MATHEMATICS MAJORS AT AN ALL-WOMEN'S COLLEGE:
EXPLORING IDENTITY AND CONTEXT

By

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ABSTRACT

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Drawing on identity theory, sociocultural theories of learning, and discourse analysis, I engage in an analysis of in-depth, individual interviews with four mathematics majors at an all-women's college over an academic year. The purpose of this qualitative study is to gain insight into the mathematical identities of senior women mathematics majors, to understand their assumptions about what it means to know and do mathematics, and to describe the role that an all-women's content might play in their descriptions of themselves or of mathematics. As such, I focus on *identity, context,* and *Discourses*. The concept of a *mathematical identity*–being recognized as a mathematical person in a given context–is central to this study. To this end, I pose the following research questions:

- *What language do senior women mathematics majors at an all-women's college use to describe their mathematical identity development?*
- *How might the context of an all-women's mathematics department be described as relevant to students' identity development? Specifically, what activities do mathematics majors at an all-women's college describe as significant to their experience and how do they describe their relationship to others within that context?*
- *What mathematical Discourses do senior women mathematics majors at an all-women's college know, assume, question, or reject? What seems to be the relationship between their identities and those Discourses?*

The first research question focuses on identity development and recognition, that is, how student's discourse describes their mathematical identity development and other related identities. The second set of questions focuses on description of the particular all-women's context of Metcalf, particularly the community practices and relationships. The third set of questions focuses on developing and understanding participants' interpretive and evaluative models– specifically, about what it means to know and do mathematics as a woman. Overall, my aim is threefold: to be able to say something meaningful about (a) who these women are, (b) what meaning is ascribed to knowing / doing mathematics by these women, and (c) how the context of an all-women's college seemed to shape their relationship with mathematics.

To My Father,
John F. Theakston

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PREFACE

Who will make the pudding and pies if women learn mathematics? Will they unfit themselves for motherhood because their minds become too abstract and unfeeling? – Wylie (1838)

Math class is tough! – Barbie (1992)

So, my mother bought [a rainbow loom] for myself and my thirteen year-old brother to share. And, um, which is actually a great gift 'cause I really enjoyed it and so did he. Um, but neither of them could figure out how to use it. And I really enjoyed it, making complex patterns. And really they're not comp--, really like a ten year-old could do it. But, my mother and my [other] brother were not into it… Didn't have the patience for it. And my mom, she was trying to do a very small, whatever bracelet pattern. She's like "Ughh, Cassie, I can't do it!" I'm like, "Ughh, Ma! Like, here are the instructions. You got this Ma!" And she was like trying and struggling, but not really investing herself in the effort. Or reading the instructions thoroughly. And finally she shoves it aside and is like "Oh, Cassie." Like, "I will just leave it to the math major to figure out." Umm, god it really bothered me. And I think it's an accurate window maybe into--, I don't know. Maybe it's my mom or our relationship or something. I don't want to be the quote "smart one" or the quote "math one." I work hard to have the understanding that I do. And I hate to see my mom sell herself short. – "Cassie" (2013)

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CHAPTER ONE: INTRODUCTION

How I Came to This Study

As this study could not be possible without four young women sharing their stories about being a mathematics student and a mathematics major, I thought it important to share some of my own story. In the paragraphs that follow, I share an abridged version of my own experience in mathematics and describe how these experiences led me to pursue a study focused on students' mathematics identities in an all-women's context.

As a primary school student, I always looked forward to my mathematics lessons. Progressing through the grades, teachers changed and topics differed, yet confidence in my mathematical abilities remained constant. Teachers, fellow students, my parents and others reinforced this confidence by telling me that I was a good student, one of the "smart kids" because I earned top grades in math. A large part of my identity was built around my ability to do mathematics.

When deciding on a major in college, I knew that being a skilled mathematician would allow me to pursue almost anything. I also was aware of the prestige associated with declaring oneself a "math major." Even when particular classes no longer satisfied my curiosity, even when I found that I did not find joy in my course work, I would remind myself that I was doing something hard and that I was one of a few people on the planet brave enough or smart enough or committed enough to earn this degree. As a woman and a first generation college student, I felt like it was my responsibility to earn a degree and do research in mathematics on behalf of the underrepresented. I had convinced myself that I was responsible for being a role model for young women interested in mathematics and science. Upon matriculation into graduate school, I began to realize that these became the primary reasons for pursing a degree in mathematics.

Early in my Master's program, I began to dread doing course work because it carried little meaning for me and I was no longer confident that I was someone who was "good" at mathematics. At the time, I felt that these struggles were because I might not be as mathematically gifted as some of my peers, or I had not worked hard enough, or I was lacking the passion one needed to be a good mathematician. Looking back on my graduate experience in mathematics, though, there were many external factors that negatively impacted my success and my beliefs about myself as a mathematician-in-training. Specifically, the department culture was one in which students were not worthy of attention or guidance until they had passed their qualifying exams. Though every student was assigned an academic advisor, most first- and second-year students only had the opportunity to meet with them once a year for ten minutes or so to fill out a short progress report. In these meetings, my advisor would ask me about my grade point average and if I had made progress on my program plan and would check the "satisfactory" box. Outside of this, there was no open-door policy and there were definitely no attempts to check in about my life, generally, or my educational or career aspirations.

Similarly, teaching, for many faculty members, was a burden—the debt they had to pay so that they could get back to their research. This perception about teaching was adopted by many graduate students as well—that talking about or thinking about teaching meant that you were not talking about or thinking about research. Therefore, graduate students were implicitly and explicitly encouraged by their advisors not to spend too much time on their teaching.

It was within this environment that I was positioned as a "good teacher." Though no one had ever observed my teaching, I was awarded a teaching award. I was asked by administrators within the mathematics department to run multiple teaching assistant orientations and workshops. I was asked to run review sessions for large groups of undergraduates. I was given teaching assignments that were known to be more time intensive than some of the others given to my male counterparts. I believe that this assumption that I was a good teacher, without any formal education in teaching and without any observation from my superiors, was gendered. By virtue of being a female, I *must* have been a good teacher. This assumption, by itself, was not the most harmful element of this, however. Instead, I was known as a good teacher within an environment where teaching was clearly seen as a distraction from the real work of mathematicians. I was simultaneously being praised for being a good teacher, while told by others that teaching was a diversion from important research.

