EXPERIENCES OF PERSISTENCE AND BELONGING:

WOMEN MATHEMATICIANS IN THE ACADEMY

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Jerelyn T. Watanabe

Dissertation Committee:

Sarah Twomey, Chairperson
Mary Hattori
Lori Ideta

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> And maybe all I want is the right
> to get mad at the wrongs in our world
> without being called those things meant to shut me up:
> like hysterical, irrational, illogical, psychotic,
> man-hater, male-basher, feminazi, or bitch.
> When I think of anger that comes from sisters,
> I think of anger that comes from love, (Kwon, 2014, p. 126)

It is no accident this research has to do with belonging. I could not have done this work without the many communities and families that support and sustain me. These include the EdD program, every aspect of it – coursework, research, faculty, cohort II colleagues: Andy, Camille, Casey, Chelsea, Dale, Desiree, Donna, Ed, Erin, Gari, Kaleihōku, Kari, Keʻalohi, Kehau, Laulia, Loea, Loke, Marlene, Natalie, Rayna Terry, Vid, Waiʻaleʻale, Winston, and Paul – because of, and with you, I found my path to becoming a researcher. Thank you to the consultancy group who brought me into the vibrant communities of the Micronesian diaspora in Hawaiʻi – Dan, Ed, Kaleihōku, Mary, Natalie, and Vid – and continues to sustain me with life giving service and research opportunities. Dr. Joanne Cooper, Dr. Walter Kahumoku III, and Dr. Dan White – thank you for your guidance and support through the long and painful reflexive process that led to this dissertation. Thank you Dr. Mary Hattori, Dr. Lori Ideta and Dr. Sarah Twomey your caring and careful work as my dissertation committee. Dr. Rachel Lentz – thank you for sharing your mother's story of her Oxford mathematics tutor, Dr. Ida Busbridge, and for your example of a STEM scholar who persists. Thank you to friends and family who forgave the missed events and the laptop and stacks of paper that I brought to the events I did attend, to swim buddies who helped me stay healthy, to my colleagues at Myron B. Thompson Academy for keeping me focused on students, and the choirsters and congregation at the Lutheran Church of Honolulu for your community.

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Abstract

This qualitative study analyzed the stories of six women mathematicians to deepen understanding of the challenges and successes they experienced as women academics in a male dominated field. Findings from 12 semi-structured interviews showed that academic mindsets of belonging and persistence contributed to the participants' successes in spite of implicit racism and sexism in the academy. Data aligned with existing belonging frameworks that linked self-perception with experiences of support and involvement, and where belonging led to persistence, a common measure of success. In additional findings, a participant's internal measure of success was defined by the interrelationship of confidence, persistence and belonging and a participant's persistence sometimes led to her belonging through *not* belonging, caring belonging, belonging on her terms, or belonging through agency. All the participants were active in support of increasing diversity in mathematics; they suggested changes to the structures of the academy, shared examples of personal agency and the importance of supporting women students financially and through thoughtful pedagogies.

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Chapter One

Introduction

This qualitative study gives voice to six women mathematicians in the academy; they shared their experiences as mathematicians from early childhood to descriptions of their agency as scholars instigating change. Their stories of internal processes and external experiences expanded my definition of *success* to include non-linear interactions between confidence, belonging, and persistence. Additionally, as a scientist trained to look for patterns in data, I found ways to complicate an existing descriptive framework relating persistence to belonging. I studied physics at a time when theories of quantum mechanics and access to supercomputing changed our understanding of the physical world; for the first time in the history of physical science, multiple, coexisting solutions were statistically defined and expected. Throughout this project, my orientation to this principle of physics kept me focused on honoring the multitude of experiences, perspectives, and stories that were shared with me by these strong, courageous women.

My Story

> I deliberately sacrifice myself in my writing. I leave no part of myself out, for that is how much I want readers to connect with me. I want them to wonder about the things I wonder about, and to think about some of the things that trouble me. (Williams, 1991, p. 92)

Children of different abilities and multiple grade levels shared my first childhood classroom. I remembered everyone reciting multiplication tables together after lunch as the teacher pointed at each of the facts with a long stick. In later years I remembered making careless mistakes to finish as quickly as possible, and in 8th grade, I remember struggling to understand what the *x* stood for in algebra. In college I needed several applied math classes for a

degree in physics, but I wanted to learn *real* math. Against my advisor's recommendation, I enrolled in a basic analysis course, couldn't make any sense of it, and dropped it within a few weeks. I began a career as a high school mathematics and science teacher. Some years later I enrolled as a PhD student in mathematics. Days before my last semester of required coursework began, the department modified the course schedule to accommodate what seemed like a particular student. My class times were changed in such a way that made it impossible to rearrange the complicated childcare for two daughters, aged 4 and 1. Since I was enrolled part-time, I was unsure if I could complete the PhD degree within the seven-year time limit stated in the department handbook. I also recalled the professors saying that I would make a good teacher at a small college when I presented my master's degree paper. I remember feeling disappointed that they did not see me as a potential researcher and thought to myself, "I hope I am a good teacher, I've been a teacher for years." Even though academically I matched the profile of a successful PhD student, I believed that I was too far out of the single, white, male department norm and therefore would have difficulty getting support from the department. I was different because I was a non-white, married woman, 33 years old, coming back to graduate school after many years out of the academy, and I was the primary caregiver for two small children. It never occurred to me to explain my situation to anyone in the department. I simply left.

Because I defined success as persistence, my decision to leave meant I had failed; I felt regret almost immediately and returned to teaching high school mathematics. At the time I didn't know that my reasoning was in line with DiPrete and Buchmann's (2013) conclusion that socialized gender roles for women include inherent conflict between work and family, even to the extent of decision making in anticipation of conflict (p. 191). I didn't know that women often returned to the academy and that they felt dislocated – belonging to neither their new or old lives

(Hughes, 2002). When I had the chance to take on a research project for this dissertation, I was drawn to this turning point in my past. My review of literature of women in science, technology, engineering and mathematics (STEM[1]) ranged from quantitative discussions of internal thought processes defined by psychology to descriptions of external cultural factors in situations where women are underrepresented. Many studies came from a deficit perspective – why do women leave? – and a definition of success as persistence. I wanted to know how and why women come to belong in STEM and in mathematics in particular. This project was timely given increasing awareness of women in STEM by the 2016 movie *Hidden Figures* (Melfi, 2016) about the stories of black female mathematicians at NASA during the space race, and Piper Harron's (2017) blog post, *Get out of the way*, asking white cis male mathematicians in the academy to resign or take a demotion. Sharing and theorizing about Zibi, Wendy, Vi, Robyn, Kate and Emily[2]'s stories addressed the need for "schemes of thought and figurations that enable us to account in empowering terms for the changes and transformations currently on the way" (Braidotti, 2013b, p. 188).

As memories from my childhood and time spent in the academy surfaced throughout this doctoral degree journey, writing about these memories helped me to understand and connect to theories presented in the literature. During the process of reviewing literature for this study, I learned most effectively from the stories that the authors used to illustrate their ideas, so I chose to privilege stories in this dissertation, those of the participants and my own. I found a statement

[1] STEM was created by the National Science Foundation as an acronym to represent the fields of science, technology, engineering and mathematics. Another acronym, STEMM, adds medical sciences to the fields of science, technology, engineering and mathematics.

[2] These are pseudonyms.

in my journal that helped me connect my exploration of memories to my practice as an educational leader:

> The point of me earning a [Doctor of Education] degree is to figure out how to become more effective as an educator, and the heart of education is teaching and learning. I like Palmer's (1997) statement that joins together the cognitive and intuitive, "*good teaching cannot be reduced to technique; good teaching comes from the identity and integrity of the teacher*." (p. 16) (personal journal, 2014)

Santamaria and Santamaria (2012) expressed a similar sentiment about the value of reflection in developing leadership: "As we hone our leadership practice, it continues to become imperative that we take the time to reflect on which critical lenses we view through and apply our leadership practice through" (p. 92).

Through the process of remembering my story, listening to the participants' stories, and reflecting on both, I gained understanding of my own identity. I made peace with my past in a way that allowed me to view my experiences as a complicated and colorful tapestry rather than a failure. Indeed, the difficult experience from my past give me additional insight into the lives of the children and families that I work with in K-12 schools. In this spirit, I share these stories with you.

Girls and Women Who Study STEM

School aged girls and boys had relatively equal cognitive performance in math according to Hedges and Nowell (1995) and Hyde (2005). However, the stereotype that girls and women are bad at math persists and affects their performance. Hyde (2005) described an experiment conducted with college students:

> In one condition, participants were told that the math test had shown gender difference in the past, and in the other condition, they were told that the test had been shown to be gender fair -- that men and women had performed equally on it. (p. 589)

The women underperformed in the gender difference condition but not in the gender fair condition; the conclusion was that context and stereotype affected performance. This implies an effect on women since parents and teachers may not recognize or encourage girls' and women interest to excel in math. Hyde (2005) states, "research has shown repeatedly that parents' expectations for their children's mathematics success relate strongly to outcomes such as the child's mathematics self-confidence and performance" (p. 590).

Research by DiPrete and Buchmann (2013) also supports the claim that girls surpass boys in school performance. Girls earned higher grades and took more middle and advanced level math and science courses in high school compared to boys, and since high grades were linked to academic success, girls were more likely to complete college. Furthermore, women might be more motivated to seek higher education because it helped them stay out of poverty, a direct result of "… higher wages, lower rates of out-of-marriage childbearing, and (because of educational homogamy) lower risks of divorce" (DiPrete & Buchmann, 2013, p. 65).

Several explanations were offered to explain why women were underrepresented as STEM majors. Xie and Shauman (2003) concluded that existing gender segregation in majors and family roles were barriers and eliminated ability and access to course work in high school as reasons for the disparity. Another explanation was that girls were more influenced by their peers and school environment than boys; for example, "…a science-intensive school environment stimulates interest in science …. [and] reduces the power of gender stereotypes concerning STEM fields, because girls are more strongly influenced by science-intensive environments"

(DiPrete & Buchmann, 2013, pp. 195–196). Rosser (2012) quoted Carol Grieder, winner of the 2009 Nobel Prize in Physiology and Medicine to suggest that women chose their major in order to work with other women researchers:

> 'I don't think it's necessarily about the subject. I think it's one of those examples of a jackpot effect, where you have somebody that trains a lot of women, and then there's a slight gravitation of women to work in the labs of other women.' (p. 17)

Whatever the reasons for underrepresentation of women in STEM, Rosser (2012) explains the importance of changing the status quo: "Increasing the diversity of the STEM workforce may also lead to benefits for science and engineering itself, since people from different backgrounds and experience may bring diverse approaches to problem solving and innovation" (p. 5). This rationale connects to the idea of the importance of multiple perspectives from a humanist point of view: "The political struggle is to see from both perspectives at once because each reveals both dominations and possibilities unimaginable from the other vantage point. Single vision produces worse illusions than double vision or many-headed monsters" (Haraway, 1991, p. 154).

The Numbers: Women in STEM

According to the National Science Foundation, National Center for Science and Engineering Statistics (NCES) *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017* (2017) report, women earn more than half of the degrees awarded in some STEM fields and are underrepresented in other fields, including mathematics. The report also stated that "in most fields, the proportion of degrees awarded to women has risen since 1995" (p. 6). DiPrete and Buchmann (2013) write, "women have not merely gained educational equity with men; on many fronts they have surpassed men by a large and growing margin" (p. 1).

NCES (2017) reports that women earned more than 70% of all bachelor's, master's and doctoral degrees in psychology, and over 50% of the degrees awarded in biosciences and social sciences with the exception of economics (p. 6).

In contrast, women were awarded around 20% of degrees at all levels in the low participation fields of engineering, computer sciences, and physics. In mathematics and statistics, the percentage of women earning bachelor's and master's degrees remained around 40% in 1995, 2004, and 2014, and the percentage earning doctoral degrees approached 30% (National Science Foundation, National Center for Science and Engineering Statistics, 2017, p. 7). Furthermore, although the number of degrees earned by women mostly increased, the proportion of degrees earned decreased (National Science Foundation, National Center for Science and Engineering Statistics, 2017, p. 7).

Women are also underrepresented in the STEM workforce. According to 2013 data, men outnumber women who work in science and engineering occupations, and Asian and underrepresented minority women account for only 10% of the workforce (National Science Foundation, National Center for Science and Engineering Statistics, 2015, p. 12). The data also reveals gender differences in the type of occupation. The report noted that "although women are more likely than men to work in a health-related occupation, they are less likely to work as a diagnosing health practitioner, such as a physician, surgeon, or dentist" (National Science Foundation, National Center for Science and Engineering Statistics, 2015, p. 12).

In the academy, women with PhD degrees in science, engineering, and health doubled their representation as full professors in their institutions between 1993 and 2013, but the proportion of women remained low. Even though median salaries for men and women of similar education and experience were similar, men received more federal grant or contract support

(National Science Foundation, National Center for Science and Engineering Statistics, 2015, p. 16).

Experiences of Women STEM Professors

> When we began our study, in the summer of 1994, I was amazed that after 25 years of affirmative action, there were only 15 tenured female faculty members in the six departments of science at M.I.T., compared with 194 tenured men. By the time we had finished the study, I was amazed that there were so many tenured women: It is notable that even 15 had succeeded in the face of such odds. (Hopkins, 1999, p. 3)

The percentage of women professors in all science and engineering fields increased from just under 10% in 1993 to just under 25% in 2013 (National Science Foundation, National Center for Science and Engineering Statistics, 2015, p. 16). Additionally, the percentage of underrepresented minorities who are full-time, full professors increased but at a slower rate. Rosser (2012) used National Science Foundation data from 2006 to calculate the percentage of women professors in academic institutions by field and rank. Percentages of women professors in physical sciences, engineering, and math and statistics were significantly lower than in psychology, social sciences and biology/life sciences. In math and statistics, the percentage of women who were assistant professors, 38.9%, was close to the overall average 40.2%. However, the percentages of women who were associate and full professors was much lower than the average. This brought down the total percentage of professors in math and statistics to 15.1%, less than half the overall total, 32.6%, that included professors, instructors and lecturers (p. 9). Rosser (2012) concluded that the barriers to women scientists and engineers have changed over the last 40 years, however "while today's obstacles seem covert and less clear, my junior colleagues continue to face similar issues, just manifested now in different forms" (p. 1).

Rosser (2001, 2006) documented the significant career barriers and supports that successful women in science faced. She conducted two studies that surveyed award winning

scientists and engineers to give voice to their concerns. Both junior and senior women professors identified balancing work and family, earning respect from colleagues, and mentoring as the most important issues. Additionally, institutional level action was identified as the way to address issues faced by women faculty: "If institutions do not evolve policies to attract and retain women, especially in STEM, there will be no issues for senior women, because there will be few or no senior women" (Rosser, 2012, p. 290).

Massachusetts Institute of Technology Biology Professor Nancy Hopkins was one of a group of 15 tenured women faculty who documented their lower salaries, less laboratory space and fewer resources for research compared to male professors. Hopkins (1999) quoted MIT Faculty Chair, Professor Lotte Bailyn, from a report released to the public to summarize gender discrimination at MIT that is "subtle but pervasive, and stems largely from unconscious ways of thinking that have been socialized into all of us, men and women alike" (p. 3). The Institute also recognized the need to set up processes that would continue even if supportive leadership was no longer in place. Specifically, "continuous monitoring of data by administrators and female professors to insure equity, placing female faculty members on search committees and in decision-making positions within departments, and removing administrators who knowingly discriminate against female faculty members" (Hopkins, 1999, p. 3).

Even though research exists to guide the academy in establishing interventions to support the success of women faculty, Association for Women in Science fellow, Harold Rubin, echoed Rosser's (2012) bleak prospect for women scientists:

> The current climate for women is bad and getting worse. Given that women constitute half the population, ignoring these disparities seems ridiculous. Women do well at the undergraduate level

> and then thin out at each stage of the pipeline. Clearly the culture has not changed rapidly enough; very few change agents exist. (p. 100)

Although I agree with Rubin's assessment of the academy culture for women, I believe we are at the brink of significant change based on the stories of the exceptional women mathematicians who participated in this study.

> *This math department is very different from any others that I've ever seen or heard of … over the last ten years we've hired a lot of new blood and because of that our number of majors has increased dramatically … and I think almost half of them are female, and our female students are really the face of the department, they're a lot more involved and outspoken, so it's really cool to see that we can encourage young women … I feel really blessed to be a part of it.*[3]

Research Question

> I never learned gender.
> The gift my mama gave me was pushing me out of the kitchen
> where I didn't really want to be in the first place. (Kwon, 2014, p. 121)

While the number of women earning degrees in science, technology, engineering, and math (STEM) fields overall has increased (DiPrete & Buchmann, 2013; National Science Foundation, National Center for Science and Engineering Statistics, 2015, 2017), women remain underrepresented in several STEM fields, including mathematics. The purpose of this study was to deepen our understanding of the challenges and rewards for women mathematicians in the academy. An important implication is determining ways to help girls and women succeed in mathematics and other STEM career pathways.

[3] Participant voices are indicated by italicized text. Individual participants are not identified in order to maintain their anonymity.

This study assumes that non-cognitive factors play an important role in academic success as described in the findings of the University of Chicago Consortium on Chicago School Research (Farrington et al., 2012). My feminist perspective privileges the voices of the participants as they act as agents of change embodying social justice by diversifying the field of mathematics as women and women of color.

The research question guiding the study is:

How do the academic mindsets of persistence and belonging influence the success of women mathematicians?

My hope was that participants' stories of this study would shift the focus to existing, often invisible, structures and processes and disrupt the sexism and racism within the academic practice and teaching of mathematics.

Definition of Key Terms

Feminist perspective/praxis.

My feminist perspective for this project focused on voice (primarily stories) and agency in the service of social justice. The idealism of hooks' (2000) definition of revolutionary feminism felt powerful but didn't provide me enough tools for action. Braidotti's (2013b) discussion of post-humanities brought in the idea of using difference as a way to facilitate communication and develop solidarity. Furthermore, Williams' (1991) operationalized critical race theory, through her use of counterstories, as a way to view more than one perspectives at once. Along the reasoning of Haraway (1991) who writes, "painful fragmentation among feminists (not to mention among women) along every possible fault line has made the concept of woman elusive, an excuse for the matrix of women's dominations of each other" (p. 155), I

chose not to define *woman* for this reason. All of the participants self-identified as women but not all identified as feminists. When asked how she defined feminism, one participant shared:

> *I don't want to be too reductionist about what it is to be a woman, and there's all different ways of being women of course, but for me, being supportive of women and what they want to do and making sure that women are included in positions of power and have voices in whatever, in the math community ... and then also valuing their contribution and the fact that it might make math look a little bit different and that's a good thin*g.

This point of view highlights aspects of feminism utilized in this project: a framework that goes beyond different and multiple ways to define gender to make sure women have a voice and influence in a community.

Academic persistence and belonging.

Academic persistence, also known in the literature as perseverance, is defined in this study as "working hard and working smart for a long time" (Dweck, Walton, & Cohen, 2014, p. 4). This is related to Duckworth's (2016) research that grit, defined as passion and persistence towards a meaningful goal, can be developed. I found it important that persistence is not a static trait:

> The four psychological assets of interest, practice, purpose, and hope are not *You have it or you don't* commodities. You can learn to discover, develop, and deepen your interests. You can acquire the habit of discipline. You can cultivate a sense of purpose and meaning. And you can teach yourself to hope. (Duckworth, 2016, p. 92)

Additionally, a model that describes the effect of effort and talent on achievement was heavily weighed towards effort in the long term (Duckworth, Eichstaedt, & Ungar, 2015).

The field of psychology defines belonging as a basic human need (Goodenow, 1992; Osterman, 2000; Walton & Cohen, 2007). Other terms in the literature were relatedness, acceptance, membership, and sense of community (Osterman, 2000). For this study, academic belonging is defined as the sense that a student feels "… personally accepted, respected, included, and supported by others – especially teachers and other adults in the school social environment" (Goodenow & Grady, 1993, pp. 60–61). Simply stated, the belonging mindset is, "I belong in this academic community" (Farrington, et al., 2012, p. 10). Psychologists connected belonging in school to learning and achievement through quantitative methods. In terms of belonging and women in math, several models described processes to increase belonging through participation and inclusion of women in the academic and social communities that make up mathematics. I found it important to conceptualize belonging as a non-static trait.

General Outline of Dissertation

Chapter 2, the literature review, consists of four major groups of research: women's perspectives, women academics in STEM, women academics in mathematics, and persistence and belonging studies.

Chapter 3 presents my methodology based on a feminist conceptual framework that privileges the voices and stories of the participants. Elements of constructivism inform the study through the shift of the participant, researcher, and colleagues as co-constructors of understanding through member checking and peer debriefing.

Chapter 4 consists of findings relating to persistence and belonging, and a definition of *success* is proposed. Several studies describe persistence as a result of belonging: self-perception linked with experiences of support and involvement leading to belonging which then leads to

persistence. I notice that confidence, an aspect of self-perception, supports both persistence and belonging, and sometimes persistence leads to belonging.

In conclusion, Chapter 5 describes implications of the findings including pathways to help girls and women succeed in mathematics and other STEM careers in which women are underrepresented. All of the participants activively advocated for other women in mathematics and I share their suggested changes to the structures of the academy, examples of personal agency, and possibilities for supportive pedagogy.

In the next chapter I discuss the literature reviewed for this project in order to situate it relative to existing scholarship. Literature comes from both quantitative bodies of work such as psychology, and qualitative traditions centered in feminist theory. This study bridges both traditions by adding the stories of successful women mathematicians to the qualitative body of work on persistence and belonging.

Chapter 2

Literature Review

> *There's a math blogger, Cathy O'Neil, who is publishing a book called* Weapons of Math Destruction*, it's just about to come out. One of the things that she always complains about is just because you put numbers on something and do some computations, that doesn't make what you did true or your conclusions true, and that people will be like, 'it's math, you wouldn't understand it but it must be right,' they bludgeon people with math.*

This review of literature focuses on four themes: a) women's perspectives, b) women in STEM, c) women in mathematics, and d) persistence and belonging. The section on women's perspectives combines historical feminist theory with a variety of qualitative methods. This theory of feminist thought supports the integration of my positionality of researcher within the study. The women in STEM literature comes from a long historical tradition concerned with the underrepresentation of women and consists of both qualitative and quantitative studies. A small selection of studies follows that concerns women in mathematics. Studies in persistence and belonging are rooted in quantitative studies in psychology. However, several qualitative studies propose models that relate self-perception, belonging, and persistence.

