms. Wilson states, “We know it means 1 inch to 5 feet but how do you explain that to a deaf student that's just like ok, 1 inch to 5 feet, now what?” (Ms. Wilson, personal communication, April 21, 2015). Teachers need professional development and support to develop mathematical knowledge for teaching to be able to go beyond restating textbook definitions, to help students make connections between prior knowledge and current instruction, and to build upon student errors and confusions to help students understand the content (Hill et al., 2008).

The students view Ms. Wilson as the authority in the classroom, despite her lack of pedagogical and content knowledge. When the students take up the normative identity in this classroom, they develop identities of competent mathematics learners in this classroom, based on problematic constructions of mathematical competence and based on their assumptions of Ms. Wilson's knowledge of mathematics.

Considering the classroom context, a DHH self-contained mathematics classroom, is critical to the discussion of the characterizations of competence and identity development in this mathematics classroom. In many DHH classrooms, teachers are not sufficiently prepared in mathematics pedagogy and content, and instruction often emphasizes practice, repetition, and textbook definitions. This highlights the importance of conducting further research that considers issues of mathematics socialization, identity, and agency among DHH learners in mathematics classrooms. Since many DHH educators have insufficient preparation in mathematics education and mathematics instruction of the DHH tends to rely on concrete mathematics, students in DHH classrooms may, possibly unknowingly, take up identities that emphasize low level mathematics.

CHAPTER 6 CASE STUDIES

In this chapter, I provide in-depth analyses of two students, Anna and Vivian, to examine how and why individual students take up the classroom and mathematical obligations as well as the identities of competence in this classroom. I focused on the cases of Anna and Vivian because both of these students are described and positioned by others as competent mathematics learners. However, they internalize the classroom obligations differently and they describe their own competence differently.

I will describe how Anna's and Vivian's mathematics identities are co-constructed in relation to the classroom obligations, as negotiations between their own beliefs about themselves as mathematics learners and others' constructions of them as mathematics learners. As I have mentioned earlier, in addition to examining the co-construction of mathematics identities in a social sense, whereby mathematics identities are co-constructed by oneself and others, I also consider how DHH identities develop alongside mathematics identities. When analyzing the cases of Anna and Vivian, the students' views about d/Deafness and the ways their views impacted how they make meaning of their mathematical experiences emerged. By operationalizing identities as narratives, I was able to study how DHH identities are co-constructed alongside mathematics identities and use the narratives to understand Anna's and Vivian's perceptions and experiences in this mathematics classroom. I will describe how Anna and Vivian narrate what it means to be DHH in the context of mathematics learning in their classroom and how they narrate what it means to be learners and doers of mathematics in the context of being DHH.

6.1 The Case of Anna

Anna is a seventh grade student and works out of the seventh grade textbook with the two eighth grade students in the class, Vivian and James. Anna identifies as deaf because she cannot hear, which is consistent with her audiological definition of deafness, in which a hard of hearing person can hear “a little” and a deaf person “completely can't hear” (Anna, personal communication, April 21, 2015). Anna has always been in a self-contained DHH classroom and has never been mainstreamed for mathematics. Anna states that she prefers to be in the DHH classroom, since she “understands more” in the DHH classroom (Anna, personal communication, April 13, 2015).

Anna’s parents sign with her at home. When Anna was a baby, her mother decided to have Anna undergo the procedure to receive a cochlear implant. At first, the noises she heard after the implantation bothered her and she recalls thinking, “get out of my head” (Anna, personal communication, April 13, 2015). Now she is happy to have a cochlear implant. When she uses her cochlear implant, she is able to hear some sounds. She prefers to be deaf, however, since she is able to turn off the sounds when it gets too noisy and she wants quiet. Given the chance, Anna would not want to become hearing (Anna, personal communication, April 13, 2015).

Anna believes that no significant differences exist between hearing and DHH students. She states that the only difference between DHH and hearing people is, “deaf can't hear and hearing can... if deaf people have a cochlear implant or a hearing aid, then it’s the same” (Anna, personal communication, March 5, 2015). Anna asserts that any discrepancies between hearing and DHH students are due to language differences, and not innate ability, repeatedly stating across interviews (e.g., the initial interview, two group interviews, and the final interview) that difficulties for DHH students in hearing classrooms is "only about language" (Anna, personal communication, April 13, 2015) and that the "only difference is language" (Group, personal communication, March 18, 2015). She asserts that a hearing classroom with a speaking teacher is more difficult for DHH students, just like a DHH classroom with a signing teacher would be more difficult for hearing students (Anna, personal communication, March 5, 2015). Anna emphasizes the importance of language and a teacher's fluency in sign language. If the teacher cannot sign fluently, then school is more difficult (Anna, personal communication, March 5, 2015). On multiple occasions (e.g., the initial individual interview, the fourth group interview, and the final individual interview), Anna states that hearing and DHH classrooms are "the same" and that she is on the same level as her hearing peers, because "I think they use the 7th grade math book, I use the 7th grade math book" (Anna, personal communication, April 13, 2015). Although Anna recognizes that the hearing students are further along in the book, Anna still believes that she is at the same level as the hearing students and continues to insist that the only difference between DHH and hearing students is language.

6.1.1 Anna's Positioning as the "Ideal" Student in this Classroom. The obligations in this classroom involve repetitive work and obedient behavior. In this classroom, a competent learner is someone who uses the established solution methods to find the correct solutions and develops fluency in the procedures. Anna's classroom behaviors and proficiencies in mathematics are aligned with this classroom's characterizations of what it means to be a good mathematics student. By adhering to the obligations, Anna is positioned as a good math student in this classroom.

Analysis of the interviews revealed that Ms. Wilson and all but one of the students in the classroom indicate that Anna is the best mathematics student in the class (James describes himself as the best student in the classroom). Vivian states that she knows Anna is the best math student in class because the teacher provides more positive feedback to Anna (Vivian, personal communication, April 15, 2015). Vivian also believes that Ms. Wilson accepts Anna's answers over her own answers, which confirms to her that Anna is a better student, stating "She thought of the problem right but I thought of it differently, and Ms. Wilson would accept hers" (Vivian, personal communication, April 15, 2015).

The students and Ms. Wilson's assertion that Anna is the best student in the class reinforces that hard work, good behavior, and diligence are the valued attributes of a good math student in this classroom. Anna adheres to the classroom obligations, completing the assigned problems and following the teacher's directions. Although Anna takes longer to complete a given problem set, she obtains the most accurate solutions and is praised as the best student. As Ms. Wilson states, "Anna, with the curly hair, shivery meticulous with everything, all of her work. So, she's slow, but slow and steady wins the race with Anna. So, she does everything, she looks at each question, and makes sure that she's right. She might be the slowest one to finish her work but she is gonna have it right by the end of the day" (Ms. Wilson, personal communication, March 2, 2015). While speed is also mentioned as an indicator of competence in this classroom, Anna is still positioned as the best student despite working slowly, because she works diligently and obtains correct solutions (Ms. Wilson, personal communication, April 21, 2015). However, even though Anna knows *how* to solve the problems, Ms. Wilson does not believe that Anna always understands the mathematical concepts behind the procedures (Ms. Wilson, personal communication, April 21, 2015). Thus, Anna is positioned by Ms. Wilson as the best student in the class based upon behavior and accuracy, rather than conceptual understanding, critical thinking skills, and problem solving skills. This characterization of Anna is aligned with Ms.

Wilson's assertion that, "if you're still not necessarily getting it, then you're still considered good, you're still a good math student" (Ms. Wilson, personal communication, April 21, 2015).

Field notes from the month-long observation were coded to examine Anna's classroom behaviors. The following behaviors were observed: working independently to complete practice problems, copying definitions from the textbook or blackboard into her notebook, and copying completed problems onto the blackboard. Across the entire month-long observation, Anna adheres to all the classroom obligations and follows all the teacher's directions. Anna only asks the teacher questions when her solution is different from the teacher's solution, which rarely occurs. In that case, the teacher tells Anna the correct solution, and Anna accepts that solution and records it in her notebook.

On one occasion, Anna presents an "alternative" way to solve a long division problem. On March 26, 2015, Day 16 of the classroom observations, the teacher had written the following long division problem on the board:

```
    0.004
52 |0.208
    - 0
       20
    -   0
       208
     - 208
         0
```

Anna tells the teacher that she completed a long division problem in a shorter way. Anna computed the long division the following way:

```
    0.004
52 |0.208
   -   208
         0
```

Anna saw that zeroes could be used as placeholders and she could then divide 208 by 52. Although Anna does not justify nor explain her work, Ms. Wilson applauds Anna and states, "Uh, huh. That's a good idea to do it a shorter way. Do you want to show [the researcher] what you did? Show her what you did" (March 26, 2015). Anna walks over to me and shows me her notebook.[8]

In Chapter 4, I showed a segment from the field notes, where James tells Ms. Wilson and Vivian that he solved the problem in a different way. In that situation, Ms. Wilson tells James that she will show him how he is "supposed to" solve the problem (observation, March 11, 2015). Likewise, later in this chapter, Vivian shares a story in which she solves a division problem in a more sophisticated way, but, according to Vivian, Ms. Wilson accepts Anna's solution, since Anna followed the established methods (Vivian, personal communication, April 15, 2015). Thus, Ms. Wilson praises Anna for solving a problem in a different way but does not acknowledge Vivian or James when they solve a problem in a different way. These examples from the interview and classroom observation data show that, in this classroom, Anna's work is validated by Ms. Wilson, and that Ms. Wilson sees Anna as a valued contributor in the classroom.

6.1.2 <u>How Anna Takes Up the Classroom Obligations.</u> Anna takes on an identity of a competent mathematics student, claiming that she is "smart in math" (Anna, personal communication, April 13, 2015) and is a good math student, since she follows the rules, works hard, pays attention, does her homework, and gets good grades (Anna, personal communication, March 5, 2015; Group, personal communication, March 25, 2015; Anna, personal

[8] This was the only time throughout the observation that a student was instructed to show me his or her work. As a non-participant observer, I sat in the back of the classroom and did not engage with the students during the classroom instruction.

communication, April 13, 2015). Anna states that her parents and teachers have always told her she is smart and a good math student (Anna, personal communication, April 13, 2015). When asked if there were other ways she knows that she is smart, she stated that she, “[does] hard math” (Anna, personal communication, April 13, 2015). Since Anna believes that she is engaging high-level mathematics successfully, she views herself as a competent mathematics learner. Anna’s view that there is no difference between DHH and hearing students, coupled with her belief that she is a competent mathematics learner, have led her to believe that DHH people can be and are successful in mathematics. Anna believes that being DHH does not hold her back from being competent in mathematics.

When asked about the importance of doing well in mathematics, Anna states that it is important to do well in mathematics to be “smart” (Group, personal communication, March 12, 2015). Being knowledgeable in mathematics can be useful in other subject areas, such as science (Group, personal communication, March 18, 2015). When discussing the value of mathematics outside of school and the kinds of mathematics that are useful for life, Anna focuses on mathematics operations and counting. For example, Anna says knowing mathematics is important “to find out how old something is” and for “counting” (Group, personal communication, March 18, 2015). When asked specifically about how she would use her knowledge of multiplying decimals outside of the classroom, she says, "to find the right numbers you want. To find money” (Group, personal communication, March 12, 2015).

Anna's motivation to learn mathematics is to progress in school and to be smart. Because Anna believes in the importance of good grades and success in school, she adheres to the general and mathematical obligations in the classroom, even when she may not identify with them. For example, Anna expresses frustration about completing homework at night. Anna believes that homework is the same as classwork, since both the homework and the classwork require her to independently complete a set of problems. Anna does not see the value in completing practice problems at home, since she works independently on isomorphic problems each day in class. Although Anna may ask Ms. Wilson to reduce the number of assigned problems, she does not voice her frustrations to the teacher, and states, “I don't know if you should ask teachers about that” (Anna, personal communication, April 13, 2015). Anna holds that in order to be a good student, she must follow the teacher’s directions, even if she does not agree with the teacher. (Anna, personal communication, April 13, 2015)

6.1.3 <u>The Consequences of Being Positioned as the “Ideal” Student.</u> In this classroom, Anna is positioned as a successful mathematics student, even though she is engaging low-level, rote exercises, and not high-level mathematics. Past and current teachers as well as peers have contributed to Anna’s identity of competence in mathematics. Anna is praised for accuracy and completion, rather than her comprehension and critical thinking.

It is important that students develop positive perceptions of their competencies and abilities in mathematics. However, Anna’s competence as a mathematics learner in this classroom may be overstated. In the excerpt below, Ms. Wilson describes Anna as the best student in the mathematics class, even though she may not understand the mathematical concepts and takes a long time to complete assignments.

> Teacher: Anna is both [a good math student and good at math]. Diligent math student, diligent, good at math.
> Interviewer: Do you think she understands the concepts easily also?
> Teacher: It's, no, I don't think so, it takes her a longer time to get them. So explain it more in different ways is a better way for her to understand it.
> Interviewer: Ok, who would you say is the best math student in the class?
> Teacher: Anna
> …

Interviewer: And why do you say Anna is the best math student?
Teacher: She takes her time, she makes sure that she understands it, um understands it to the point where she can take it home on her own.
(Ms. Wilson, personal communication, April 21, 2015).

Since accuracy and completing practice problems is valued in this classroom, Anna is a successful, competent mathematics learner in this context. As a result, Anna believes that she is smart, is working at the same level as her hearing peers, and is prepared to be successful outside of the classroom.

In Chapter 5, I presented an example, where Ms. Wilson wrote the following number sentences on the board:

Day 14, March 24, 2015: Dividing decimals and compatible numbers:

$$6 / 3 = 2$$

$$60 / 30 = 2$$

$$600 / 300 = 2$$

$$6000 / 3000 = 2$$

The dialogue during the group interview that followed this lesson exemplifies why Anna's beliefs about her own competence may be problematic. During this lesson, Ms. Wilson tells the students that if she "adds one zero" to each number, the answer is the same, if she "adds two zeroes" to each number the answer is the same, and so forth. Anna believes that she understands the mathematics, because she is recognized for obtaining the correct solution, but is unable to explain the mathematical concepts, only that the solutions are the same.

Interviewer: [Ms. Wilson] said, "add zeroes add zeroes". Do you know why?
[Interviewer shows Anna and Vivian the problem]
Anna looks at Vivian and Vivian shakes her head.
Interviewer: No? So you didn't understand why? But you didn't ask for help? You all said "ok ok".

Vivian: I kind of did understand because after, I think after, the decimal those two numbers are not important.
Interviewer: Ok, tell me more.
Anna: If you have 2.0 and then it is 2.
Interviewer: Ok, but yesterday Ms. Wilson she said, add zeros, add zeros. Remember she said 6/3 = 2, 60/30=2. And she said it doesn't matter if you add zeros. What does that mean?
Anna: You get the same answer.
(Group, personal communication, March 25, 2015)

Anna states that 2.0 is equivalent to 2, which, although mathematically correct, is not the same mathematical concept as the extended facts problems discussed during class. In addition, Anna emphasizes the solution, stating that "you get the same answer." Since this classroom values accurate solutions, Anna is merely looking to the solutions, rather than attempting to understand the patterns and underlying concepts. In another example, when Anna is asked to explain why the decimals do not need to be lined up when multiplying numbers with decimals, as they do in addition and subtraction, she is unable to provide an explanation related to multiplication or place value concepts, and responds by providing an example of a multiplication problem, multiplying each digit in the first factor by each digit in the second factor (Anna, personal communication, April 13, 2015).