This assumption shaped the ways others saw me. But, more importantly, it shaped the way I saw myself. Although I was happy to see the work that I had put into my teaching was being recognized, I felt uneasy about talking about teaching with my peers. I felt torn between spending my time on teaching or on research. Even though I enjoyed teaching and found compelled to think about the issues I was seeing in the classroom, I felt concerned about making that too visible to other graduate students or to faculty. I believe that this experience was complicated even more by the fact that I wanted to blend in and to belong. As a woman in a predominately male department, it was important to me to be able to succeed and this sort of recognition seemed to detract from doing the things that were valued by others in the department.

It was not until a few years into my doctoral program in mathematics education that I finally started to understand the degree to which my experience in mathematics was shaped by the context and the culture of the department I was in. I started to wonder about the ways in which my experience in a predominately male environment might have impacted my mathematical identity development and to ask questions and trouble that experience. I wondered if there were mathematics departments where the attitudes toward teaching and mentorship were not so incongruous with faculty research; where interactions with students were valued and students were given time and support throughout their program. I wondered if there were environments where students were encouraged to ask questions in class or where students were not so highly competitive with one another.

I came to this study because I wanted to gain insight into the ways that women in all-women's environments might think about mathematics and about themselves in relation to mathematics. I desired to better understand the ways in which the environment might support women to participate and engage with mathematics at advanced levels, and to see themselves as people who can succeed in mathematics.

In the following section, I engage in a brief historical overview of the role of women in mathematics, including a more in-depth review of the gender research in mathematics. Through a review of the relevant literature, I first demonstrate that there is a lack of research focusing on women in mathematics. Further, of the work that is currently being done in that area, there is a tendency to "'blame the victim' by locating the problem with the girls themselves without considering the wider context which produced the behaviour identified" (Rodd & Bartholomew, 2006, p. 40). Therefore, I argue that there is a need for research that attends to context and focuses on how and why women succeed in mathematics.

Women in Mathematics

In 2008, newspaper headlines everywhere declared the "gender gap" closed–'*Math class is tough' no more: Girls' skills now equal to boys* in USA Today (Quaid, 2008), *The myth of the math gender gap* in TIME Magazine (Park, 2008), and *Girls bridge gender divide in math* from ABC News (Potter, 2008). The current national tenor is that, when it comes to learning and teaching mathematics, we are now living in a society where gender is no longer a factor.

Researchers note that more women are taking Calculus in high school (Moore & Slate, 2008), and that women make up approximately half of all college students and earn more than half of associate's and bachelor's degrees in mathematics (National Center for Education Statistics, 2012). Further, the number of women mathematics majors has grown over time.

Despite growth in absolute terms, however, recent statistics have indicated that "in mathematics, women's participation at advanced levels is still unusually low and either improving slowly or, in some cases, making no progress whatsoever" (Becerra & Barnes, 2012, p. 34). That is, even though the number of women attending college has increased substantially, the *relative* number of mathematics majors has decreased. National Science Foundation (2013) data support this finding, indicating that the percentage of women who hold a bachelor's degree in mathematics has steadily decreased from 48 percent to 43 percent between 2001 and 2010. At the graduate level, the percentage of women enrolling in a mathematics graduate program has "remained relatively static in the decade—38 percent in 2000 and 36 percent in 2009" (Becerra & Barnes, 2012, p. 34). After increasing to 32% in 2014, the percentage of women to earn doctorates in the mathematical sciences decreased to 31% in 2015. Further, in 2015 "of the 864 new PhDs hired into academic positions, 31% (268) were women, down from 32% last year" (Vélez, Barr & Rose, 2015, p. 759). According to a 2010 survey by the Conference Board of the Mathematical Sciences, women comprise only 21% of tenured faculty in four-year college and university mathematics departments and only 16% of the tenured faculty at doctorate-granting institutions (Blair et al., 2013). As such, the greatest discrepancy in terms of participation and achievement exists at the more advanced levels of mathematics.

As Stinson (2004) has noted, mathematics in particular has served as a gatekeeper to advanced educational and work opportunities, particularly for women and students of color.

Even for those students who maintain interest in the subject and decide to pursue advanced studies in mathematics at the college level, issues of retention and success remain prominent. Earlier claims about the genetic differences between boys and girls have been debunked (Boaler, 2007; Fennema, 2000). Yet, there is still much work to be done to understand the role of context in producing such outcomes. I believe that more attention should be given to those spaces that are potentially supportive or empowering for those groups traditionally underrepresented and underserved by the system. Specifically, I argue that gaining insight into contexts that have historically supported women in higher levels of academic achievement is necessary. Women's colleges are particularly important settings to consider given that they have a higher number of women enrolling in traditionally male-dominated disciplines like mathematics, science, and engineering and that they graduate women in these disciplines at a rate of 1.5 times that of their coeducational counterparts (Lennon, 2005; Miller, 2005). Further, graduates of all-women's colleges continue toward doctorates in math, science and engineering in disproportionately large numbers. In fact, "five-women's colleges–Barnard, Bryn Mawr, Mount Holyoke, Smith, and Wellesley–accounted for 43% of the math doctorates…earned by women in the 1970s and 1980s" (Unger, 2007, p. 480). As such, women's colleges are important contexts to consider when thinking about supporting women to participate and engage with mathematics at advanced levels.

A Brief History on Gender Research in Mathematics Education

In the 1970's and 1980's, educational researchers began to give great attention to gender-related issues in mathematics education. During this time, there were many studies aimed at finding and explaining differences in mathematics performance between boys and girls. In some instances, researchers sought to find and explain natural or biological differences between genders (e.g., Benbow & Stanley, 1980; Benbow, 1988)[1] or to seek differences in mathematical aptitudes like spatial ability and problem solving (e.g., Friedman, 1989). In other instances, researchers looked to gender differences regarding affective responses, confidence, or attitudes. Although such findings were rarely reported in the media, popular media coverage on difference in mathematical ability between genders received an extraordinary amount of press. Jacobs and Eccles (1985) found that exposure to media coverage of such findings led to changes in parents' attitudes about gender in mathematics. When exposed to this media, mothers of girls in particular, became more conscious of gender differences–stating that "boys have a tendency to *understand* the principles (of math) but girls are trying to just *memorize* the principles" and that "boys and girls have basic, but slight, differences between inherited abilities" (p. 22). This early research "has largely been a study of female failure to succeed in mathematics" (Damarin, 2008, p. 109); often attributing the mathematical success of girls and women with external conditions and failures with internal states (e.g., Stipek & Gralinski, 1991). That is, this research oftentimes attributed underachievement of girls to internal deficits (like having mathematics anxiety) rather than acknowledging the ways in which performance and engagement might be related to the teaching and learning environments (Boaler, 2007).