Women's Perspectives

Tisdell's (2000) description of becoming a feminist educator helped me understand my own story. She wrote, "my development as a feminist educator cannot be separated from my own understanding of the development of my feminist consciousness" (p. 158), and "the earliest development of my feminist consciousness came about as a result of my being aware of differences in gender socialization and of how it affected my psychological development" (p.162). This was similar for me as I reflected on my own childhood experience:

> My only brother was born when I was five and I remember noticing my grandparents' pride and excitement at his arrival. My grandfather wrote calligraphy for him but had not done that for me or for my younger sister. Experiences were different based on gender. Like my father, my brother attended the all-boys school. My extra-curricular activities consisted of watching television after school but my brother began playing baseball when he was five. (personal journal, 2015)

Understanding that being a girl made me *less,* caused me to work hard to try to prove that I was as good as a boy. The one place that I could do this was at school because I loved physical science and math. Through the reflexive process of writing this dissertation, I have become more aware of the patriarchal structures that confined my life. hooks (2000) writes about an awareness that I did not have: "We all knew firsthand that we had been socialized as females by patriarchal thinking to see ourselves as inferior to men, to see ourselves as always and only in competition for patriarchal approval" (p. 14). However, I have moved past competition for external approval, to self-awareness of my identity as a woman, as a scholar, and as an educator. My goal has become to balance these three parts of my identity instead of feeling like I needed to sacrifice one part to develop the other.

I have chosen to shape my review of women's perspectives into two categories: *Why feminism?* and *Women's (brave) voices*. The first section describes several important feminists and other women-centered epistemologies. The second section describes other voices that became relevant to this study: women who returned to the academy after a break and women leaders in business.

Why feminism?

> Feminism is a movement to end sexism, sexist exploitation, and oppression. (hooks, 2000, p. 1)

Women's perspectives inform the theoretical framework for this project and the decision to include feminist and other women-centered epistemologies. Authors hooks (2000), Williams (1991), and Braidotti (1992, 2008, 2013a, 2013b) contributed their various perspectives to my conceptualization of feminism based on their unique positionalities as women scholars in the academy. bell hooks' *Feminism Is for Everybody*, was described by Lamothe (2005) as a "handbook for those who are wary of, or put off by, the idea of feminism: men (she states) and girls and young women (she implies)" (para. 5). hooks (2000) defines institutionalized sexism, not men or individual offenses, as the problem. Williams (1991), an influential legal scholar and critical race theorist, uses rhetoric to challenge the dominance of a single perspective and recognizes the power of language to define and often restrict human rights. Finally, the scope of Braidotti's (1992, 2008, 2013a, 2013b) research extends beyond feminism, defined by binary gender and region, to a critique of international feminism in the context of the formation of the European Union. Her work theorizes post-secular feminism and posthumanities. She proposes that differences are the catalyst for communication and that critique has the potential to instigate change. These authors' commentary and perspectives underscore the importance of both internal action, guided by self-reflection, and external change through agency.

Several authors brought out their unique perspectives by giving voice to their experiences and positionality. Harvard educated legal scholar, Patricia Williams' positionality was influenced by being a descendent of an eleven year old slave named Sophie who was purchased, and then immediately impregnated, by a white, Harvard educated attorney (Williams, 1991; Chamallas,

1993). While recounting a conversation that she had with her sister, Williams (1991) articulated her perspective on the law and its potential to bring forth different factors of an issue:

> I want to look at legal issues within a framework inscribed not just within the four corners of a document-be it contract or the Constitution-but by the disciplines of psychology, sociology, history, criticism, and philosophy. The advantage of this approach is that it highlights factors that would otherwise go unremarked. (Williams, 1991, p. 7)

hooks (2000) addressed perspective through answering the question, *which women?* when describing feminism. She focused on the importance of providing basic needs to economically disadvantaged women because "the only genuine hope of feminist liberation lies with a vision of social change which challenges class elitism" (p. 43). Williams (2013) shared this focus on the overlooked in society. In the text of a speech given at a symposium in her honor, she wrote about the power of language to demarcate those who are human:

> I began to worry about the line between human and subhuman in an era when the limits of incarceration, torture, human trafficking, medical experimentation, and the right to due process often turn on newly minted meanings of words like corporate personhood, enemy combatant, market force, IQ, underclass, genocide, genes, gender, torture, race, hunger, home, and alienability. (p. 54)

Braidotti (1992) took a different approach to question if international feminism in the European Union is defined at the expense of the reality of women's national and local status. She wrote: "No discussion of the feminist international perspective is complete unless is rests on a lucid analysis of one's own national roots, of one's own inscription in the networks of power and signification that make up one's culture" (p. 7). She goes further to state that "proposing an international perspective without critical scrutiny of women's respective roles in our cultural,

national contexts would only be a form of supranationalism, that is, ultimately a form of planetary exile" (Braidotti, 1992, p. 8).

In addition to the idea of exile, nomad and migrant are two other perspectives described by Braidotti (1992). Woman as nomad describes a wanderer who never puts down roots but takes knowledge and power with her as she moves. She "allows us to think of international dispersal of ideas as forms of resistance, as a way of preserving ideas that may otherwise have been forgotten or destroyed: condemned to willful obliteration and collectively produced amnesia" (p. 9). Braidotti's (1992) idea of woman as migrant is powerful because it situates women in local contexts with inherent complexity arising from difference. She asks that "differences become the stuff communication is made of, instead of acting as major dividers," and proposes "one of the ways in which multiply differentiated and situated feminist perspective could be visualized is through the image of multiple literacies, that is, of being able to engage in conversation" (Braidotti, 1992, p. 10). This perspective renders the question *which women?* meaningless because difference is not only assumed, difference contains the potential for engagement.

Similarily, hooks (2000) suggests that this perspective encourages self-reflection since often "the enemy within must be transformed" (p. 12). She states consciousness-raising as a feminist method of,

> learning about patriarchy as a system of domination, how it became institutionalized and how it is perpetuated and maintained. Understanding the way male domination and sexism was expressed in everyday life created awareness in women of the ways we were victimized, exploited, and, in worse case scenarios, oppressed. (p. 7)

Williams (1991) describes the importance of being connected to reality even though it is easier to use language to create simpler truths; she states "that life is complicated is a fact of

great analytic importance. Law too often seeks to avoid this truth by making up its own breed of narrower, simpler, but hypnotically powerful rhetorical truths" (p. 10).

Self-reflection also informs the ethics of a feminist perspective according to hooks (2000):

> Visionary feminism offers us hope for the future. By emphasizing an ethics of mutuality and interdependency feminist thinking offers us a way to end domination while simultaneously changing the impact of inequality. In a universe where mutuality is the norm, there may be times when all is not equal, but the consequences of that inequality will not be subordination, colonization, and dehumanization. (p. 117)

Braidotti (2008) also considers the connection between reflection and ethics when writing about "the issue of the affirmative power of critical theory and the kind of ethical values it may be able to engender" (p. 1). She revisits the idea that difference generates communication since "the ethical good is equated with radical relationality aiming at affirmative empowerment, the ethical ideal is to increase one's ability to enter into modes of relation with multiple others" (Braidotti, 2008, pp. 15–16). She further adds to the idea that ethics are actualized through "oppositional consciousness and the political subjectivity or agency it engenders" (Braidotti, 2008, p. 16). Finally, Braidotti (2008) adds a creative and hopeful element, that "ethical relations create possible worlds by mobilizing resources that have been left untapped, including our desires and imagination" (p. 16).

hooks' (2000) visionary feminism has a similar theme of hope for social justice that contributes to the relevance of a feminist perspective:

> The fact that participants in the feminist movement could face critique and challenge while still remaining wholeheartedly committed to a vision of justice, of liberation, is a

> testament to the movement's strength and power. It shows us that no matter how misguided feminist thinkers have been in the past, the will to change, the will to create the context for struggle and liberation, remains stronger than the need to hold on to wrong beliefs and assumptions. (p. 58)

The need for agency connects ethics to critical theory. Williams' (1991) agency is driven by critical race theory with a goal of challenging and changing the structures that prefer one group over another:

> The whole historical object of equal opportunity, formal or informal, is to structure preferences for rather than against -- to like rather than dislike -- the participation of black people.... Remedying this, therefore, must be society's most pressing area of representational responsibility; ... in closely examining the ways in which the law operates to omit women and people of color at all levels including the most subtle – to omit them from the literature of the law, from the ranks of lawyers, and from the numbers of those served by its interests. (pp. 103-104)

Braidotti's (2008) discussion of posthumanities begins with the call for "schemes of thought and figurations that enable us to account in empowering terms for the changes and transformations currently on the way" (p. 188). Along with recognition of difference as a starting point for communication, she joins the reality of the human situation: "the issue of geo-centred perspectives and the change of location of humans from mere biological to geological agents, calls for recompositions of both subjectivity and community" (Braidotti, 2013b, p. 192).

Women's (brave) voices.

Following the concepts of subjectivity and community, two other voices emerged in this review of literature highlighting belonging as an issue. First, women returning to "the unfinished

business of higher education" (Hughes, 2002, p. 415), and women leaders in the academy and business who share survival strategies. Scholarship regarding women leaders in the academy and business are included as relevant contexts to this study in which women choose to take action to change a culture of sexism and racism.

Returners.

Hughes (2002) writes about women *returners* "metaphorically, and literally, seeking to leave aspects of their lives behind in order to have a better view on the future" (p. 415). She discusses how this may have been motivated by a change in employment, children becoming adults and leaving home, gaining a supportive or losing an unsupportive relationship. Women returning to higher education became the *other* in the context of being a student as well as in their non-education context. She described this feeling as "the simultaneous location of being neither fully part of one culture nor another means that such students experience the more general feeling of *dis*location that Boehmer (1995, p. 232) refers to as 'not quite' and 'in between'" (Hughes, 2002, p. 419). Hughes (2002) intends this discussion to move the academy away from binaries that create the *other* and towards recognizing the range and variety of experiences of academics.

Twomey's (2005) experience as a woman returner led her to "explore the boundaries of subjectification in moving beyond the systemic and institutional barriers that limit how one imagines her multiple selves and future" (pp. 333-334). She found that the feeling of dislocation described by Hughes created a pathway to possibilities: "What opens up is the possibility not just for post-structuralist plurality of self, but also a plurality of locations in which to position myself as a student" (p. 334).

Leaders in the academy and business.

Lord and Preston (2009) were colleagues in an Australian university who took on leadership roles in administration and discovered "the need to 'survive'" (p. 771). They described an environment hostile to them, not in overt ways, but through countless, small injustices embedded in gendered *normal* practices. They wrote,

> A key challenge remains naming and recognising 'small' gendered practices…. It is the cumulative effect of these everyday micro-political experiences that combine to create an exhausting, chilly climate: one where women do not always feel welcome and where, without the benefit of good networks and strong support circles, the process of attrition eventually wears women out. (pp. 772-773)

Morley's (1999) experience with "colleagues who have applied their creativity to making my life as difficult as possible, in order to ensure that I never soared above them in the academic hierarchy" (p. 2) led her to consider the micropolitics of gender oppression. She proposed that feminism could be used to document micropolitics in the processes of the academy. This was important because academy policies (structures) might have been modified to present as gender neutral but the implementation (process) remained gendered.

> Both feminism and micropolitics privilege processes, rather than structures. Both can label unnamed feelings, experiences, practices and transactions, because the language in which oppressed groups express these phenomena is often politically and socially subjugated and relegated irrelevant or illegitimate by dominant discourses. (Morley, 1999, p. 6)

Writing about the business world, Meyerson and Fletcher (2000), similarly identified discrimination against women as an insidious part of a gendered system:

> Today discrimination against women lingers in a plethora of work practices and cultural norms that only appear unbiased. They are common and mundane -- and woven into the fabric of an organization's status quo -- which is why most people don't notice them, let alone question them. But they create a subtle pattern of *systemic* disadvantage, which blocks all but a few women from career advancement. (p. 128)

Lord and Preston (2009) also identified a problem with different standards for men and women. For example, "how behaviours and feelings are expressed, perceived and interpreted in organisations also continues to entrench gendered notions of 'appropriate' behaviour" (2009, p. 774). They referred to Wacjman's (1998) analysis of managers in high-tech multinational corporations located in Britain: "the crucial problem is that the same behaviors exhibited by a woman are interpreted differently. For example, women who adopt a high profile are commonly regarded as "pushy" (p. 96). Meyerson and Fletcher (2000) shared a similar example about women and men speaking up in meetings:

> The meetings themselves were run in a way that put women in a double bind. People often had to speak up to defend their turf, but when women did so, they were vilified. They were labeled 'control freaks'; men acting the same way were called 'passionate.' As one female executive told us, 'If you stick your neck out, you're dead.' (p. 129)

Lord and Preston (2009) identified several strategies that allowed them to "… challenge the system, whilst remaining within it …" (p.775), including providing a women's support network, reading literature to understand other women's stories, creating a safe space for women to share their experiences, and committing to gender equity in universities through the regular collection and sharing of statistical information and establishing programs to address culture change. Morley (1999) envisioned feminist academics as "knowledge agents, micropolitically

making interventions, not only in course provision and organizational practices, but also about the discourses and regimes of truth that inform them" (pp. 6-7).

Meyerson and Fletcher (2000) propose a small wins approach that "emphasizes that existing systems can be reinvented by altering the raw materials of the organizing – concrete, everyday practices in which biases are expressed" (p. 311). Small wins begin by naming a practice that is problematic, then link changes in behavior with understanding, and connect local changes with global effects. Small wins tend to snowball and finally, small wins "[fix] the organization, not the women who work for it…. [freeing] women from feelings of self-blame and anger that can come with invisible inequity…. and [removing] the label of troublemaker from women who complain that something is not right" (p. 136).

A second foundational theme for this review of literature was the importance of equitable access to education and careers for women. Additionally, some of the participants shared a worldview based on race and therefore were keenly aware of inequity caused by racism. Others raised issues of access to mathematics because of socioeconomic status. I begin the next section with a memory of my experience as a woman in STEM.

Women in STEM

> Being hapa (half Asian, half white) was okay when I was growing up. The majority of people who live in Hawai'i have complicated ethnic backgrounds because of the waves of ethnic migrants that arrived at different points in time. But being hapa meant that I felt like I wasn't accepted fully by either my dad's family or my mom's Midwest family. I was physically different from both families and therefore somewhat of a curiosity to both sides. My skin is light enough so that when I don't get much sun people think I'm white, or 'what are you?' But in my grandma's church in Ohio, I still stood out just as if my skin

was green. Being refused communion in a church because of different skin color is not a big deal, but this and other incidents give me insight into the day-to-day experience of those who are not of the dominant culture. (personal journal, 2015)

Smith (2012) writes, "the struggle to assert and claim humanity has been a consistent thread of anti-colonial discourses on colonialism and oppression" (p. 68). Smith (2012) ties her discussion to basic human rights and states the reality that the dominant culture systematically denied those rights to indigenous people. I would never say that I was denied humanity because of my race, but my experiences as sometimes the other, sometimes of the dominant group, meant that equity became a core value. As an educator this translated into making sure that all of my students had access to resources at school. This meant sustaining their culture in addition to supporting their academic achievement. Kornhaber, Griffith, and Tyler (2014) provide an expansive conception of educational equity that resonates with this value:

> The expansive view builds on what social science has long revealed: disparate student achievement is strongly associated with influences outside schools' purview. Therefore, the expansive conception provides for compensatory resources within and beyond the education system to close achievement gaps. It is both compensatory and comprehensive. (p. 8)

Since children and their mothers were likely to be the ones who need this kind of comprehensive support, I was particularly called to hooks' (2000) revolutionary feminism that can "transform that system, to bring an end to patriarchy and sexism" (p. 4).

Educational equity and kindness became the foundation for my philosophy of education, first articulated during my teacher certification program in 1995. Though I began my teaching

career in a private school, I felt called to serve in public education. I wrote the following statement at the beginning of this doctoral journey:

> I believe that each child deserves an excellent education and that our society bears the responsibility for preparing every child for success. This means that students leave our K-12 educational system (1) prepared for college even if they don't pursue that option immediately, (2) ready to immediately implement a college or career plan, (3) willing and able to be lifelong learners, and (4) empowered to participate in the democratic process. (personal journal, 2014)

Although gender, class and race are not specifically mentioned, I recognize feminist values of social justice in my focus on equity, agency in the importance of preparing students for their futures, and voice through emphasis on participation in democracy. Care has evolved into a core value of my life because of its emphasis on relationship.

The goal of equitable access for women in STEM motivated my review of literature that fell into three areas of study: career barriers and supports for women who do become junior and senior faculty in STEM fields, women of color in STEM, and a feminist perspective on STEM diversity research.

Career barrier: Balancing work and family.

The top concern raised by participants in a study by Rosser (2001, 2006), was the difficulty of balancing work and family responsibilities including access to childcare, options to delay or stop the tenure clock, and placement for two career families. Moors, Malley, and Stewart (2014) studied the relationship between gender, perceived institutional support for family commitments and job satisfaction for postdoctoral appointees and tenure-track faculty in science, technology, engineering, mathematics and the medical sciences (STEMM). The context

for this qualitative study was that the decade or longer that it takes for "emerging academic professionals [to] pursue graduate degrees, undertake postdoctoral training positions, and work toward tenure also coincide with the optimal years for having children" (Moors et al., 2014, pp. 460–461). If women perceive their department climate as unsupportive of families, they would be less satisfied with their jobs and feel less belonging. Job satisfaction and sense of belonging might explain why women leave STEMM careers. The study confirmed that for both postdoctoral appointees and faculty, perception of support for families was predictive of job satisfaction and sense of belonging, however, women postdoctoral appointees in STEMM fields were more likely to suffer when they "perceive lower levels of support for family responsibilities" (Moors et al., 2014, p. 467). A second concern showed sexism infiltrated the interactions of men with their women colleagues and the inherent sexism of academy culture.

Career barrier: Respect from colleagues.

Rosser (2001, 2006) documented that women scientists' interactions with colleagues was definitely related to gender. Participants talked about women having to "prove their competence" with men having "to prove their incompetence" (Rosser, 2001, p. 15). Rosser (2012) states:

> The more an individual deviates from the expectation of what a 'professional in the field looks like' with regard to gender, race, class, age, and other factors, the more others inside and outside the profession will question the individual's professional competence. (p. 79)

Other issues raised included the existence of an old-boys' network, outright harassment, inequitable treatment by their university, microinequities, and difference in research style that often led to fewer papers accepted in high impact journals and fewer grants awarded to women (Rosser, 2006, p. 282). Women faculty also reported having to live with harassment by senior

faculty and colleagues which often resulted in isolation (Rosser, 2001, p. 15). Women faculty who were loyal to their institutions ended up being paid less than men who sought positions at other universities and were offered pay raises to remain. Women also tended to be modest about their success. Rosser (2012) stated, "in order to succeed, women must be aggressive and ask. This runs contrary to most women's notions that they will get what they deserve if they are good" (p. 115). Also, women specifically in mathematics are not helped by the "young boy genius expectation that if you haven't made a major contributions by age 25 you're washed up" (Rosser, 2012, p. 119). Women's approach to science, especially in their labs, also differed from traditional (male) practices. For example, some STEM fields such as physics separated theory from experimental verification. In contrast, for women scientists, "the fusion of theory and practice in science classrooms and laboratories has a long tradition" (Rosser, 2012, p. 29).

As a result of these many barriers, mentoring was an important support for women STEM scholars in the academy.

Career support: Mentoring.

Dunham, Weathers, Hoo, and Heintz (2012) described the purpose of mentoring "as a way to expand an individual's social capital by providing personal and professional advice and equipping the protégée with strategies that will help them thrive" (p. 80). Mentoring programs were established at many universities to provide equitable support for women (and men) seeking tenure and promotion. They interviewed women faculty in science and engineering to learn about their experiences with mentoring and found three types of mentoring: "(1) global mentoring, [an] involved and committed mentoring relationship; (2) formal targeted mentoring… aimed specifically toward providing advice and support toward attaining a career goal; and (3) informal global mentoring often initiated by the protégée herself" (Dunham et al., 2012, p. 79). The

practice of mentoring was placed within a context where women were a minority in a male-dominated culture. This may have affected a woman's access to support such as mentoring. Furthermore, mentors worked in a "gendered social setting based upon expectations for behavior that may or may not be based on cultural gender expectations that have the potential to affect the way in which women are evaluated and their ability to succeed in their careers" (Dunham et al., 2012, p. 85).

One interesting finding was that "formal mentoring was ineffective if there was a lack of trust or feelings of disappointment in a mentor who had been assigned to them" (Dunham et al., 2012, p. 89). This may explain why women often preferred informal mentoring when a specific issue arose, perhaps because they could control the scope, time commitment, and choice of mentor; they could "seek out colleagues with whom they had a pre-existing rapport and whom they felt they could trust for help, especially with issues that might put them in a vulnerable position" (Dunham et al., 2012, p. 91). A disadvantage to working with an informal mentor was that these mentors might not have had the resources or power to advocate for their protégée. As in other studies, the respondents did not prefer either gender for a mentor; men and women mentors offered their protégées different perspectives:

> Men can provide insights from the male perspective that can be valuable for female faculty who need these insights in order to be successful. Other women valued the advice and interactions with female mentors and felt that they could speak with them in more informal and meaningful ways. (Dunham et al., 2012, p. 91)

Gorman, Durmowicz, Roskes, and Slattery (2010) presented a case study of Stevenson University where women made up 71% of full-time STEM faculty and 100% of STEM leadership. This was in stark comparison to the National Science Foundation data available at the

time of the publication regarding women in STEM: 31% full-time faculty and 27% deans and department heads (Gorman et al., 2010, p. 1). The authors identified the development of a "mentoring web … developed to support and sustain the leaders, faculty, staff, and students" as an important contribution to the increase in the presence of women in their STEM departments because "the mentoring contributes to professional growth and development … and to an increased sense of community and collegiality" (Gorman et al., 2010, p. 1).

Initiatives at Stevenson University included the establishment of formal mentoring and evaluation committees by faculty members eligible for promotion. The committee held the responsibility of recommending the faculty member for promotion and did so through "a more collaborative environment for professional academic growth and development" (Gorman et al., 2010, p. 8). Another important mentoring context was faculty working with students on research projects. From the university perspective, "perhaps the greatest value of an inquiry-based, research-rich learning environment is in the opportunity for students and faculty to develop strong relationships and to learn by doing" (Gorman et al., 2010, p. 9).

A more recent, quantitative study by Primé, Bernstein, Wilkins and Bekki (2015) supports the importance of advising support for women graduate students in STEM. Based on the Advisory Working Alliance Inventory created by Schlosser and Gelso (2001), the context of their study is that the "advising relationship may be a key component in career decision making and the retention of highly selective and qualified female scientists" (Primé et al., 2015, p. 64). They found that analysis of the advisor – advisee relationship provides important information about "whether the student is receiving instrumental support for their academic endeavors as well as clear expectations and feedback about what is expected of the students to complete their degree" (Primé et al., 2015, p. 74). Additionally, they learned that increasing psychosocial

support for women in STEM may increase persistence by helping the women "feel that their personal choices and their lives outside of school are important" (Primé et al., 2015, p. 74).