Although Anna was not able to explain the concepts or procedures involved in the mathematics activities in this classroom, the ways that Anna has been positioned in the classroom, by herself and others, reaffirms her views that she and all DHH students can be successful in mathematics. Anna has always been placed in the self-contained mathematics classroom and, for as long as she can remember, has always been praised as a smart, capable, hard-working mathematics student by her family, teachers, and peers. Anna takes up this identity and believes that with hard work she is, and can continue to be, a successful DHH mathematics learner.

While it is important that classroom environments foster the development of positive mathematics identities, at the same time, students need to be engaging in high-level mathematics. Anna is praised as a great student because of her good behavior in the classroom as well as her knowledge of the procedures and accuracy of her solutions. This may be problematic when Anna enters High School or is required to use mathematics in real-world contexts. Without the necessary conceptual understanding, she may not have the tools to apply the procedures she has learned in school, which could influence how she later sees herself as a mathematics learner.

6.2 The Case of Vivian

Vivian identifies as hard of hearing. She defines a deaf person as a person who “can't talk or hear”, and a hard of hearing person as a person who “can talk but you can't hear” (Vivian, personal communication, April 15, 2015). Vivian has always wished she could be hearing. She states that DHH people have many more obstacles, and that hearing people “don’t have to go through a lot. You don’t have to find a deaf high school, you don’t have to make hearing friends” and that being deaf is “not really easy” (Group, personal communication, March 31, 2015). Given the opportunity, Vivian would choose to become hearing. She frequently wonders what it feels like to be able to hear without the use of hearing aids and feels that she is missing out on opportunities afforded to hearing students. For example, when she sees hearing people with headphones, she wishes she could hear the music the same way as hearing people (Group, personal communication, March 31, 2015).

As mentioned in Chapter 3, Vivian’s mother had a difficult delivery. Vivian was born extremely small and she and her mother almost passed away during childbirth. Vivian states that, "sometimes I blame it on God for me being deaf. But now I’m thankful for Him because when I was born I was almost dead”. Because of this experience, she feels “blessed to have a good life”

(Group, personal communication, March 31, 2015). When she was younger, Vivian was more upset about being hard of hearing, but as she has gotten older her feelings about being hard of hearing have changed. “I was upset when I was born hard of hearing, I mean I'm not upset any more, I'm fine with the way I am, it's not like I'm a different person from a hearing kid, we're both the same but I'm just not hear as much” (Vivian, personal communication, April 15, 2015).

Vivian prefers to socialize with hearing students but also believes that it is more difficult to become friends with hearing people when you are DHH. The hearing students do not learn sign language at WV so she must rely on her residual hearing and hearing aids to communicate with her hearing peers. At times, this can be frustrating and limiting.

> Vivian: My friends don't sign but I sometimes understand what um, like when they try to tell me, like when they whisper, I am a little uncomfortable with it because I can't really hear but I'll just pretend I heard them.
> Interviewer: Oh? You’ll just pretend you heard them?
> Vivian: mm hmm
> Interviewer: Why do you do that?
> Vivian: Because if I say, “what did you say?”, they will say, “never mind” and I hate when people say “never mind.”
> (Group, personal communication, March 31, 2015)

If she misses part of a conversation and asks her friends to repeat what they said, they often dismiss her question. This upsets Vivian, and she feels that her friends often “forgot that [she is] hard of hearing,” in part because she is able to speak and has been in classes with the hearing students since first grade (Vivian, personal communication, April 15, 2015). Vivian is uncomfortable when her friends whisper and copes by pretending to understand what they are saying. She fears that if she asks them to repeat themselves, they will brush off her questions, which makes her “feel sad” (Group, personal communication, March 31, 2015). Vivian wishes that her friends would sign but has found that her eighth-grade peers are not interested in learning sign. She states, however, that younger children at the school are excited to learn sign. Vivian feels proud and excited when hearing people take an interest in learning ASL (Vivian, personal communication, April 15, 2015).

6.2.1 Vivian's Past Experiences in the Mainstream Classroom Shape Her Perceptions of Her Competence in Mathematics. Vivian is the only student in this self-contained mathematics classroom that had been mainstreamed for mathematics in previous school years at WV. Vivian feels accepted in both the DHH and the hearing communities stating, "I feel like I'm included with both communities because I have been with the hearing since for the rest of my life a lot" (Group, personal communication, March 31, 2015). She likes being in the hearing classroom, particularly because the students in her class are the same age. However, through a series of negative experiences in the mainstream mathematics classroom, Vivian began to see herself as less competent than her hearing peers.

In Vivian's final year in the mainstream mathematics classroom, sixth grade, she had a hearing teacher who did not sign. Vivian describes this experience:

> "I think 2 years in 6th grade I had a hearing teacher. She didn't know sign language. I was the only hard of hearing girl in her class. She had an FM system and, um, never, didn't use it. I don't know why but it was, it was a really, really hard year for me in math because I was embarrassed. I was frustrated with math problems and I'd get in trouble with the teacher."
> (Vivian, personal communication, March 4, 2015)

Although the classroom was equipped with an FM system, the teacher did not utilize the system during instruction. Without an interpreter and an FM system, Vivian missed much of the mathematics instruction, particularly when the teacher looked away (e.g., she spoke while facing the blackboard instead of the class). As a result, Vivian did not always understand the lessons and felt less competent than her hearing peers.

In addition, Vivian felt embarrassed when she was treated differently by the hearing teacher.

> "I mean I've been to her class before and I was her 4th grade student and then she moved up, that year I didn't like the way she talked to me because I'm the only hard of hearing kid in her class and she would say go to the bathroom, like she would move her mouth like she had never talked to a deaf kid before. That kind of hurt me a little…Because it was like when she talked to me I felt like I was slow or something...I told her before that 'you can talk to me normally because I'm hard of hearing I can hear you.'
> (Vivian, personal communication, April 15, 2015)

In order to communicate with Vivian, the teacher moved her lips slowly, which caused Vivian to think of herself as a slow learner. Vivian told the teacher to speak as she normally would, but the teacher continued to talk to her differently. Since Vivian often had difficulty following along with the lesson, particularly when the teacher was facing away from Vivian, she felt uncomfortable and discouraged. Vivian states that "[she'd] get in trouble with the teacher." (Vivian, personal communication, March 4, 2015). When asked to elaborate upon her experiences of getting into trouble, Vivian shared the following story:

> "I remember learning about scale drawing. She told me to draw anything. We have to draw a larger drawing. I did not understand because while she was talking she was not looking at me so I couldn't read her lips so I asked my friend sitting next to me and she said to draw a picture of something real and then said to draw a scaled new one. I thought that was easy so I am good at art. And the next morning I gave it to my teacher and she said, 'who drew that?' and I said, 'I did'. She said, 'I don't believe you'. She said I had to do the whole thing again. My mom had to get involved.
> (Vivian, personal communication, March 4, 2015)

Vivian was confident in the mathematics assignment, particularly because it bridged her art skills with mathematics. When the teacher did not believe that she had done the work, Vivian's mother came to speak to the teacher and confirmed that she did, in fact, complete the assignment on her own. Vivian's teacher did not believe that Vivian was capable of completing the assignment so quickly on her own. Vivian felt embarrassed and saw herself as an incompetent learner when the teacher did not accept her assignment. The teacher's disbelief that Vivian could complete the assignment successfully in such a short period of time also caused Vivian to feel that she was a difficult student who got into trouble.

Across multiple interviews, Vivian expresses her frustration trying to follow along with the pace in the mainstream classroom setting (e.g., the initial individual interview, the final individual interview). Due to her experiences in the mainstream classroom, Vivian came to believe that "a hearing person knows math easier than [she]" and that "a hearing person…can understand quickly. A deaf person, it is slower" (Vivian, personal communication, March 4, 2015). Ultimately, Vivian decided to leave the mainstream setting and move into the DHH classroom. Vivian's experiences in the mainstream setting have shaped her perceptions about her own abilities and competence, as well as her perceptions of other DHH students' abilities and competence in mathematics.

Vivian did not realize that many of her frustrations in the mainstream setting were due to inadequate services and modifications. For example, her teacher should have utilized the FM system, and Vivian should have been provided with a note-taker and interpreter, when necessary. Vivian was not provided with the resources to enable her to engage productively in the mainstream classroom. The teacher did not sign, was unable to help her if she solved a problem incorrectly, and would merely read her the procedures from the book (Vivian, personal communication, April 15, 2015). Yet, Vivian attributes her difficulty in the mainstream setting to her perceived low competence and ability. Vivian explains that she was not able to follow along with the pace of instruction and missed much of the information because she is not as smart as the hearing kids (Vivian, personal communication, March 4, 2015; Vivian, personal communication, April 15, 2015). She feels disappointed with her low grades in the mainstream classroom, and believes that her grades are a reflection of her ability as a mathematics learner.

Vivian's negative experiences in the mainstream classroom led her to believe that she is not as competent in mathematics as the hearing kids and that the hearing kids understand mathematics more easily. Since Vivian was not provided with accommodations that would enable her to be successful in the mainstream classroom, she came to believe that hearing students innately understand mathematics much more easily than DHH students. When mainstream programs do not provide students with support and appropriate accommodations, DHH students in mainstream classrooms, like Vivian, are hindered from realizing their potential (Angelides & Charalambous, 2005; Kluwin & Stinson, M., 1993; Stinson, M. & Liu, 1999).

6.2.2 Vivian's Competence in the Self-Contained DHH Mathematics Classroom.

Vivian is described by others as a good math student because she learns well, pays attention, and always tries to understand the mathematics (Ms. Wilson, personal communication, March 2, 2015; Vivian, personal communication, April 15, 2015). Ms. Wilson identifies Vivian as the student with the highest mathematics ability in the self-contained classroom because, "she gets the concepts of the math easier and quicker and can apply it in different places" (Ms. Wilson, personal communication, April 21, 2015). Ms. Wilson states that Vivian is a competent learner who "has a better grasp of everything when I'm talking about it in class" (Ms. Wilson, personal communication, March 2, 2015). Ms. Wilson asserts that "because she's mainstreamed, she has a better grasp" (Ms. Wilson, personal communication, March 2, 2015). Thus, Ms. Wilson believes that Vivian's experiences in the mainstream classroom have better prepared her for mathematics in the self-contained classroom. The students in the classroom also describe and position Vivian as a competent mathematics learner. Anna states that if she ever needs help in class, she would ask Vivian (Anna, personal communication, April 13, 2015) and James checks his work with Vivian during mathematics class (e.g., Observation, Day 6, March 11, 2015).

Vivian's perceptions of her own competence in the self-contained mathematics classroom, however, are not aligned with Ms. Wilson's and the other students' perceptions of Vivian's competence. Although she recognizes that others view her as competent, she questions her own competence, stating, "I have a lot of teachers tell me I'm a good student and they say I'm good in math but I think I'm not because I have problems at math" (Vivian, personal communication, March 4, 2015).

Vivian's gauges her competence in mathematics relative to the other students in her class. In the mainstream classroom, since Vivian was not able to follow along with the pace of instruction, she describes herself as slower and less capable than hearing students. Just as Vivian defined her competence in relation to the hearing students in the mainstream classroom, in the self-contained classroom, Vivian defines her competence in relation to "the best student in the class", Anna. In the excerpt below, Vivian describes a time when she completes a long division problem. Vivian explains that during class, she noticed that the first number in the dividend could not be divided by the divisor, so she looked at the subsequent number in the dividend and divided. Anna, on the other hand, wrote a zero for the first number in the quotient above the digit in the dividend that could not be divided, which was consistent with the way Ms. Wilson computed a similar problem. Although Vivian thought her solution was correct and more efficient, Vivian believes that the teacher favored Anna's solution:

> Interviewer: Who do you think is the best math student in the class?
> Vivian: Anna.
> Interviewer: Why Anna?
> Vivian: She's good and she's better than me.
> Interviewer: How?

> Vivian: Not better, we're both equal but I think she's good.
> Interviewer: What makes her good?
> Vivian: She thought of the problem right but I thought of it differently, and Ms. Wilson would accept hers.
> Interviewer: How would you solve it differently? Can you give me an example?
> Vivian: Like dividing for example like for example she would go 21 to the 1st column where you would put a 0, I would skip it, like I would pick a whole full number that is bigger than 24, so like 35.
> Interviewer: Let's write it down.
> Interviewer: Show me what you mean right here and don't worry about your hands.
> Vivian: Like
> [Vivian writes]
> Vivian: Like that show that or like subtract 1 show that 4 can't go into 1 so she would a 0 but I would skip it, so I already know 4 can't go into 1 so I just skip it
> Interviewer: Do you think it's better the way she solves it or the way you do?
> Vivian: The way I do it, because it's easier.
> Interviewer: So then why do you think she's better at math?
> Vivian: I don't know she's just smarter, I don't know.
> Interviewer: How did you know that the teacher accepts her answers more than yours?
> Vivian: Because she'll say "good job!" but to me she would say "you did good."
> (Vivian, personal communication, April 15, 2015)

Vivian measures her competence in mathematics based off feedback from the teacher. When Ms. Wilson praises Anna, it reinforces to Vivian that Anna is a better mathematics student in this classroom. Vivian’s interpretation of the interaction above also highlights how the student-teacher interactions at a micro-level may be consequential to Vivian’s identity development (e.g., Bishop, 2012; Langer-Osuna, 2015, 2016; Wood, 2013). Vivian takes up an identity of less-competent, in part due to micro-level interactions such as this one. Vivian’s values the teacher’s feedback, and determines her own competence based upon Ms. Wilson’s assessment. Vivian believes that Anna is the better student, not because she has personally evaluated Anna’s work, but because she perceived that Ms. Wilson provided Anna with more favorable feedback.

In addition, Vivian evaluates her competence in mathematics based off her ability to explain the procedures for solving the mathematics problems. In this classroom, competence is characterized by accuracy and fluency of procedures. However, even when Vivian accurately completes the assigned problems using the established procedures, she does not necessarily take up an identity of a competent learner. Unlike the other students in the class who take up identities of competent learners when they complete the practice problems successfully, Vivian seeks to understand the reasoning behind the procedures. When Vivian successfully completes the problems but is unable to explain the procedures, she internalizes it as a personal failure and attributes it to being less capable.