In the early 1990's, findings from a meta-analysis conducted by Hyde challenged this earlier research, indicating that gender differences were small enough not to be statistically significant (Hyde, 1993). At this point, however, popular discourse on gender differences in mathematics had already taken hold. Hyde noted that even in 2008, "the stereotype that boys are

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[1] According to Damarin (2008), "Benbow and her research have been vilified within many communities of women concerned with mathematics. In the 1970s she coauthored an article in *Science* that argues that women are biologically inferior at high levels of mathematics (Benbow and Stanley 1980). This article was widely publicized and precipitated much heated discussion. Since then Benbow's work has continued in the same direction" (p. 106)

better at math is alive and strong…Parents still believe it, and teachers still believe it" (as cited in Park, 2008, p. 1). "Stereotypes that girls and women lack mathematical ability persist and are [still] widely held by parents and teachers (Hyde, 2008, p. 494). Evidenced by incidents like Harvard President Larry Summer's (2005) speech at a conference on Diversifying the Science and Engineering workforce suggesting that women's lack of representation in STEM fields may be due to a lack of intrinsic aptitude, it is clear that such beliefs remain woven into the fabric of our national discourse.

Girls (Versus Boys?)

Looking across popular media and empirical research, it is evident that researchers, teachers, and educators alike have been concerned with the "gender gap"–why it exists and what can be done about it. As Damarin and Erchick (2010) argued, this research paradigm "is a deficit model, better at explaining how girls fail at mathematics than how they succeed" (pp. 316-317). In short, the conversation in the field has been dominated by comparisons between boys and girls, and by positivist approaches to gender mathematics education research. Gutiérrez (2008) argued that relying predominantly on achievement-gap studies may be giving us an impoverished picture: "the lens sends an unintended message that marginalized students are not worth studying in their own right—that a comparison group is necessary" (p. 359). In the same way that she argued that "Whiteness" has become the norm within studies of race in mathematics education, so has "maleness" become the normative benchmark by which women are evaluated and studied (Burton, 2004; Mendick, 2005, 2006).

Purpose of the Study

Speaking back to current research paradigms, which focus on comparison between groups, I have chosen to focus on the identities, experiences, and assumptions of mathematics majors at an all-women's college. By choosing an all-women's context for my study, I have reduced "maleness" as the benchmark by which to gauge female success and performance. As such, this study serves a counter example to these "gender-gap" and comparative studies, which assume a male performance as the normative measure. Therefore, I argue that this study underscores the argument that women's experiences are worth studying in their own right and are not only important relative to the experiences of men. Further, as I will explain in more detail below, this study highlights the multiplicity of women student's identities, and in doing so, challenge much of the research that currently treats women as a homogenous group. I believe that it is particularly important to focus on mathematics at the undergraduate level because, as indicated earlier, this is where issues regarding interest and retention become most apparent. Overall, then, I argue for a focus on collegiate mathematics, use of non-comparative, non-essentializing framings and methodologies, and attention to the identities and experiences of women (understood as a non-homogenous group).

Overview of Forthcoming Chapters

In the section that follows, I provide an overview of the forthcoming chapters. Before I summarize my work, however, I would like to briefly take a look at the state of the field so that I might better situate the present study within it. According to Damarin (2008), studies of women, gender, and mathematics can be broadly categorized into four genres: (a) studies within the field of mathematics education, (b) studies in social or differential psychology, (c) institutional studies of the conditions of women in mathematics, and (d) biographical studies of women mathematicians. Each of these genres, Damarin noted, has given little attention to feminist theories and interdisciplinary gender studies: "…major developments such as the deconstruction of male-female and sex-gender dichotomies and the consideration of gender as performance are largely outside the mainstream literatures in each of these genres" (2008, p. 103). Further, she said that issues of diversity amongst women or the role of gender within intersectionality have not been taken up by any of these genres. The role of feminism in mathematics education, she argued, "has been slow at best" (2008, p. 104).[2] Damarin (2008) further argued that this exclusion has been bi-directional. That is, scholars in feminist theory or in interdisciplinary women's studies have likewise paid little attention to mathematics: "feminist theories have not addressed mathematics at fundamental level comparable to the ways in which they have taken on the humanities, social sciences, and, more recently, biological and physical sciences and technology, challenging the legitimacy of their authority, expanse, and power" (p. 115). In short, research genres focused on women and mathematics are not only disparate from one another, but also from feminist theories and interdisciplinary studies.

Though I use some feminist theories to reflect on and interrogate some of the findings I report, I have chosen to primarily situate the current study within the foundational mathematics education research focused on gender. I do so for two primary reasons: First, as Damarin's assessment of "the field" reveals, there is a dearth of literature on women and mathematics shaped by feminist theories or interdisciplinary women's studies. As a result, it is exceedingly difficult to make connections to or build upon this slim body of work. Second, as I mentioned earlier in this chapter, the conversation within the mathematics education research community

[2] Damarin (2008) noted that in the decade following Fennema and Hart's 1994 assessment of the field and their subsequent call for research focused on gender and mathematics which draws on feminist theories, the *Journal for Research in Mathematics Education* "published exactly one article (Walshaw, 2001) based in feminist and postmodern theories" (p. 104).

has turned away from issues related to gender or sex in recent years. There is a presumption amongst many that "the gender problem" has been solved (Becerra & Barnes, 2012). Therefore, I am compelled to draw upon theories and methodologies that are more widely used and accepted within the mathematics education research community in order to make the case to this specific community that studies of women in mathematics are valuable and needed using the research and language valued by that community. Specifically, I hope to make the argument that women are worth studying in their own right and that the things that they have to say about their own experience are important and valuable to mathematics educators and researchers. I believe that this is important for the reader to understand because my choice to primarily draw upon studies in mathematics education impacts the focus of this particular piece of research. Namely, the literature I draw from (and speaking back to) is the work that has been conducted by and used within the mathematics education research community, rather than a primary focus on critical, feminist theories and epistemologies.