In Rosser's (2006) study, many senior women scientists shared the positive experience of having a supportive mentor. Senior women scientists also identified mentoring as the most important intervention for junior faculty; ironically, because there were so few senior women professors, mentoring junior women professors was a factor in burnout (Rosser, 2006).

As with evident in this study, in addition to dealing with sexism, women of color also have to deal with institutionalized racism in the academy.

Women of color in STEM.

Ong, Wright, Espinosa and Orfield (2011) reviewed forty years of literature on the educational experiences of women of color in STEM postsecondary education and careers. They refer to an American Association for the Advancement of Science publication by Malcolm, Hall and Brown (1976) that first identified the *double bind*, "the unique challenge minority women faced as they *simultaneously* experienced sexism and racism" (Ong et al., 2011, p. 175). The authors draw on a social capital perspective, that "failure to advance the women of color and move them into productive STEM careers represents a failure of the United States to maximize our own talent pool at a moment when we can ill afford it – socially, technologically, or economically" (Ong et al., 2011, p. 173), and social justice which "creates an imperative for positive action to overcome the continuing impacts of a history of excluding women of color from full participation in STEM" (Ong et al., 2011, p. 176). In spite of this historical context,

> … women of color seek out academic and personal support vigorously and with serious intent. These relationships serve to bolster their confidence and learning in STEM majors as well as their determination to graduate. Women of color tap into a host of networks

> that include parents, faculty members, university administrators, and peers in- and outside STEM fields. (p. 185)

The authors also presented the idea that existing literature,

> overwhelmingly identifies the STEM social and cultural climate – that is, the interpersonal relationships with other members of the local STEM communities and the cultural beliefs and practices within STEM that govern those relationships – as the leading challenge to the persistence of women of color in STEM career trajectories. (Ong et al., 2011, p. 192).

An example of the importance of culture and climate was the conclusion that faculty mentoring was "rare but extremely valuable" (Ong et al., 2011, p. 193).

Racism was a second example given, embedded in the cultural belief of white male superiority. Drawing from a longitudinal study on minority women who earned STEM PhDs, MacLachlan (2006) reported that the women experienced "different treatment fairly extensively" from faculty who "were often unaware of treating women or persons of color differently" (p. 241). The author described the racism felt by the women as:

> subtle changes in behavior suggesting they did not belong, that they were seen as 'a' or still 'the' minority, not as a student or a potential colleague. The women of color felt that they were not seen as themselves, as persons, or future scientists, but as 'representatives of their race,' and were scrutinized and judged on that basis. (MacLachlan, 2006, p. 242)

Even when describing racist and sexist behavior as unintentional and based on ignorance, MacLachlan (2006) concluded that "the accumulation of all these negative experiences can form a substantial barrier to success for women of color in science and engineering graduate programs" (p. 242).

Another term used to describe this phenomenon was microagression, an idea related to microinequities – small incidences of unfairness that, taken together, have a significant impact on a person's career. Although microinequities could be positive or negative, women tended to experience negative incidents and a multitude of "microinequities over a lengthy career take their toll in a variety of ways" (Rosser, 2012, p. 281).

Writing about women belonging in mathematics, Herzig (2006) acknowledges that women of color:

> face additional obstacles, which may influence their low rates of retention. These obstacles spanned all four of the dimensions discussed: faculty beliefs about teaching and learning, faculty beliefs about mathematics, students' relationships with faculty, and students' relationships with other students. (p. 265)

She recommended that departments implement changes that would "create an educational experience that is built around helping *all* students participate in the discipline and develop a sense of belonging" (Herzig, 2006, p. 266).

A final group of literature on women in STEM shared a feminist perspective on carrying out institutional level strategies to increase diversity.

Feminist perspective on STEM and diversity.

Based on the premise that diversity in the academy improves the quality of STEM research, the United States government supports diversity efforts such as the National Science Foundation's Task Force on Programs for Women. These initiatives were designed to provide funding for programs to "level the scientific playing field and increase participation of women and underrepresented racial/ethnic groups in STEM disciplines" (Morimoto & Zajicek, 2014, p. 136). These early initiatives defined barriers to recruitment and persistence as "*individual*

problems stemming from personal preferences, choices, and/or biases rather than *institutional issues*" (Morimoto & Zajicek, 2014, p. 136). Beginning in 2001, Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE) awards were granted to institutions by the National Science Foundation (NSF) in order to increase the number of women STEM faculty and enable institutional change that supports women in STEM. Morimoto and Zajicek (2014) reviewed 28 publicly available ADVANCE grant proposals and the websites of the 37 ADVANCE institutions who received funding between 2001 and 2009. Important assumptions about ADVANCE institutions were (a) men and women are equally capable of success in STEM fields given equitable access, (b) "the NSF insists on the need to change rules, policies, and practices, *not women* [emphasis added] thus recognizing that organizations differently structure women's and men's routes to success" (Morimoto & Zajicek, 2014, p. 138), and (c) transformation will only occur with the cooperation of both men and women across the entire campus. Most ADVANCE institutions combine individually focused initiatives with structural initiatives, but an inherent contradiction has to do with:

> tension in the ability of the NSF, an organization that is recognized as a major player in enhancing US competitive edge and the gatekeeper and sanctifier of academic excellence built upon traditional (i.e. hegemonic masculine) scientific scholarship, to sponsor a successful gender equity effort. (Morimoto & Zajicek, 2014, p. 142)

To conclude, Morimoto and Zajicek (2014) considered Lorde's (1984) statement: The master's tools will never dismantle the master's house. They proposed that ADVANCE initiatives, such as restating language so that family obligations were expected, were tools to "remodel the house, they do not radically change it…. Hence, institutionalizing changes to the

academic structure also entails an examination of the context that gives rise to these structures" (Morimoto & Zajicek, 2014, p. 145).

Nielsen, Marschke, Sheff and Rankin (2005) wrote about their evaluation of a university's interventions to " change university policies, structures, and climates … in ways that would increase the number of women in the sciences, technology, engineering, and math (STEM) disciplines" (p. 1). Assessment included quantitative pre- and post-test measures of salary differences between male and female faculty and a count of the women faculty. A climate survey was included to measure "feminist consciousness (defined as having awareness of and opposing gender-related inequities) on the part of faculty and administrators" (Nielsen et al., 2005, p. 2). When analyzing the effect of gender on faculty, the researchers found that traditional variables such as rank, discipline, tenure status and age account for the majority of the difference in salary. The researchers proposed that the remaining difference was caused by other *vital variables* such as family and marital status, starting salary and negotiations and work climate. In response to regression analysis, "adding variables to a model in order to increase the explained variance and thus implicitly justifying the salary differences" (Nielsen et al., 2005, p. 10), the authors conducted analysis with a feminist regression technique, the Oaxaca model. One finding was that "women, if they were paid like men, would earn $7,100 more than they do now for being tenured. Conversely, men would earn $23,000 less for tenure status if they were paid according to women's salary structure" (Morimoto & Zajicek, 2014, p. 11). The Oaxaca model "reflects the fact that the salary structures of the two groups are different, their characteristics are different, and more than one variable is entered in to the equations" (Nielsen et al., 2005, p. 11).

One variable they also attempted to measure was feminist consciousness in the context of work climate. The authors created a questionnaire to collect quantitative data but questioned the difficult and possibly unethical outcome of measuring feminist consciousness.

> The results were disastrous but informative… both feminist and non-feminist colleagues were either offended by the questions, did not understand them, became defensive, could not respond without considerably more clarification and context, or some combination of the above. (Nielsen et al., 2005, pp. 12–13)

The authors proceeded with a more general climate survey but noted the incongruity of using a linear tool to measure "multidimensional, dynamic, elusive, contradictory, ambiguous, interactional, situationally specific, shifting, and contextual" (Nielsen et al., 2005, p. 13) feminist consciousness. They commented, "although the decision to use a survey format in order to communicate more effectively with the funding agency was a practical one, it also shows how a dominant paradigm works to reinforce itself" (Nielsen et al., 2005, p. 14).

Lorde (1984) presents her rationale with a question and answer: "What does it mean when the tools of a racist patriarchy are used to examine the fruits of that same patriarchy? It means that only the most narrow perimeters of change are possible and allowable" (pp. 110-111). Lorde (1984) describes an alternate path to generate change that depends on interdependency of women. Her statement, "difference is that raw and powerful connection from which our personal power is forged" (p. 112) resonates a decade later with Braidotti's (1992) proposition that communication can be generated through differences. Lorde (1984) explains further:

> Difference must not be merely tolerated, but seen as a fund of necessary polarities between which our creativity can spark like a dialectic. Only then does the necessity for interdependency become unthreatening. Only within that interdependency of different

> strengths, acknowledged and equal, can the power to seek new ways to actively 'be' in the world generate, as well as the courage and sustenance to act where there are no charters. (p. 111)

She concludes that the master's tools "may allow us temporarily to beat him at his own game, but they will never enable us to bring about genuine change" (Lorde, 1984, p. 112).

As there was less literature specifically focused on women in mathematics, a brief discussion of research on women and math culture and mentoring in math follows.

Women and Math Culture

I found just a few studies focused on women in mathematics. Several perspectives considered the ways that math culture does not support women mathematicians. Authors also agreed that math culture was male dominated yet oppressive for both men and women graduate students. Noddings (1996) assessed the state of mathematics and stated, "the idea that mathematics is a male activity is widespread and serves to fulfill itself" (p. 611). Herzig (2004b) described men's experiences and concerns as similar to those of women in math departments, however:

> What was unique to the women was their unanimous descriptions of feeling that they do not fit into the male-dominated culture of mathematics, a feeling that presents a substantial obstacle in their path to developing a sense of belonging in mathematics. (p. 392).

Herzig (2004b) identified integration into the culture and community of mathematics as the most important reason for women to persist in mathematics, specifically, "relationships with department faculty, particularly advisors, are a critical mechanism by which graduate students become integrated and persist in graduate school" (p. 381). All of the women graduate students

in mathematics who participated in Herzig's (2004b) study described "limited or negative relationships they had with faculty…. In particular, they spoke about feeling invisible, needing guidance, wanting better teaching, lacking moral support, and wishing to be mentored" (pp. 383-384).

Noddings (1996) wonders if people do not choose math because of its culture. "Something about the subject or the way it is taught that attracts a significant number of young people with underdeveloped social skills …. many talented young people may question whether they *want* to be part of it. (p. 611). This is an important perspective because it undermines the assumption of math's culture that only a few people – the young geniuses – are talented enough to do math. Similarly, Damarin (2000) explicitly disagrees with the assumption, "that women's mathematical abilities, attitudes, performances and so on can be attributed to biological, psychological, or social factors over which they have little or no control" (p. 70). She counters with her own assumption that women have agency and chose how math would (or would not) become part of their lives. Damarin (2000) concluded that people who are good at math were in a *marked category* – a minority group who shared a deviance, in this case mathematical ability. Women who were good at mathematics were doubly marked since they were in a minority position within the marked category of mathematically able, they "typically find themselves at the margins of each [category], their membership in one category marking them as deviant within the other" (Damarin, 2000, p. 73).

The lack of diversity in math culture raised issues for several authors. Noddings (1996) proposes that if the mathematically able do not learn to communicate effectively outside of math, then exclusion might result. "*Mathematical* communication may aggravate inequalities, and both insiders and outsiders may opt for exclusion. One group is hurt, then, by exclusion from

mathematics; the other may be hurt by exclusion from a fuller and more sensitive social life" (p. 611). Herzig (2004a) argues that "by broadening the focus of mathematics to include a more diverse range of scholars, the discipline of mathematics would likely be enriched by an expanded range of mathematical thought" (pp. 173-174). Finally, Damarin (2000) asks a question about girls and women who were interested in mathematics:

> Doubly marked
> (as women and as mathematically able),
> and thus
> Doubly deviant
> how many young women leave the study of mathematics
> because they are
> Doubly silenced …
> and their mathematical realities
> Doubly denied? (p. 83)

Support for women in math (mentoring and culture).

Several studies described mentoring and advising supports created specifically for women in mathematics. Although some women in mathematics had access to mentoring by other women mathematicians, most were mentored by men. Participants in Stage and Maple's (1996) study "related stories of mentors who provided guidance, encouragement, and friendship" (p. 29). Students also relied on peers for academic and moral support, however, some needed to find support outside of the math department (Herzig, 2006; Stage & Maple, 1996).

Bozeman and Hughes (2004) analyzed the effect of implementing the Enhancing Diversity in Graduate Education (EDGE) Program, a collaboration of two women's liberal arts colleges, one a historically black college. The program's goal was to increase the number of women, especially women of color, who successfully completed graduate programs in math. The program was "designed to create positive initial conditions for students and to assist them in replacing disadvantages or setbacks with a series of small positive advantages that can have a

long-term cumulative effect." (Bozeman & Hughes, 2004, p. 244). An interesting result was that awareness of the graduate school culture and challenges helped women students persist and "seek options and take positive action when challenges are encountered" (Bozeman & Hughes, 2004, p. 246).

Another finding identified that mathematics students typically encountered crises that may have caused a loss of confidence and "disillusionment with graduate study or to dissatisfaction with one's particular graduate program" (Bozeman & Hughes, 2004, p. 252). Furthermore the program recognized that respondents struggled with balancing academic achievement with other aspects of their lives and encouraged respondents to create their success stories. In summary, the EDGE Program "demonstrates to its participants many paths by which 'it can be done,' primarily through a variety of role models," and "that structures and strategies will be identified that can be used to create a more positive environment for all graduate students" (Bozeman & Hughes, 2004, p. 253).

I begin the next section on persistence and belonging with my own experiences of belonging when I went to college at the age of 17.

Persistence and Belonging

> I arrived alone in Boston's Logan International Airport with four giant suitcases and a bicycle. I was happy to be far away from Hawai'i and from my family. At college I joined the novice crew team and found a job at Toscanini's, the local ice cream store. For the first time in my life I felt like I belonged. (personal journal, 2015)

I had a very different experience as a PhD student in mathematics after several years of teaching science and math at a high school. I remembered myself as a failure for not persisting to earn the terminal degree. I didn't remember how hard I worked to continue with the program

until I came across the stack of scholarship applications that I submitted. (I was not awarded any scholarships.) I wrote honestly about being a non-traditional student attempting to balance my role as a mother with my goal of a career in the academy. I was qualified academically with high grades in graduate school, a BS degree in Physics, a second BS degree in Earth, Atmospheric, and Planetary Sciences, and perfect scores on the Quantitative and Analytical Reasoning sections of the General Record Examinations. In my Narrative Autobiography of the American Association of University Women Educational Foundation 2003-2004 Selected Professions Fellowship Application Form I wrote:

> I work hard to balance my life so that I can be a stay-at-home mom and pursue my dream of studying mathematics … when I feel like giving up I remember that I will have to answer to my daughters when they are older. I believe that I need to model for them a woman who pursues her dreams and cares for her family. (excerpt, 2002)

Did I give up by returning to teaching? Or did I make a prudent choice in light of the academy's message that I wasn't going to make it because I was different and because I wasn't willing to sacrifice caring for my family to succeed?

> ******

> 'People assume you have to have some special talent to do mathematics,' … 'They think you're either born with it, or you're not. But Rhonda and I keep saying, 'You actually develop the ability to do mathematics. *Don't give up!'* (Sylvia Bozeman in Duckworth, 2016, p. 194).

Studies on persistence and belonging begin with the idea of persistence as a non-cognitive factor in student achievement. Grit is discussed since persistence is a part of its definition. A starting place to define belonging is as a basic psychological need. Other qualitative studies operationalized belonging through models that proposed causality between factors such

as self-perception, support, engagement, belonging and persistence. Literature connecting persistence to achievement is discussed next since persistence was used in some studies as a starting point to define success.

Persistence and achievement.

Rockinson-Szapkiw, Spaulding, and Spaulding (2016), identified research on higher education dropout and student attrition as the foundation for studies on academic persistence: "Tinto (1975) posited that in order to persist, students need to integrate into both academic (e.g., evidenced by GPA) and social systems (e.g., extracurricular activities) within the university" (p. 102). Dweck, Walton and Cohen (2014) defined academic persistence, also labeled tenacity or perseverance, as "working hard and working smart for a long time" (p. 4). This related to Duckworth's (2016) research that grit, defined as passion and persistence towards a meaningful goal, could be developed. She explained the importance of learning from purposeful role models who demonstrate pushing through the difficulties and enjoying the intrinsic rewards of helping others. Hope, defined as "the expectation that our own efforts can improve our future… has nothing to do with luck and everything to do with getting up again" (Duckworth, 2016, p. 169).

Duckworth (2016) described the experiences of Rhonda Hughes, mathematician and co-founder of the EDGE program to support women mathematicians in graduate school, because "she almost never got back up all by herself. Instead she figured out that asking for help was a good way to hold on to hope" (p. 194). Rhonda Hughes and the other EDGE co-founder, Sylvia Bozeman, were adamant that mathematical ability was developed.

Another important finding from Duckworth (2016) was that culture, defined by our psychological environment as "…shared norms and values of a group…" (p. 244), has a strong influence on us. She wrote:

> in the long run, culture has the power to shape our identity. Over time and under the right circumstances, the norms and values of the group to which we belong become our own. We internalize them. We carry them with us. (Duckworth, 2016, p. 247)

Connecting culture to grit, she stated "*If you want to be gritter, find a gritty culture and join it*" (Duckworth, 2016, p. 245).

Herzig (2004a) described a feedback loop that depended on the nature of experiences that would either increase or decrease a women student's persistence in mathematics:

> Experiences that enhance students' participation lead to increased integration, increasing the likelihood that they will persist; experiences that inhibit their participation make it more difficult for them to become integrated, making it less likely that they will persist. (p. 181)

She raised several personal and interpersonal factors that also affected the persistence of women and people of color in mathematics including "…independence and autonomy, achievement, confidence, and family responsibilities" (Herzig, 2004a, p. 185). Another important aspect of this persistence framework was that participation happened in three "… planes of analysis: individual, interpersonal, and community" (Herzig, 2004a, p. 201). This was important for aspiring women mathematicians because "… students do not have equitable opportunities to participate, which led to unequal chances that they will persist" (Herzig, 2004a, p. 200). An example of how this related to gender follows:

> male science students have enhanced relationships with faculty … that provide them with increased opportunities to develop a sense of belonging. This feeling of acceptance is a prerequisite for independent and autonomous work. Denied the same degree of

relationships with faculty, female students in science have a more difficult time acting independently. (Herzig, 2004a, p. 186)

The following section describes literature on belonging beginning with quantitative psychological definitions of belonging and ending with a qualitative model describing women graduate students in mathematics.

Belonging.

In psychology, belonging or relatedness is identified as a basic need (Goodenow, 1992; Osterman, 2000; Walton & Cohen, 2007). In addition to those two terms, Osterman (2000) list related terms from other research: "'support,' 'acceptance,' 'membership,' or 'sense of community' – they all deal directly with students' psychological experiences" (p. 326). Goodenow and Grady (1993) define academic belonging in a school or classroom as "the extent to which they feel personally accepted, respected, included, and supported by others – especially teachers and other adults in the school social environment" (pp. 60-61). Psychologists such as Walton and Cohen (2007) measure belongingness with quantitative tools that assess a student's social fit and academic identification. Goodenow and Grady (1993) assessed students' perceived belonging with Goodenow's (1993) Psychological Sense of School Membership Scale.

Findings in psychology support the importance of belonging. Osterman (2000) states, "being part of a supportive network reduces stress, whereas being deprived of stable and supportive relationships has far-reaching consequences" (p. 327). She connects belonging to community by explaining how both members of the community and the community itself experienced mutual gains:

A community exists when its members experience a sense of belonging or personal relatedness. In a community, the members feel that the group is important to them and

> that they are important to the group. Members of a community feel that the group will satisfy their needs; they will be cared for or supported. Finally, the community has a shared and emotional sense of connection. (Osterman, 2000, p. 324)

Cheryan (2012) proposes that masculine stereotypes of math-related fields kept women from pursuing math-related careers. She uses the word *paradox* because "while *doing well* in math classes may now be stereotyped as feminine, *seeking out* math-related careers is still a gender role violation for women," (p. 184). Because stereotypes interfered with belonging, a possible solution to increasing the number of women in math was "broadening the image of who belongs in math related fields," (p. 186). Cheryan (2012) calls for the media to change its representation of people who work in math related careers, for more visible role-models who break the stereotype, and for student exposure to math-related careers. She concludes by stating, "women may also become more interested in math-related careers if gender roles are relaxed to enable them to select careers that deviate from female gender role prescriptions" (p. 188).

Herzig (2010) interviewed women graduate students in mathematics to learn about their experiences and sense of belonging in their department. Three themes emerged: "the importance of having and being role models, the challenges they feel 'fitting in,' and their unwillingness or inability to focus on mathematics to the exclusion of all else" (pp. 185 - 186). Role models helped these women create a sense that they belonged in a community (department), but this came with pressure to "prove their worth and invalidate negative stereotypes of mathematical women" (Herzig, 2010, p. 188). Furthermore, the women, and especially women of color and mothers "did not feel that they fit in mathematics. They felt uncomfortable in classes and other settings in which there were few women; … these women faced explicit obstacles and clear messages about ways that they did not belong" (Herzig, 2010, p. 191). All of the women in

Herzig's (2010) study felt doubt about pursuing graduate study in mathematics because of the high cost to their personal lives.

Referring to Damarin's (2000) analysis of marked categories, Herzig (2010) explains why being mathematically able could be doubly problematic for women:

> If students in advanced mathematics are indeed marked as 'deviant' because of their mathematical talent, women students are marked within this group, and may suffer the double stigma of not being 'real' mathematicians because of their gender, and not being 'real' women because of their work in mathematics. Thus for some students who already feel marginalized in some communities, belonging in mathematics may not be an entirely good thing: while belonging facilitates persistence and success in mathematics, it also 'marks' a student as deviant, as socially inept. (p. 194)

Herzig (2010) also shares the idea of 'critical mass' – that having a number of women (and women of color) in a department would create conditions that were more conducive to women developing a sense of belonging.

Describing a particular experience of belonging, Solomon, Radovic, and Black (2016) tell the story of Roz, a 52 year-old woman who earned undergraduate, masters and PhD degrees in mathematics after raising a family. As a post-doctoral researcher at a prestigious university in the United Kingdom, Roz recognized the contradiction inherent in being a female and a mathematician and believed other women mathematicians became more masculine in order to belong. In contrast, Roz "… has chosen to be different – to enact a different kind of mathematical identity, which retains simultaneously a strong and visible femininity (signaled by the use of the cultural tools of skirt and heels) alongside the mathematics" (Solomon et al., 2016,

p. 63). Of interest was the observation that Roz changed the culture of her department in order to belong:

> Roz enacts her femininity around her mathematics activity in various ways, preserving the (male, according to her) mathematics while carving out an interface with it which calls on classically feminine characteristics of caring and helping others. This requires creating new spaces within the department and academia more generally, and her use of mathematics itself. (Solomon et al., 2016, p. 68)

The authors celebrated Roz' progress towards her goal of becoming a professor because she was "also world-making as she creates the possibility for change not just for herself but also for the wider community of mathematics" (Solomon et al., 2016, p. 69).