In the following excerpt from the field notes, Vivian asks the teacher to explain front-end estimation:

March 5, 2015, Day 3, Addition and subtraction with estimation:

> Vivian: How did you get this?
> Teacher reads problem.
> Teacher: You're adding the front end so don't worry about those.
> Vivian: So the first number before the decimals and after the decimals?
> Teacher: Just before the decimal.
> Vivian: So what do you do with those?
> Teacher: Add them to each other. You're going to estimate those.
> Vivian: I don't understand.
> Teacher: See how they did it here? At the front-end is the dollars. I didn't estimate before I added the numbers together. You just add the front numbers first.
> Vivian: But why would it be 1?
> Teacher: That's near 1, that's how they're thinking about it.
> Vivian: So you have to get closer?
> Teacher: The closer whole number.

Following this interaction, Vivian follows Ms. Wilson's instruction and completes the assigned practice problems involving front-end estimation correctly. However, during the next group interview, Vivian says, "The work I still don't understand was front-end estimation. I still don't know what to do with that" (Group, personal communication, March 18, 2015). Thus, even though Vivian accurately completes the problems based on the teacher's instruction, she does not feel confident in her understanding of the procedures.

When Vivian grasps a mathematical concept in class, she is eager to describe the concept during subsequent interviews. For example, during a lesson involving division of decimals, Ms. Wilson instructs the students to multiply the divisor and the dividend by powers of ten. Vivian asks Ms. Wilson if she could move the decimal place, rather than multiplying by powers of ten, not realizing that by moving the decimals, she is, in fact, multiplying by powers of ten. By moving the decimal, Vivian consistently receives the correct answer, but does not understand the underlying place value concepts. A few days later in class, Vivian overhears Ms. Wilson explaining the procedure to Anna. Suddenly, Vivian looks excited and exclaims that she now understands. In the following group interview, we discuss this "ah-ha moment".

> Interviewer: You had a light bulb this week!
> Vivian: Yes.
> Interviewer: You said, "ahh now I understand".
> Vivian: Yeah.
> Interviewer: You noticed that when you multiply by ten, you move the decimal.
> Vivian: Move it one time it would be ten and two times would be 100.
> Interviewer: How did you notice that?
> Vivian: When Ms. Wilson explained to Anna, I was just looking. Like I was supposed to do, like my homework but I was just looking and she said to move the decimal every 100 and then I was like ok, then if you move it twice, its 200. And then I was oh my god yes I understand it now and she was just explaining it and I understood.
> Interviewer: So if you move it one time how much is it? Times?
> Vivian: 10
> Interviewer: Times 10, and move it twice?
> Vivian: It's 100.
> (Group, personal communication, March 25, 2015)

Throughout the month-long observation, Vivian completes problems accurately in class and acknowledges that she is considered successful in this classroom context. However, Vivian values understanding the procedures and does not identify as competent when she is merely following the teacher's instructions and unable to explain the procedures.

Moreover, Vivian believes that even if she completes the problems correctly and is able to explain the procedures, she is still less competent than the hearing students, since she is working below grade level in mathematics. Vivian expresses frustrations with content and pace in the DHH classroom. She states, "The hearing kids learn so much in 7th grade math and 8th grade. I did not learn that in 8th grade. In 7th grade I learned 6th grade math. Yes, and then in 8th grade I learn 7th grade math. I don't know I am embarrassed to go [to high school]" (Vivian, personal communication, March 4, 2015). While the hearing kids work quickly and on grade level, she works out of a 7th grade book in the DHH classroom, learning content that she has already learned in prior years. Vivian feels that she is not adequately prepared for high school and college because of the slow pace and remedial content taught in the self-contained mathematics classroom.

Since the grade-level of the textbook in the self-contained DHH classroom is one year behind the textbook in the hearing classroom, Vivian believes that she and the other students in the DHH classroom are slower and not as knowledgeable as hearing students (with the exception of Anna who is working out of her grade-level text). When describing the self-contained DHH mathematics classroom, Vivian states, "I feel like I'm slow when I'm surrounded by the deaf kids...I feel like a stupid kid" (Group, personal communication, March 25, 2015). To Vivian, the mathematical obligations in the self-contained classroom - *following established solution methods* and *developing fluency of procedures* - are constructed this way, because it is a DHH classroom. Vivian asserts that in DHH self-contained classrooms students must be explicitly taught mathematics procedures, "We need to understand step-by-step and in the other program they are fast, like they know it already and they understand and it like. Like they understand good" (Group, personal communication, March 25, 2015). In other words, unlike hearing students, DHH students require direct instruction that emphasizes procedures. This assertion is supported by the example provided earlier, whereby Anna followed the steps as outlined by the teacher and her solution was favored.

In this classroom, Vivian has limited opportunities to exercise conceptual agency. Vivian does not believe that she has the authority to make mathematical decisions in this classroom. She views Ms. Wilson as the authority in the classroom and believes that all teachers are knowledgeable (Vivian, personal communication, April 15, 2015). As a result, Vivian trusts that all instruction is mathematically correct. However, in the example below, Ms. Wilson provides an incomplete explanation of compatible numbers. Ms. Wilson tells the students to round the numbers, then divide, often resulting in a long division problem. As a result, Vivian does not grasp that the purpose of finding compatible numbers is to be able to estimate the quotient without doing long division. Vivian even tells Ms. Wilson that long division is less work, and asks if she can compute the long division without finding compatible numbers.

March 24, 2015, Day 14, Dividing decimals and compatible numbers:

> Problem written on blackboard: $574.75 \div 11$.
> Teacher asks for a number close to 11 that's easier to divide by.
> James says 10.
> Teacher turns to Anna and asks the same question.
> Anna: 7
> Teacher: 7?
> Anna: 57?
> Teacher tells Anna to look at the 11.
> Vivian: So you round those numbers down?

Teacher: mm hmm
Teacher asks for a number close to 574.75 and Anna says 570.
Teacher turns to James and asks him what number is close and James says 580.
Teacher tells James to round down.
Teacher completes a long division problem dividing 570 by 10.

```
   057
10|570
   -0
   57
  - 50
     70
   - 70
      0
```

Later, Vivian asks if the “number always needs to go down”. Teacher says that it depends on the number.

During the subsequent group interview (Group, personal communication, March 25, 2015), Vivian states that she had difficulty with the homework and was unable to complete all the assigned problems. Vivian does not question the teacher’s explanation, but rather believes that her inability to complete the assignment is due to her inability to grasp the content.

Vivian’s experiences in the mainstream and self-contained classrooms have led her to believe that she and all of the DHH students in the self-contained classroom are placed in this classroom because they cannot keep up with the pace in the mainstream setting. According to Vivian, the self-contained mathematics classroom is less academically challenging than the mainstream mathematics classroom because hearing students can understand the mathematics content at a faster pace than DHH students. Furthermore, the mathematics instruction in the self-contained classroom has not sufficiently prepared her for her future (Vivian, personal communication, March 4, 2015).

6.3 Discussion of Anna's and Vivian's Classroom Experiences and Identities of Competence

Competence in mathematics is an identity that may or may not be taken up by the students in the classroom. In both of these cases, the students are described by others as competent. Anna takes up an identity of competence but Vivian does not. Anna is positioned as the best math student in the class because she consistently follows the rules in the classroom, and completes the assigned problems accurately. Yet, Ms. Wilson identifies Vivian as the student with the highest ability in mathematics, because she believes that Vivian understands the content more readily. Anna believes that she is smart and competent in mathematics (Ms. Wilson, personal communication, April 21, 2015). Vivian, however, recognizes that others (such as her teachers) describe her as competent, but does not believe that she easily understands the mathematics and does not feel prepared for later mathematics. Vivian attributes her successes in class to hard work and effort, and does not see herself as Ms. Wilson describes her: someone who innately and easily understands mathematics. Furthermore, unlike the other students who take up identities of competence when they accurately complete the practice problems, Vivian does not see herself as competent when she completes the problems successfully using the instructed solution methods.

Three themes emerged from this analysis of Anna's and Vivian's narratives: (1) views of d/Deafness relate to perceptions of competence; (2) classroom obligations relate to how the students are positioned in different ways; and (3) perceptions of prior classroom experiences influence perceptions of current classroom experiences. First, Anna's and Vivian's views of d/Deafness relate to how they take up identities of competence in this classroom. Anna enjoys being DHH, believes that DHH and hearing students are the same, and that being DHH does not hinder her success. She believes that because she is working at the same grade level as her hearing peers and is successful in class, she is smart, knowledgeable in mathematics, and prepared to be successful outside of school. Conversely, Vivian sees d/Deafness as an obstacle that hinders success in mathematics. She believes that DHH students are slower learners, and that accurate performance does not fully equate to competence. Because Vivian views the hearing students as more knowledgeable and faster learners, she sees herself as less competent in mathematics.

Second, Vivian and Anna differ in the ways that they take up the classroom obligations and the characterizations of competence. In this classroom setting, procedural knowledge serves as a proxy of confidence for Anna but not for Vivian. Anna describes herself as a smart and competent mathematics learner when she accurately completes the assigned problems using the established solution methods. She identifies with the mathematical obligations of *using established solution methods* and *developing fluency in procedures*, and believes that it is important to do well in mathematics class to become “smart” (Group, personal communication, March 12, 2015). Vivian, however, does not identify with the mathematical obligations in the classroom. Vivian believes that instruction in self-contained DHH classrooms emphasize procedures and repetition because DHH students are slower and less competent than hearing students. To Vivian, even if she is successful in the DHH classroom, she is not a competent mathematics learner.

Third, Anna’s and Vivian’s narratives reveal that their perspectives of themselves as DHH mathematics learners are shaped by their interpretations of their past and present classroom experiences. Anna’s positive mathematics experiences and the consistent praise she receives in the DHH mathematics classroom have contributed to her beliefs that DHH individuals can be, and are, successful in mathematics. For Vivian, her difficulties in the mainstream mathematics classroom led her to believe that she and all DHH learners are less competent in mathematics, when compared to hearing learners. Although she may be viewed as competent in the context of this classroom, Vivian does not believe that she is as smart or as capable as hearing students.

Across both cases, the ways these students perceive their competence in mathematics is influenced by their views of d/Deafness, internalizations of the classroom obligations and practices, and prior experiences. Anna has strong beliefs about her competence in mathematics, even though she is engaging in low level mathematics. Vivian believes that she is slower and less competent than her hearing peers in mathematics when, in fact, she may not have been provided the resources to be successful in the mainstream setting and was not afforded opportunities to engage in high-level mathematics in the self-contained classroom.

CHAPTER 7 DISCUSSION AND IMPLICATIONS

Issues of mathematics identity, agency and socialization among DHH learners is currently understudied in DHH mathematics education literature. By foregrounding the perspectives of DHH learners, this study furthers our understanding of mathematics teaching and learning among DHH learners. At the same time, it provides a new context and population for applying theories of mathematics identities. On a more personal level, this work is a first step to understanding how DHH students experience learning mathematics, which will contribute to my ultimate goal of developing instructional design and mathematics curricula specifically for DHH learners, informed and shaped by the experiences and identities of the DHH learners.

The previous three chapters presented the findings of in-depth analyses of interview and classroom observation data that examined how a group of DHH learners narrate and experience learning mathematics in a self-contained DHH mathematics classroom. The purpose of the analyses was to explore the ways these DHH students co-construct their mathematics identities by themselves and others in a self-contained classroom, particularly in relation to the normative mathematics identity in their classroom. As I pursued my research questions, new questions emerged. In this chapter, I summarize and discuss salient findings from this dissertation work and discuss potential implications and recommendations for future research, practice, and policy.

7.1 Discussion of Findings

This dissertation work provides insight into the mathematics learning experiences of four DHH learners. As analysis of the student interviews revealed, the students narrate their identities through stories about practices and behaviors in the specific classroom context. The students' experiences are internalized and expressed in particular ways because of the particular classroom situation. In this section, I will discuss issues that emerged related to competence, co-

construction, and agency. I will then discuss findings related to the co-construction of DHH and mathematics identities.

7.1.1 <u>Classroom Obligations and Identities of Competence.</u> I am concerned with how the obligations of the classroom are defined and interpreted by the students, and how it may be consequential to identity development when the students do or do not take up the classroom obligations. In this classroom, the general and mathematical obligations involve expectations of compliant behavior as well as procedural fluency of low level activities, and include: *following the rules of the classroom*, *completing practice problems in class and for homework*, and *using established solution methods to complete practice problems*. The teacher is the primary authority in the classroom and has the power to determine the legitimacy of a response and accuracy of a solution. Adhering to the obligations in this classroom makes one a good math student in this classroom. Although complying with these obligations in this setting may position a DHH learner as competent, it may not fuel, in the long run, what it means to be a good mathematics student.

Characterizations of competence and of competent (or non-competent) learners are influenced by the classroom obligations. Competence in mathematics is in the context, and not in the individual student. It is located in the opportunities afforded to the students in the classroom. In this classroom, the identities of competence that are being made available to the students are rooted in low-level activities. If the opportunities are limited, the students may take up limited perceptions of competence, to no fault of their own.

The ways students are positioned as more or less competent depends upon what is valued in this classroom, and what it means to do mathematics in this classroom. Considering the low-level demands of the activities and the emphasis on repetition, procedural competence, and accuracy, the mathematics performed in this classroom may contribute to the development of problematic identities of competent mathematics learners. Anna, James, and Mario describe themselves as competent mathematics learners when they complete the practice problems successfully. While these students' perceptions of their own competencies may be aligned with the obligations of the classroom, they are misaligned with general mathematics education standards (e.g., NCTM *Principles and Standards*; The *Common Core State Standards in Mathematics*, CCSS-M). Identities of competence in mathematics are made available to the students in this classroom, but they are available in the context of low-level activities and rote practice and instruction that do not align with the larger mathematics community's characterizations of competence.

This study only involved one classroom and is not intended to be generalized to all DHH self-contained classrooms. That said, the situation in this classroom is consistent with the broader DHH mathematics education literature. In this classroom, students do not have many opportunities for challenging, high-level instruction (e.g., Angelides & Aravi, 2007; Stewart & Kluwin, 2001). Although Ms. Wilson has great intentions, she, like many mathematics teachers of the DHH, does not have adequate training in mathematics education, content and pedagogy (e.g., Dietz, 1995; Pagliaro, 1998a, 2010; Pagliaro & Kritzer, 2005). When teachers are not well prepared, students may not have the same opportunities to learn concepts (Schoenfeld, 2002). Moreover, mathematics content knowledge is essential for teachers in DHH classrooms that use sign language, so that teachers utilize conceptually accurate signs in mathematics (Lang, Hupper, Monte, Scheifele, Brown, & Babb, 2007).

Ms. Wilson employs traditional teaching techniques (e.g., Pagliaro, 1998b). Instruction in this classroom, like many DHH mathematics classrooms, focuses on skill and computation, rote practice, memorization, and textbook definitions (e.g., Pagliaro, 1998b; Pagliaro & Ansell, 2002; Pagliaro and Ansell, 2012). As a result, most of the students in this classroom describe themselves as competent, yet lack understanding of the underlying mathematical concepts. They only know the skills to follow specific procedures from the textbook and do not have the authority to determine the legitimacy of the mathematical responses.