Chapter 2 begins with a review of this literature on identity and gender in mathematics education. I then explain in detail what I mean by each of the focal constructs of my study: *identity, mathematical figured worlds and Discourses,* and *context*. I close Chapter 2 with the research questions and a description of how Gee's theory of identity provides a theoretical framework for the study. Chapter 3 begins with an overview of the design of the study, strategies of inquiry and data collection, data management and processing, and analytic procedures. I then describe both the setting and participants for the study.

In Chapter 4, I explore participants' descriptions of themselves as students of mathematics and how those descriptions reflected the context of their mathematical identity-building stories. Because there are many ways to be a mathematical person, I focus more narrowly on two mathematical identities: "someone who is good at mathematics" and "someone who is bad at mathematics." Specifically, I consider how the descriptions of these identities shift over time and context.

In Chapter 5, I focus on the various institutional practices participants named as being relevant to their experience at Metcalf. Specifically, I consider the role and impact of the degree structure itself, as well as the options for majors and specializations that were the norm at Metcalf. Following this, I look across participants' descriptions of activities, such as attending class or office hours, and of their relationships with peers, faculty, and the institution to gain insight into the ways that the context shaped their experience.

In Chapter 6, I explore and unpack the Discourses that seemed to frame participants' descriptions of their experiences as a mathematics major. I specifically begin with an investigation of the global Discourses about being a woman and about being a "math person." I then proceed to investigate participants' descriptions of their experiences at Metcalf specifically, with the goal of identifying and examining various institutional mathematical Discourses. Taken together, I argue that these Discourses give rise to the conception that mathematics is not for everyone and mathematical people are different from others.

Chapters 4 through 6 each reflect the different grain sizes for the analysis. Chapter 4 focuses on individual students' developing mathematics identities and how those stories seemed to change over time and context. Here, the unit of analysis is individuals' descriptions. In Chapter 5, I move to an analysis that builds on individuals' perspectives and experiences to include aspects of the specific context of an all-women's environment. In Chapter 6, I expand the focus to groups of individuals and Discourses that seem to be present inside and outside of the Metcalf context.

In Chapter 7, I conclude with reflections on the posited answers to the research questions and make explicit connections back to the existing research on mathematical identity development for women in mathematics. I raise questions about some of this research in light of my exploration and findings. I also provide some of the key lessons from the study about conducting this type of research, as well as key lessons for educators. I finish with a reflection on my positionality as a researcher, concluding remarks, and some ideas about directions for future work related to the mathematical identity development of women as it relates to context.

CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Looking across the relevant literature, a common sentiment emerges: "If pinned down, most of us would find it difficult to explain just what we do mean by identity. Its very obviousness seems to defy elucidation: identity is what a thing is!" (Gleason, 1983, p. 910). Despite its fairly straightforward colloquial use, an all-encompassing and functional definition for identity has been elusive. Further, even a clear definition does not always lend itself to a clear and useful research agenda. As Bishop (2012) argued, "One difficulty stems from the challenges of operationalizing identity in a tractable, observable, and measurable way" (p. 37).

Although different conceptions of identity–as *positioning* (e.g., Wagner & Herbel-Eisenmann, 2009; Yamakawa, Forman, & Ansell, 2009), as *narrative* or *story* (e.g., Juzwik, 2006; Sfard & Prusak, 2005), and as *belief* or *disposition* (e.g., Bishop, 2012; Martin, 2000; Solomon, 2009)–are valuable for different theoretical purposes, I will use only one conception of *identity* within the confines of this study–namely, the definition offered by Gee (2000): "being recognized [by oneself or others] as a certain kind of person in a given context" (p. 99). I do so because this conception attends to the role of context in identity construction, highlights the subjectivity inherent in such identifications, and implies a discursive mechanism for identity construction.

Because identity is a term that has been employed by many different researchers with various theoretical and philosophical aims, and because the educational research community has yet to agree upon a working definition, I begin with a short background on identity. Here, I provide a rationale for why I chose identity over other possible theoretical contenders and give an overview of the primary theoretical debates in identity. In doing so, I situate my study theoretically and justify my choice to define identity as I have.

An Introduction to Identity

Though popularized as early as the 1950's by social scientists, the concept of identity has experienced a recent resurgence within the educational research literature: "the time-honored notion is experiencing an obvious renaissance, with its comeback even more impressive than its original appearance" (Sfard & Prusak, 2005, p. 14). Although the concept has been examined and debated for many years by researchers and philosophers alike, educational researchers have recently gained affinity for identity over other related affective concepts.

Identity Research in Mathematics Education

Until relatively recently, mathematics education research specifically focused on identity has been limited. Scholars in mathematics education focusing on educational equity, in particular, have embraced identity theories in order to study issues, for example, of curriculum and pedagogy (Boaler, 1997; Boaler & Greeno, 2000), and classroom norms and interactions (Bishop, 2012; Cobb, Gresalfi, & Hodge, 2009) in relationship to the identities students develop in relation to mathematics (other recent examples include Anderson, 2007; Berry, 2008; Horn, 2008; Jackson, 2009; Martin, 2000, 2009; Nasir, 2002; Sfard & Prusak, 2005; Solomon, 2009; Spencer, 2009; Walshaw, 2005). A few studies, in particular, are worth noting because of their relatively early influence within the field of mathematics education research.