This chapter described the major themes of literature that framed the project, feminist and other women-centered perspectives, women in STEM, women's experiences in mathematics, and persistence and belonging. Chapter 3 describes the methodology used to conduct this study.

Chapter 3

Methods

Research Design and Questions

The purpose of this feminist qualitative study is to deepen understanding of the challenges and rewards of being a woman mathematician in the academy. By listening to their stories, I hope this study will contribute to the discussion on how to help girls and women succeed in mathematics and other STEM career pathways. This is important in light of the trend of women not pursuing degrees and careers in mathematics even though women excel overall in higher education (DiPrete & Buchmann, 2013). Although there are many studies that explore the correlation of cognitive factors to academic success, this study privileges the findings of the University of Chicago Consortium on Chicago School Research, that non-cognitive factors such as academic mindsets play an important role in academic success; academic mindsets are defined as "…beliefs, attitudes, or ways of perceiving oneself in relation to learning and intellectual work that support academic performance" (Farrington et al., 2012, p. 28). Specifically, I consider if academic belonging and persistence mindsets are factors in the success of women mathematicians in the academy.

Dweck, Walton and Cohen (2014) define academic persistence, also labeled tenacity or perseverance, as "… working hard and working smart for a long time" (p. 4). In the literature reviewed for this study, a result of student persistence was retention, for example, remaining in graduate school to complete a Master's or PhD degree. Belonging mindset is defined by Farrington et al. (2012) as "… a sense that one has a rightful place in a given academic setting" (p. 10). Osterman (2000) identifies other words used in the literature when referring to this mindset, "… 'belongingness,' 'relatedness,' 'support,' 'acceptance,' 'membership,' or 'sense of

community' – they all deal directly with students' psychological experiences" (p. 326). To operationalize the mindset definition, I designed the study to draw out memories and other reflections from participants that explored their sense of belonging in their college, graduate school, and professional mathematics communities.

I use a feminist conceptual framework to honor the idea that women's varying perspectives arise from different backgrounds and local situations and that "differences become the stuff communication is made of" (Braidotti, 1992, p. 10). This means that the range of experiences expressed by the respondents in this study create opportunities for further discussion and research. Elements of constructivism also inform the study as my understanding of these women's experiences developed through each interview. Guba and Lincoln (1989) write:

> the findings are not 'facts' in some ultimate sense but are, instead, literally *created* through an interactive process that *includes* the evaluator (so much for objectivity!) …. What emerges from this process is one or more *constructions* that *are* the realities of the case. (p. 8)

These ideas set the context for the study.

The broad research question guiding the study was: What social and academic factors influence the success of women mathematicians? Specifically, the study looked at two academic mindsets, perseverance (persistence), and belonging, as important factors in the success of the participants. The study also looked for ways to support girls and women interested in careers in mathematics and other STEM fields. These questions are broad in scope because of my limited experience with mathematics in the academy. This fit with the idea that "… constructivists are unwilling to assume that they know enough about the time/context frame a priori to know what questions to ask" (Guba & Lincoln, 1989, p. 175). I intend this stance to be respectful to the

participants. Reading existing literature about women in mathematics and other STEM fields helped me to understand some of the context for this study, yet I relied on the participants' stories to shape and guide the research.

My Feminist Methodology: A Bricolage

> "the most viable strategy for feminist research is, evidently, to abandon any quest for one true method." (Code, 1995, p. 42)

Methods chosen for this study were drawn from a wide range of sources, not all of which were identified as feminist. However feminist methodology empowered me to pick and choose the methods that resonated most with my research goals. Most important to me were methods that (a) brought voice to the forefront (stories, dialogue, narrative), (b) empowered the researcher as the research tool along with positionality, multiple perspectives, reflexivity, journaling and field notes, and (c) required me to co-construct meaning with others through interviews, transcriptions, member checks, peer debriefing, and caring. In this chapter, I include both the literature reviewed in the process of choosing these methods and how the methods were used in the study. I include more background information than is typical for a traditional methods chapter to honor the researchers who provided me with tools and the freedom to conduct research in a way that was meaningful to me, and hopefully to the research community as well.

Why consider gender?

In the introduction of her book *Doing Feminist Research*, Roberts (1981) writes about the importance of seriously considering gender in non-sexist research. In a later chapter, Woodward and Chisholm (1981) discuss the difficulty of writing interview questions that do not include gender-based assumptions. They conclude that their findings must be understood in the context of the researchers' understandings and society: "No single unitary 'feminist perspective' can be

(a) identified and then (b) applied to the research situation. Rather we had a certain imperfectly articulated view of society and how it operates and changes" (p. 183). This meant that my research process needed to adapt to my developing understanding of the participants experiences as women as part of my choice to do feminist research.

Why do feminist research?

Code (1995) defines feminist scholarship in terms of embracing subjectivity in contrast with the androcentric assumption that objectivity is the ideal, "to be a feminist is, in effect, to conduct value-laden research and hence not to be properly objective," (p. 17). The first step is "learning to see what is not there and hear what is not being said," (p. 23). She connects feminism to critical race theory, the power of the counternarrative, and women reclaiming their agency. Additionally, since knowledge and its creation only make sense within the context of a community, the feminist scholar must be accepted by the academy in order to have access to discourse surrounding her research. Another reason identified by Code (1995) for feminist researchers to work within the academy is the value of people bringing their different perspectives to inform decision-making and other work of a society. She writes:

> Here it is not a matter of an advocate speaking from within another's experience imperialistically, but rather of an advocate who has learned to see the hithero unseen, and who can claim feminist and "public" credibility, reframing received knowledge within a feminist-informed analysis of asymmetrical social structures. Such vigilance for traces of the untold story is central to many feminist research and activist methods. (Code, 1995, p. 32)

Code's (1995) basic recommendations for feminist research include incorporating other facets of identity into research methods and analysis, becoming aware of internalized misogyny

in both researcher and participant, including feminist agency, maintaining integrity in analysis by taking into account context, and assuring that effects of research are positive. She summarizes the importance of flexibility in feminist research since appropriate methods might not be apparent until the research was underway:

> questions of knowledge and method can rarely be answered satisfactorily in abstraction, before the fact. Rather, these questions have to be addressed locally, in piece-by-piece analyses of specific instances of knowledge-making, in which innovative techniques are adduced and tested, and the best of older methods and assumptions are re-evaluated for their residual viability. (Code, 1995, p. 43)

Reinharz (1992) defines feminist research in a number of ways: through self-identification by the researcher, validation by a peer-reviewed journal, or recognition by an organization promoting feminist research because it "bypasses the danger of applying a one-sided definition to *all* feminist researchers…. and avoid[s] deducing what feminist research is from the standpoint of my personal definition" (p. 7). She identifies a number of original feminist research methods – consciousness-raising (usually not for publication); an anonymous shared diary as a safe forum for women to communicate with each other and plan for action; drama through collaboration, finding voice, concrete and context-dependency; diagrams illustrating friendship webs; fiction to communicate sociology or a specific perspective; and, unplanned personal experiences which either become the research or inform it. A researcher-created method "reflects the researcher's effort to create a new approach that met her feminist criteria" (Reinharz, 1992, p. 215).

The next part of this chapter explains the methods that focus on the importance of voice, the researcher as the research tool, and co-constructing meaning with participants.

The Importance of Voice

Reinharz (1992) stresses the importance of voice through the process of feminist research, specifically, finding one's voice to ultimately communicate understandings and to appropriately speak for research participants. Feminist researcher "Renate Klein suggests that we cannot speak for others, but that we can, and must speak *out* for others" (Reinharz, 1992, p. 16). Reinharz (1992) shares powerful arguments for a feminist researcher to write in her own voice, and states "the more subjective the voice …the greater the potential that the material will dissolve differences between the reader and the speaker… [and] they are better able to challenge the dominant ideology" (p. 228). This is explained in part by the idea of *deep identification* in which the feminist scholar "discloses herself, sharing her story and inviting the reader to identify with her" (Reinharz, 1992, p. 232).

Lugones and Spelman (1983) define feminist methods through women's voice and stories. Women's voice is a feminist method because it addresses the fact that many women are systematically silenced by the dominant culture. They write, "virtually no women have had a voice, whatever their race, class, ethnicity, religion, sexual alliance, whatever place and period in history" (p. 574).

Voice is associated with personal and professional risk. Lord and Preston (2009) shared their experience with leadership in higher education in Australia. They contrasted the personal and professional risk of telling their stories with the risk that that the culture would not change if they remained silent; the "risk of not writing the story is that the experiences remain individualised and potentially trivialised by others and the culture remains unexamined and unchallenged" (p. 770). Thus, interviewing my participants, was the primary method used to honor their voices.

Interviewing.

> You want your 'pitches' -- your questions -- to stimulate verbal flights from the important respondents who know what you do not. (Glesne, 2011, p. 102)

Oakley (1981) lists many context-dependent aspects of interviewing that are usually not included in research reports. She describes the traditional research interview, as a "mechanical instrument of data-collection [and]… specialized form of conversation in which one person asks the questions and another gives the answers," (p. 36). In this framework, both interviewees and interviewers were reduced to limited and somewhat passive roles. In contrast, Oakley (1981) asserts that a feminist can not morally follow the traditional model and that both interviewer and interviewee be involved with the interview. She states that "the goal of finding out about people through interviewing is best achieved when the relationship of interviewer and interviewee is non-hierarchical and when the interviewer is prepared to invest his or her own personal identity in the relationship" (Oakley, 1981, p. 41). The importance of this shift in paradigm is the emphasis on women documenting other women's stories. The research then becomes a political act since the interview gives more women a voice.

Cotterill's (1992) description of the interview places the interviewer and interviewee on equal terms and acknowledges the vulnerability of both parties. She states, "the subjective experience of women researchers is vitally important and must be acknowledged," (Cotterill, 1992, p. 593). The researcher hopes for outcomes that positively affect both the individual and women's collective interests. Reinharz' (1983) model is described in detail:

> This model aims to produce non-hierarchical, non-manipulative research relationships which have the potential to overcome the separation between the researcher and the

> researched …. Most seem to agree that the best way to find out about women's lives is to make interviewing an interactive experience. (Cotterill, 1992, p. 594)

Cotterill (1992) encourages building trust between researcher and interviewee, but cautions against developing friendship because it might create an ethical issue since the interviewee's words are being used for the researcher's purposes. She writes, "respondents may feel more comfortable talking to a 'friendly stranger' because it allows them to exercise some control over the relationship," (p. 596). Cotterill (1992) notes that the "final shift of power between researcher and respondent is balanced in favour of the researcher, for it is she who eventually walks away," (p. 604). Finally, Cotterill (1992) identifies the need for feminist research to be positioned properly within the academy and in literature and other scholarly (and perhaps not so scholarly) venues. This ensures that feminist research positively influences women's collective interests.

Glesne (2011) writes about the practical considerations of interviewing including the idea that theories can generate relevant questions. She references Patton (2002) when listing categories of questions, including the "*grand tour* question, a request for the respondent to take the interviewer through a place, a time period, a sequence of events or activities, or some group of people or objects," (Glesne, 2011, p. 108). According to Glesne (2011), the interviewer's role is "that of a conversational partner or collaborator whose conversational actions facilitate others in the telling of their stories," (p. 120). She also lists desirable interviewer attributes which include being caring and grateful, and suggests to "leave time after your interviews for the expression of your gratitude and for other informal talk" (Glesne, 2011, p. 127).

Narrative.

Leggo (1995) describes how narratives can bring experience to life and honor multiple realities: **"**Surely truth must be multifaceted and diverse and kaleidoscopic and prismatic and organic and ever changing, a disseminating multiplicity of truths like the weather and the seasons, both predictable and unpredictable, both the same and different" (p. 8). In this spirit, much of this dissertation relies on narrative – my stories, the stories that participants shared about their experiences, and other stories that impacted them. I do this intentionally, but also cognizant of my own limitation in properly honoring the participant's voices. Leggo (1995) identifies tensions that arise when using narratives to describe lived experience: "(1) storing life/storying life, (2) truth/fiction, and (3) collection/selection" (p. 5). I suggest that relying on narratives as *research* threatens the positivistic theory/practice binary, making the academic posture of the researcher subject to a different kind of scrutiny. This risk was real for me as a student and an outsider to the academy because I needed to share my lack of persistence and belonging as a PhD student in STEM to give meaning and context to my study and reentry to the academy.

Renee Norman's narrative description of her actions after a negative experience with a professor captured her need to use her voice and the fear that went along with her agency:

> Understanding my vulnerability as a student and a woman, but wanting to take some action that could effect some social change. I wrote an article in which I recorded my hurt and my fear. It was printed in the local newspaper. Lately, I have been feeling afraid to even say I am a feminist. It takes courage to write what you believe when you know the words cause strife and stridency, and I am tired. Tired and afraid. I am losing my courage

these days. I have finally found my voice but it may be dangerous to use it. (Norman & Leggo, 1995, p. 20)

Related to the voice of narrative, dialogue requires relationship and coexistence of multiple perspectives. Relationship through dialogue was proposed by several studies as a possibility for precipitating social justice and learning. This was an important principle that guided the conceptual framework of this study.

Dialogue as a social justice method.

Lugones and Spelman (1983) identify the importance of positionality, specifically questioning the validity of an outsider conducting research. They offer dialogue as a solution, "only when genuine and reciprocal dialogue takes place between 'outsiders' and 'insiders' can we trust the outsider's account," (p. 577), and friendship as a motive because it came with "appropriate reciprocity of care for your and our wellbeing as whole beings," and "reciprocity of understanding that will enable you to follow us in our experiences as we are able to follow you in yours" (p. 581).

Noddings (1984) offers another perspective. She defines caring through two required interactions between two people, the one-caring and the cared-for. The first is the action of caring by the one-caring, "the displacement of interest from my own reality to the reality of the other" (p. 44), the second is the acceptance of the care by the cared-for. In addition, Noddings (1992) argues that "the first job of the schools is to care for our children. We should educate our children not only for competence but also for caring. Our aim should be to encourage the growth of competent, caring, loving, and lovable people" (p. xiv). When discussing math education, Herzig (2004b) describes this caring framework as a way to improve students' engagement with

mathematics content and community. One component is dialogue, simply defined as "meaningful, mutual, open-ended discussion" (p. 391).

Norman and Leggo (1995) collaborated to express the potential of dialogue for learning: "In our collaboration we engage in a dialogue that reminds us persistently that, if we are willing and brave enough, there are many lessons we can learn from the other and with the other" (p. 15). In this case, dialogue was a choice made by professor and student to challenge the traditional process of knowledge making and power hierarchy.

The researcher in dialogue with participants or peers or committee members is a defining factor of this qualitative research project. The next section described this role of researcher as the research tool through the concepts of reflexivity, journaling, and field notes.

The Researcher as the Research Tool

This project began with a question about what led me to become an educator. The answer, an early, aborted attempt at graduate school in a STEM field because of a family crisis, and a failed second attempt to earn a PhD in mathematics, required me to work through intense feelings of failure and loss. The wisdom and guidance of faculty members, who provided thought-provoking readings and opportunities for structured writing, eventually made it possible for me to take on another perspective and view my past as an intricate quilt of experiences rather than a series of failures. This process kept me focused on self-reflection as a necessary part of qualitative research.

As I began to feel more comfortable with the topic of successful women in mathematics, I began sharing my ideas with others. Each person offered a slightly different perspective based on her experience. I spoke with a university administrator about her journey from oceanography to veterinary medicine and research. I spoke with a second-generation woman scientist who

shared with me the story of Ida Busbridge, an Oxford tutor who mentored many women and men in mathematics.

While the many perspectives helped me grasp the scope of my topic, I realized that everyone had a strong opinion about the meaning of women in STEM. Researching women's experiences in math required that I focus on my research questions, welcome the multitude of perspectives shared with me, and, as in the lesson described by Williams (1991), see it all at the same time:

> the lesson I learned from her wild perceptions is that it really is possible to see things-even the most concrete things-simultaneously yet differently; and that seeing simultaneously yet differently is more easily done by two people than one, but that one person can get the hang of it with time and effort." (p. 150)

Practicing reflexivity was an important method used to simultaneously honor multiple perspectives at one time, including my own.

Multiple perspectives.

Narayan (1989) discusses in detail the perspective of a non-western feminist. She begins with the idea that including women's perspectives to existing scholarship will change scholarship. She suggests that the goal of feminist epistemology is empowerment and reclaiming experiences. Narayan (1989) raises an interesting point of view. She argues that groups oppressed by the dominant culture had an advantage because they were able to operate in both the dominant culture and their home culture. However, this has consequences for an individual; she might "be tempted to dichotomize her life" or "reject the practices of her own context and try to be as much as possible like members of the dominant group" (Narayan, 1989, p. 266).

Reflexivity.

I first became aware of the idea of reflexivity in a class with Joanne Cooper. I still have the pink post-it note above my desk that reads "reflexivity – author's self-awareness." While this simple definition provides only one layer of meaning, it gave me access into the world of qualitative research, where the researcher is the research tool. Collins and Cooper (2014) state, "in qualitative research, the parallel process to refining the instrument rests primarily with researcher reflexivity. The more self-aware and forthright the researcher was, the better the audience can understand the perspective of the research" (p. 89). These authors offer Goleman's (1995) concept of emotional intelligence as a way to measure and develop researcher reflexivity and describe a framework in terms of two areas: personal competence, defined as self-awareness, self-regulation, and motivation. Also, social competence, defined as empathy and social skills which include political awareness (Collins & Cooper, 2014, p. 92).

Lather (1992) is quoted by Tilley (2003) to establish "active reflexivity as core to the process" of critical feminist research (p. 849). The connection to practice is that reflexivity "pushes the researcher to ask questions often not voiced" (Tilley, 2003, p. 835). Tilley (2003) writes about reflexivity in the context of transcription since the researcher chooses what and how to record the spoken word. Davidson (2009) explains the relationship between transcription and theory through reflexivity: "researchers 'reflexively document and affirm theoretical positions' (Mischler, 1991, p. 271) during the process of transcription and analysis" (p. 37). Hesse-Biber (2012) proposes that reflexivity improves the research process: "By disclosing their values, attitudes, and biases in their approaches to particular research questions and by engaging in strong reflexivity throughout the research process, feminist researchers can actually improve the objectivity of research" (p. 10).

Lambrev (2017) defines reflexivity in terms of Callaway's (1992) "continuous mode of self analysis and political awareness" (p. 33). She describes Hertz's (1997) perspective as a "process of continuous exploration of the research work in which researcher account for their own subjectivity and examine the participants' positionality stance at the same time" (Lambrev, 2017, p. 6). Lambrev (2017) provides several examples of how reflexivity can help a researcher. For example, experiencing an emotional reaction while conducting her research meant that she needed to "reflect on my own representation and to see whether it harmed or facilitated the right interpretation of the data" (p. 2.) She also recognized that reflexivity helped her understand that her research depended on relationships that encouraged her to explore her own positionality and the positionality of her participants. Lambrev (2017) points out an interesting aspect of positionality; that it does shift during the research process. She states, "in this research my positionality was not a steady dimension and many times my participants and I changed identity locations that brought us closer to each other" (Lambrev, 2017, p. 6). Guidance from these scholars helped me monitor my positionality and practice reflexivity through the use of journaling and field notes.

Journaling and field notes.

Almost daily reflective writing and taking field notes were important aspects of this research. Reed and McEwan (2014) wrote, "constant reflection, reflexivity, and monitoring of emotions and perceptions can be valuable tools in the inquiry process and should be part of any inquiry process" (p.14). Journaling became a way for me to document all of these aspects of the research process.

Stevens and Cooper (2009) describe the process of recording experiences and reflecting on them:

> the journal offers a unique opportunity to chronicle and examine more closely and carefully our concrete experiences, and then to ask the hard questions about how these experiences relate to what is already known.... During writing, journal writers can readily examine their concrete experiences, and even step back and reflect on how those observations might relate to other experiences. (p. 25)

Journal writing also lent itself to reflexivity since it provided a way for me to examine assumptions from a distance:

> Because perceptions and insights based on reflections can be distorted by prior knowledge and beliefs, writing these reflections down and reviewing them allows the journal writer to scrutinize assumptions and beliefs and glean a different understanding of the assumptions that underlie their decision making. (Stevens & Cooper, 2009, p. 29)

Journal writing was also a crucial tool for ensuring that I tracked the development of my understanding (construction) as it changed based on my interaction with the participants' stories. This is evidence of the constructivist technique of progressive subjectivity (Guba & Lincoln, 1989).

Co-construction of Meaning

Interviews were the main method for gathering data for this study. Although the first interviews were conducted with a structured interview guide, questions for each second interview varied for each participant. Other important methods for constructing meaning with others were transcription, member checks, caring, and peer debriefing. These are described in detail in the following sections.

Participants and interviews.

This study involved six participants, all women who earned PhD degrees in Mathematics and are employed in the academy. Two women were contacted in person before an email was sent to explain the study and request their participation; these women responded to the email and agreed to participate in the study. Two other women were sent the email request. When I did not receive a response, I called the women at the contact numbers provided on their department websites. One woman stated that she was too busy to participate; I left a message for the other woman and did not hear back from her. The two initial participants were asked to refer other women mathematicians in order to have purposeful snowball sampling for the study. From these referrals, I contacted four other women through email. Three of these women agreed to participate in the study. The fourth shared that she was too busy but provided the name of another potential participant. I emailed this woman and she agreed to participate in the study.

This qualitative study used a series of two semi-structured interviews with each participant to gather descriptive data related to the objectives of study. More than one interview with each participant helped me to develop a research relationship with each of them (Cotterill, 1992, p. 596). Glesne (2011) agrees with this strategy: the first interview gathered background information, and the second interview probed based on the first interview (p. 108). Cotterill (1992) suggests that the researcher take on the role of "sympathetic listener" (p. 598) and "whatever her inner feelings, outwardly at least, the researcher must appear relaxed, unworried, and capable" (p. 601). Glesne's (2011) list of interviewer attributes – anticipatory, a learner, analytic, therapeutic, patiently probing, nonthreatening, aware of power and hierarchy, and caring and grateful – while extensive, seemed more realistic and respectful of the research

relationship. Guba and Lincoln (1989) describe the constructive method of research which also is respectful of the participant:

> As a constructivist interviews a first respondent, or makes a first observation, or reads a first document, he or she endeavors to uncover items of information that appear, on their face, to be relevant to the study's focus (in the case of evaluation, the evaluand). Only broad-ranging questions are asked of these sources, so that the respondent (or document) can offer up testimony in its own terms. In effect, the inquirer says, 'Tell me the questions I ought to be asking and then answer them for me.' (p. 178)

The first interviews were scheduled to be no longer than 60 minutes in length. Two were longer than an hour. The meetings were scheduled according to the availability of the participant and at places that were comfortable for them to talk freely. Interviews were conducted on and off campus. Several interviews were conducted by phone when a convenient time and place to meet could not be determined. After the first interview, each participant was given and/or emailed a biographical data form and asked to return it before the second interview. I explained to the participants that the information in the form was intended to provide me with factual context to understand the content of the interviews; specific information would not be included in the study results. The biographical data form also asked participants to generate a pseudonym. I took field notes before and after each interview to record my thoughts and feelings. This was an important part of the constructivist technique of progressive subjectivity; a process used to monitor my developing understanding of the topic and ensure that the construction was evolving throughout the collection and analysis of data (Guba & Lincoln, 1989).