7.1.2 Issues of Co-Construction. In this study, I examined how these DHH students' identities are co-constructed by an individual and others. However, the ways that James and Vivian do not take up certain identities in the classroom problematizes and exposes complexities to the study of the co-construction of mathematics identities. Analysis of the semi-structured interviews with James reveals that he does not take up an identity of a mischievous and less competent student. James describes himself as a competent, hard-working, well-behaved mathematics learner and even identifies himself as the best mathematics student in the classroom. Like Anna and Mario, when he answers questions accurately, he sees himself as competent. Yet, when his answers are incorrect, he attributes the errors to carelessness, and not to being less competent or mischievous. James's self-perceptions are not aligned with the classroom's construction of him and, consequently, he does not see himself the ways that the other students and teacher position him.

Unlike James, Anna, and Mario, Vivian does not take up an identity of competence when she attains correct solutions to the practice problems, in part due to her prior experiences and beliefs about what it means to do mathematics. She is described and positioned by others as a competent and capable mathematics student. In fact, Ms. Wilson states that she has the highest ability out of all the students in the mathematics class, Anna states that she would ask Vivian if she ever needs help, and James turns to Vivian in class to check his work (Ms. Wilson, personal communication, April 21, 2015; Anna, personal communication, April 13, 2015; Observation, Day 9, March 11, 2015). Vivian believes that she may be successful in this classroom, but does not feel that this DHH classroom adequately prepares her for high school or the outside world. When she compares her experiences in mainstream and self-contained settings, she deduces that DHH students (including herself) are not as smart, need more direct instruction, and are unable to keep up at the same pace as their hearing peers. Vivian's views of herself as less competent mathematics learner are not aligned with others' views of Vivian.

Math identities evolve and are always under construction. If I had conducted this study at a different point in time, I may not have had the opportunity to observe these misalignments. Perhaps James and Vivian would have eventually taken up the identities of mischievous and competent, respectively. Alternatively, the teacher and students may have changed their perceptions of James and Vivian. It remains unknown whether or not they would have ultimately reached agreement. Sfard and Prusak (2005) emphasize that narratives may vary and that, as researchers, we should attend to the "activity of identifying rather than its end product" (p. 17). Thus, researchers examining the co-construction of mathematics identities should embrace and explore misalignments between how an individual describes him or herself and how he or she is described and positioned by others.

7.1.3 Issues of Agency. In addition to considering the complexities involved in studying co-construction, this study made me think more deeply about the opportunities and the ways students exercise agency in this particular classroom, in relation to the mathematics content and the classroom obligations (Cobb, Gresalfi, & Hodge, 2009). Cobb, Gresalfi, & Hodge (2009) distinguish between conceptual agency, where students make meaning of the mathematics by choosing methods and justifying their solutions, and disciplinary agency, where students follow directions and use the established solutions methods.

In this classroom, Ms. Wilson answers all questions and determines the legitimacy of the solutions. So, the students are not provided opportunities to exercise conceptual agency. Moreover, I believe that the students have limited opportunities to *even* exercise disciplinary agency. For example, in Chapter 5, I presented a constellation of instances where Mario is learning about scale factor. Across this set of instances, Mario does not develop proficiency of the procedures at the level that the scale factor activities and classroom obligations require. In other words, there was a reduction of cognitive demand of the activities even around disciplinary agency. Ms. Wilson simplified the problems to one-step arithmetic calculations, and, as a result, the level of the cognitive demands of the activities were reduced. Although one may argue that Mario is exercising disciplinary agency when the teacher asks, for example, "what is 5x3?", it is certainly at a different level than the scale factor problem. These limited opportunities to exercise conceptual and disciplinary agency restrict the identities that students can take up. Later in this chapter, I will discuss recommendations for instruction and research related to issues of agency and identity development.

7.1.3 Co-Construction DHH and Mathematics Identities. In this study, I drew on and illuminated the idea of co-construction in two ways: (1) to refer to the ways that DHH learners' mathematics identities are negotiated socially in contexts with others, highlighting that our identities are not solely our own productions, and (2) to refer to the simultaneous development of DHH identities as a certain kind of mathematical person. The co-construction of DHH and mathematics identities manifested through the collective narratives about classroom practices and behaviors, as well as through the individual narratives about specific mathematics experiences (e.g., the case studies).

At a classroom level, the findings revealed that opportunities (or the lack of opportunities) for students to positively align their DHH and mathematics identities are shaped, in part, by the particular classroom practices and activity structures. For example, the use of the audio from the CD-ROM for mathematics instruction, relies on the students' residual hearing, auditory processing skills, and English language skills. Likewise, using textbook definitions and word problems from the textbook, and translating them into sign with English word order and structure, relies heavily on the students' reading and English language skills. Ms. Wilson acknowledges that the language in the textbook may not be appropriate for her DHH students, and Anna explains that word problems tend to be difficult, since she does not always understand the words in the problems (Ms. Wilson, personal communication, April 21, 2015; Group, personal communication, March 12, 2015).

The classroom practices and activity structures, which utilize auditory, verbal, and written mediums, potentially afford the development of audiological identities of deafness, and potentially restrict the development of cultural identities of Deafness. All four students in the classroom define d/Deafness using audiological, and not cultural, definitions. Vivian, James, and Anna state that being able to hear instruction makes understanding mathematics easier. Vivian asserts that mathematics is easier for hearing students and that d/Deafness, in and of itself, hinders success in mathematics. These DHH learners may have personally chosen to identify as audiologically (little "d") deaf or they may not have had access to culturally (big "D") Deaf identities.

Attending to the unique communication and learning styles of DHH learners provides greater opportunities for DHH learners to develop multiple identities, and also makes mathematics more accessible to the DHH learners. Limiting instruction to oral/aural and English language presumes that English language is the only acceptable form of communication in mathematics and it potentially restricts DHH students from developing other modalities that could support their understandings of mathematics. To improve mathematics learning and instruction among the DHH, mathematics educators of the DHH should make mathematics more accessible to DHH students, by providing various approaches to address the learners' unique communication needs, and by utilizing various mathematically accurate representations (e.g., Hill & Ball, 2009).

In addition, the findings from the case study analyses revealed ways that DHH and mathematics identities develop within an individual. In the case of Vivian, her prior experiences as the only DHH student in the mainstream classroom negatively impacted her perceptions of her competence in mathematics in the self-contained classroom. Vivian's narratives highlight the importance of attending to a learner's prior DHH *and* mathematics experiences when studying how DHH and mathematics identities are co-constructed in a classroom context. Vivian's views of d/Deafness, and specifically that DHH learners are "slower" and less competent, impacted her valuations of the classroom obligations, as well as how she internalizes and makes meaning of her mathematics experiences (Vivian, personal communication, March 4, 2015). Vivian never acknowledged that she was not provided with the appropriate accommodations or adequately prepared to be successful in a mainstream environment (e.g., Kluwin & Stinson, M., 1993). In fact, she may not have even been aware that accommodations and resources exist and that she *could* have access to them. Instead, Vivian believed that she was not able to follow along with the pace of instruction in the mainstream classroom because she is not as smart as the hearing kids and that she was placed into the self-contained classroom because she, and all other DHH students in the self-contained classroom, must learn rote procedures and are not able to keep up with hearing students.

In addition to the development of DHH and mathematics identities, the learners in this study negotiate many other identities related to, but not limited to, race, gender, class, and sexual orientation. While I addressed issues of co-construction, I was not able to address intersectionality framed in terms of race, gender, class, and sexual orientation (e.g., Collins & Bilge, 2016; Crenshaw, 1991). Utilizing Martin's (2000, 2002, 2006, 2007a, 2009) multilevel framework to study the intersectionalities of other identities, has potential to provide even greater insight related to how these learners interpret their experiences in the mathematics classroom. For example, Mario, who identifies as Hispanic, explains that he is close with his father, "because he talks English and [he] understands but [his] mom talks Spanish and [he doesn't] understand" (Group, personal communication, March 31, 2015). The communication barrier between Mario and his mother exposes additional complexities to investigating issues of identity among DHH learners. Further research exploring co-construction and intersectionality is needed, to better understand intersectionalities and the multi-layered experiences of DHH learners.

7.2 Implications and Recommendations

The experiences of the DHH learners, how a DHH student comes to understand what it means to do mathematics, and the extent to which a DHH individual identifies with particular mathematics should inform research, curriculum development, and instruction in mathematics. Potential implications from the findings of this dissertation study are discussed below.

7.2.1 Implications and Recommendations for Research. Through this work, I drew upon and sought to coordinate frameworks and conceptualizations of identity and agency from Martin (2000, 2002, 2006, 2007a, 2009) and Cobb, Gresalfi, and Hodge (2009). Martin (2000, 2002, 2006, 2007a, 2009) examines issues of mathematics socialization, identity, and agency at multiple levels (sociohistorical, community, classroom, and intrapersonal) and Cobb, Gresalfi, and Hodge (2009) examine mathematics identity and agency within a classroom context. In this study, I drew upon conceptualizations and frameworks by Martin (2000, 2002, 2006, 2007a, 2009) and Cobb, Gresalfi, and Hodge (2009) to examine how a group of DHH students narrate their experiences and co-construct their mathematics identities in a particular classroom context, in relation to the normative identity in the classroom. I focus on the individual, classroom, and school levels of Martin's framework, in the context of the broader community and sociohistorical contexts. However, this study does not deeply explore sociohistorical and community forces and the relationships between the forces, which also influence what it means to be a DHH learner of mathematics. While this deeper examination of the community and sociohistorical forces was beyond the scope of this study, I believe that findings from the case studies expose potential for further coordination of the two frameworks in future research. For example, Vivian's narratives about d/Deafness and her prior experiences show that a DHH learner's views of d/Deafness may influence how s/he takes up particular mathematics activities and particular classroom obligations. More work is needed to study how the multiple levels of the development of mathematics identities are interrelated and impact the ways that DHH learners' mathematics identities develop in specific classroom contexts. In addition, as discussed in the prior section, while Cobb, Gresalfi, and Hodge's (2009) framework may not be adequate for studying intersectionalities, Martin's (2000, 2002, 2006, 2007a, 2009) framework has great potential for addressing intersectionality, framed in terms of race, gender, class, and sexual orientation.

In my analytic approach, I also sought to coordinate the two interpretive schemes for analyzing mathematics identities: identities-as-narratives, and identities-in-practice. By examining identities both as narratives and practices, the interview and classroom observation data informed and supported one another. Analysis of the narratives reveals that students reference practice-based behaviors through their narratives. To investigate the narratives about practices and behaviors, the interview data was recoded and analyzed to focus on important components within the narratives that related directly to mathematics learning and instruction. My analyses of the narratives informed my subsequent analyses of the classroom observation data. Analyses of narrative identities and identities-in-practice are connected and complement one another. Narratives have the potential to shape DHH students' actions, classroom obligations have the potential to shape identities and the narratives, and identities have the potential to shape the norms and the narratives (Sfard & Prusak, 2005).

This study also highlights the importance of researchers attending to the narratives that the students share about the practices and behaviors in the mathematics classroom. Students' narratives serve as a starting point for researchers to examine the salient (and not so salient) obligations in that particular classroom. By attending to the students' descriptions of the norms and obligations in the classroom, I was able to examine which obligations are most salient from the perspectives of the participants and, moreover, which obligations are not as salient and why. As a researcher, there were times when I observed classroom norms that I believed to be noteworthy, such as the repeated use of the auditory CD-ROM in a DHH classroom. However, the students did not mention the use of the CD-ROM unprompted, and did not have strong opinions about the use of the CD-ROM when probed. Thus, the researcher's and the participants' perspectives of the norms were not always aligned. By examining the students' interpretations of the obligations, I could recognize such discrepancies and formulate questions as to why these discrepancies existed.

In addition, through this work I emphasize that when studying mathematics identities, it is not only important to examine whether an individual identifies with the obligations in the classroom and with particular mathematics activities, but it is also important for researchers to examine the obligations (in and of themselves) and the related mathematics activity structures. Classrooms that characterize competence based on obligations related to low-level activities are problematic, because when the students adhere to the obligations of the classroom, the development of their identities is based on obligations that are limited and may be detrimental to future learning in mathematics. By primarily engaging in low-level mathematics activities, students have minimal opportunities to exercise agency, and may develop a misleading sense of security as doers of mathematics. Researchers in science education have called for more attention to structure in studies of identity and have applied structure-agency perspectives to examine engagement in science (e.g., Shanahan, 2009; Varelas, Tucker-Raymond, & Richards, K., 2015). Specifically, how structures in curriculum and in instruction afford or restrict agency and how their agency impacts the structures. Research in mathematics education, and specifically mathematics education of the DHH, may benefit from applying such perspectives to the study of identity and engagement in mathematics.

Finally, analyses from this study show the value of examining identity at a broader level and at a micro level (Bishop, 2012; Wood, 2013). In this study, Vivian defines her competence partly based upon micro-level interactions with the teacher. For example, as discussed in Chapter

6, when Anna is told "good job!" but the teacher tells Vivian "you did good", Vivian sees herself as less competent than Anna. This interaction, which may seem minute to an observer, was quite significant to Vivian. Thus, research examining identity in classrooms must still attend to broader sociohistoric, community, school, and classroom forces (Martin, 2000, 2002, 2006, 2007a, 2009), but should also attend to micro-level interactions (Bishop, 2012; Langer-Osuna, 2015, 2016; Wood, 2013), such as this one, to examine how such interactions impact how a student sees him or herself as a learner and doer of mathematics.

7.2.2 Implications and Recommendations for Practice and Instruction. d/Deafness, in and of itself, does not impact intelligence, yet DHH students continue to lag behind their hearing peers in mathematics (Gallaudet Research Institute, 2003; Kritzer, 2008; Nunes & Moreno, 2002; Swanwick, Oddy, & Roper, 2005). In my review of the literature, I discussed several factors to which researchers attribute this discrepancy, including teacher preparation and teacher expectations (Lang & Pagliaro, 2007; Pagliaro, 1998a, 1998b; Pagliaro & Kritzer, 2005; Schullo & Alperson, 1998). In this discussion, I expound upon some of the factors discussed and offer suggestions for improving mathematics education of the DHH.

Competence, as I define it in this study, is situational and is not static, and the particular situation in the classroom allows the students to narrate their identities in particular ways. That is, competence is defined and interpreted within the classroom, based upon the jointly constructed expectations in the classroom. “Opportunities for students to be understood as being competent depend on the tasks that they are assigned to work on, and on the agency and accountability with which they are positioned to do that work” (Gresalfi, Martin, Hand, & Greeno, 2008, p. 67). In this classroom, compliant behavior and low-level repetitive activities are valued. Thus, the students are deemed competent based upon the characterizations of competence specifically defined in this particular classroom. Eisenhart and Allen (2016) describe "hollowed-out" identities and caution that such identities "could be easily disrupted when circumstances changed," since the students possess "meager resources to reposition themselves when these identities were challenged" (Eisenhart & Allen, 2016, p.196). For example, James asserts that knowing, "How to [solve problems] will help to your future not why, not why you're doing it. We already know why you're doing it". When asked "why [he is] doing it", James responded "to be smart…to help with your future" (James, personal communication, April 14, 2015). James believes that gaining procedural fluency will prepare him for his future and sees himself as competent when he solves a decontextualized mathematics problem successfully. However, if James does not fully understand the concepts and procedures, he will not have the tools to be able to apply the mathematics in other contexts (e.g., Boaler, 1998, p. 42). Moreover, his identity of competence may be challenged when he is exposed to different situations. It is imperative that DHH mathematics classrooms foster engagement in high level mathematics activities *and* create learning environments that encourage the development of positive mathematics identities in DHH learners (e.g., Varelas, Tucker-Raymond, & Richards, K., 2015).