In a study of the experiences of high school Calculus students, Boaler and Greeno (2000) found that students' classroom experiences had negatively impacted their beliefs about the discipline and about themselves as knowers and doers of mathematics. Many of the students they interviewed expressed that they did "not want to author their identities as passive receivers of knowledge" (p. 188), but felt that this was necessary for continued engagement with and persistence in mathematics. As such, they argued that these students' identity development and, relatedly, their persistence was influenced by "traditional" classroom practices and expectations. Cobb, Gresalfi, and Hodge (2009) came to similar conclusions while studying the identities of middle school Algebra students. Namely, they concluded that classroom practices and norms are necessary considerations when studying student identity. Specifically, in a comparative case study between two "contrasting classrooms in which what it meant to know and do mathematics differed significantly," they found that students' affiliation with classroom practices differed substantially (p. 40). That is, students in the classroom that might be described as traditional felt that they lacked agency to change classroom practices and that the teacher was the sole authority for determining the correctness of mathematical solutions. Cobb and colleagues indicated that these students were developing passive identities and that they were motivated by obligation to the teacher rather than having developed an intrinsic interest. These two studies, in particular, have enhanced our understandings about the relationship between classroom practices, norms, and pedagogy and the authoring of student identity. Specifically, these studies indicate that classroom practices and norms are inextricably linked to student identity development.

Martin's (2000, 2009) research on the racialized mathematical experiences of middle school students has also been foundational within mathematics education research on identity. Through his research, he was able to develop a four-tiered framework, making explicit contextual factors that significantly impacted student identity. Specifically, this work is unique in that it extended beyond the mathematics classroom in order to account for social, historical, community, and school factors within students' identity development. He found that differences between students' personal identities and histories influenced their mathematical learning trajectories. In particular, his study reveals that students' mathematics identities must be studied in conjunction with their broader academic, racial, and cultural identities.

Of the current empirical examples, most focus on the classroom experiences of middle school students and emphasize either the racialized (Berry, 2008; Jackson, 2009; Martin, 2000, 2009; Nasir, 2002) or gendered (e.g., Boaler & Greeno, 2000; Walshaw, 2005) identities of those students. Few studies focus on identity at the post-secondary level and, of those studies, even fewer attend to *student* identity (as opposed to teacher identity). Beisiegel's (2009) dissertation study serves as one of the few examples of identity research focused on experiences of mathematics graduate teaching assistants. The goal of her qualitative study was to develop a theory of identity development for graduate students who were also teaching assistants. In particular, she focused on what she called the "mathematician-as-teacher" identities that these individuals were developing. She found that across participants, there was a general tenor of "detatched inevitability." That is, these mathematics teaching assistants believed that, despite a general lack of contentment their teaching experiences, they did not feel that they had the agency to change classroom practices. Overall, she argued that their identities of mathematician-in-training was developed at the detriment of their developing mathematician-as-teacher identities because of the departmental culture which devalued the importance and difficulty of teaching.

My study is uniquely situated within the field because, as I explain in more detail later, it not only attends to gender as a salient facet of student identity, but also focuses on identity at the undergraduate level. This study is further set apart from existing research in that I explore a unique learning context: an all women's college. Although most of the relevant identity research accounts for contextual factors in some way, and some even consider nontraditional learning environments, no current research on identity focuses on undergraduate women mathematics majors at an all women's college.

Why Identity?

The studies mentioned above, in addition to my proposed study, could broadly be framed as study of affective aspects of learning mathematics. The question remains, however, as to why it is necessary to invoke identity, in particular, as a central construct. In contrast to notions like *nature* or *character* that connote innate or biologically determined characteristics, concepts like *emotions, attitudes, beliefs,* and *identity* have been adopted more recently by researchers within education and social science in order to reflect shifts away from inherent traits. Of those constructs used by educational researchers interested in affective aspects of learning, beliefs and identity have come out as the theoretical frontrunners (Philipp, 2008; Sfard & Prusak, 2005). Although there exists some overlap in their conceptualizations, *belief* is a term typically reserved within the educational literature for internal, psychological entities.[3] Identity, in contrast, is not internally bound. Additionally, as I will explain in more detail below, identity is a term that spans the continuum from individual to social.

Some scholars argue that constructs like belief present methodological difficulties. Sfard and Prusak, echoing the concerns of Geertz (1973), indicated that when employing the construct of belief, one must "[assume] their discourse-independent existence without specifying where and how one could get ahold of them" (Sfard and Prusak, 2005, p. 15). In other words, as conceptualized, beliefs are contained in the proverbial black box. Therefore, in addition to being ill suited for a socio-cultural project in that they are reflective solely of internal states, beliefs had not been defined in a way that allowed for their study. Comparable affective constructs like *attitude* suffered similar constraints. *Identity*, in contrast, has been put forth by some educational

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[3] Some educational researchers also extend the notion of identity beyond a strict psychological entity to also include dispositions to act (e.g., Cooney, 2001).

researchers and social scientists as a possible alternative because of its discursive construction and explication.

Theoretical Debates on Identity

Identity has been theorized and employed by researchers from various philosophical and theoretical traditions. An analysis of the literature indicates that identity is a highly complex concept and "is not a single 'entity' that can be understood from any one perspective alone" (Grootenboer, Smith, & Lowrie, 2006, p. 612). Although there is some broad consensus that identity can be used to describe how someone or something is characterized as being a member of a group, an in-depth look at the relevant literature reveals three noticeable theoretical divisions (two of which are noted by Grootenboer et al., 2006).

The first and most prominent of the theoretical debates concerns the locus of identity. Depending on what lens is employed, the location of identity generally falls into one of three categories: located internally, distributed between individuals and community, or highly relativistic and fundamentally non-agential. Second, and related to the locus of identity, scholars take multiple stances with respect to identity formation. Therefore, the mechanisms by which identity is formed and the agents involved in that development are debated within the literature. The extent to which identity formation is subject to influence of others may be the most hotly contested issue amongst researchers; known in sociological circles as the "structure-agency" debate (Cote and Levine, 2002, p. 9). Some would describe identity formation as a cognitive process whereby individuals–through assimilation and accommodation–develop internal sets of beliefs. Within this lens, the responsibility of identity development falls to the individual. In contrast, others would focus on the social and cultural practices influencing identity development. Within this perspective, identity is not solely self-determined, instead being constructed and reconstructed through social interaction. Here, agency is distributed across individuals and community.

The third consideration in the relevant literature involves the stability of identity. Some researchers take the stance that identity is a fairly stable entity. That is, identity characteristics like gender, race, ethnicity, religion, ability, etc., are either innate or formed in early adolescence and endure throughout adulthood. These identity characteristics are not contextually dependent. In contrast, other researchers maintain that identity is fluid and is responsive to social, historical, political, and cultural contexts.