There were a total of 12 interviews conducted for this study. Three first interviews were conducted in April 2016 using the Interview Guide designed for both the first and second

interviews (Appendix A). I transcribed these interviews and a new set of questions based on themes from the transcripts was generated before two second interviews were conducted in May 2016. In every instance, a participant's first transcript was reviewed before the second interview occurred, and themes particular to a participant were noted. The second interviews were scheduled to last no longer than 90 minutes in length and all were between 80 and 100 minutes long. Time was closely watched since these women were extremely busy; Glesne's (2011) recommendation was to "keep track of time when interviewing in time-conscious cultures" (p. 120). Three more first interviews were conducted in May and June of 2016. Transcripts of these interviews were completed before each second interview was conducted in June, July or August of 2016.

The last question of each interview asked the participant if there was anything else they wanted to share. On one occasion this led to sharing a very important incident in the professional experience of the participant. A participant also suggested an additional question in a follow-up email. This inclusion of the participants' voices in the research process was part of the constructivist paradigm that unites the researcher and participants in a creative interaction (Guba & Lincoln, 1989, p. 13). Further, the purpose of including participant voices and thoughts was a way "to interact with those humans in a manner respecting their dignity, their integrity, and their privacy" (Guba & Lincoln, 1989, p. 11).

Transcription.

Digital audio recordings and field notes were used to create transcriptions of each interview. Themes that emerged from the transcripts and email communication from participants were also used to guide the research over the course of data collection. Guba and Lincoln (1989) state that "discovery and verification are, within the constructivist paradigm, inseparable,

synergistic processes" (p. 166). Member checks furthered the interaction between interview data, researcher generated transcripts, and the participants' stories.

Transcription was part of this research process because each interview was recorded and then the researcher listened to the recording and produced a written record. The assumption that a verbatim transcript faithfully represents the interaction was questioned by Poland (1995) who noted that a transcript can only record the spoken words. He pointed out that most, if not all, non-verbal communication and emotional context were not captured, and standardized syntax was needed to record the verbalized emotional context (e.g., a sigh or laughter). A more realistic assumption about the accuracy of a transcript would acknowledge the "socially constructed nature of the research interview as a coauthored conversation-in-context … instead of a quasi-positivistic reification of the transcript as 'data'," (Poland, 1995, p. 292). In his qualitative study on transcript accuracy, Poland (1995) recorded three categories of transcript error: deliberate alterations that "reflected an honest desire to be helpful on the part of the transcriber," (p. 297); accidental alterations that "included problems with sentence structure, the use of quotation marks, omissions, and mistaking words and phrases for others," (p. 297); and, unavoidable alterations through the process of turning a verbal interaction into a written document. He notes that the amount of detail needed depends on the kind of analysis being done, but that being able to document transcript accuracy improves the quality of the research.

Tilley (2003) looks at how transcription by someone other than the researcher affected the research process. She states, "another party in the body of the transcriber interacting with data creates interference that complicates the analysis process" (p. 840). Tilley (2003) also encourages researchers to verify the accuracy of their transcripts as part of their research process following Poland's (1995) suggestions. Davidson's (2009) review of thirty years of literature on

transcription emphasized the stability of its definition based on Ochs' (1979) claim that "transcription is a selective process reflecting theoretical goals and definitions," (p. 44). Transcript selectivity was a practical matter because of the limitations of transferring a context-rich interaction between two people into a written record.

Davidson (2009) states that transcripts are selective by nature "because it is impossible to record all features of talk and interaction" (p. 38), and that the researcher needs to proactively make choices about what is recorded based on the goals of the project. Based on this advice, I decided to transcribe all twelve interviews. Referring to Oliver et al.'s (2005) continuum of transcript practice[4], my transcripts tended towards naturalism, recording everything that I could capture, including all of the extra words. I was unable to record the many instances of laughter and I did not have a standard way to record the pauses. I found that when the participants repeated themselves or used filler words, they seemed to be thinking aloud. When quotes were selected to be included in this dissertation, they were then edited into prose-style speech. This denaturalized representation of the data meant that the participants' stories and voices were published in a way that was comfortable for (and complimentary to) them.

Member checks.

After the transcripts of the first two interviews were completed for each participant, the documents were prepared for member checks. Guba and Lincoln (1989) define member checks

[4] Differences in transcription relate to the variety of theoretical frameworks and research methods used by researchers. A continuum proposed by Oliver, Serovich and Mason (2005) has naturalism at one end and denaturalism at the other. Naturalism describes transcription practices that includes as much of the non-verbal and emotional context as possible. Denaturalism transcription practices smooth out the words so that it reads like we think we speak. Davidson (2009) references Oliver et al. (2005) to encourage researchers to consider transcription practice early in their research process else "researchers might end up with transcripts that do not match their research objectives if they fail to think about transcription style before beginning transcription of recorded data" (p. 1274).

as “the process of testing hypotheses, data, preliminary categories and interpretations with members of the stakeholding groups from whom the original constructions were collected” (p. 238-239), and were the “single most crucial technique for establishing credibility” (p. 239). An interesting distinction made by Guba and Lincoln (1989) is that member checking verifies that I correctly recorded the participants’ thoughts and stories (constructions), in contrast to triangulation, “cross-checking specific data items of a factual nature” (p. 241), done with the biographical data sheets. Thus, member checking is an appropriate and necessary method of verification for a qualitative study that honors multiple realities.

The process of preparing transcripts for member checks required protecting their identities through the inclusion the participants’ self-selected pseudonyms and changing all names of people and universities that were part of each participant’s history. A few place names and references to research areas within mathematics were left in for the initial round of member checking with an assurance that those details could be removed at a later time if needed. These transcripts were shared with participants for their approval to proceed with data analysis. Participants were asked to check that the transcripts captured the big ideas from each interview and to indicate any text that they didn’t want included in the data analysis or used as direct quotes in the final paper. They were also asked to ignore any typos, errors in grammar, and missed or repeated words, with the understanding that if any direct quotes were used from their transcripts, the participant would be able to check and correct those quotes before publication.

After the transcripts were analyzed, an early draft of the results was shared for a member check to verify that participants’ experiences were represented accurately. Participants were asked to add other experiences to the narrative to ensure that their stories come to life through “a thick description that not only clarifies the all-important context but that makes it possible for the

reader vicariously to experience it" (Guba & Lincoln, 1989, p. 181). Participants were also asked to comment on the experiences of other participants as a way to further co-construct and verify findings. One participant commented, "*there were times when I was reading someone else's story, certain that it was my own*." At that time it was determined that a third interview was not needed.

All audio recordings and biographical data forms were stored in a secured location for the duration of the study and were destroyed upon completion of the transcripts.

Caring and peer debriefing.

As a new researcher, I was a grateful recipient of care from my professors, especially the amazing group of women who made up my committee. My respect for them, and their continued willingness to help me, kept me believing that I could complete this project. Their care supported me through this research by keeping me on track with their inexhaustible supply of affirmation, high expectations, technical advice, and understanding of my need to balance family, career and research. These women brought Noddings' (1984) words to life: "the commitment to act in behalf of the cared-for, the continued interest in his reality, and a continual renewal of commitment are the essential elements of caring from the view of the one-caring" (p. 46).

I was both the one-caring and cared-for in a group of peers who met regularly to keep each other on track with our research. Group meetings were a safe place for me to raise questions, share fears and celebrate success. In turn, I was honored to be the one-caring to support the other group members during their doctoral journeys.

In one on one meetings, my committee members also took the time to listen to me wonder, question, and explain my research process and findings as they emerged. This was an

example of the constructivist technique of peer debriefing. Guba and Lincoln (1989) describe the process as:

> The disinterested peer poses searching questions in order to help the evaluator understand his or her own posture and values and their role in the inquiry; to facilitate working hypotheses outside the context; to provide an opportunity to search out and try next methodological steps in an emergent design; and as a means of reducing the psychological stress that normally comes with fieldwork – a means of catharsis within a confidential, professional relationship. (p. 237)

The final section of this chapter describes the process of data analysis.

Analysis

Analysis of interviews and field notes took place both during data collection and after all of the interviews were completed. Guba and Lincoln (1989) state that "…discovery and verification are, within the constructivist paradigm, inseparable, synergistic processes …" (p. 166). Coding was used as a primary method of qualitative data analysis. Saldaña (2016) defines a code as "most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data" (p.4). A first round of coding was needed to develop questions for the participants' second interviews. Coding was also done after all of the interviews were transcribed and member checked to develop findings.

Coding to develop questions for the second interview.

Questions for the second interview arose through the process of transcribing the first interviews of three participants, Emily, Robyn and Wendy, and considering information on their biographical data sheets. This was necessary to prepare for the second interviews because the

questions developed in the interview guide for both first and second interviews were mostly addressed in the first interview. Guba and Lincoln (1989) describe the need for the researcher to incorporate information gathered from each participant throughout the research process:

> In effect, the inquirer says, 'Tell me the questions I ought to be asking and then answer them for me.' General responses of this sort are analyzed as soon as they are obtained, so that they become part of the agenda in all subsequent data collection. (p. 178)

The main themes that emerged in the second interview questions (Appendix B) were math culture, academy and department structures, balance, feminism, and supports. Since the interviews were semi-structured, the questions asked of each participant varied depending on the content of her first interview.

Coding to develop findings.

Qualitative analysis of the data addresses the stated purpose of this study – to deepen our understanding of the challenges and rewards that women mathematics academics experience – with an important implication of determining ways to help girls and women succeed in mathematics and other STEM career pathways. First cycle coding of all twelve interviews involved several methods. To respond to the research question guiding the study – What social and academic factors influence women mathematicians' success? – broad categories were identified to reflect the study objectives: (a) to find out if academic persistence and belonging mindset are factors when women become professors, (b) to identify other social and academic factors that influence success, and, (c) how to support girls and women in mathematics career pathways.

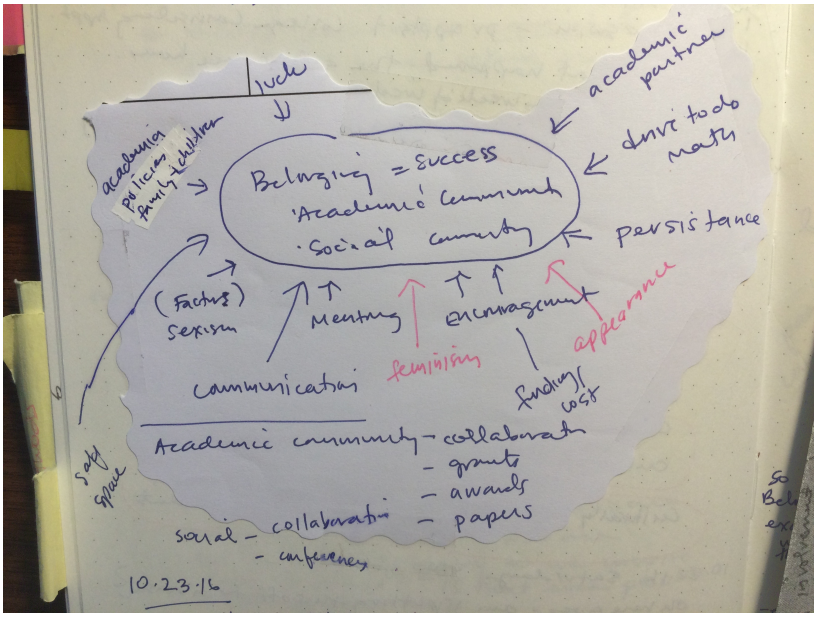
The process of preparing the twelve interviews for member checking and review of field notes and post-interview reflections generated descriptive and in vivo codes (Appendix C).

Defined by Saldaña (2016), descriptive coding "summarizes in a word or short phrase – most often a noun – the basic topic of a passage of qualitative data" (p. 103), and in vivo coding draws words and phrases "from the actual language found in the qualitative data record" (p. 105). These two kinds of codes were chosen because they created different pathways into understanding the data; descriptive codes lent themselves to categories, tables, and summaries while in vivo codes emphasized participants' voices (Saldaña, 2016). This list of codes was extensive and was a first hint at the complexity and range of the participants' experiences. For example, the in vivo code "luck" surprised me since the participants worked diligently for many years to get to where they are now. The code Appearance was closely linked to sexist practices: in math departments who imposed different standards for men and women and as a way male faculty judge the research of women mathematicians.

In addition to the broad categories defined by the research question and objectives, this list was used to guide the preliminary analysis of two first interviews of participants with vast differences in experiences as undergraduates, in graduate school, and in their careers: for example, one majored in math, the other did not, one has tenure, the other began her academic career very recently. This involved physically cutting out and organizing quotes from a set of transcripts. Participant's information and quotations were also organized into exploratory displays, "intended as heuristics for the researcher to analyze data in progress," (Miles, Huberman, & Saldaña, 2014, p. 122). The basic principle of meta-matrices defined by Miles, Huberman, and Saldaña as "master charts assembling descriptive data from each of several cases in a standard format, … is *inclusion* of all relevant, condensed data" (2014, p. 135). One meta-matrix included both positive and negative examples of a code and I was surprised by the intensity of the negative examples. For example, for the code of belonging, one participant

stated, "*I kept stepping into stuff that I was completely unaware of because there was this whole long history, and I would say things that would really upset people or who were like, that's not how we do things, it took me a while to find my way.*" After the two interviews were coded, the following diagram (Figure 1) emerged.

Figure 1: Diagram of Possible Connections Between Initial Codes



In this diagram, belonging was synonymous with success. Examples of belonging came from participant experiences in both the academic and social communities of the department. Belonging in the academic community looked like collaboration, earning grants and other awards, and having papers published. Belonging in the social community looked like collaboration and conferences. Other factors also seemed to affect belonging: academic policies around family and children, luck, a partner in the academy, drive to do math, persistence, appearance, encouragement, funding/cost, feminism, mentoring, communication, a safe space, among others.

At this point the coding process stopped because it felt like the context of participants' experiences was lost in the multitude of codes and complexity of the relationships between the codes. A second set of color-coded transcripts was prepared. This time, text from the twelve interviews was cut out and separated according to the three categories defined by the research question: belonging, persistence, and pathways. Everything else went into an "other" pile. Data was then coded within the categories and organized into a series of memos: Persistence, Belonging – Childhood and Family, Belonging – College, Belonging – Grad School, Belonging – Career, Belonging – Overall, and Pathways. A final round of analysis looked at (a) the alignment of data with the existing belonging frameworks and (b) themes of belonging differently that emerged as the beginnings of a dialogue for change.

The next chapter discusses the findings of the study beginning with a chronological description of the participants' range of experiences, both similarities and differences. Next, experiences of persistence and belonging were considered in relation to existing studies. Finally, I noticed that some participants persisted in order to belong in experiences of not-belonging, caring belonging, belonging on her terms, and belonging through agency.

Chapter 4

Findings

In response to the research question – How do the academic mindsets of persistence and belonging influence the success of women mathematicians? – similarities and differences emerged from the participants' stories. The theme of belonging, by far, had the most data compared to persistence. In alignment with previous studies, belonging led to persistence for some participants. For others, persistence seemed to be a way for participants to belong. For example, one identified academic persistence during coursework as a pathway to success. She explained that each person would encounter a difficult math course at some point and their response would affect their success since "*at some point it's going to be hard, and so how you deal with that is really important*." Persisting to belong was also found in experiences of not-belonging, caring belonging, belonging on her terms, and belonging through agency.

All of the participants had persisted with PhD degrees and finding employment in the academy. However, instead of talking about their persistence, they spoke extensively about the challenges they faced while persisting, specifically sexism and racism.

The next section begins an overview of the participants' experiences as women mathematicians in the academy. This includes both similarities in their stories and the range of experiences. I have included many participant quotes to honor their voices. Their stories came to life through inclusion of context and rich description. Privileging participant's voices aligned with my feminist worldview, specifically, voice being a means to inform agency which I defined as taking action with the intention of furthering social justice. In order to protect participants' anonymity, participant pseudonyms were not included with direct quotations from their transcripts.

Experiences of Emily, Kate, Robyn, Vi, Wendy and Zibi

To understand the participants' experiences as a group, a time-ordered meta-matrix was created that listed Carnegie Classification of the institutions associated with their education (undergraduate, graduate school) and employment, including post-doctoral appointments if applicable, chronologically. This yielded an overview of the participants' paths to becoming mathematicians. All six of the women who were interviewed for this research earned PhDs in mathematics from public and private R1 universities, defined as institutions with the highest research activity that awarded at least twenty PhD degrees in 2015 (Indiana University Center for Postsecondary Research, 2017). The institutions represented in their undergraduate degrees, post-doctoral appointments, and current and previous employment (in the academy) included public and private institutions classified as R1 universities, women's colleges, baccalaureate colleges, Christian colleges, and master's colleges. Most participants were mentored by a woman at some point in their history in the academy. All participants were actively mentoring women students formally, as academic or research advisors, and/or informally, as role models for others, including women of color. Some of the women were tenured and others were just beginning their careers in the academy. Some returned to their mathematics career pathway after a significant break in their education. This meta-matrix was not included here in order to maintain the anonymity of the participants.

The paths of the participants shared some basic similarities: all began to excel at math during their K-12 schooling, all studied math in some capacity as undergraduates (not all majored in math), all encountered challenges once in graduate school, and finally, all six of these women are now successfully navigating their careers in the academy. Their stories are told together, and all institutions were named "University of X" in order to maintain participants'

anonymity. The range of experiences was included to spark discussion about the ways institutions can support girls and women in mathematics.

Family of origin and school experiences.

Participants' family of origin varied in their connection to mathematics. Some participants had families that were not academic,

> *I never really was taught to take school very seriously, my parents didn't even check my grades or anything, so the only thing that really drove me was … once I started doing math in high school I just realized that I enjoyed it, I enjoyed the problem solving, it was fun and I was good at it.*

Others grew up with family members that were involved in math as their career or passion or had older siblings who taught them math at an early age. One parent's advocacy meant that opportunities to excel in math continued to be available to her daughter as she progressed through elementary school. In another case, a participant's mother, an academic, modeled work and earning money as the woman's role in the family. This set up her goal of pursuing a career as an academic.

> *So my dad's the one that cooks so I thought all men cook and women don't cook, women just work … men stay at home and take care of the children, women work for the money and they make all the money, and men will only work if we need more money. Woo hoo! Reverse role modeling!*

Many participants shared memories of enjoying and excelling in math as children:

> *I remember as a kid going to the store and like, a special day, our parents tell us to pick out a toy or something, and there were times when I would pick out a math book instead of a toy because I really liked working math problems. I just got a lot of joy out of that.*

In middle school, the participants continued to excel in math and gendered interactions with peers were mentioned. In one case the girls' performance in mathematics outshone the boys'. In another middle school experience, peers were aware of a participant's skill in math but the teacher, a woman, was not:

> *So Danny and I were the top two in the class and when the tests got handed back everybody would look and see which one of us got the better score. Then I got my report card and I had a C in Algebra and I knew instantly that it was wrong. I was so mad that the teacher didn't know instantly when she wrote down a C for me. I was crying and I went and asked her about it, and she had just sort of moved down a row and calculated the row below me. I even said to her, 'if it had been Danny's grade you would have known it was wrong.' So I was really mad. It was clear that my peers recognized me as being really good at this but she did not.*

Participants enjoyed the challenge of high school math. They specifically mentioned enjoying calculus and proofs, even if they were the only girl in the class, and interacting with other peers who shared their enjoyment: "*I remember thinking really, really hard about proofs and having a buddy, and once I figured it out I would call them up and I was freaking out, I figured out how to prove it!*" Several calculus teachers were mentioned. One participant admired her teacher because "*she was really good at presenting math in an interesting way. She definitely knew her stuff and was very excited about it."* Another made calculus class fun through collaboration and celebration of the elegance of mathematical thinking: "*He spent the entire class proving that* $e^{i\pi}$ *is minus one, and he took up, you know it was blackboards wrapped around the room, and he took up the whole room.*"

Participants also shared that they did not have any particular support or encouragement to pursue math beyond high school. One participant did not take math one year in high school.

> *I'm kind of shocked that they let me just not take math my junior year. It's actually kind of bad that they let me do that, I mean it worked out fine in the end but nobody blinked an eye, nobody said you really shouldn't skip a year of math.*

College.

Participants attended different kinds of institutions as undergraduates and this was reflected in their memories. Their schools ranged from women's colleges, to an engineering-focused school where most of the students were men, to urban universities. More than one participant thrived on the supportive community that her college provided. Those who attended women's colleges felt that it was a significant experience in gaining confidence.

Although all participants took enough math classes as undergraduates to be accepted in mathematics graduate school, not all were math majors. Several participants switched majors to end up in math. One participant who was not a math major described being inspired to study math in graduate school when she realized that it was a research science that continually creates knowledge.

> *When I was actually looking at PhD programs and realizing that people do research in math and create new math I was like, 'What on earth that's so crazy, that's so awesome, that's what I want to do.'*

Both men and women professors were an important influence for some participants. They shared stories of kindness, caring, patience, and guidance from professors during their college years.

I took Calculus from Dr. Darcy who was a woman, and I really, really liked her. She was tough but very kind at the same time, and really caring, I remember one time my freshman year we had 4 or 4:30 am basketball practices and I had an 8 am class, and so we would go to practice, eat breakfast and go to class, and there were several nights where I didn't go to bed until about 3 am. There was one time she was lecturing and I'm writing and then my pen falls out of my hand, I'm totally asleep in the middle of class and I had never slept through a class in my entire life, I was just totally exhausted. She pulled me aside after class, and asked if I was okay, not upset, just, 'Hey, are you okay?Is everything going okay?'... I think probably she inspired me more than anybody else to pursue [math] because I just liked her that much.

Not all math departments were supportive of women students. In the case of one participant, the department's "*not very hidden hostility*" toward women didn't keep her from becoming a very successful mathematician, but she took a break before attending graduate school.

My department was not a particularly friendly place for women ... so there was only one woman professor, and there weren't very many women graduate students, and there was just this not very hidden hostility ... at one point my undergraduate advisor said, 'Why aren't you going to graduate school in math?' and I said, 'Why should I go to graduate school in math? So you can deny me a job in six years?' and he didn't know what to say to that.