While it is important that DHH students feel confident in their mathematics ability and realize the value of mathematics in their everyday lives, students must also engage in high-level mathematics. The students in this classroom equate competence in mathematics with completing a set of assigned problems accurately. In this classroom, the students' identities of competence may be problematic. Since the mathematics activities were overwhelmingly low-level and the obligations involved procedures and repetition, the students developed identities of competent mathematics learners based on learning experiences that primarily involved low-level mathematics. The students, at best, developed procedural competence and had limited opportunities to develop conceptual or disciplinary agency. It is critical that curriculum developers and mathematics educators of the DHH develop mathematics activities that enable high-level thinking and conceptual understanding. Mathematics classrooms must afford DHH learners opportunities to exercise conceptual and disciplinary agency while engaging in high-level mathematics.

"All children, especially those who are deaf or hard of hearing, [should] be taught in a way that develops a conceptual understanding of mathematics and of problem solving in particular" (Pagliaro & Ansell, 2012, p. 456). In order to improve mathematics instruction among DHH learners, teachers of the DHH must have high expectations and be adequately prepared to teach mathematics, and the curriculum must be appropriate for DHH learners. Unfortunately, research in DHH education reports that teachers of the DHH do not have sufficient content and pedagogical knowledge in mathematics to instruct mathematics to DHH learners successfully (Pagliaro, 1998a). In addition, teachers often do not teach mathematical concepts that they believe would be too complex for DHH students (Pagliaro & Kritzer, 2005).

Mathematics instruction of the DHH should support high-level thinking through high-level mathematics activities, and curricula should be designed to serve the specific needs of this unique population. In the classroom under study, Ms. Wilson asserts that, "things that they introduce in the book aren't like we say for students who are deaf and learning language" (Ms. Wilson, personal communication, April 21, 2015). The textbook and the mathematics activities were not specifically designed for DHH learners and Ms. Wilson did not have the pedagogical and content knowledge to adapt and modify the curriculum. Teachers of the DHH must have the flexibility and knowledge base to work in and around the textbook, in order to attend to the needs of DHH learners. The National Council of Teachers of Mathematics (NCTM) Council for the

Accreditation for Teacher Preparation (CAEP) has put forth standards for teacher preparation programs in mathematics (see http://www.nctm.org/Standards-and-Positions/CAEP-Standards/). Teacher education programs for teachers of DHH could benefit from following the guidelines set forth by NCTM CAEP.

During my time working in DHH education, the majority of mathematics teachers I have worked with have incredible respect for their students and have great intentions. However, many lack content and pedagogical knowledge to teach mathematics successfully to DHH learners. Throughout this study, Ms. Wilson repeatedly sought my counsel and advice (which I regretfully was unable to provide during the study). She is eager and willing to learn, and wants to become a better mathematics teacher but isn't aware of resources to enable her to do so. The students recognize and appreciate her commitment. As Vivian describes, "Wilson explains and helps me with everything. She sits with me and helps me but in the mainstream class, you work alone. I like Ms. Wilson's room better than my old class" (Vivian, personal communication, March 4, 2015). Furthermore, Ms. Wilson expresses high expectations of her students, asserting that DHH students have great potential in mathematics, despite general discourse that she believes frames DHH learners as less competent, "I would probably say the majority probably think that there's a certain level that deaf students can get to and then there's a certain level that hearing students can get to and they probably think that hearing students can get to a higher level but I don't believe that that's the case. I believe that if you push hard enough and get them to the level that they need to go to, it works out." (Ms. Wilson, personal communication, March 2, 2015). Yet, even though Ms. Wilson has great intentions and asserts that she has high expectations, she lacks the knowledge necessary for teaching and for assessing students' mathematical competence (Hill et al., 2008; Hill, Rowan, & Ball, 2005).

Similarly, I was recently approached by a former colleague to assist her in designing a mathematics curriculum for her middle grades students. This teacher and I worked together in the middle grades DHH department of a public school seven years ago. I was the only teacher in the DHH department with a Masters degree in Mathematics Education. However, due to budget cuts and my low seniority in the public school system, my position was eliminated, and teachers with the bare-minimum requirements to teach mathematics (no Bachelors or Masters degrees in mathematics education) were assigned to instruct mathematics. My colleague, like so many great teachers I have encountered over the last fifteen years, admittedly feels that she was underprepared to teach mathematics. She wants her students to receive the education they deserve, but does not feel that she has the tools to be able to do so. She, like Ms. Wilson, has great intentions for her students, and is hard-working, engaging, and deeply committed. However, both teachers lack the support, as well as the content and pedagogical knowledge necessary for high-level mathematics instruction (Hill et al., 2008; Hill, Rowan, & Ball, 2005). Mathematics teachers of the DHH must be provided with adequate training and professional development in order to teach mathematics to DHH learners effectively.

Furthermore, in addition to content and pedagogical knowledge, teachers of the DHH should be aware of and attend to issues of identity. Delpit (2012) found most of the success stories she reported relating to African American students involved African American teachers. She argues that these teachers were not successful because of their race, but rather they were successful because they were knowledgeable of their students' cultures. It is of upmost importance that teachers of the DHH pay close attention to the multi-layered experiences, the evolving identities, and the racial, gender, sexual, and other intersectionalities of identities of DHH learners (Foley, 2016; Langer-Osuna, 2016; Wood, 2013). Teachers must focus on student thinking and understand the unique experiences that the students bring, in order to build upon their experiences to develop rich and equitable mathematics instruction (Ladson-Billings, 1997) "Knowing students," Delpit argues, "is a prerequisite for teaching them well" (Delpit, 2012, p. 87).

To improve mathematics education of the DHH, instruction must involve high-level activities geared towards developing conceptual understanding and critical thinking in classrooms that foster positive identity development and that afford opportunities for students to exercise agency. Teachers must be provided with the training and support necessary to teach DHH students for conceptual understanding, and mathematics activities must support high level thinking, beyond procedural fluency. In mainstream mathematics education, there has been growing support for project-based mathematics instruction and process-based forms of mathematics (Boaler, 1998; Holmes & Hwang, 2016). Mathematics education of the DHH must move beyond traditional instruction, which has less flexibility and may not prepare the students to apply the mathematics procedures in real-world situations (e.g., Boaler, 1998; Eisenhart & Allen, 2016; Schoenfeld, 1988). Process-based and project-based instruction has great potential for improving mathematics education of the DHH by preparing DHH learners to think critically about mathematics, while also providing opportunities to exercise agency and develop strong mathematics identities.

7.2.3 Implications and Recommendations for Policy. Some of the issues I have raised, including the school and classroom context and teacher preparation and knowledge, reveal significant underlying policy and systemic issues. In this study, no DHH middle grade students at WV school were mainstreamed for mathematics. This situation is not limited to this particular school. As I initially searched for potential school sites, I found a very limited number of mainstreamed students across all schools in this Midwestern city. As mentioned earlier, at a large High School Deaf program in the public school system, no more than one student was mainstreamed at each grade level at the time of this study. The question remains, why aren't more DHH children mainstreamed? According to IDEA, a DHH student should be educated with hearing students unless "the severity of the disability of a child is such that education in regular classes with the use of supplementary aids and services cannot be achieved satisfactorily" (IDEA, Section 5A). Although mainstream classrooms do not offer the best learning environment for all DHH learners, it must be further investigated as to why such a small number of DHH students are placed into mainstream settings. Specifically, how and why is it determined that education in the mainstream setting cannot "be achieved satisfactorily?" To be successful in mainstream settings, DHH students must be adequately prepared and provided with the necessary support (Angelides & Charalambous, 2005; Kluwin & Stinson, M., 1993; Stinson, M. & Liu, 1999). It is critical to investigate whether DHH students in mainstream settings in mathematics are provided with the support necessary to reach their full potential. Furthermore, if schools and districts do not provide students with adequate support, they must be held accountable. The Supreme Court ruling for the Endrew F. versus Douglas County School District case may have a great impact on the standards of services that students with "disabilities" receive in public school settings.

Another issue that must be further examined is the content and pedagogical knowledge of mathematics teachers of the DHH. Classrooms with teachers who are not adequately trained, often do not prepare students to think critically about mathematics and do not afford students opportunities to exercise agency. Inadequate teacher preparation is not only a practical issue, but must also be addressed at the broader policy level. Private schools, like WV, do not require that teachers obtain state certification to teach mathematics. Furthermore, middle grade certification in this Midwestern state merely requires teachers to enroll in five courses, one in teaching middle grades mathematics, and the other four in specific content and subject areas, such as geometry, history of mathematics, and computer science. Consequently, middle grades mathematics teachers may not have been exposed to the mathematics they are teaching since they have been in middle school! In addition, the required courses do not educate middle grades teachers on the progression of mathematics instruction, including what concepts and skills form the foundation for the current instruction, and what concepts and skills will build upon the current instruction in the future. State requirements in middle grades mathematics instruction should require that all teachers of mathematics, including teachers of DHH, be sufficiently trained in the subject areas they teach (e.g., aligned with NCTM CAEP).

7.2.4. Recommendations for Future Work on Issues of Identity among DHH learners. Further research is needed to examine the mathematics experiences and the co-construction of mathematics identities among DHH learners in classrooms in diverse settings and contexts. In the original design of this dissertation study, I sought to examine both mainstream and self-contained settings. In this school, however, there were no middle grades students mainstreamed for mathematics. Future research should investigate the prevalence of and access to mainstream and inclusion settings among DHH students. Research should examine how DHH learners' mathematics identities are co-constructed in mainstream and self-contained classrooms, and if and why mathematics identities develop differently in different settings.

Furthermore, future research should explore spaces where students do and do not have the opportunities to engage in high-level mathematics activities. Given the low-level of the activities in this classroom and the structure of the classroom, my ability to explore how and to what extent these DHH students identified with particular mathematics and mathematics activities, was limited. The mathematics activities in this classroom were homogeneous, and consisted of students working independently to complete practice problems. Since the students were not engaging in high-level mathematics and were merely completing sets of isomorphic practice problems, I was not afforded the opportunity to observe high-level engagement in mathematics and was unable to examine at a deeper level how the DHH students identify with mathematics and mathematics activities, beyond surface level examinations. Further work is needed to examine how DHH students identify with particular mathematics activities, when instruction includes high-level mathematics.

7.3 Concluding Thoughts

In order to shift to research and instruction that emphasize and build upon the experiences and potentiality of the DHH learners, we must first understand what it means to be a learner and doer of mathematics from the perspectives of the DHH students. Ultimately, to improve mathematics education of the DHH and make it more suitable for the participants, "it appears logical that those who would have the most to offer in this regard are the Deaf themselves" (Booker, Markey, & Power, 2003, p. 10)

Martin (2006) asks, "What does it mean to be Black in the context of mathematics learning?" and "What does it mean to a learner of mathematics in the context of being Black?" I raise similar questions as Martin and ask, "What does it mean to be DHH in the context of mathematics learning?" and, "What does it mean to be a learner and doer of mathematics in the context of being DHH?" DHH students must continuously negotiate and renegotiate their mathematics identities, as well as their DHH identities and other salient identities. Considering what it means to be DHH in the context of mathematics learning, and what it means to be a learner and doer of mathematics in the context of being DHH, can provide insight as to how current curricula, mathematics activities, instruction, and policies and agendas, do or do not benefit the DHH learners, and how students co-construct their identities between self-conceptualizations and extraneously imposed identifications. Encouraging the DHH students to share their mathematics learning experiences as well as the value and importance of mathematics education in their lives, enables them to become active participants. Moreover, it provides a foundation for meaningful mathematics instruction.

Furthermore, in order to improve mathematics learning and instruction among DHH learners, we must bridge the gap between research and practice. Currently, there is a "visible gulf between research and practice, expressing itself in the lack of significant, lasting improvement in teaching and learning that the research is supposed to bring" (Sfard, 2001, p. 14). Policy must support research in DHH mathematics education, research and policy must be informed by instruction, and mathematics instruction of the DHH must be grounded in research involving DHH learners (Hermann, 2016). As research and instruction in mathematics education of the DHH evolve, so too must communication between researchers and educators. We must build upon research (such as research concerning identity) as well as insights from educators, to structure classrooms and build curricula that will foster productive engagement in mathematics.

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APPENDIX A. INFORMED CONSENT, PERMISSION, AND ASSENT DOCUMENTS

UIC UNIVERSITY OF ILLINOIS AT CHICAGO

STARTS APPROVAL EXPIRES

JAN 13 2015 JAN 13 2016

UNIVERSITY OF ILLINOIS AT CHICAGO
INSTITUTIONAL REVIEW BOARD

Dear Administrator,

You are being asked to participate in a research project, *Mathematical Identities Among Deaf Students*, which focuses on understanding the nature of Deaf and hard of hearing students' mathematical experiences and how mathematical identities are negotiated in response to their experiences. I am conducting the project as my doctoral dissertation research at the University of Illinois at Chicago.

The purposes of the research are to: 1) develop an understanding of Deaf and mathematical identities through stories and experiences, 2) investigate how the Deaf and hard of hearing students contribute to, and negotiate the mathematics identities that are established in their classrooms, and how students identify, or do not identify, with particular mathematics activities and 3) inform instructional practices—including curricular designs and teaching practices.

In this research, case studies of Deaf and hard of hearing students from one mainstream and one self-contained classroom will be analyzed. Through classroom observations, analysis of student work and notes, and teacher, administrator, and student interviews, I will study how the students experience learning mathematics and identify with particular mathematics activities.

If you agree to participate, you will be asked to:

- Identify teachers from one mainstream classroom and one self-contained classroom
- Participate in one short interview to provide general background information about the school and student placement

To protect your identity and the identities of the participating teachers and students, pseudonyms and participant codes will replace identifying information on any data that is collected, including any recordings made during the course of the research. Pseudonyms and participant codes will be substituted prior to data analysis. It will be stored in password-protected electronic form or in locked file cabinets. In this way, your confidentiality will be maintained. Data will be destroyed after completion of the dissertation project. Any possible risks are minimal and include the possibility of a breach of (i) privacy in that others may find out that you are participating in the research, or (ii) confidentiality in that others may find out information about you gathered as part of the research. These data will not be used to evaluate administrators, teachers, or students. Your participation in this study is completely voluntary and you may change your mind at any point with no negative consequences.

I will use the data to understand the teaching and learning processes of Deaf and hard of hearing students and how to support these, although there may be no direct benefit to you for

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may also contact my faculty sponsor, Dr. Danny Martin at dbmartin@uic.edu or (312) 413-0304. If you have any questions or concerns about the protection of research subjects at UIC, please contact the Office for the Protection of Research Subjects, Office of the Vice Chancellor for Research at 312-996-1711 or email uicirb@uic.edu.