These different debates within the literature suggest that any viable theory of identity must take a stance with respect to each of the following variables: *location* (individual/social), *formation* (internal/external), and *stability* (static/dynamic). Grootenboer et al. (2006) reasoned that these differences point to three possible theoretical lenses:

- *psychological/developmental*, which primarily interprets identity as individual, internal, and fairly static;
- *socio-cultural*, which posits that identity is located both within and outside of individuals, is formed in and through socio-cultural practices, and is fluid across context; and
- *poststructural*, which views identity formation as a continual, relatively unstable process informed by historical, political, and institutional practices or discourses.[4]

Staking a claim to any one of these theoretical perspectives has definitional and methodological implications. That is, any one of these lenses answers differently the question of how one "captures" identity. What does one look for when attempting to study an identity? What is the

[4] In fact, poststructuralists are likely to take issue with the term identity and, instead, use the term *identity work* in order to challenge the conception of a 'fixed self'.

unit of analysis and, fundamentally, what does that unit represent? These questions will be considered in more detail below.

Gee's Theory of Identity and Related Constructs

As mentioned previously, I use a modified version of Gee's (2000, 2011) definition of *identity* as "being recognized as a certain kind of person in a given context." This definition implies certain theoretical and methodological commitments. In the section that follows, I begin with a suggested modification to this definition. I then unpack the important features of this modified definition and substantiate the claim that it falls primarily into the socio-cultural frame. Accordingly, I situate my study that operationalizes this definition within the aforementioned theoretical debates. Because Gee's theory of identity and the relevant constructs are not particular to mathematics, I also specify their meaning within a mathematics education context.

A Modification

One may note that the phrase "being recognized" within Gee's definition implies an actor or an individual engaged in the act of recognizing another as being a certain kind of person. As written, however, this definition does not explicate who is doing the recognizing and, therefore, is ambiguous about whether one can know or name oneself. As I take the stance that subjectivity is essential (i.e., the lens, values, prior experiences of the recognizer informs the recognition) and that the individual maintains some agency in their identity development, I would like to slightly modify the Gee definition to allow for self-recognition. That is, I define *identity* as "being recognized [by oneself or others] as a certain kind of person in a given context" (modification in brackets). This modification does not, by any means, conflict with Gee's interpretation. Instead, I make this addition in order to emphasize the relevant actors within identification or recognition. Of course, making this distinction begs the question, what happens if self-recognitions do not match the recognitions by others. For example, I may recognize myself as a *tough, but fair mathematics teacher* and my students might recognize me as a *difficult or mean math teacher* (even based on the same observations). The short answer to this quandary is that I consider both of these recognitions to be important "t-ruths" (as opposed to T-ruths, which are universal). That is, both identities are significant to the individuals engaged in that recognition. How such discrepancies will be dealt with methodologically is another concern, which I will address below.

Defining Mathematical Identity

Selecting mathematics as a particular set of practices with which individuals can engage allows us to modify Gee's definition of identity to define a *mathematical identity* as follows "being recognized by oneself or others as a *mathematical person* in a given context." Mathematical persons might include the socially recognized identities of a mathematics major, a mathematician, a mathematics teacher, someone who is good at mathematics, and so on. As is true with the broader definition of identity, this definition of a mathematical identity emphasizes identification as a social process and highlights the importance of context.

Identity Location, Formation, and Stability

Given these modified definitions of identity and mathematical identity, I attempt to situate Gee's conception of identity within the three previously described debates related to identity work. First, Gee's definition of identity is fundamentally social in that identity can only be generated through another's recognition (or at least, in the case of self-recognition, one's interpretation of how others recognized is necessary to consider). Said another way, one's identity cannot exist independent of individuals who might recognize it. Therefore, in terms of location, identity is fundamentally social, and is distributed across individuals within a context.

It is important to note that although not explicitly addressed in this definition, Gee's (2000, 2011) theory of identity does attend to interplay between agency and structure. Even though Gee's definition does not explicate a formation process as such, he offers something to the aforementioned structure-agency debate. In particular, he describes the process of *bidding* for an identity (Gee, 2011, p. 17). That is, at any moment, any individual attempts to be recognized by others as a certain kind of person. That is, an individual, through action and language, bids for the recognition of others as being a certain type of person. Whether or not the bid is accepted by others reflects one's ability to say and do what others would expect that type of person to do.

Therefore, within this construction, an attempt to identify oneself can be successful or not. In order for a person to successfully be recognized as a certain kind of person, however, requires that the identification is agreed upon by others. Therefore, identification is understood to be socially-constructed and the naming of ones' identity is necessarily social.

Finally, because identity involves being recognized as a type of person in a *given context*, this definition offered by Gee stresses contextual-dependency. That is, identity is understood to vary across space and time. Gee acknowledges, however, that some aspects of identity may be more "core" than others. According to Gee, individuals "through time, in a certain order, had specific experiences within specific Discourses (i.e., been recognized, at a time and place, one way and not another), some recurring and others not" (Gee, 2000, p. 111). This potential for reoccurrence means that some identities are theoretically more stable or enduring than others. In order to distinguish between those identities that are highly contextually dependent and those that may be more stable over time and space, Gee introduces the terms socially situated and core identities.

Core and Socially Situated (Mathematical) Identities

Core identity. Gee uses the term *core identity* for “whatever continuous and relatively (but only relatively) ‘fixed’ sense of self underlies our contextually shifting multiple identities” (Gee, 2011, p. 41). According to Gee, “We have this core identity thanks to being in one and the same body over time and thanks to being able to tell ourselves a reasonably (but only reasonably) coherent life story in which we are the "hero" (or, at least, central character)” (2003, p. 4). Examples of such identities might be being the eldest sibling or having a “genius” IQ. Naming these as core identities reflects the conceived persistence of these identities over time and space. In each of these examples, it is likely that those being recognized as that kind of person may reoccur and arguably may be somewhat stable over time and space. Nevertheless, as Gee would likely agree, although it may be true that a “certified genius” is a genius whether she is at the beach or at a MENSA meeting, being a genius may be more salient in one context over the other. Further, the implications of being a genius may change with age or with company kept, etc. Therefore even core identities are subject to change.