Other participants recalled a lack of guidance and information, especially regarding the transition from high school to college and for important decisions like choosing a major or deciding to go to graduate school. One participant chose to go to graduate school without

securing funding, a decision that surprised her advisors: *"They were super surprised on what I decided, and I was like, I don't know, nobody said that it wasn't a good idea … I guess I missed some of the more important bits of advice."*

Graduate students in mathematics were paid to teach or do research, and some of the participants mentioned this specifically as a factor in their decision to attend graduate school.

> *I was at University of X on scholarship so I couldn't just add a fifth year to get a bachelors in math, so I was like, I guess I'll apply for grad school.… I was looking at master's programs because that's the next degree and they were expensive, and then I found out that PhD programs pay you and it was like, great! I'm going to get a PhD in math!*

Graduate school coursework.

Participants talked about transitioning to graduate level work in terms of preparation, pedagogy, and support. One participant transitioned to graduate level courses with ease because she had enough background. Others were surprised when they found out that their peers had much more preparation for graduate level courses.

> *All of my so called peers had taken 20 to 30 math classes and I couldn't have been more shocked. It never even occurred to me to take more classes than I was required to … I could not have been more unprepared for that piece of information.*

Support from peers and faculty also affected participants. One participant felt unprepared for her graduate school courses, but the program built in peer support and that helped her get through. Another encountered instructor pedagogy that required students to work individually but did not provide them with support: "*There were times where I ended up working with somebody anyway even though it was discouraged because I was like, I'm not getting anywhere,*

I need somebody to talk to, and talking to the professors was not always productive." This participant remembered that only one of her professors had office hours. And when she did go to see him she "*was laughed out of his office*." She went on to describe an animation on his website that captured his attitude toward supporting students:

> *It's a picture of his face and there's text below that says, 'I've been told I don't offer enough positive reinforcement for my students. Click here for your positive reinforcement.' And you click and this frilly elevator music comes up in the background, and you hear his voice come in and it says, 'Good job, good job. Do you like the word great better? Great job.' And it goes on. I know actually all of it word for word because I've listened to it several times and just thought my head was going to explode I was so angry."*

It did not come as a surprise that many participants did not feel comfortable asking for help from their professors:

> *So you got the feeling that you needed to be careful how much help you tried to get and there are professors at University of X who are just jerks. One person asks a question to a jerk and that goes through the whole student body, we all know, 'oh I can't believe that happened.' So it just feeds into this idea that they're not there to support you. They're there to do their own work and they will help you because that's their job, sort of, but you don't know how much they're going to give.*

Graduate school peer interactions.

Participants shared various experiences with peer group interactions but individual interactions with men were often difficult. Some participants spoke positively about their graduate school peer groups, both in mathematics and across disciplines:

I was part of this graduate student Christian group, and there were female students in other disciplines that had more women so I was able to have more friends who were female grad students. I think that that was really positive for me. There was this one girl who was in philosophy, and philosophy is I guess very male dominated … she was a really awesome grad student in the philosophy department and she had the same experience as me being one of the few females and being better than a lot of the guys in terms of professional credentials. It was helpful to have people like that 'cause sometimes things were really hard. Grad school got really hard and discouraging and frustrating and it wasn't all like rainbows and unicorns or whatever. It's good to have people that you can talk to and people who you can relate to.

However, some peer groups were not helpful to participants:

There was a women's group that met … I didn't get along with them …. That's one of things that I've always felt, that math needs more diversity but not just demographics but also personality, because even when I was with women mathematicians, I still didn't feel like I was with people I related to."

Participants mostly shared negative experiences with individual peers, especially men, who couldn't relate to or understand them:

He initially would get really frustrated with me because I couldn't understand as quickly. It was kind of this weird relationship where I needed him because he was the only one who would help me but he would also kind of tear me down and make me feel really stupid a lot, not intentionally maybe, but he would just get really frustrated like, 'I don't understand why you can't understand this.'

One woman described interactions with well-intentioned peers who ended up "blowing [her] cover" since she explained how internalizing systems of oppression in which sexism and racism was normal:

> *I didn't know normal could be bad … I just wanted to fit in and I just wanted to be part of the normal world. So I remember an older grad student, a woman, she wanted to talk to me to help me and to be nice and to check on me, but I just felt she's checking on me because I'm a woman. And the same thing with race. I remember a black student, at the time it felt like he accosted me. He shows up with this black woman who's also in math and is like, 'Here you guys should meet.' I'm like, 'Why? Why should we meet? You don't know anything about me. You don't know anything about my personality. So it doesn't make sense to me why you would assume that we could be friends because we have similar physical attributes.' I found this really upsetting because it was again like, you are not normal, here's somebody else who is not normal, you guys should stick together…. I regret pushing those people away but at the time I was like, 'Please stop doing this to me. I'm trying to blend, you're blowing my cover.' That's how I felt. So I think there were more opportunities for support than I got because I didn't understand the extra obstacles that I was ignoring.*

Graduate school advisor.

The participants had a range of experiences with advisors, both positive and negative, and most worked with more than one advisor during graduate school. Some worked with women advisors but most did not have that option: "*I guess that's the problem, you have to have very helpful guys because there's no [women] there to help*."

Gender was a crucial factor in some of the advising relationships, both positive and negative. One woman felt that her advisor protected her from the sexism embedded in the culture of mathematics.

> *Your advisor makes all the difference in the world whether or not you will stay in graduate school. There is a lot of sexism still in math and I haven't experienced too much of it because my advisor acts as the buffer between me and the mathematical community that might actually try to harm me because I am a woman.*

Another experienced sexism directly from her advisor:

> *With my first adviser I definitely got treated differently, being a woman … one of the big things was the subtle implications that I would follow my husband around for his job and not the other way around … so he almost didn't seem to really take my career that seriously and that was very difficult because if someone's not taking your career seriously and they're your advisor, obviously, well, there's a whole bunch of implications that are bad.*

More than one participant commented that advisors were not trained to help students: "*University of X doesn't prepare their professors any more than they prepare their students.*" All participants spoke positively about their experience with the advisor with whom they completed their PhD research. One woman described her PhD adviser as someone who guided her both personally and professionally: a global mentor as defined by Dunham, Weathers, Hoo, and Heintz (2012).

> *I was at a conference and I ran into somebody that my PhD advisor had introduced me to, and she congratulated me on my post-doctoral appointment, and I was like, 'Yeah I know my advisor had a lot to do with that, and I'm really, really thankful.' And she was*

*like, 'No, she didn't have anything to do with it, you did this on your own, you should be proud of yourself,' which meant a lot to me. I don't know if I totally believed her…. I just got married last year and [my advisor] flew all the way from ***** just to come to my wedding and you know weddings you don't get to see people. I felt really bad that I couldn't spend more time with her, but that really meant a lot. She's just an amazing person, super encouraging.*

Graduate school research opportunities.

Participants spoke of various ways to enter into the research community as graduate students. The structure of one department's academic requirements prepared students to work collaboratively on research: "*We had very hard exams that you had to pass so then you would get into study groups and you would work together … so it was like a first step at having a collaborative research group*." Another department ran a fellowship that required students to be paired with a research advisor. Other students were pulled into research by professors.

The more he talked about what he was doing, the more fascinated I was … I worked with him for a summer basically just reading papers and trying to understand more of what he was doing, and he connected me with his colleague … and she connected me with a guy who wanted a math student to work on some modeling for some of the things they were doing.

Career.

The participants described a mathematician's job in the academy in three parts: conducting research, teaching, and service. Based on the interviews, tenure seemed to be primarily dependent on receiving external recognition through research that was accepted for publication and winning funding through grants. Teaching responsibilities included advising

students, and all participants engaged in service to their departments. The more established participants were actively serving their international research communities through conference organizing and refereeing of papers for journals. Some women were engaged in local community service projects or committee work for the national professional organizations.

Participants sought out opportunities to focus on research through introductions facilitated by advisors and through conversations at conferences. More than one worried about her lack of new results because "*as a young academic you have to publish or at least have a new project to talk about, I have nothing new to talk about*." Participants also spoke of setting up periodic meetings with colleagues to ensure that they engaged in research. One woman wondered if working in a small department that was geographically isolated from other mathematicians in her field was hurting her career.

All of the participants were involved with teaching and both formal and informal advising. Several of the participants spoke extensively about teaching. One felt that it was very important to be accessible to students, even at the expense of her research time:

> *I have a lot of students that come and visit me during office hours, or I just tell them whenever my door is open, which is maybe not great. I think I should change it next semester because I will have, depending on what's going on, students all day long…. I like having the open door so that they can just know, whenever, just come see me, but it means that I don't get that much research done most of the time.*

Collaboration when teaching courses served more than one purpose. For one participant, regular meetings to plan for teaching a common course became a safe space to share her frustrations and get advice. Another participant applied for and won a grant that taught her how to mentor groups of students during the school year.

Participants did a variety of service for their department and research communities. One woman worked to organize events on campus with undergraduate majors. Another woman was involved in interdisciplinary curriculum development in response to a need identified by national organizations and industry. One participant spoke about offering a specific service to her department:

> *They actually had sort of an agreement in principle from the chancellor at the time that they could hire people who had … an interest in working with the College of Education doing classes for teachers, doing outreach stuff…. It's like my niche in the department.*

Examples of service also included political activism through math outreach projects for girls and women from indigenous and low-income communities.

Unfortunately, a description of the participant's experiences would not be complete without the many examples of sexism and racism they encountered.

Sexism and racism.

Participants shared many instances of sexism and racism from professors, peers, and students that seemed to be tolerated by the culture of the department. One participant spoke of being publicly shamed in a college math class, another believed that a male colleague attempted to take credit for her work and that her concern about this behavior was ignored by more senior colleagues. In another instance, a participant was invited to speak at an event but her invitation was sent to a male colleague rather than directly to her. When another participant was an invited speaker at an event, she was not recognized as a conference attendee; the assumption was that she was the guest of a man or one of the women helping at the registration table. One participant shared her astonishment about a colleague's inappropriate comments after she wrote a student by writing a letter of recommendation:

One of the professors said something along the lines of, 'Do you think she'll get it because she's a black female?' And I was like, 'I don't even know how to answer this question. She's a really good candidate, and I don't think this even should be coming up, and if that played a role in their decision it shouldn't even be brought up because she has so many disadvantages against her that if she happens to get a slight edge for being a black female once in her life, then get over it, and don't even mention it.'

For one participant, instances of microaggressions – small, seemingly insignificant incidents – became significant because there were so many of them.

There's just all these little things, like people commenting on what I should be dressing. I had to change some of my wardrobe because I'm a woman, whereas if I were a man I would never have been asked any of these things…. It's very subtle…. I guess the difference between being a woman or being a person of color in these environments, is you're always wondering. When someone is doing something, are they doing it just because they're a jerk or are they doing it because you're a woman or because you're a person of color? And this will always cross your mind, no matter what, and it kind of matters which of these things it is because if it's a jerk, I can dismiss him, if it's actual, systemic racism and sexism, we need to address this and fix this, because it will bleed to everyone else.

Another participation identified sexism in the structure of academia since the tenure timeline coincided with a woman's opportunity to have children. She also noticed that when a woman's partner was also an academic, the woman's career was the one that is compromised, even if she was the "*hot property*." Another participant commented on male faculty marrying

former students or post-doctoral appointees. She also noticed that wives of academics seemed to be systematically hired into non-faculty positions:

> *Right now a lot of the spouses don't have faculty positions…. I'm just trying to think about the last time I was like, oh fucking men, you know, and we were talking about these specialist positions, and the only examples that anyone could think of were wives … it was just like, this is a special category for wives. I know all of them make sense in the particulars … but also I sort of disagree. In some of these cases she should just be a faculty member…. I was like, this is crazy, how did this happen? And no one reacts to it.*

The participants recognized that students and colleagues treated them differently by because of their gender. One participant wasn't given a raise because the department personnel committee didn't think she would leave the institution; they gave the raise to a male colleague who had an earlier PhD date but fewer qualifications. Because math departments offer courses that are required by other departments, for example, engineering, some participants taught many more men than women. One participant commented, "*it's very easy for me to show cleavage so I have to be very careful when selecting clothes for that reason. I'm mostly teaching 18-year-old guys.*" Participants also needed to dress more formally when teaching in order to be recognized as the instructor instead of a student:

> *The first day of class, I would try to dress formally just so that people would recognize me…. I need to look the part a little more. The other math professor has a beard and stuff, and obviously, you look at him and you don't have questions about whether he's a math professor.*

Another reported a common pattern for engineering students treating women professors differently:

One of the most obvious ways that we are treated differently is, a lot of the male engineering students will address their male professors as Dr. so and so, and they will address their female professors as Ms. so and so…that's just their default, so until they're told, and even when they're told, they will still sometimes say that…. If I ever had an issue with a student it's been a male engineering student.

Gendered expectations for a department's dress code were another example where women were treated differently:

All of the men in my department wear jeans almost every day, and tennis shoes, or some sort of rugged shoe, and one day this guy, he used to work at the university, he showed up in the hallway one day and looked at me, and I was wearing jeans and probably like a button up shirt or something, he was like, 'They let you wear that here?' He was joking, but at the same time I knew that he wasn't completely joking, but I looked at him and he's wearing a sweatsuit, like sweatpants and a sweatshirt, and I'm like, 'Who are you to talk? You're wearing sweatpants!' [laughter] … I do worry if faculty in other departments look at me and think that I need to be dressing up more.

One person shared that she had positive experiences because of her gender, "*I think that there's been a lot of situations where I stuck out because I am a woman, in a good way … I've never really felt that someone was really putting me down because I'm a woman*." However, several participants commented about gendered division of labor in their departments; the few women were disproportionately asked to do tasks that were not helpful for their careers:

We had a faculty meeting recently and our dean had said he was going to order food and have brunch for us because it was like, 8 am, that the meeting started. And then he mentioned to me, 'Oh I'm not going to do brunch, and there won't be brunch unless

someone organizes it,' so, kind of meant, you organize it. So I organized brunch by emailing people and saying, 'Hey we're going to do a potluck, let me know if you're going to bring something,' and I get emails back only from female members and none from any of the guys. I was so mad, so I went around and bugged several of the guys and a few of them brought stuff ... that's a thing that happens.

The participants were aware that things were worse for the previous generations of women mathematicians but that similar dynamics were still in place.

She told me how things were, I want to say in the 70s, and there were fewer women then so it was much worse, much more isolating, but at the same time the dynamics are still there because there are more women now but we still don't own things, we don't have power over things. So it's like you have more friends, I guess if you get along with the other few women, but the dynamics are still the same."

However, more than one participant stated that she would rather spend her time thinking about math instead of issues of racism and sexism within her department:

If it was uncomfortable that people thought I didn't belong there, that's their opinion and maybe I don't ... that's their opinion and maybe their opinion is right because I look around and I don't see anyone like me. And so there's a lot of internal crises going on that cost you a lot of energy and effort when, instead of focusing on math, you're focusing on, 'Should I be even focusing on this math? Is it even worth it?'

Other participants were negatively affected by sexism in the community:

Yesterday, since I'm at this conference, I was walking down the street talking to a really awesome professor who I was very excited about chatting with. I was walking towards his hotel and a car drove by and some guys decided to try to get my attention out the

window of their car, and that was annoying and I was like, 'What is this? What kind of impact is something like that having?' because I was having a good discussion with this guy. I wonder how that influences someone's image of me, and maybe I spend more time worrying about how people perceive me as a woman when something like that happens than I need to, but the whole thing was just a distraction and unfortunate because I think it took away from my conversation.

One participant shared that male peers complained about unfair treatment because she received an occasional free lunch from the department for a women's event and won a competitive grant to attend a conference:

They weren't like bad people, they weren't trying to be mean or destructive, but they were being mean or destructive regardless of their intentions, and I just found that frustrating…. I would have gladly handed over my free lunches to them if I could've never heard all these stupid comments about, oh, you only got this because you're a female, or, oh you have an advantage because you're a female.

This illustrated the important fact that even if there was no harm intended, sexism affected the participants negatively. As with experiences of racism, more than one participant acknowledged that their peers and professors did not intend to hurt. However, one participant was clear that intentions didn't matter; what mattered was the outcome and it was not her responsibility to decipher intention.

Persistence

Participants did not speak as frequently about academic persistence compared to the theme of belonging even though it would have been impossible for any of them to succeed without it. For example, one participant explained how she persisted as an undergraduate:

I had a very hard time learning some of the mathematics so I would just be in there asking the same question every day … one professor had me three years in a row and he's just like, 'You still don't know what this is?' I'm like, 'No. I still don't know. Please explain again.' So he was very patient in explaining … until I could really lock in.

Although most participants discussed academic persistence in the context of graduate school, some talked about persistence in grade school, when choosing an adviser, and when looking for a job. More than one participant talked about how her academic persistence did not seem to produce academic success in learning mathematics. Duckworth's (2016) model of academic persistence proposed that practice leads to improvement of skill. One participant enjoyed this process, "*if you're good at it you like it more*," and identified a positive feedback loop for her persistence, "*the more I learned the more I wanted to stay with it*." She was willing to work hard to succeed: "*I was very competitive and I liked being the best in the class so I did the extra work needed to be good*." Another participant took challenging courses at another university as an undergraduate and felt that it was a good experience even though she didn't earn high grades:

I took some math courses that were way above anything that I ever took, and it was really hard but it was good. I got a C which in my mind it was not so bad, but now I know that getting a C in a grad course is, they failed me basically … looking back I must have been really terrible, so it was good.

Participants also discussed supports that helped them persist. More than one person described the importance of financial support while working towards her goals:

I think grad school was definitely way more challenging than anything I've ever done, and there were many times when I wanted to quit. I think the first semester I cried every

day, and I was not someone who cried ever, so there were a lot of growing pains for several years. But I think for me the fact that they were paying for my education, and that I knew eventually it would get me to where I thought I wanted to be – that kind of kept me motivated.

Another participant mentioned the importance of financial support but also relied on the idea that the faculty at her selective university believed in her ability to succeed:

When [grad school] got really I hard I'd be like, I'm just going to keep going because the faculty, they've done this a million times and they know what they're doing and they thought I was good enough, so I'm just going to believe I'm good enough because they do…. So I remember my first year, you didn't have to teach your first year, and every two weeks they'd give me a check and I'd be like, 'Holy crap I'm getting paid for this, this is amazing, I'm just sitting around doing math, I'm going to class and doing math, that's all I'm doing and you guys are paying me.'

The participants' academic persistence in graduate school manifested itself through intrinsic motivation (drive), even without a supportive advisor, "*I'm like some weird Energizer bunny. I'm like, math, math, keep going.*" Others persisted through self-discipline:

I had a very strict schedule: I would wake up at 6 am without an alarm, I would go to the gym, I would come home take a shower, I'd get dressed, and I would go to this cafe on campus and I would work there from like 10 am to, not midnight, I don't know, 10 am to like 10 or 11 pm, I'd go home, I'd sleep from midnight to 6. I had the books I needed to read for my generals written out by page number. I had it divided in my calendar how many pages do I have to read if I'm going to finish, because I wanted to take my generals

for the first time at the end of that first semester because you only have two chances and you have to finish by the end of your second year;

hard work: "*I was the only American student who actually finished the program, not because I was the brightest, because I was the one who was the most stubborn;"* and confidence:

One of the hardest parts about math is you're going to fail and you're going to be stuck for a long time. You really have to keep working and you have to have a lot of confidence to keep working at it.

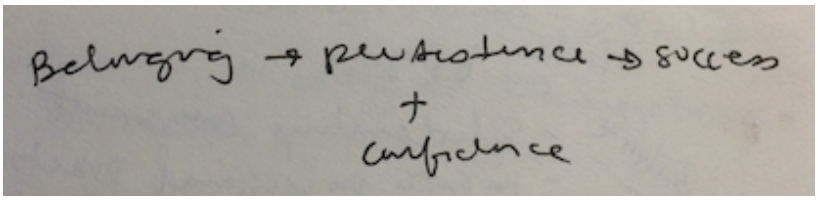
Participants also identified hard work (academic persistence) and confidence as pathways to success. One participant shared that confidence was important for women in math because it seemed that persistence alone was not enough to be successful. She remarked that being considered *smart* was more about a person's confidence in their abilities rather than their talent, and that women needed to learn how to be more confident to be successful.

"It seems like you're successful in math if you're smart, and so there isn't this idea that you can work hard and be successful… if you're not successful you get the idea that you're not smart. So I think that what's really hard for women in math is that they're not super confident, and then the idea is if you don't get it, it's just that you're not smart. Whereas I think that guys are very confident about it. So even if they don't know it they're just like, 'Yeah, whatever, I could figure it out.'

As confidence was not included in previous models that described a causal relationship in which belonging led to persistence (Herzig, 2004a, 2006; Osterman, 2000), I propose Figure 2 as a model for success based on an interrelationship between belonging and persistence with confidence as a central factor. An important implication of this more complicated definition of

success is that persistence sometimes leads to belonging since the drive, self-motivation and hard work described by the participants eventually led them to success as mathematicians.

Figure 2: Success Model: Interrelationship of Persistence, Confidence and Belonging



The next section discusses the participants' experiences of belonging.

Belonging

Belonging was the main theme that emerged from the data. In addition to the belonging mindset definition, "I belong in this academic community," proposed by Farrington et al. (2012, p. 10), two belonging frameworks were considered to guide this analysis. Osterman (2000) describes belonging in K-12 school that is not specific to mathematics. Herzig (2006) assumes that women who choose to enter graduate school felt belonging in mathematics as undergraduates; in graduate school, women had to figure out how to belong (again) in two communities, social and academic.

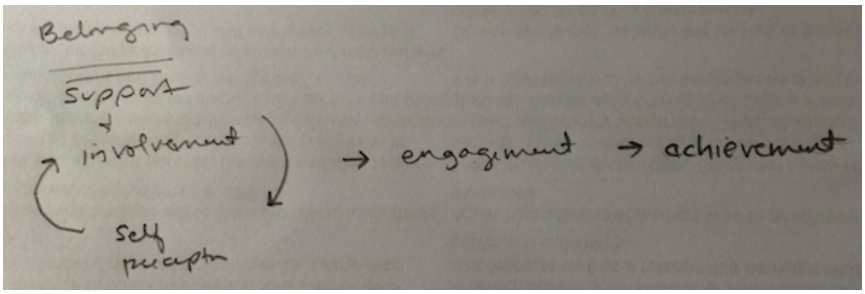
These frameworks were confirmed by examples of belonging that led to persistence and therefore success. Participants' experiences also suggested that persistence leads to belonging through building collaboration and relationships (caring belonging), belonging on her terms, and belonging through agency.

Osterman's belonging: K-12 students.