Sincerely,

Deena Soffer Goldstein, Principal Investigator
University of Illinois at Chicago

UIC UNIVERSITY OF ILLINOIS AT CHICAGO

Administrator Consent Form:
Mathematical Identities Among Deaf Students Study

I have read the attached information about this study. I fully understand that my participation in the *Mathematical Identities Among Deaf Students Study* is voluntary and that I am free to withdraw my permission at any time. The research procedures and their purposes have been explained to me and the investigator, Deena Soffer Goldstein, has offered to answer any questions concerning the research procedures.

If I have any questions regarding my rights as a participant in this research, I can contact the University of Illinois at Chicago Office for the Protection of Research Subjects at 312-996-1711 or email uicirb@uic.edu.

Please check "Yes" for those research activities you agree to participate. Please check "No" for those activities you do not agree to participate.

Research Activity	YES	NO
I agree to participate in one initial interview. This interview will be recorded.		
I agree to identify teachers from one mainstream classroom and one self-contained classroom.		

Signature ______________________________ Date____________________

Name (*please print*) ______________________________________

School Name____________________

UIC UNIVERSITY OF ILLINOIS AT CHICAGO

Dear Teacher,

You are being asked to participate in a research project, *Mathematical Identities Among Deaf Students*, which focuses on understanding the nature of Deaf and hard of hearing students' mathematical experiences and how mathematical identities are negotiated in response to their experiences. I am conducting the project as my doctoral dissertation research at the University of Illinois at Chicago.

The purposes of the research are to: 1) develop an understanding of Deaf and mathematical identities through stories and experiences, 2) investigate how the Deaf and hard of hearing students contribute to, and negotiate the mathematics identities that are established in their classrooms, and how students identify, or do not identify, with particular mathematics activities and 3) inform instructional practices—including curricular designs and teaching practices.

In this research, case studies of case studies of Deaf and hard of hearing students from a one mainstream and one self-contained classrooms will be analyzed. Through classroom observations, analysis of student work and notes, and teacher, administrator, and student interviews, I will study how the students' experience learning mathematics and identify with particular mathematics activities.

Research activities will begin with an initial set of administrator, teacher and student intervews to begin at your earliest convenience. The remaining lesson observations and interviews would be conducted in the second semester of the 2014-15 school year. The research is entirely voluntary on the part of participating teachers and students. Parents will also be given the opportunity to learn about the study and provide permission for their child to participate.

If you agree to participate, you will be asked to

- Participate in one initial and one final interview. Each interview will be approximately 30-45 minutes and will be recorded.
- Provide the researcher with a list of all Deaf and Hard of Hearing students enrolled his/her mathematics class.
- Consult with the researcher about the scheduling of observations and interviews
- Allow the researcher to distribute and collect parental permission and assent forms to students.

To protect your identity, pseudonyms and participant codes will replace teacher and student identifying information on any data that is collected, including any recordings made during the course of the research. Pseudonyms and participant codes will be substituted prior to data

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may find out that you are participating in the research, or (ii) confidentiality in that others may find out information about you gathered as part of the research. The researcher is not there to evaluate you or your students. Your participation in this study is completely voluntary and you may change your mind at any point with no negative consequences.

I will use the data to understand the teaching and learning processes of your students and how to support these, although there may be no direct benefit to you for participating in the research. As well, I expect to share the project's findings with the educational community. I welcome you to read any of the reports that are based upon these data.

If you have any additional questions about this research, at any time, please feel free to contact the project principal investigator, Deena Goldstein at dsoffe2@uic.edu or 734-834-0479. You may also contact my faculty sponsor, Dr. Danny Martin at dbmartin@uic.edu or (312) 413-0304. If you have any questions or concerns about the protection of research subjects at UIC, please contact the Office for the Protection of Research Subjects, Office of the Vice Chancellor for Research at 312-996-1711 or email uicirb@uic.edu.

Sincerely,

Deena Soffer Goldstein, Principal Investigator
University of Illinois at Chicago

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Teacher Consent Form:
Mathematical Identities Among Deaf Students Study

I have read the attached information about this study. I fully understand that my participation in the *Mathematical Identities Among Deaf Students Study* is voluntary and that I am free to withdraw my permission at any time. The research procedures and their purposes have been explained to me and the investigator, Deena Soffer Goldstein, has offered to answer any questions concerning the research procedures.

If I have any questions regarding my rights as a participant in this research, I can contact the University of Illinois at Chicago Office for the Protection of Research Subjects at 312-996-1711 or email uicirb@uic.edu.

Please check "Yes" for those research activities you agree to participate. Please check "No" for those activities you do not agree to participate.

Research Activity	**YES**	**NO**
I agree to participate in one initial and one final interview. These interviews will be recorded.		
I agree to provide the researcher with a list of all Deaf and Hard of Hearing students enrolled my mathematics class.		
I agree to allow the researcher to observe and videotape classroom instruction.		
I agree to allow the researcher to make copies of student work.		
I agree to allow the researcher to distribute and collect parental permission a[illegible] assent forms to students.		

Signature ______________________________ Date____________________

Name *(please print)* ______________________________________

School Name____________________

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<u>Permission to Participate in Research</u>:
Mathematical Identities Among Deaf Students Study (Parent Copy)

Thank you for your interest in the Mathematical Identities Among Deaf Students Study. My name is Deena Soffer Goldstein, the principal investigator for the study. Please read this document carefully. If you agree to allow your child to participate in this study, please check "yes" for those research activities you agree to participate on page 4. Please check "No" for those activities you do not agree to participate. Then, complete the form and have your child return it to his/her teacher in the envelope provided. Thanks again!

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Permission to Participate in Research:
Mathematical Identities Among Deaf Students Study (Parent Copy)

1. This letter is from Deena Soffer Goldstein from the University of Illinois at Chicago.
2. I am asking your permission for your child to take part in a research study, *Mathematical Identities Among Deaf Students*, to explore the nature of Deaf and hard of hearing (DHH) students' experiences in mathematics.
3. Students in your child's classroom who participate in the study will be observed and videotaped for one month during math class.
4. Observation and videotaping will not interrupt the normal classroom activity, and your child's teacher will be present in the room.
5. Students who participate will be individually interviewed, at two (2) separate times during the year. The interviews will be videotaped.
6. The individual interviews will focus on students' life experiences as a mathematics learner.
7. Students who participate will also participate in four (4) weekly group interviews. The interviews will be videotaped.
8. The group interviews will focus on students' experiences in math class.
9. Each interview will take about 45 minutes, and will be scheduled at times that do not interrupt classroom learning, either: before school, after school, or during free periods.
10. Although we ask everyone in the group to respect everyone's privacy and confidentiality, and not to identify anyone in the group or repeat what is said during the group discussion, please remember that other participants in the group may accidentally disclose what was said.
11. To make sure that the transcriptions of the interviews are accurate and complete, I will review the transcriptions with your child. I will sit with your child and we will read the transcription together. If s/he states that a statement is not accurate or is incomplete, we will watch the video together and your child will clarify his/her statement.
12. I will take pictures or make copies of some of your child's written work.
13. Your child's name will be removed from all the information we collect from your child, so no one other than myself outside of your child's classroom will know that your child participated in this study. Data will be coded and pseudonyms will be substituted prior to data analysis. It will be stored in a password-protected electronic form or in locked file cabinets and destroyed after completion of the dissertation project.
14. Data that cannot be de-identified, including all audio and video data will be secured and locked at all times during transit and stored on a secure server accessible only to the principle investigator.
15. I am asking that you allow me to use the information from the observations and interviews with other researchers and teachers about how DHH students experience learning mathematics. I will not use your child's real name in sharing this information. Sharing the information will help researchers and teachers understand how to improve instruction, although there may be no direct benefit to your child for participating in the research.

presented by this research, which include the possibility of a breach of (i) privacy in that others may find out that your child is participating in the research, or (ii) confidentiality in that others may find out information about your child gathered as part of the research.

17. Allowing me to use your child's work is voluntary. Your response to this request in no way affects your child's educational experience. If you permit your child's information to be shared, you may withdraw this permission at any time. Deciding to participate or not will not affect your child's grades and relationship with the teacher.
18. Even if you do not allow us to use your child's work, your child will still participate in all of the classroom tasks. If he/she consents, his/her classroom participation may be analyzed for our research.
19. Please talk this over with your child before you decide whether or not to participate. We will also ask your child to give his or her assent to take part in this study.
20. You can ask any questions that you have about this study. If you have a question later that you did not think of now, you can call Deena Soffer Goldstein at (734) 834-0479. You may also contact my faculty sponsor, Dr. Danny Martin at dbmartin@uic.edu or (312) 413-0304. If you have any questions regarding your child's rights as a participant in this research, please contact the University of Illinois at Chicago Office for Protection of Research Subjects at 312-996-1711 or email uicirb@uic.edu.
21. Parents please be aware that under the Protection of Pupil Rights Act, 20U.S.C. Section 1232(c)(1)(A), you have the right to review a copy of the questions asked of or the materials that will be used with your students. If you would like to do so, you should contact Deena Soffer Goldstein at (734) 834-0479 to obtain a copy of the questions or materials.

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Permission to Participate in Research:
Mathematical Identities Among Deaf Students (Parent Copy)

I have read (or someone has read to me) the attached information about this study. I fully understand that my child's participation in the *Mathematical Identities of Deaf and Hard of Hearing Students* study is voluntary and that I am free to withdraw my permission at any time. The research procedures and their purposes have been explained to me and the investigator, Deena Soffer Goldstein (734) 834-0479 has offered to answer any questions concerning the research procedures. I have been given the opportunity to ask questions and my questions have been answered to my satisfaction.

If I have any questions regarding my rights as a participant in this research, I can contact the University of Illinois at Chicago Office for the Protection of Research Subjects at 312-996-1711 or email uicirb@uic.edu.

Please check "Yes" for those research activities you agree to participate. Please check "No" for those activities you do not agree to participate.

Research Activity	**YES**	**NO**
I agree to allow my child to be videotaped during mathematics class.		
I agree to allow my child to have his/her written work photographed/copied.		
I agree to allow my child to be interviewed individually. The interviews will be videotaped.		
I agree to allow my child participate in group interviews. The interviews will be videotaped.		

Signature of Parent/Guardian ________________________________ Date __________

Name of Student (*please print*) ____

STARTS **APPROVAL** EXPIRES

UIC UNIVERSITY OF ILLINOIS AT CHICAGO

JAN 13 2015 JAN 13 2016

UNIVERSITY OF ILLINOIS AT CHICAGO
INSTITUTIONAL REVIEW BOARD

Agreement to Participate in Research:
Mathematical Identities Among Deaf Students Study (Student Copy)

1. This letter is from Deena Goldstein from the University of Illinois at Chicago.
2. I am asking you to take part in a research study, *Mathematical Identities Among Deaf Students Study,* to understand the nature of Deaf and hard of hearing students' mathematical experiences.
3. If you agree to participate in the study, you will participate in two (2) individual interviews and four (4) group interviews. The interviews will be recorded.
4. Although I ask everyone in the group to respect everyone's privacy and confidentiality, and not to identify anyone in the group or repeat what is said during the group discussion, please remember that other participants in the group may accidentally disclose what was said.
5. Each interview will take about 45 minutes, and will be scheduled either before school, after school, during free periods, or during class when students are working individually on assignments.
6. In the interviews I will ask you about your life experiences learning mathematics and your experiences in your mathematics class.
7. To make sure that the transcriptions of the interviews are accurate and complete, I will review the transcriptions with you. If you think that a statement is not accurate or is incomplete, we will watch the video together and you will clarify your statement.
8. I will also take pictures or make copies of some of your written work in class and any notes you would like to share.
9. You will also be observed and videotaped in mathematics class for four (4) weeks.
10. The observations will not interrupt your normal activity in class, and your teacher will be present in the room throughout the observations.
11. I will never use your real name when sharing information. What researchers and teachers learn will help make instruction better for you and for other students.
12. During observations, you will be doing tasks that you normally do as a part of your school lessons and activities. I will make every effort to make sure you do not feel uncomfortable having me in your classroom.
13. Participation is voluntary. If you decide to participate now, you can change your mind at any time. No one will be upset if you change your mind later. Your teacher may know if you are participating or not, but this will not affect your grades or your relationship with your teacher in any way.
14. If you do not choose to participate in the research, you will still take part in the normal activities of your class during observations.
15. You can talk this over with your parents before you decide whether or not to take part. I will also ask your parents to give their permission for you to take part in this study. Even if your parents say "yes," you can still decide not to participate.
16. All collected data will be kept private and stored in a secure location. However, there are risks presented by this research, which include the possibility of: (1) a breach of privacy: others may find out that you are participating in the research, or (2) confidentiality: others may find out

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participant in this research, please contact the University of Illinois at Chicago Office for Protection of Research Subjects at 312-996-1711.

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Agreement to Participate in Research:
Mathematical Identities Among Deaf Students Study (Student Copy)

I have read (or someone has read to me) the attached information about this study. I fully understand that my participation in the *Mathematical Identities Among Deaf Students Study,* study is voluntary and that I am free to withdraw my permission at any time. The research procedures and their purposes have been explained to me and the investigator, Deena Goldstein (312-413-1888), has offered to answer any questions concerning the research procedures. I have been given the opportunity to ask questions and my questions have been answered to my satisfaction.

If I have any questions regarding my rights as a participant in this research, I can contact the University of Illinois at Chicago Office for the Protection of Research Subjects at 312-996-1711.

Please check "Yes" for those research activities you agree to participate. Please check "No" for those activities you do not agree to participate.

Research Activity	**YES**	**NO**
I agree to be videotaped during mathematics class.		
I agree to allow my written work photographed/copied.		
I agree to participate in two (2) individual interviews. The interviews will be videotaped.		
I agree to participate in four (4) group interviews. The interviews will be videotaped.		

Signature of Student ____________________________________ Date______________

Name of Student (*please print*) ____

Name of Parent(s)/Guardian(s) (*please print*)________________________________

APPENDIX B. RECRUITMENT MATERIALS

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JAN 13 2015 JAN 13 2016

UNIVERSITY OF ILLINOIS AT CHICAGO INSTITUTIONAL REVIEW BOARD

Mathematical Identities Among Deaf Students Study
Principal Follow-up Script

Thank you for your interest in the *Mathematical Identities Among Deaf Students Study*. My name is Deena Soffer Goldstein, the principal investigator for the study being conducted at UIC. I'd like to share with you some details about the study and then, if you are interested in moving forward, ask if you would allow me to contact your teachers with Deaf and Hard of Hearing students (DHH), in one mainstream classroom and one self-contained classrooms, to share information about the study with them.

I am asking you to participate in research being conducted for a doctoral dissertation, called *The co-construction of mathematical identities among Deaf and Heard of Hearing high school students*. The purposes of the study are to:

- Develop an understanding of Deaf and mathematical identities through stories and experiences;
- Investigate how the Deaf and hard of hearing students contribute to, and negotiate the mathematics identities that are established in their classrooms, and how students identify, or do not identify, with particular mathematics activities, and;
- Inform instructional practices—including curricular designs and teaching practices.