Core mathematical identity. Drawing on Gee’s notion of *core identity* (1999, 2011), Cobb and Hodge (2007) stated that the *core (mathematical) identity* for students is chiefly “concerned with [mathematics] students’ more enduring sense of who they are and who they want to become” (p. 167). As described above, this part of identity might be how most people think about a mathematical identity; a potentially more stable, longstanding understanding of the self in relationship to mathematics. As mentioned previously, aspects of a person’s core identity might include their religious or political affiliations, their career, or their gender, for example. Within the context of mathematics, a person’s *core mathematical identity* might describe how they engage with the discipline (e.g., as a student, teacher, accountant, researcher, etc.) or, possibly, their long-term beliefs about mathematics (e.g., girls aren't as good as boys at math, mathematics is necessary for my future success).

Socially situated identity. In contrast, Gee uses the term *socially situated identities* to designate how people "recognize and act out different social roles or different social positions in society" (2011, p. 207). Such identities are multiple in that any one individual enacts numerous identities when engaging in different practices or contexts. For example, an individual might be identified simultaneously as a White, middle-aged, out-spoken, male, factory worker, father, and golfer. But, which of these identities is most salient–and, therefore, which facets of identity are recognizable at any moment–depends on the context. Akin to the previous example, his identity as a golfer may be more tacit at work than if he were at a clubhouse, for example.

Socially situated mathematical identity. Alternatively, a student's *personal mathematical identity* is defined as "an ongoing process of being a particular kind of person in the local social world of the classroom" (Cobb & Hodge, 2007, p. 168; Cobb et al., 2009). This would be what Gee would refer to as a *situated identity*. Thus, it considers the individual aspects of identity that are immediate to the classroom context, for example. Because Cobb and Hodge were solely interested in classroom interactions, they defined the personal identity in relationship to the classroom context. This definition could be modified, however, to account for other local and social mathematical contexts. This is especially true within the context of my study, which considers other mathematical spaces, like colloquium talks, meetings, study groups, and the like. Consequently, I use the following modified definition for *personal mathematical identity*: "an ongoing process of being a particular kind of person in the local social world of *a mathematics community*" (modifications in italics).

To illustrate, consider a student who identifies himself as being a strong mathematics student, generally speaking. His experiences in mathematics have always been positive ones and he has been successful in previous mathematics classes. ‘Being good at math,’ then, might be an aspect of his core identity. Upon entry into an undergraduate Calculus course, though, he begins to perform poorly on examinations. His lack of success in this new course may cause him to renegotiate his core identity. Or, as I have witnessed with such students on multiple occasions, he might believe that his struggle is situational. He may believe that the immediate classroom context is somehow hindering his usual success. Therefore, his personal mathematical identity within that Calculus classroom may be very different from his core mathematical identity as a successful mathematics student. If this student continues to struggle in all of his future mathematics classes, however, his core identity may be disturbed and, as a result, may shift to account for his more recent experiences with mathematics. Thus, in the process of negotiating his personal experiences in the classroom, this student has questioned and reformed his core identity.

Core or situated identities. It is important to note that Gee’s primary concern is not the classifying identities as either core *or* as socially situated. Although he does not explicitly frame it in these terms, I understand Gee’s theory of identity in terms of a spectrum, which reflects contextual stability (See Figure 1). On one end of the spectrum are those identities that are static across space and time, and are, therefore, contextually independent. At the other end are those identities that are entirely dynamic over time.

Static Across Time and Space (Contextually Independent)	⟷	Highly Dynamic Across Time and Space (Contextually Dependent)

Figure 1. Identity Spectrum

Describing these extrema serves only a theoretical purpose, however, as neither of these conceptualizations of identity is operational. Identities on the right end of the spectrum are not traceable, as the relationship between identity and context is entirely chaotic. Here, there is absolutely no consistency of identities across contexts. It could be argued that this conceptualization reflects a most extreme poststructuralist perspective. On the left end of the spectrum, we have immutable identities–those that are completely fixed across contexts. Even though some from the psychological tradition might lean toward this conception of identity, most would agree that even those most basic categories of self–woman, White, heterosexual, and so on–evolve over time and across contexts. As such, a completely fixed conception of identity is not tenable either. I, along with Gee, take the stance that all identities are constructed and reconstructed through social interaction and, therefore, to some extent, are all socially situated.

Gee has argued that although core identity may be of interest, his work is primarily concerned with those identities that are socially situated. Because Gee gives his attention to identities enacted in relatively short time periods and confined within particular contexts, his theory does not give much attention to consistency of identity over time. Others (e.g., Anderson, 2007; Lemke, 2000) are more concerned with broader timescales and, consequently, formations of identity as seen across units of time and space. That is to say that other identity frameworks might be better suited to distinguish between core identities and others that are more socially situated.

Four Types of Identity

Thus far, I have described the ways in which the modification of Gee's definition of identity as "being recognized [by oneself or others] as a certain kind of person in a given context" and the complimentary definition of mathematical identity as "being recognized [by oneself or others] as a mathematical person in a given context" fit in the aforementioned theoretical debates. That is, identity is located both across individuals, is formed in and through social practices, and is fluid across context. Because I have yet to describe what is meant by "a certain kind of person," though, I do so in this section.

In order to clarify what is meant by a "certain kind of person," Gee (2000) designated four types of individual identities (what Gee calls *views of identity*). Table 1 summarizes these four types, each of which can be framed in terms of the *process* by which the identity is developed, the type identifying agent or *power*, and the *source of that power*.

Table 1

Four Types of Identity, Gee (2000)

		Process	Power	Source of Power
Nature-Identity (N-Identity)	a state	developed from	forces	in nature
Institution-Identity (I-Identity)	a position	authorized by	authorities	within institutions
Discourse-Identity (D-Identity)	an individual trait	recognized in	the discourse / dialogue	of / with "rational" individuals
Affinity-Identity (A-Identity)	experiences	shared in	the practice	of "affinity groups"

To clarify, each type of identity named in Table 1 describes individual identities. For example, even though the phrase Institution-identity might connote an *institutional* identity, instead, this phrase is meant to indicate that the institution was an agent in imparting that identity upon an individual. I explain each type of identity here.