Osterman's (2000) belonging for students in K-12 school begins with a feedback loop of support and involvement by teachers, which positively affects a students' perception of being

good at math. This feedback loop leads to student engagement, which is then positively correlated to student achievement. Figure 3 is my diagram of this framework.

Figure 3: Diagram of Belonging Based on Osterman (2000)



Several of the participants received recognition for their skill in math as young as elementary school, for example, by being selected for accelerated instruction. This was an example of support by the school that led to further involvement of the student and a change in her self-perception. Several quotes linked external recognition by the school with participant self-perception in elementary school, high school, and college:

> *They do these math groups like the bluebirds and the ravens or whatever they are, and I was always my own group … and people would look at my math book and be like what is that anyway, but I kind of felt special, I was okay with it.*

Another participant questioned whether thinking that she loved math was linked to the external praise that she received for being good at it:

> *"I liked math as a kid. I was told I was good at math like my whole childhood, so math was kind of something that was, I don't want to say imposed on me, but it's really hard for me to separate out an internal desire to do math from all the external applause that I got. And sometimes I wonder if people weren't so math phobic, would I have thought I loved math just because I was good at it.*

Osterman's (2000) belonging also seems to apply to college because engagement occurred when a participant interacted with a supportive professor who eventually encouraged her to major in math:

> *So it was this huge lecture class, like 400 people, and he said, 'I want to see the following people after class,' and he read a list of names and there were maybe six or seven of us. He said, 'I know you guys are bored, you know all of this, you did way too well on the exam because it wasn't an easy exam.' So he started scheduling us as a study group. He had us all go get a more advanced calculus book and we met with him every week and went through problems in this calculus book. And he was the one who said, 'Keep taking math.' It was in one of those study groups where he said, 'What are you taking next?' and I said, 'I'm done', and he said, 'No you're not.'*

Similarly, engagement in mathematics occurred for this participant because she felt comfortable interacting with her peers while attending a women's college:

> *When you're at a women's college, everyone around you is a woman, so everyone and every role in the society is filled by women, all your leadership roles, your class clown, the brilliant student, the dumb student, everyone is a woman, and that's kind of amazing. And then you're going to your math courses and everyone is a woman, like of course women can do mathematics 'cause we're all there.*

Lack of interaction with faculty led to disengagement with math for this participant:

> *So I didn't do so well in that class and I remember thinking, 'I'm just going to deal with this at the final,' and I spent two days before the final trying to learn all of [the] math at once and it didn't work out. I was like, 'I guess I'm not good at math anymore,' that's the thought that actually ran through my head. And because I was a first year I hadn't*

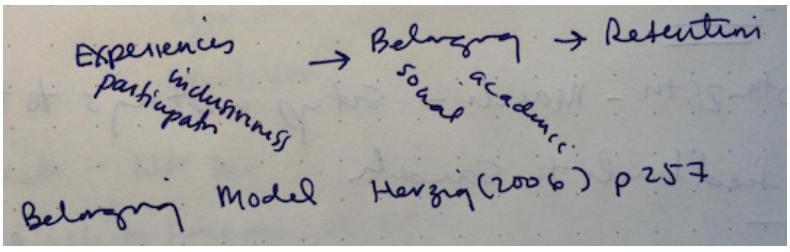
declared math so I didn't have to tell anyone, nobody was checking on me, so I just never declared math.

Belonging in Herzig's (2006) study of women graduate students in mathematics is described in the next section.

Herzig's belonging: Women graduate students in mathematics.

Herzig's (2006) study recognized that although women graduate students previously experienced belonging in mathematics as undergraduates, they needed to negotiate belonging again both socially and academically. Furthermore, because of the typical structure of a PhD program in mathematics, women students needed to find academic belonging while taking course work, and then, after passing the general exams, they needed academic belonging in the research community. Herzig's (2006) belonging in graduate school focused on the importance of experiences that increased student participation and inclusion, which then led to social and academic belonging. Belonging led to retention (persistence). In Figure 4, I diagram my understanding of Herzig's belonging for women graduate students in mathematics.

Figure 4: Diagram of Belonging Based on Herzig (2006)



In terms of Herzig's (2006) framework for creating academic belonging during course work, one participant's experience stood out. She entered graduate school less prepared than her peers, but the structure of the program required students to study together to pass their exams. This was an example of participation and inclusiveness that created academic belonging:

Their first couple years are really broad so you take a lot of core courses, you have to take a lot of exams. At that time there was a reasonable number of women…so initially there was probably six or seven of us, but also men in the study groups and it was a really tight knit group, and you were studying really hard. And I think that made a big difference. For me it was a little bit tough because I wasn't ready the way a lot of people were, like I don't feel like I had taken enough courses to prepare me, but I just jumped into it and so it worked out in the end.

Other women described experiences with peers or professors in their departments where they were able to interact in the research community as young graduate students and then belong to the research community as contributing members.

I don't know if this is just the kind of math I do, but I feel like people are just, they're really great – there's a lot of people who are willing to talk to you – and really helpful. And even the really awesome professors who are well known tend to be very, I don't know, humble, easy to talk to, willing to give you advice. And I think that definitely influences me, like having received so much, so many people helping me and reaching out to me, that it definitely influences me to want to help other people, and help keep the community strong and a positive experience for people.

Both examples align with Herzig's (2006) framework for academic belonging in research for women graduate students in mathematics.

In terms of social belonging for women graduate students in mathematics, interactions with peers, faculty and department all affected participants' sense of belonging to the social communities. While some participants were explicit in talking about this positively, "*I had this*

an amazing collection of friends in my graduate program that are still among my best friends," others had negative experiences, "*the professor that I couldn't understand and he clicked on the board a lot, I would go to his office a few times, but there were times I was just so nervous and so insecure, there were times if his door was closed I would leave, I wouldn't even knock because I didn't want to disturb him.*" Yet all persisted to earn PhD degrees. This raised the question if the social belonging aspect of Herzig's (2006) framework is supported by data from this research project.

Persist to Belong

Some women persisted in order to belong and succeed as mathematicians. Some did this despite unwritten, unspoken cultural norms in their math departments to which they did not have access. Others found caring belonging by seeking out collaboration with colleagues and relationships. Gaining confidence and seeking balance developed belonging on the participants' own terms. Belonging also happened as a result of their agency when they acted in ways to create space in the culture for themselves and other women.

Not belonging: Overcoming department culture and communication.

Some participants felt that they did not belong in mathematics. One reason was that communication within some departments felt dysfunctional because of unwritten and unspoken cultural norms. These norms seemed to operate around student performance and support (talking about students, allowing for special rules, providing help), and gender roles. For some participants these norms caused them to feel unsafe in their departments.

Some norms existed around student performance. One participant was recognized for her academic progress by a professor she didn't know; she was surprised to learn that the professors in her graduate program were familiar with her and her work:

I remember at some point in my first year, one of the professors that I didn't know, I mean I knew who he was but I had never had a class with him or had a conversation with him or anything, he stopped me in the hall and he said, 'I hear you're doing really well in your classes, I'm so pleased,' and he just sort of gave me a pat on the back and walked away. I was like, okay, so he knows who I am, so that's weird first of all, because the University of X professors didn't know who I was when I was in their class, and he just stopped to give me words of encouragement for no reason. And also I was like, 'Wait they're talking about me? They care how I'm doing and they're talking about it?'

Another participant's department allowed and even expected students to ask for different rules. For example, one participant didn't know that she could have more time to pass her general examinations if she asked for it; not having that information severely impacted her health due to stress. Another unwritten norm had to do with the assumption that it was okay to not know the details as long as you didn't admit it by asking for help. This left one participant feeling frustrated and wondering if her department valued communication at all.

I would ask them why something and they would give me some answer full of attitude, and I would ask them, 'Wait, but why?' It took me a while to realize that they didn't know, they didn't know the details, they knew it was true, they knew that they were right … they were minimizing any gap in their knowledge, and well, they would sound important.

Others commented on the norm of blatant sexism regarding women's roles and abilities: "*The female students were treated differently, not necessarily intentionally, but I think there was a perception that we just weren't as good*." At a university that actively recruited women

students, one professor made the assumption that a prospective woman student would be recognized for her teaching instead of her research[5]:

> *There was a grad student lounge and there are two plaques for the grad student awards, the research award and the teaching award, and [the director of grad studies] took her in there and he pointed to the teaching award and he said, your name could be on this one day. She was so pissed off but he thought he was being really nice…. My friend and I ended up graduating at the same time, and she won the teaching award but I actually got the research award. I'm pretty sure she was genuine when she said, 'I was way more excited that you got the research award than I got the teaching award because I just wanted to look in his face and be like See! See!' So it was pretty funny.*

Sexist gender roles extended from cooking for potlucks to being asked to host prospective students, all of which detracted from participants' research time and focus:

> *If we had some sort of departmental party or get together they'd be like, bring a dessert, and a lot of the guys would come and be like, my girlfriend made this, and I would come and be like, I made this, 'cause it's my event, … there's also those kinds of expectations and it gets frustrating that people feel the need to brag about things, like, oh my girlfriend made this, my girlfriend packed me lunch, my wife is at home cleaning so I came here so I didn't have to clean, and now I'm going to get more work done, so there's a lot of weird expectations about household kind of duties that get rubbed in your face too often and makes you feel like you're never going to be able to work as efficiently as a lot of the guys.*

[5] I encountered this same assumption when I was defending my MA project!

One woman felt silenced by the department culture which labeled speaking up about sexism as being "*whiny*":

> *Whenever you complain about something like this, you're frowned upon, like you're just being whiny and people will say, 'Just drop it and stop making such a big deal about it.' But it is a big deal because you add up the number of hours I've lost over just being asked to do things because I'm a girl, it really adds up.*

Another participant clearly articulated how gender and race enter into communication:

> *"I think people think that math is so pure and mathematicians are so logical, and I think that they might be even more hesitant to think about these issues because, what does race and gender have to do with math? We're just talking about abstract concepts ...* [But] if I have to learn via talking to people then I have to communicate with people and at that point sometimes race and gender do come in *[emphasis added]*. *Sometimes we can't communicate across these divides because you don't stick to math. You make some joke that's really offensive, or there are hierarchies, not everything is valued. When only a certain group of people get to decide what's valuable and what's not there, that's part of their identity, they just don't see it, it's only the white men who think you can leave your identity behind, and meanwhile it's the white men who bring your identity back in.*

This created an environment where she felt unsafe. Another participant described the extreme discomfort of her first year:

> *So my first year, I realized that I needed a lot of help but ... it wasn't a very friendly atmosphere for someone who was struggling. And again, I don't think it was necessarily malicious. I think they just didn't really understand how to help students, and maybe some of them thought they were helping, but didn't really. I was constantly intimidated*

and part of that's probably just my personality but I think part of it was also the culture in the department.

For one participant the role of her advisor was another unwritten, unspoken norm:

Where I went to school there wasn't a support system, they didn't tell you what your advisor was there for, it wasn't a safe environment to not know anything…. If you didn't already feel comfortable, nothing about the situation was going to make you feel more comfortable.

Even though some participants felt that they did not belong in their departments, all persisted and completed PhD degrees. The next sections describe ways that they came to belong.

Caring belonging.

Noddings' (1984) definition of caring requires action from the one-caring and the cared-for. I suggest that this describes the relationships that were cultivated by the participants. Developing caring relationships with colleagues, students and mentors established participants firmly within the academic communities of their professional practice.

Collaboration with colleagues on research was described as more of the norm compared to the idea of the genius mathematician working in isolation:

The number of authors or the lack of their being as many authors doesn't reflect accurately the collaboration 'cause there's lots of collaboration that still goes on, like giving a talk at a conference and getting feedback from other people. I was talking to a guy today about something I was trying to do and he was like, 'Oh why don't you just try this method?' ... I think it's quite collaborative in the sense that you would rarely publish a paper without having talked it over with some other people.

Furthermore, the genius stereotype was described as being gendered. Women were not even allowed within the description of a genius:

> *Math has a genius problem, and you know geniuses were always men. I forget the history of it but the idea of genius is very gendered and very problematic. They talk about Noether who, she was clearly a genius and it was kind of confusing, what do you call a woman genius? And descriptions of her always point out her size and try to portray her more as masculine.*

Caring came with a cost for some participants. One expressed that the culture of the academy values research results at the expense of caring about people – both current and future mathematicians – because expository work that helped to explain new results was not valued by the academy:

> *There's no incentive for doing work that is helpful, there's only incentive for pushing new results ... I don't know who's the overlord of academia but between journals and actual prestigious departments there's just no reward for caring about people.*

However, most participants felt cared for by their departments, "*I think everyone wants me to succeed and if I ask for it, they would help me*," or were supported by women who were senior faculty:

> *So when I came in to the department there was one other woman ... she's awesome, and she has been super. So the same way that I try to help the people behind me, she's been doing that for me all along. She's definitely been super supportive of me and really encouraging, and really, any time I needed anything, she was there before I knew I needed it.*

Participants felt supported by other faculty in their universities; in one example a faculty group was organized with the goal of increasing diversity. Other participants were supported by national organizations. For example, a participant describes her experience at a conference organized to promote diversity in STEM: "*You get to see new mathematics that are happening and the people who are presenting are people of color … and so you get a chance to talk to them, and maybe make collaborations, if not, you get to network*."

Teaching was another area where participants built caring relationships with colleagues and students. One participant felt strongly that caring was a core value for her current department:

> *I think everybody in my department really cares about students. We definitely have different personalities and different ways of expressing that care. I think some of it comes across as kindness or gentleness, some of it comes across as sarcasm or, being really firm, but I think each of my colleagues really cares about the students, and cares about their learning, and is trying to help them, in whatever way they see as best. That's not something that I saw in grad school… I'm really happy to be in a place where people do care about one another.*

Another participant felt that creating an inclusive environment in her classroom was necessary for her to care for all of her students. In one story, she had support from her department to make the decision to cancel class for a sit-in:

> *You don't want your students feeling like they do not belong in your classroom, and I have definitely had students that feel that way about the campus…. So we had a sit-in in support of Black Lives Matter, and it was going to be happening over my Calculus 2 courses, both of them, and so… I cancelled classes for them so they didn't feel like they*

had to choose between their education and what they felt was intrinsically right…. I did get an email from one of my students thanking me and she was just like, 'I felt like I wasn't wanted on this campus since I came here, and this was a big deal for me.'

Mentoring relationships were very important to participants. One participant mentioned a previous employer who encouraged her to earn her PhD, others mentioned graduate school and post-doctoral research advisors. Many relationships with mentors continued beyond graduation:

He actually visited me here in January and we spent a week doing math together and we're planning a conference together that's going to be held next month…. We're working on a project together so he probably emails me three or four times a week, and I email back one time, because compared to him, I'm very, very slow…. And now I've had two students of my own and he's also been really helpful and wonderful to them, they're like his grand-students.

Belonging on her terms.

Perhaps because of the importance placed on external recognition through research and publishing by the academy, each participant's confidence and intrinsic motivation was crucial to her success; each found ways to belong on her own terms. For some this meant being confident that her beliefs would carry her through difficult situations. For others it meant finding a balance between personal and professional lives. All participants were very specific about their focus on mathematics and how they viewed their careers.

Confidence.

Some of these incredibly accomplished women mentioned luck when they talked about their success: "*I'm happy I'm here, everything worked out really nicely … it was just super clear, I've lucked out in each thing, just sort of transitioning nicely, didn't have to think too much, just*

go." For one participant, her good fortune created a sense of obligation to leverage her growing influence towards increased equity in her field:

> *I'm very aware of ways in which I've been lucky.… I feel like it's kind of a responsibility to be aware of the fact that I started the race way ahead, so to be very conscious of that and then to sort of work for more equity and help other people. And I think it's really clear every time I move into a better position, I try to think about, what does this allow me to do now?*

One participant credited her beliefs with having confidence in herself in spite of inequity:

> *I have ideals of maybe how the world should be and how it's supposed to be, how God would want things to be. And somehow having those ideals and just being able to not hold on too tightly that I'm treated unfairly, it's definitely important to me … I'm able to minimize it more and have confidence in myself and say, 'You know what? Even if silly social constructs which are not perfect are causing these issues, I'm still good, I'm still special,' and … just let go of the fact that our world is imperfect is going to hurt certain parts of my career.*

Another participant mentioned learning about the systemic difficulty of being a person of color in the academy and how that tied into her student evaluations. She was confident enough to push back against systemic racism:

> *I learned about this from some other women faculty of color at University of X…. So they're having trouble getting tenure because their student evaluations are really poor, and it turns out that there's research*[6]*…. If you're a faculty of color and you're perceived*

[6] This participant is referring to Reid (2010), "The Role of Perceived Race and Gender in the Evaluation of College Teaching on RateMyProfessors.com." Other recent studies on bias are

as strict, you are going to get really bad student reviews, because you're strict. Meanwhile if you're not a faculty of color, and you're strict, they're going to be like, 'Oh you're great!' And so in order to get just okay reviews, or just the normal, average reviews, you have to be perceived as lenient as a faculty of color…. My reviews are really bad, and part of that is I'm a new professor … I understand there's a lot of improvement I can do, but part of it, I can't help but seeing my reviews wondering, 'Okay, are they really judging me because of my skill in teaching? Or are they judging me because of the color of my skin?'

Intrinsic motivation: career focus and goals.

Participants shared how their career focus and goals fit into the math community and also commented on the role of luck, the option of taking another kind of job, or writing a book if an academic career did not work out. Participants realized that external recognition would not affect their identities as mathematicians. This reflected both confidence in their abilities and an understanding that their pathway and success depended on external factors beyond their control:

Even when I went to graduate school I wasn't totally convinced I would become a mathematician. I just wanted to go do that thing I wanted to do when I was a kid, prove some theorems, figure out something nobody ever knew before, be a scientist and then I would figure it out after that. And it turned out that I really, really liked teaching at the college level and I liked the balance of doing research and teaching college students that an academic career provides. I mean I got lucky that I got a job. I would have been very

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Boring, Ottoboni, and Stark (2016), "Student Evaluations of Teaching (Mostly) Do Not Measure Teaching Effectiveness," and Savonick and Davidson (2017) "Gender Bias in Academe: An Annotated Bibliography of Important Recent Studies."

happy if I didn't get an academic job, I would have gone into something else and I would have been fine.

Others were focused on research:

My primary interest is to do math and I also think that is valuable for the community as a whole…. I feel like I'm excited about research and by being a woman doing research I'm thinking and hoping that makes a difference, just my presence.

Some participants talked about teaching being their primary goal:

I had never wanted to be a top-notch researcher, that's never been something that I've strived for, but I did want to be a good mentor to students. I knew that having some sort of research experience at the undergraduate level was something that would take them far in their careers regardless of what they did, but especially if they were interested in graduate school. And so I really wanted to be able to give them a rich research experience.

More than one participant connected her work to political activism:

I would definitely call myself a feminist. I would definitely say that I'm still very liberal and I have these same political views…. For me, being here, what I've been really interested in trying to do is more locally-based…. What I hope my activism will look like here is to work more with indigenous communities and local communities and get more of these types of people through STEM, because this what I know the most … I'm good at math, I like doing math, this is my field. Okay, then how do I bring the politics into that? how do I … help but also collaborate and learn more about where I'm living and what are the issues that are important? and then try to sort of work, develop something around that.

Balance.

Some participants talked about having control over their work setting as an important aspect of their career since it led to greater productivity. One had a department chair tell her to find time for her research every day and to choose a hobby, *"So I appreciate this coming from a senior mathematician woman…. That's permission for me to do things for myself. And so I do a lot … anything to keep my sanity and to escape for a little bit. And it helps if you take breaks from doing mathematics, then your brain figures out mathematics while you're not looking."*

One participant talked about the process of balancing research and teaching during grad school; as a professor she chose a less stressful career path with lower pay:

> *I wouldn't mind getting paid what R1 research professors get paid [laughter] … but the pressure of writing grants and knowing that the ability to get funded in writing a grant, would heavily weigh upon my ability to get tenure or to keep my job, I don't care for that stress. So I think the trade-off is my job is a little bit less stressful and a little bit lower paid but that's okay with me. I would rather be able to have a less stressful life than more money, which isn't really going to bring me any more happiness anyway.*

Another participant found that tenure allowed her to choose her workload according to her interests and, "*you get to be self-directed in a way that you can't be at really any other job, so it's easier to find the balance when you're the person who gets to make the choices*." Another participant spoke about ending her workday at 5:30 pm each day even though that went against an academic stereotype:

> *Maybe it's a wrong perception, but I have this perception that these really well known mathematicians, it seems like they just spend so much of their time doing math, they work*

on weekends and they work in the evenings and I don't do those things. So maybe, it is possible I'll always feel a little bit like an outlier 'cause in some sense I am, in the fact that I don't work as many hours as others and I refuse to.

One participant hoped to become a parent and was concerned that she still brought work home. Another participant who was a parent talked about the difficulty balancing care for her children and her research. At her second interview, she and her husband had full-time childcare set up so that she could focus on her career. However, she later emailed with an update that their childcare plan had not worked out and she was setting aside her grant applications and research to make new arrangements:

*Securing childcare has been soooo awful…. Apparently this is just a thing, it's not personal even though it feels so personal and I feel so stuck in my situation and it feels so much like the universe saying I was foolish to try to have anything for myself... *sigh*

Belonging through agency.

Participants developed belonging through taking action in ways that created space for them as women and for other women and people of color. One participant was appreciative of this research project because it meant that women mathematician's stories would be documented and heard:

I really appreciate that you're doing this research by the way, I just want you to know that…. It's true that women get marginalized, it happens, and I think putting, like actually collecting some data in a really thorough, methodical way is awesome. It gives us something to point to.

Another participant was active in a network of women set up to counter the old boys network that dominated research prizes and grant funding:

I think I wrote to you about these research collaboration conferences. So one of the founders, her philosophy is very explicitly, screw your old boys network and trying to break in, we're going to make our old girls network and we're going to support each other and advocate for each other. And so we really explicitly do stuff like when there is a prize that's accepting nominations, we'll email out to the list and say 'nominate a woman,' because you see a lot of these prizes that they go to men always, and the woman always gets the service prize or the education prize, and the men get the research prize. So we really explicitly are like, nominate each other for this, build each other up, and it really changes things to sort of support each other in that way.

She also talked about making the invisible visible – exposing the unwritten rules and processes that women typically don't know and therefore can't navigate:

This is making the invisible stuff visible, people saying, let's talk about how hiring really works. Because until you're on a hiring committee, which you aren't until you're quite senior, you don't really realize what people care about, like what those conversations are. And those conversations are weird, they're not about the math the person does, they're all about the letters, that's all they talk about. 'This famous person said this thing, but this famous person said this thing. What famous person are we more impressed by and which phrase do we care [about]?' I mean it's all very strange. So the fact that I'm part of a community that's like, 'Let me tell you how it works,' and then you can game the system a little bit if you are given that kind of insight or knowledge. Whereas like the guys, they don't need it, right? 'Cause they're already brought along in the stream.