Who is conducting the study?

- The project is being conducted by Deena Soffer Goldstein, a doctoral candidate in the Curriculum Studies program at the University of Illinois at Chicago (UIC), acting under the supervision of Professor Danny Martin, Department Chair of Curriculum Studies in the College of Education at UIC.

Components of the study:

- In this study, I will analyze the mathematical experiences of DHH students in self-contained and mainstream classrooms over the course of 6 weeks.
- The following data-collection activities will be conducted during the study:
    1. A brief interview with school administration to gather general background information on the school and classrooms.
    2. An initial, individual interview with the student and teacher participants, focusing on their personal experiences related to mathematics
    3. Classroom observation and videotaping for one month
    4. Weekly group interviews with students to discuss experiences in the mathematics classroom, including specific math instruction and math activities
    5. Follow-up interviews with the student and teacher participants, following the classroom observation

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- Allow researcher to distribute and collect parental permission and assent forms to students.
- Participate in two interviews, an initial interview and a final interview following the observation.

Privacy information:

- To protect administrator's, teachers' and students' identities, pseudonyms will replace administrator, teacher and student identifying information on any data that is collected, transcribed, or reported.
- Data that cannot be de-identified, including all audio and video data will be secured and locked at all times during transit and stored on a secure server accessible only to the principle investigator.
- Data will be stored in password-protected electronic form or in locked file cabinets.
- Data, including video and audio recordings, will be destroyed after completion of the project.
- Any possible risks are minimal and may involve:
  - Feeling self-conscious about a researcher in the classroom.
  - The possibility of a breach of (i) privacy in that others may find out that you are participating in the research, or (ii) confidentiality in that others may find out information about you gathered as part of the research.
- Administrator, teacher and student participation in this study is completely voluntary, and they may change their mind at any point with no negative consequences.

If you have questions about this research, please contact the Principal Investigator, Deena Soffer Goldstein 734-834-0479 or dsoffe2@uic.edu. You may also contact my faculty sponsor, Dr. Danny Martin at dbmartin@uic.edu or (312) 413-0304. If you have questions or concerns about the protection of research subjects at UIC: Office for the Protection of Research Subjects, Office of the Vice Chancellor for Research at 312-996-1711 or email uicirb@uic.edu.

If you are interested in pursuing this further, please share this information with your teachers and invite them to contact me for more information. If you would like me to contact teachers directly and you grant me permission to do so, please provide me with email addresses of potential teacher participants and I will share this information with them directly.

Thank you for your time and interest.

STARTS APPROVAL EXPIRES

JAN 1 3 2015 JAN 1 3 2016

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INSTITUTIONAL REVIEW BOARD

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Dear Administrator,

Furthering understanding of the Deaf and hard of hearing learners' mathematical experiences will potentially inform instructional design and teaching for the Deaf and hard of hearing learners. In my doctoral dissertation research in mathematics education at the University of Illinois at Chicago, I will focus on understanding the nature of Deaf and hard of hearing students' mathematical experiences and how mathematical identities are negotiated in response to their experiences. The purpose of this letter is to inquire if you would be interested in participating in this ressearch and having the teachers and Deaf and hard of hearing students from two of your mathematics classrooms, one mainstream classroom and one self-contained Deaf and hard of hearing classroom, participate in this research.

The purposes of the research are to: 1) develop an understanding of Deaf and mathematical identities through stories and experiences, 2) investigate how the Deaf and hard of hearing students contribute to, and negotiate the mathematics identities that are established in their classrooms, and how students identify, or do not identify, with particular mathematics activities and 3) inform instructional practices—including curricular designs and teaching practices.

Through classroom observations, analysis of student work, and teacher, administrator, and student interviews, I will study how the students' experience learning mathematics and identify with particular mathematics activities. In this qualitative study, case studies of Deaf and hard of hearing students from one mainstream classroom and one self-contained classrooms will be analyzed.

If you agree to participate, you will be asked to

- Identify potential teachers from one mainstream classroom and one self-contained classroom
- Participate in one short interview to provide general background information about the school and student placement

Research activities will begin with an initial set of administrator, student, and teacher intervews to begin at your earliest convenience. The remaining lesson observations and interviews would be conducted in the second semester of this 2014-15 school year. The research is entirely voluntary on the part of participating teachers and students. Parents will also be given the opportunity to learn about the study and provide permission for their child to participate.

If you are interested and/or have any questions, please contact Deena Goldstein at dsoffe2@uic.edu or by phone at 734-834-0479. You may also contact my faculty sponsor, Dr. Danny Martin at dbmartin@uic.edu or (312) 413-0304. Thank you!

Sincerely,

DATE

Deena S. Goldstein
University of Illinois at Chicago
Learning Sciences Research Institute
1240 West Harrison Street, Room 1535
Chicago, Illinois 60607

Dear Mrs. Goldstein,

[NAME OF SCHOOL] willingly supports the research work to be carried out for the study entitled *The Co-construction of Mathematical Identities Among Deaf and Hard of Hearing High School Students*, conducted by Deena Goldstein at the University of Illinois at Chicago. [NAME OF SCHOOL] agrees to participate in all efforts of data collection and documentation of identifiable data, including access to class lists, video or audio taping of classroom observations and interviews, and collection of student work, with the understanding that information collected in the participating classrooms will be eligible for review in this study.

Sincerely,

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Mathematical Identities Among Deaf Students Study
Teacher Recruitment Email Script

Thank you for your interest in the *Mathematical Identities Among Deaf Students* Study. My name is Deena Soffer Goldstein, the principal investigator for the study being conducted at UIC. I'd like to share with you some details about the study and then, if you are interested in moving forward, ask if you would allow me to meet with your Deaf and Hard of Hearing students (DHH), to share information about the study with them.

I am asking you to participate in research being conducted for a doctoral dissertation, called *The co-construction of mathematical identities among Deaf and Heard of Hearing high school students*. The purposes of the study are to:

- Develop an understanding of Deaf and mathematical identities through stories and experiences;
- Investigate how the Deaf and hard of hearing students contribute to, and negotiate the mathematics identities that are established in their classrooms, and how students identify, or do not identify, with particular mathematics activities, and;
- Inform instructional practices—including curricular designs and teaching practices.

Who is conducting the study?

- The project is being conducted by Deena Soffer Goldstein, a doctoral candidate in the Curriculum Studies program at the University of Illinois at Chicago (UIC), acting under the supervision of Professor Danny Martin, Department Chair of Curriculum Studies in the College of Education at UIC.

Components of the study:

- In this study, I will analyze the mathematical experiences of DHH students in self-contained and mainstream classrooms over the course of 6 weeks.
- The following data-collection activities will be conducted during the study:
    1. An initial, individual interview with the student and teacher participants, focusing on personal experiences related to mathematics
    2. Classroom observation and videotaping for one month
    3. Weekly group interviews with students to discuss experiences in the mathematics classroom, including specific math instruction and math activities
    4. Follow-up interviews with the student and teacher participants, following the classroom observation

Teacher responsibilities:

- Provide me with a list of all Deaf and Hard of Hearing students enrolled your

Privacy information:

- To protect your identity, pseudonyms will replace all identifying information on any data that is collected, transcribed, or reported.
- Data that cannot be de-identified, including all audio and video data will be secured and locked at all times during transit and stored on a secure server accessible only to the principle investigator.
- Data will be stored in password-protected electronic form or in locked file cabinets.
- All identifiers will be destroyed after completion of the project.
- Any possible risks are minimal and may involve:
    - Feeling self-conscious about a researcher in the classroom.
    - The possibility of a breach of (i) privacy in that others may find out that you are participating in the research, or (ii) confidentiality in that others may find out information about you gathered as part of the research.
- Participation in this study is completely voluntary, and you may change your mind at any point with no negative consequences.

If you have questions about this research, please contact the Principal Investigator, Deena Soffer Goldstein 734-834-0479 or dsoffe2@uic.edu. You may also contact my faculty sponsor, Dr. Danny Martin at dbmartin@uic.edu or (312) 413-0304. If you have questions or concerns about the protection of research subjects at UIC: Office for the Protection of Research Subjects, Office of the Vice Chancellor for Research at 312-996-1711 or email uicirb@uic.edu.

Thank you for your time and interest.

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Mathematical Identities Among Deaf Students Study
Recruitment Script for Potential Student Subjects

1. My name is Deena Goldstein and I am a doctoral student from the University of Illinois at Chicago.
2. I am asking you to take part in a research study, *Mathematical Identities Among Deaf Students Study,* to understand the nature of Deaf and hard of hearing students' mathematical experiences.
3. If you agree to participate in the study, you will participate in two (2) individual interviews and four (4) group interviews. The interviews will be recorded.
4. Each interview will take about 45 minutes, and will be scheduled either before school, after school, during free periods, or during class when students are working individually on assignments.
5. In the interviews I will ask you about your life experiences learning mathematics and your experiences in your mathematics class.
6. I will also take pictures or make copies of some of your written work in class and any notes you would like to share.
7. You will also be observed and videotaped in mathematics class for four (4) weeks.
8. The observations will not interrupt your normal activity in class, and your teacher will be present in the room throughout the observations.
9. I will never use your real name when sharing information. What researchers and teachers learn will help make instruction better for you and for other students.
10. During observations, you will be doing tasks that you normally do as a part of your school lessons and activities. I will make every effort to make sure you do not feel uncomfortable having me in your classroom.
11. Participation is voluntary. If you decide to participate now, you can change your mind at any time. No one will be upset if you change your mind later. Your teacher may know if you are participating or not, but this will not affect your grades or your relationship with your teacher in any way.
12. If you do not choose to participate in the research, you will still take part in the normal activities of your class during observations.
13. You can talk this over with your parents before you decide whether or not to take part. I will also ask your parents to give their permission for you to take part in this study. Even if your parents say "yes," you can still decide not to participate.
14. If you agree to participate in this study, please check "yes" for those research activities you agree to participate. Please check "No" for those activities you do not agree to participate. Then, complete the form and return it to me in the envelope provided.

You can ask any questions that you have about this study. If you have a question later that you did not think of now, you can text or call Deena Goldstein at 734-834-0479 or email at dsoffe2@uic.edu. You may also contact my faculty sponsor, Dr. Danny Martin at dbmartin@uic.edu or (312) 413-0304. If you have any questions regarding your rights as a participant in this research, please contact the

APPENDIX C. INTERVIEW PROTOCOLS

Interview with the Administrator of the DHH program

- How are DHH students admitted to the school?
- How many students are at the school? How many DHH students? What grades?
- How many students are mainstreamed? How many students are mainstreamed for mathematics?
- How is mainstream/self-contained determined?
- Anything that stands out about your DHH program? Anything you want to share?

Initial Student Interview Guiding Questions

Review purposes of the study:

- To address the students' background, and classroom stories and experiences.
- To understand what it means for you to be learners of mathematics.
- To understand how you:
    - See yourselves as math learners
    - Believe you are positioned in the classroom and the larger society
    - Limitations and opportunities you have had in your lives
    - Approaches to gaining knowledge in mathematics

Questions:

- Age
- Educational backgrounds
- Familial backgrounds
    - Do you have DHH parents or siblings?
    - What language(s) do you speak/sign at home?
    - Do you have a cochlear implant? Who decided?
- Questions about the learner:
    - How would you describe yourself as a person? Why do you say those things?
    - How do others describe you? Why do you believe they describe you in these ways?
- Experiences learning and perceptions of mathematics:
    - Who are good math students? Who are not good math students?
    - What was your highest math level? What math courses did you take in middle school? What kinds of grades did you receive?
    - Are there any classroom experiences that you can remember in mathematics? Why are those instances most memorable? Did those experiences impact you - positively or negatively?
    - Do you know anyone in your family or neighborhood who did mathematics on a regular basis, or whom you would say benefited from mathematics?

- What it means to be a DHH learner and doer of mathematics:
  - Do you think you were expected to achieve and do as well in math as other students?
  - Do you think there are things that make it harder for DHH students in mathematics class, doing well, and sticking with it? Did any of those things affect you? How?
  - Do you think schools, teachers, and the world think that DHH and Hearing students have different abilities in math? How?
  - You think people (parents, children, teachers, adults, etc.) act differently to DHH students compared to other students? How? What do you think schools and teachers should do to encourage students in math?
  - How do you think DHH students can change these perceptions of DHH students in math classes?
  - How can math education be improved?
- Hand out journals (draw pictures, write stories, make collages, or use any other method to express your mathematics experiences)
- Tell students about weekly interviews

Group Interview Guiding Questions[9]

- Check my notes from observations and ask specific follow-up questions
- Describe your typical math class
- Are you allowed to solve problems in different ways?
- Did you do well in class this week? How do you know?
- Did Ms. Wilson think you did well? How do you know?
- When you make mistakes, what kind of mistakes do you make?
- Describe the pace (slow, fast, etc.)
- Did you understand the math you learned this week? If you did not understand something, what did you do? If you still didn't understand?
- What were your strengths? Why?
- Which activities were important to you? Why?
- What are some of the most difficult things about learning math? Most enjoyable things?
- What math is important for you to know? Why?
- Are you confident in your math ability (you feel you good at math)? Why?
- Was it important to do well in math this week? Why or why not? Do you think it is important to the other students around you (DHH or hearing)? Why or why not?
- Do you think you could have done better than you did?
- Do you have a desire learn more?
- Do you think your teacher believes you can do well in math? How do you know?
- What does it mean to be a good student?
- Can you be a good student but get the answers wrong?
- How do you know if other students think you are a good math student?
- Are DHH students good math students?

[9] These questions were also used for the second individual interview with James, since he was unable to participate in the group interviews.

- What does it mean to be a good math student in this class? Is it different from other math classes?
- Do you think instruction is fair?
- Did anything make learning more difficult/easier?
- How do you think math class this week could be improved?
- Look at specific activities that the students completed in class:
  - Share easy or difficult activities. Why do you think this is easier/harder?
  - Share activities you enjoyed, did not enjoy. Why do you think this was more/less enjoyable?
  - Do you think that the mathematics instruction for that week is meaningful and useful? Why or why not?
- Any stories you want to share?

Final Student Interview Guiding Questions

- Describe yourself to me
- How would your family describe you? Your friends? Your teachers?
  - What things are important to you?
  - What are some of your interests?
- Tell me about your family
- You said ….. Tell me more about that.
- Does your family sign? How does that make you feel?
- Do your friends sign? How does that make you feel?
- How did you become DHH?
- How do you feel about being DHH?
- Has anyone ever made you feel bad about being DHH?
- What do your parents and family say about d/Deafness?
- Is school harder for DHH children?
- Is math harder for DHH children?
- Are you at the same level as your hearing friends? Why (not)?
- Do you think schools, teachers, and the world think that DHH and hearing students have different abilities in math? How?
- Are you a good student? Why?
- Before, you said that good students …. Do you? What else makes you a good student?
- In math class, if you get the answer right, does it mean you understand? If you get the answer wrong, does it mean you do not understand?
- What's more important to you:
  - To know how to do something or know why?
  - To get the right answer or know why?
- Being a good math student/being good at math. Is there a difference?
- Are you a good math student? Why?
- Is it important to be a good math student? Why?
- If you don't understand something in math, what do you do? What if you still don't understand?