Another participant's department had a strict, formal dress code for women but she decided to dress more informally since that helped her connect with her students:

> *I remember one year when I was still dressing up every day, I had a review session at the end of the semester, and since it was on a Sunday evening I was like, I'm not going to dress up, I'm going to wear a t-shirt and jeans, and it's going to be fine. And when I showed up, I felt like the students were interacting with me differently, and in a positive way…. I don't know if it was because I was more comfortable, or if they were viewing me a little bit differently, but I liked it. So that was really what started causing me to intentionally not dress up quite as much.*

Other participants were clear that agency meant being present as women in the field: "*one of my themes is just to be completely selfish, that like when you're marginalized being selfish can be revolutionary because you're not supposed to value yourself.*" Another commented "*so in this committee for example, I really didn't do anything to bring up that you should have women, but just by being there, maybe I brought up some women, and I would point at women, like the guys would get it*."

Some women were aware of needing to speak out on behalf of other women in their department:

> *Sometimes women who are really vocal and very aggressive are pushed back against more than a guy who would be equally vocal and cranky… so it's important to back up other women. If it's just one voice then it's easier to have a real big pushback, versus if there's a couple of you and you can take the same stand, or similar stands, or sort of say, 'No, this isn't just one person being crazy, this is something that you should deal with,' it's much more helpful.*

One participant's anger at explicit racism empowered her to move her career forward:

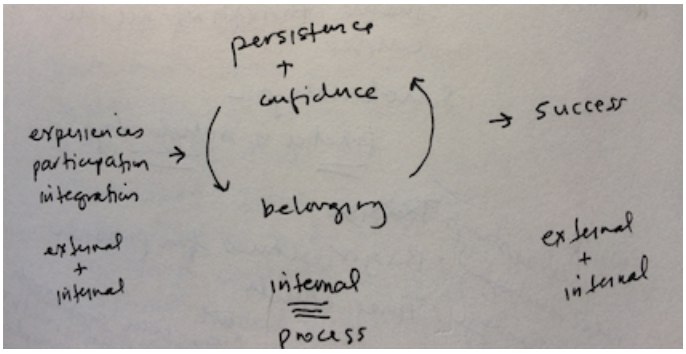
I felt empowered when my anger broke everything and I was just like, I'm done being nice, I'm done apologizing, it didn't work, it didn't get me anywhere, everything is still terrible and more people being like me is not going to help, making it seem like it's okay for racism to happen as long as only good people are doing it is not helping, it's only helping people be racist.

All of the actions described in this section – choosing how to dress, networking, presence, speaking up for other women, and anger – enabled these mathematicians to belong in the academy.

A complicated belonging model.

Based on the frameworks of Ostermann (2000) and Herzig (2006), I propose a model (Figure 5) for women belonging in the academic communities of mathematics.

Figure 5: Complicated Belonging Model



First of all, I include confidence, an aspect of self-perception, as an essential factor in participants' processes of developing academic persistence and belonging. Secondly, persistence sometimes led to belonging and sometimes belonging led to persistence. The participants established themselves in their academic communities through both mindsets. Further, it seemed that this process was internal, involving self-reflection and seeking out supports such as mentors.

Thirdly, success was defined both internally by participants, and externally, through recognition such as publication and tenure. Participants recognized that external factors such as department structure, culture and norms, affected their experiences but were beyond their control. For at least one participant, personal integrity was more important than being defined as successful externally, even if it meant that she would lose her job. Finally, as in graduate school, a woman entering a career in mathematics in the academy had figure out how to belong again in a new role and department. At this point, belonging allowed her to become a powerful agent of change on behalf of women in her department and other aspiring women mathematicians, especially if she had earned tenure.

This chapter described the similarities and range of experiences of the participants chronologically. Discussion of persistence and belonging followed with consideration given to frameworks described by previous studies in which a sense of belonging led to persistence and persistence was a measure of success. Based on participant experiences, I proposed a model for success based on the interrelationship of persistence, confidence and belonging. Additionally, since persistence sometimes led to belonging, I proposed a complicated model for belonging based on my model for success and that identified internal and external processes at each stage of the model. The final chapter discusses the implications of these findings.

Chapter 5

Implications

Project Summary

This qualitative research study consisted of a series of semi-structured interviews with six women who earned PhD degrees in mathematics and were employed in the academy. They were asked to share memories of their experiences with becoming mathematicians. Through their stories of success and challenge, I suggest they have deepened our understanding of what it means to be a woman mathematician in the academy. This study was conducted from my feminist perspective defined by voice, agency and social justice where difference in experiences facilitated communication and learning. Furthermore, institutionalized structures and processes that propagated sexism and racism, not individuals, were identified as the proposed sites for change.

Implications

Does math need more women?

An important implication for this study is to answer the question if the low numbers of women in math is even an issue for women mathematicians. As a result, I chose to directly ask my participants this question as part of the interview process. One participant identified the lack of women as a symptom and defined gendered assumptions about math as the cause of the problem. Others addressed how math in the academy systematically excluded people with diverse backgrounds and the arbitrary nature of our gendered socialization that only allowed some people to be part of the process that furthers knowledge:

> *We push out people who enjoy math but don't think about it or don't talk about it in a certain way. We push out people who would be interested in problems that others have*

decided aren't worth value. But math doesn't work that way. You can't tell ahead of time how valuable something will be, so I think it doesn't make sense to pre-determine who gets to be in math, to pre-determine what ideas get to be worked on, none of that makes any sense, but that's the system that we're in. So we need more of the people who are pushed out. We need them back in.

Ironically, thinking about math in different ways – thinking out of the box – was ultimately valued by mathematicians who awarded the top prize in mathematics, the Fields Medal, for the first time to a woman, Maryam Mirzakhani, in 2014. A colleague described Mirzakhani and her work: "What's so special about Maryam, the thing that really separates her, is the originality in how she puts together these disparate pieces … the novelty of her approach made it a real tour de force" (Carey, 2014). This rationale aligned with the participants' call for valuing the variety of perspectives, experiences and skill sets that diversity brings to mathematics.

Several participants commented on the importance of including more women and diversity because the added backgrounds and perspectives would strengthen the field. One commented that diversity in graduate school admissions was an important factor in establishing a healthy department culture. Others mentioned that having more women faculty created a buffer to sexism in their department. Additionally, worry about belonging detracted from a person's productivity. One proposed solution was for women to take on leadership positions. Other changes were happening in the participants' departments and research communities. For example, some conference sessions were organized with a majority of women speakers, and some math departments did have a fairly even split between men and women faculty which was then reflected in fairly even numbers of men and women majors.

Academic persistence and belonging.

Academic persistence and belonging were both evident in the participants' stories. Persistence appeared less frequently possibly because it was taken for granted that if a participant was to succeed as a mathematician, she had to persist. As in Duckworth, Eichstaedt, and Ungar's (2015) model, participants emphasized that effort was the most important factor in success.

Belonging was the prominent theme that arose from the interviews. Ostermann's (2000) description of belonging in school – a feedback loop of support and involvement with self-perception increased engagement – was supported by participants' K-12 school and college experiences. Herzig's (2006) framework for women's belonging in graduate school mathematics – inclusive experiences that increased participation by women graduate students led to belonging – seemed to be supported by participants' experiences in belonging to the academic community but not necessarily for belonging in their departments' social communities. In this framework, women graduate students needed to establish belonging several times during their graduate student careers in both the academic and social communities.

I propose two models based on the themes I found in the participants' experiences. First, I noticed that an individual's success could be viewed in terms of three interrelated factors: confidence, persistence and belonging. Second, noting that confidence, persistence and belonging are internal processes, defined and controlled by an individual, I added this conceptualization of success to the existing frameworks: experiences that may include external processes – for example, the structure of a graduate program – influence an individual's confidence, persistence and belonging, which then affects external measures of success such as completion of an advanced degree, publication or tenure.

Pathways

> *As we investigate different ways of teaching mathematics, a different type of student is able to succeed, and if we can bring in people with different ways of learning mathematics, how much richer are the discoveries that we can make?*

Participants shared ideas and examples of pathways that might improve the experience of women and/or increase the number of women in mathematics. Themes discussed by participants were math department/research culture and peer interactions, pedagogy and other supports for students, and their own personal actions for change.

Culture and external pathways.

The participants identified several cultural aspects of the academy that helped or hurt women. Technology was mentioned as a way to change how research is conducted through facilitating collaboration and enabling computations. Participants identified that since there are so few women, "*helpful men*" were needed as allies. Educating men on women's issues was one suggestion since "*a lot of guys don't even realize the horrifying statistics of women still getting paid less for jobs or, whatever, and I think a lot of white guys are just oblivious, and they're not trying to be but they just are.*" Diversity training to educate faculty on student bias linked to race and gender was another suggested pathway. Another participant emphasized the importance of department policy and community culture that holds professors accountable for gender-based and other kinds of harassment.

Hiring was described as a complicated process that had the potential to help or hurt women mathematicians. One participant gave an example of a woman university president who increased the number of women faculty at her institution by hiring one woman through a creative initiative. Another explained how she used her connections and insider knowledge of this "*invisible*" process to support her students during the hiring process:

Your advisor and your panel write letters on your behalf, and more than what the letters say are the names on those letters and the name recognition of them. So I mean my name on somebody's letter isn't worth as much frankly as my advisors name 'cause he's very, very famous and I'm not, but the fact that I'm tied to him now sort of lifts me up. And so what do I do with my graduate students? I make damn sure they know my adviser. I bring them to conferences with me, I have them give talks, I make sure they know him so when they apply for jobs I write a letter but so does he, so they have his name too…. If I hadn't known how much that matters, then it wouldn't occur to me to really make sure my students have letter writers who are famous guys, but I do. I always make sure of it.

Spousal hiring policies and bureaucracy also detracted from hiring both men and women mathematicians. One participant noticed that her department in general responded to women candidates differently, since "*sometimes the men [candidates] are seen to have stronger results than the women, maybe the way women present things, … there were a couple women who had good results and they weren't taken super seriously*."

Agency.

The participants chose many different pathways for their personal agency. Some spoke of making the invisible visible as a way to advocate for others, sometimes through professional organizations and an "*old girls*" network. Others chose agency through their presence as women researchers. Using power to help others and work for social justice were also important pathways.

More than one participant discussed the need for more women to apply for grants and awards and the need to provide assistance with navigating the "*invisible*" processes.

I didn't see grant writing as a feminist issue but it really is…. If you have a small number of women applying for grants, then they can fund one of those women and say, 'Good job us,' because, the way that they check whether they're being sexist is they look at the application rate versus the funding rate and so if only like ten women applied then they can say, 'Look we funded 10% of women, and we only funded like 5% of men,' because way more men applied…. So they were really encouraging everyone to apply, just apply for grants even though it's hard and it takes a lot of work, and you're not going to get funding. Just apply because that's what men do.

Participants also felt that their presence in mathematics made an important statement on its own. This included being visible as members in professional organizations and participating in conferences. More than one pointed out the importance of women being recognized for their research. One stated, "*I think it's nice for them to actually see and talk to a mathematician who doesn't look and sound like the other mathematicians that they know.*"

Pedagogy and support for students.

Participants discussed several pathways that had to do with teaching and supporting their students. Broad categories included consideration of the structure and goals of the program, alignment of personal with department values, and use of resources for outreach.

As mentioned earlier, participants had a range of experiences with their graduate school programs. One commented that she wasn't sure there was any way to prepare incoming students for the challenge. Others noted structural aspects of programs that contributed to student success, for example, setting up collaboration among graduate students since that modeled collaboration in research. Other suggested mechanisms were to increase the difficulty of the general examinations to encourage students to study in groups, create research opportunities for

undergraduates and first or second year graduate students, and offer financial support. Receiving a regular paycheck during graduate school motivated more than one participant.

Math departments offer classes to other majors and this brought up discussion regarding opportunity and challenge. One participant talked about the chance to inspire pre-service teachers. Her "*primary goal is that they understand that math should make sense and that there's something kind of fun or cool or interesting there.*" Undergraduate research opportunities were discussed by one participant as a pathway for students to consider graduate school: "*I really like working one on one with students because I feel like that's what brings me the most joy, and that's also what's going to give them the best opportunities for the future.*" Another participant talked at length about the sexism that she encountered from engineering students taking her classes. Since math majors took the same introductory level classes as the engineering students, women math majors might have been adversely affected by the sexism embedded in the 90-95% male engineering student culture.

Remaining true to values through their work as mathematicians was important for all participants. One participant felt that her graduate school experience taught her the importance of empathy since it was:

> *not the best experience as far as a supportive learning environment, but I also think that I learned a lot through that experience, and in particular I've learned how important it is to try to empathize with my students when they're struggling on things that maybe I think are simple. I still remember vividly what it feels like to be treated like I was not very smart and how counterproductive that is to learning.*

Another participant talked about how social justice affected every aspect of her life and work:

Justice is part of everything … it's not something that turns off for me. For instance I'd be more interested in collaborating with women or women of color, 'cause why not? … just wanting to communicate with people, caring about whether people can understand what I'm saying, and finding ways to participate in programs that are encouraging women and other minorities to be in, that and to make everything less sucky for them, I think that's important…. Who I interact with and how, that will always be focused on being pro-justice, or it might get me fired, I don't know.

Some participants identified resources as pathways for students to access math. One was involved in community outreach to the "right women" – those with socioeconomic or other challenges instead of those who already have access, "*it's the women but then it's also like which women … and so I'd like to do more about getting the different communities [involved], that's my new political activism*." Another earned grants that gave her access to training for mentoring students in research, or offered the opportunity for students to work with a business partner to solve a problem in industry.

Personal Reflection

It is no accident that this research had to do with belonging. This was an intensely personal journey because unlike the participants, I did not persist or belong as a women STEM graduate student (twice), and I left the academy for a career as a practitioner – a STEM teacher (twice). Once I began reading the literature for this project, I found that my path was very typical because there are many reasons for women in STEM to leave the academy. The literature flashed facets of my own story time and time again. Reflexivity helped me to make peace with my non-persistent path, so in this project I chose to celebrate the participants' success as scientists and to attempt to learn from their experiences of belonging and persistence.

I am thankful for the practice of reflexivity because constructivist subjectivity came up constantly. Sticky notes decorated my notebooks and surrounded my computer keyboard: "they think she belongs for different reasons than why she belongs," and "belonging on your terms – balance," and "needs constructivist subjectivity?" I recorded an intermittent stream of understandings as the research process unfolded and my understanding of the range of experiences of the participants developed. While writing I mourned for the ideas I didn't record, and regretted the times I chose not to sit with my thoughts after an interview or peer debriefing.

Reflexivity also helped me, a practitioner, negotiate my belonging as a scholar because outside of the support of the cohort and program, debate raged about rigor and the value of an EdD degree relative to a PhD degree. Was I less of a scholar because I come from a background of practice? Or because I pieced together my theoretical framework from a variety of perspectives rather than building on ideas from one school of thought? I wondered if practice – as a member of a research community, not in isolation – is true scholarship. After all, if we as scholars assume the identity of migrant – moving between the academy and practice – then we are situated in both our local community and the culture of research. Our differences in practice and research create the opportunity to constantly engage in conversation; then the strength of scholarship lies in the potential to learn from one another and our willingness to do so.

Future Research

Future research possibilities include expanding the range of the study to document more stories of women mathematicians and women in other STEM fields and to find out if the proposed models of persistence, belonging, and success remain viable. Dialogue might also continue with the current group of participants in a longitudinal study to add to their stories, especially their efforts to promote diversity in mathematics. Additional analysis of the transcripts

around the themes of genius, mentoring, and different ways to belong might yield other important findings for STEM diversity.

Participants' stories and findings about persistence, belonging, and success need to be shared with K-12 and university educators and administrators. Although ultimately, each person decides if they will persist, if they belong, and if they find success, schools and the academy control student experiences, supports, and policies. As a math and science teacher and administrator in a high school I wonder what experiences can we provide for our students to support the internal processes of persistence, belonging and success? I wonder which supports increase student participation? Also, how can policies encourage integration into our academic community? While these questions apply directly to students in high school mathematics, could these wonderings expand to all of our educational contexts? If belonging is an integral part of success then I suggest that it is in our best interest to ensure that all of our students, teachers, and staff feel that they belong.

Finally, telling these stories makes the invisible visible and grievous realities are exposed. It is my hope that the experiences of these women, both their challenges and successes, become opportunities for discussion and action to increase the diversity in mathematics.

Appendix A

Interview Guides and Biographical Data Sheet

First Interview Guide

Hello _____. Thank you for meeting with me today. I doctoral student in the College of Education at the University of Hawai'i at Mānoa and am conducting a study to learn more about the challenges and rewards of being a woman Professor of Mathematics. I am inviting you to participate in this study because you are a professor of mathematics in the University of Hawai'i system or you have been referred by a professor who is participating in this study. Your participation will provide valuable information to help me understand social and academic factors that contribute to success in mathematics and other science, engineering and technology careers.

If you agree to participate, you will be interviewed individually two times during the period of March through June 2015 and once more during July or August of 2015. Today's meeting will last no longer than 60 minutes. At the end of today's interview I will ask you to choose a pseudonym and will give you a biographical data sheet to complete before our next meeting. The second and third interviews will last no longer than 90 minutes. Meetings will be scheduled for a time and place that are convenient and comfortable for you. The interviews will be informal, a time to share your experiences as a women working and/or studying in the field of mathematics.

Each interview will be audio recorded and I will take brief notes so that I can create a written record that can be analyzed later. In typed transcripts, a pseudonym will be used; your real name or any other personally identifying information will not be used. I will also ask you to read through my transcripts to check that I have faithfully represented your thoughts. You may make any corrections and changes and those will be recorded in the final transcript. If responses and direct quotations from your transcript are published, you will be identified only by your pseudonym and the information will be written and quotations included in a way that maintains the confidentiality of your responses.

While you will receive no direct benefit from participating in this study, your sharing is meaningful and will help girls and women who choose to study mathematics in the future. I believe there is little or no risk to you in participating in this study. If, however, you are uncomfortable with any of the interview questions, we will skip the question, or take a break, or stop the interview, or you may withdraw from the study altogether.

Here is the consent form. Please read it through and complete the signature portion if you agree to participate.

Do you have any questions before we start?

The seeds of this study were planted long ago but sprouted when I watched the live-stream of the Mars Rover landing on my laptop. I expected to see a room full of men and women and was surprised to see only a few women in the control room and no women on the lead team.

As I began my research for this project I learned that while the gender achievement gap in science has closed -- meaning, there are significant numbers of women earning degrees in STEM fields (psychology: 70%, biosciences & most social sciences: 49 - 58%) -- women are still underrepresented in certain fields: physics, economics, engineering, computer sciences, statistics and mathematics.

I'm interested in learning from your experience as a successful woman in the field of mathematics to find ways for other girls and women to follow your lead.

First Interview Questions

1. Why did you choose to study math?
2. What childhood memories do you have about going to school? About math?
3. What opportunities led you to where you are now (a professor of mathematics)? (Events? People? Other guidance?)

Before we end, I would like you to choose a pseudonym for my transcript and ask that you complete this Biographical Data Sheet before our next meeting.

Biographical Data Sheet

Pseudonym:	Ethnicity/nationality:
Age range (circle): 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89	
Elementary School Middle School High School Undergraduate Education Graduate Education	List places lived/approximate dates

Post-Doctoral work Work experiences	
Extracurricular activities in high school/college/graduate school	Membership in professional and/or community organizations
Current hobbies & Interests	Anything else?

Second and Third Interviews

Hello. Thank you for meeting with me again. I am looking forward to hearing about more of your experiences. I would like to remind you that if you are uncomfortable with any of the interview questions, we will skip the question, or take a break, or stop the interview, or you may withdraw from the study altogether.

Thank you also for completing the Biographical Data Sheet.

Do you have any questions before we start?

Interview Questions

1. What positive memories do you have as an undergraduate or graduate student in mathematics?
2. What challenges did you encounter as an undergraduate or graduate student?
3. Who influenced and/or supported you as an undergraduate or graduate student?
4. Who influences and/or supports you now?
5. What advice would you give to a girl in high school? A woman undergraduate? A woman graduate student?

Appendix B

Second Interview Questions

Possible questions for interview #2

0. Day in the life of … (academic year & intersession)
1. Memories, challenges - from your math journey since we last talked

…

n. Anything else you'd like to tell me?

Math culture

Do we need more women in math? Why?
When did you begin to think of yourself as a mathematician?
Do you do math (research) with others? Siblings, former advisors, colleagues - how do you make connections?
Is math a solitary (abc conjecture) or collaborative science?
If it is becoming more collaborative, is that a change in paradigm?
Do your values align with math values (congruent with male norms - Seymour & Hewitt, 1997)?
How do you live out your values and beliefs to support other women mathematicians?
Do you need the culture of mathematics to change?

(recognition by meaningful others)
Describe the importance of NSF grants for your career?
Are there other external indicators of success?
Are academic jobs scarce? Other jobs for mathematicians?

University/Department structure

Has the "two-body problem" affected your career?
What helps?
What hinders?
What needs to change?

Balance

Explain how you balance family/work/fun.
Explain how you balance teaching/research/advising/other (admin, professional organizations, etc.)

Feminism questions

Do you think feminism is relevant to your life?
What does feminism mean to you?
Do you think you've been treated differently because of your gender?
I'm wondering if I should place my work in feminism. What do you think?
Do you have power? Do you view yourself as powerful?
How do you use your power to further the 'cause'?

How do you define power?

(woman returner)
What was it like to return to academia? You mentioned tears and being comforted by friends that the first year is difficult for everyone.

Supports

What supports were in place for you during your education?
What supports are in place for you as you progress through your career?
Were there other supports in place that you didn't use?

How do you live out your values of supporting other women mathematicians?
When you are teaching are you consciously mentoring or changing the paradigm?

Appendix C

Descriptive and In Vivo Codes

Codes from Transcript Preparation, Field Notes, and Reflections	
Finding two-academic jobs	Kindness
Balance (Teaching/Research/Life)	"F-ing Men"
Collaboration	Service to Community
Teaching	Missing Skills (when entering Grad School)
Mentoring	Dedication to Teaching and Students
Change at institutions	"the word Accessible implies a handicap"
Values shared with colleagues	Appearance
Confidence	Visualization of success
Woman mentor as a shield	Choose work to be in line with values
Not wanting to do that kind of job – it's a lame job – someone else can do it	Women in positions to control journals, R1 universities, admin, money
No time to waste	Internal v. external motivation
Power	"Rockstar" "Superstar"
"Whiny if you speak up"	Women's College
Make it happen	Missing advising
Diversity of people means a diversity of ideas and approaches	Math as communication "Math is all about talking to other people"
Mentoring women	"think I'm weird"
Faith	Self-care prioritized/Balance
External recognition	Growth mindset
Safe places	"Luck"
Time to process	Genius

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