- What grades do you get in math? Is that good?
- In class, what do you have to do to get good grades?
- Is it important to get good grades? For who? You? Your parents? Your classmates?
- Are the grades fair?
- Who is the best in class? Why?
- Who is mainstreamed for math?
- Why aren't you mainstreamed for math? Do you want to be?
- How do you feel about math class?
- Any frustrations?
- You often…Do you like …?
- How can math education be improved?
- Where do you want to go to high school? College? Do you think that being DHH makes it harder or easier to get into school?
- Do you want to share any stories?

<u>Initial Teacher Interview Guiding Questions</u>

Review the purpose of study:

- Develop an understanding of DHH and mathematics identities through stories and experiences,
- Investigate how the DHH students contribute to and take up the mathematics identities that are established in their classrooms, and how students identify, or do not identify, with particular mathematics activities and
- Inform instructional practices—including curricular designs and teaching practices.

Review the purpose of this interview:

- Gather basic background information about you
- Understand the broader federal and district policies and initiatives that impact mathematics instruction
- Understand perceptions of mathematics learning and instruction among the DHH learners as well as your beliefs about the students' abilities and success in mathematics.

Questions:

- Educational and teaching history:
  - Undergraduate and graduate institutions and degrees, certifications and endorsements (*math and DHH)
  - Years teaching mathematics
  - Years teaching DHH students
  - Years teaching these students
- Language
  - Preferred language
  - Mode of communication in the classroom
- Federal and legal initiatives
  - How have (or have not) federal and legal initiatives impacted classroom instruction for the DHH students?
  - How have (or have not) the implementation of the Common Core State Standards in Mathematics impacted your mathematics curriculum?

- Curriculum
  - What mathematics curriculum do you use?
  - Who chooses the curriculum? Is it different from the mainstream 7th and 8th grade curricula?
  - How are students placed in your classroom (vs. mainstream)?
- Perceptions of DHH mathematics learning and instruction
  - Describe what it means to be a good mathematics student
  - Has there been a change in your attitude toward teaching mathematics during the course of your teaching experience?
  - Do you think schools, teachers, and the world send a different message to the DHH students than to hearing kids about their ability to do mathematics? How?
  - Are the DHH students treated any differently than other students? In what ways?
  - What do you think schools and teachers should do to encourage students?
  - Do you think your DHH students are expected to achieve and do as well in math as other students in the school?
  - Are there factors that prevent or discourage DHH students from taking mathematics, doing well, and sticking with mathematics?
- Your class
  - Grade level
  - Are you satisfied with your math instruction?
  - What are the most difficult and most enjoyable parts of teaching mathematics to this particular group of DHH students?
  - How would you describe your students? Why do you say those things?
  - How confident are you in their math abilities? Why?
  - How do others describe your students? Why?
  - What is your outlook for their future? Do you think there will be things that will prevent them from achieving those goals?

Final Teacher Interview Guiding Questions

- Background:
  - Math courses in high school and college
  - Sign language:
    - Background learning sign language
    - Content area signs
  - Testing: Does the DHH department have any testing? The hearing department?
- Curriculum: How do you feel about the math books you used for this past month and a half? You told me that you wish the book wasn't so rigid. You said that especially for a new teacher like you, you feel like you need to follow the book in order, strictly. Can you tell me more about this?
- How confident are you in your knowledge of the math? (Front-end estimation, Multiplying and dividing decimals, Scale factor, Area and perimeter, Organizing data)
- How confident do you feel about your instruction? Are you satisfied with your math instruction?
- How do you feel about the pace of instruction?

- How do you feel about the structure of the instruction? You often jump from one student to another student. Who do you think it benefits the most? The least?
- How confident are you in your students understanding of the math content?
- How do you know if the students understood?
- How do you assess the students? How did you determine their grades?
- What do you do if a student is confused? What if they still don't understand?
- In math class, if a student got the answer right, does it mean s/he understood? If a student gets the answer wrong, does it mean s/he did not understand?
- What was more important to you –
    - That your students knew how to do something or know why?
    - Got the right answer or know why?
- How do you assign HW? Do you think the HW benefits the students?
- Is there a difference between being a good math student and being good at math? What it means to be a good math student? What does it mean to be good at math?
- Describe each student's performance this last month:
    - How would you describe ____? Why do you say those things?
    - How confident are you in ____ math ability? Why?
    - How do others describe _____? Why?
    - What is your outlook for _____future? Do you think there will be things that will prevent ____ from achieving those goals?
- What were the most difficult and most enjoyable parts of teaching mathematics?
- Has there been a change in your attitude toward teaching mathematics during the course of my observations?

VITA

Deena Soffer Goldstein

Ph.D. Candidate
Curriculum and Instruction
University of Illinois at Chicago
734-834-0479
dsoffe2@uic.edu

RESEARCH INTERESTS

- Studying the mathematics learning experiences of d/Deaf and hard of hearing (DHH) students in self-contained DHH and mainstream classrooms, giving particular attention to the co-construction of mathematics identities.
- Investigating the efficacy of mathematics curricula among general education students and among d/Deaf and hard of hearing students

EDUCATION

Doctoral (ABD) 2008-present	**Curriculum Studies** University of Illinois at Chicago (UIC), Chicago, IL College of Education, Department of Curriculum and Instruction Dissertation Project: The Co-Construction of Mathematics Identities Among d/Deaf and Hard of Hearing Middle Grade Students Dissertation Committee: Dr. Danny B. Martin (Chair), Dr. Robert Kretschmer, Dr. Gregory Larnell, Dr. Mara Martinez, and Dr. Elizabeth Talbott
M.Ed. 2004-2000	**Deaf and Hard of Hearing Education** Columbia University, New York, NY Teachers College
M.A. 2004-2006	**Mathematics Education** Columbia University, New York, NY Teachers College
B.B.A. 2000-2003	**Finance** University of Michigan, Ann Arbor, MI Ross School of Business

ACADEMIC APPOINTMENTS

2010-2016	**Research Associate** Department of Liberal Arts and Sciences Learning Sciences Research Institute Serving as key research personnel on three Federally funded mathematics education research projects: Center for Cognition and Mathematics Learning ("Math Center," funded by IES); The Cognitive, Psychometric, and Instructional Validity of Curriculum-Embedded Assessments: In-Depth Analyses of the Resources Available to Teachers Within Everyday Mathematics (funded by IES); and Evaluation of the Cognitive, Psychometric, and Instructional Affordances of Curriculum-Embedded Assessments: A Comprehensive Validity-Based Approach (funded by NSF)

PK-12 EDUCATION APPOINTMENTS

2006-2010	**Mathematics and Deaf and Hard of Hearing Instructor** Alexander Graham Bell Elementary School, Chicago IL Taught mathematics in self-contained fifth through eighth grade d/Deaf and hard of hearing classrooms; Mainstreamed and co-taught first through eighth grade d/Deaf and hard of hearing students in mathematics, history, language arts, and science; taught seventh and eighth grade mathematics in the hearing neighborhood department; coached track and field.

INDUSTRY APPOINTMENTS

2003-2004	**Research Manager** Marcus & Millichap Real Estate Brokerage, New York, NY Researched and analyzed triple-net leased properties; composed proposals and marketing packages for properties; computed cap rates and sales prices for portfolio sales; specialized in sale-leasebacks and 1031 exchanges; worked with buyers to find properties to meet specifications and time restraints.

PUBLICATIONS

Articles in Progress

Stoelinga, T. M., Soffer Goldstein, D., Heffernan, C. L., Pellegrino, J. W., Goldman, S. R., Heffernan, N. T., & Ostrow, K. S. (in progress). Comparison of types of feedback provided during technology-based practice of mathematics skills.

Soffer-Goldstein, D., Pellegrino, J. W., Goldman, S. R., Stoelinga, T., Heffernan, N. T., & Heffernan, C. L. (under review). The effect of Automatic Reassessment and Relearning on the retention of mathematical knowledge and skills.

Canty, R.S., Goldman, S. R., Soffer Goldstein, D., & Caduk, C. (under review). "What's My Rule" Function Machine Tables: Influence of Design Structure on Difficulty and Relational Reasoning

Canty, R.S., Soffer Goldstein, D., Caduk, C., & DeJaresco, T. (in progress). Top-Down Bottom-Up Categorization in Function Table Problem-Solving: A Display-Based Reasoning Perspective

Soffer Goldstein, D., DiBello, L. & Canty, R.S. (in progress). Interpreting Multiple Sources of Evidence About the Validity of the "What's My Rule" Activity in Everyday Mathematics

PRESENTATIONS

Peer Reviewed Conference Papers, Posters, and Presentations

Soffer-Goldstein, D., Pellegrino, J. W., Goldman, S. R., Stoelinga, T., Heffernan, N. T., Heffernan, C. L., & Dietz, K. (2016, April). Improving mathematical learning outcomes through applying principles of practice and assessment with feedback. Poster session presented at the Annual Conference of the American Educational Research Association, Washington, DC.

Soffer-Goldstein, D., Dietz, K., Heffernan, C. L., Pellegrino, J. W., & Goldman, S. R., (2016, April). Mapping Skills and Knowledge in the Connected Mathematics Project 2 (CMP2) Curriculum. Poster session presented at the Annual Conference of the American Educational Research Association, Washington, DC.

Stoelinga, T. M., Soffer Goldstein, D., Heffernan, C. L., Pellegrino, J. W., Goldman, S. R., Heffernan, N. T., & Ostrow, K. S. (2016, April). Evaluating differences in students' learning and retention of mathematics skills given various forms of feedback. Poster session presented at the Annual Conference of the American Educational Research Association, Washington, DC.

Pellegrino, J.W., Heffernan, N., Goldman, S., Soffer-Goldstein, D., Stoelinga, T., & Heffernan, C. (2015). Applying cognitive principles of "spacing" and "testing" in the context of a curriculum. Symposium presentation at the annual conference of the American Educational Research Association, Chicago, IL, April 16-20.

Kelly, K., Heffernan, N., Heffernan, C., Goldman, S., Pellegrino, J.W., & Soffer-Goldstein, D. (2014). Improving student learning in math through web-based homework review. In P. Liljedahl & S. Oesterle, (Eds.), Proceedings of the Joint Meeting of the International Group for the Psychology of Mathematics Education (PME 38) and the North American Chapter of the Psychology of Mathematics Education (PME-NA 36). Vancouver, BC: University of British Columbia.

Soffer-Goldstein, D., Pellegrino, J. W, Goldman, S., Stoelinga, T., Heffernan, N., Heffernan, C., Nair Das, V., & Dietz, K. (2014). Improving long-term retention of mathematical knowledge through automatic reassessment and relearning. Poster presentation at the annual conference of the American Educational Research Association, Philadelphia, PA, April 3-7.

Kelly, K., Heffernan, N., Heffernan, C., Goldman, S., Pellegrino, J. W., & Soffer-Goldstein, D. (2013). Estimating the effect of Web-based homework. In H.C. Lane, K. Yacef, J. Motow, & P. I. Pavlik (Eds.) Proceedings of the Artificial Intelligence in Education Conference (pp. 824-827). Memphis, TN: Springer-Verlag.

Heffernan, N., Heffernan, C., Dietz, K., Soffer-Goldstein, D., Pellegrino, J. W., & Goldman, S. (2013). Applying principles of "spacing" and "testing" to improve student learning of mathematics. Presentation at the annual meeting of the American Educational Research Association, San Francisco, CA, April 27-May 1.

Soffer Goldstein, D., DiBello, L., Kaduk, C., & Li, W (2013, November). *Comparing students' perception of mathematical understanding and their performance*. Poster presented at the Psychology of Mathematics Education North America Meeting, November 2013.

Canty, R., Kaduk, C. & Soffer Goldstein, D. (2012, November). A Model for Designing Cognition and Instruction Based Goal Trajectories for K6Math Curricula. Paper presented at the 34th Annual Conference of the PMENA, Kalamazoo, MI: Western Michigan University.

Kaduk, C., & Soffer Goldstein, D. (2012). Grading Student Work to Support Teaching and Learning. Presentation at the National Council of Teachers of Mathematics Regional Meeting, Chicago, IL, November, 2012.

Kaduk, C., & Soffer Goldstein, D. (2012). Differentiating Instruction Effectively Based on Classroom Activities and Assessments. Presentation at National Council of Teachers of Mathematics Annual Meeting, Philadelphia, PA, April 2012. Philadelphia, PA.

Heffernan, N. T., Heffernan, C. L., Dietz, K., Soffer, D. A., Goldman, S. R., & Pellegrino, J. W. (2012). Spacing practice, assessment, and feedback to promote learning and retention. Presentation at the annual meeting of the Scientific Research on Educational Effectiveness, Washington, DC, March 8-11.

Heffernan, N. T., Heffernan, C. L., Dietz, K., Soffer, D. A., Pellegrino, J. W., & Goldman, S. R. (2012). Improving Mathematical Learning Outcomes Through Applying Principles of Practice and Assessment with Feedback. Poster presentation at the annual meeting of the American Educational Research Association, Vancouver, BC, Canada, April 13-17.

Dietz, K., Goldman, S. R., Heffernan, N. T., Heffernan, C. L., Pellegrino, J. W., & Soffer, D. A., (2012). Spacing and formative assessment. Presentation at the annual meeting of the American Educational Research Association, Vancouver, BC, Canada, April 13-17.

Soffer, D. (2011). Reframing Debates about Mathematics Education of the d/Deaf and Hard of Hearing. Presentation at the annual meeting of the National Association for Multicultural Education, Chicago, IL, November 2-5.

Undergraduate Research Presentations, Research Supervisor and Mentor

Biedron, K., Lem, S., Horton, Z., Soffer Goldstein, D, DiBello, L, & Pellegrino, J. (2013, April). Scoring and Analysis of Student Classwork in Mathematics. 85th Annual Meeting of the Midwestern Psychological Association. Chicago, IL.

Dejaresco, T., Trolia, M., Mueller, F., Soffer Goldstein, D., DiBello, L., & Pellegrino, J. (2013, April). Scoring and Interpretive Analysis of Student Classwork in Mathematics Involving Fractions. 85th Annual Meeting of the Midwestern Psychological Association. Chicago, IL.

Yum, G., Soffer Goldstein, D., DiBello, L., & Pellegrino, J. (2013, April). Examining Frequently Recurring Embedded Assessments and their Effects on Student Performance in an Elementary School Mathematics Curriculum. 85th Annual Meeting of the Midwestern Psychological Association. Chicago, IL.

PROFESSIONAL SERVICE

2014	**Proposal Reviewer, Psychology of Mathematics Education North America**
2013	Local Planning Committee, Psychology of Mathematics Education – North America (PME-NA 2013) 2013 Conference, Chicago, IL
2014-2016	Research supervisor and mentor for undergraduates, University of Illinois at Chicago