According to Gee, a *nature-identity* (N-Identity) is "a state developed from forces in nature" (2000, p. 100). Such an identity is understood as being *innate* or *natural*. Some of these identities might be biological (e.g., sex). Others, in contrast, might be perceived as biological, but are essentially social (e.g., race). Examples of such an identity might be being Vietnamese, being a twin, or being female. As Gee noted, however, any one of these categories are only meaningful because we give them meaning. That is, these physical or genetic qualities are not *ipso facto* identities as we might think of them. For example, being biologically female is not, in and of itself, meaningful. It is those qualities that people ascribe to females (e.g., females are more emotional and less logical, females are more maternal than non-females) that make the identity worth noting and, therefore, establish the identity "female." Gee (2000), in contrast, argued that although it is true that he has a spleen, this does not constitute anything meaningful in terms of his identity. That is, when we think of "certain kinds of people," most individuals would not attend to the division between "spleen-havers" and "non-spleen-havers." Thus, despite having (or not having) a spleen may be just as natural as having (or not having) female sexual organs; only the latter is typically given identifying power as a result of its social meaning. Within mathematics, a *nature-identity* to which I have heard students, teachers, and parents refer to is the possession of a "math gene." Anecdotally, I have heard many people who do not identify as mathematically competent relate that perceived lack of competency to a "natural" state wherein they were not born with a math gene.

An *institution-identity* (I-identity), in contrast, is "a position authorized by authorities within institutions" (Gee, 2000, p. 100). Such an individual identity depends on the approval of the appropriate authorizing bodies. Here, the source of power is not nature, but institutions. Being an actuary might be one such example. In order to earn the title and position of actuary, an individual has to gain approval by appropriate institutions and acquire the necessary documentation–a Bachelor's degree in mathematics or actuarial science and passing scores on the required preliminary actuarial examinations. Without approval from these institutions, an actuary is unlikely to be recognized as such. That is, no matter how knowledgeable this individual may be about mathematics, statistics, or economics, firms will not employ an un-licensed individual. An institution-identity, then, is dependent upon authorization of other socially recognized bodies. Within mathematics, being a mathematics teacher, mathematics professor, a research mathematician or another type of mathematics specialist would be examples of institution-identities.

The third view of identity is that of a *discourse-identity* (D-identity), which Gee defined to be "an individual trait recognized in the discourse/dialogue or/with 'rational' individuals" (2000, p. 100). An example of such an identity is "being a good problem-solver." Being a good problem-solver, Gee argued, is informed and reinforced by social interaction. If I identify another person as a good problem solver, I will treat them as if they are a good problem solver. Through implicit and explicit communication (asking a friend for help when thinking through a mathematics problem, or telling my friend that I she is really good at this whole problem-solving thing), my discourse creates and reinforces an identity as a good problem solver. As Gee (2000) argued with respect to charisma, "It is only because other people treat, talk about, and interact with my friend as a charismatic person that she is one" (p. 103). Thus, discourse-identities are those personal traits created and maintained through dialogue with others.

The last view of identity according to Gee is an *affinity-identity* (A-Identity), which reflects "experiences shared in the practice of 'affinity groups'" (2000, p. 100). Examples of affinity groups may include sports fans (e.g., being a Detroit Tigers fan), fans of popular cultural (e.g., being a "Whovian" or a Doctor Who fan), or being a member of a club (e.g., the Putnam Examination Club). The important thing to note about affinity-identities is that they are primarily about participation in certain practices. For example, one is unlikely to be recognized as a member of your school's Putnam Examination Club if they do not attend meetings. Gee argued, "for members of an affinity group, their allegiance is primarily to a set of common endeavors or practices and secondarily to other people in terms of shared culture or traits" (2000, p. 105). In other words, the practices of being a certain type of member are central when it comes to affinity groups. Although those practices are likely to involve others, the compulsion to engage in those activities lies within the activities themselves rather than a desire to interact with others. For example, having an A-Identity as a "Putnam Club Member" means attending weekly problem-solving sessions, reading and responding to group e-mail, taking an annual, six-hour William Lowell Putnam Mathematical Competition Examination, practicing previous Putnam problems at home, attending a celebratory dinner after the examination, looking at school and individual rankings, etc. Although being a Putnam Club Member may include interactions with other members, this is not the primary motivation for engaging in related affinity-group practices.

It is important to note that these views on identity are not mutually exclusive. Any identity may be viewed through multiple lenses in order to illuminate different ways of "being recognized as a certain kind of person." "Being intelligent" is one such example. Some people believe that intelligence is innate–that people are naturally gifted with intellectual capabilities. For example, Thorndike (1922) described children as either *bright* or *dull* in order to distinguish between those who he believed had "high native ability" and those that did not. Although it may be less common for teachers and educational researchers to use these terms, such views on the innateness of intelligence persist and are reflected in discourses (e.g., left-brained students are better in mathematics or science). Thus, intelligence can be framed as a nature-identity. This, of course, may be closely related to intelligence as a discourse-identity. For example, being smart in school mathematics is often portrayed as an individual trait and is enforced by others through discursive action. Rephrasing an earlier quotation by Gee, "It is only because other people treat, talk about, and interact with the student as a smart person that she is one" (2000, p. 100).[5]

Being intelligent can be framed yet another way, as an institution-identity. One way of being recognized as having exceptional intellectual ability is to earn high scores on examinations like the SAT or ACT. When students earn top scores on such examinations, it increases the likelihood of their being accepted at top schools and earning financial scholarships because these examinations are assumed to be some measure of intelligence and, relatedly, to predict academic success. As such, standardized testing agencies, using examination scores, can endorse a student's status as intelligent. Relatedly, taking an IQ examination and earning a high score opens us the possibility of joining intelligence affinity groups like Mensa, "the High IQ society." The only qualification for membership to Mensa is "being exceptionally intelligent"–determined by the attainment of an IQ score within the upper two percent of the population. As such, being a member of Mensa is an "intelligence" affinity identity.

Using each of the four views on identity, then, we are able to see how "being recognized as an intelligent person" might take on different meanings. The process by which intelligence is developed, the implicated identifying powers, and the sources of those powers differs from one view to the next. Which view is evoked, however, can tell us something about power and about

[5] Here, it is also important to recognize the importance of contextual discourses in determining such identities. For example, some people identified as "intelligent" might be considered "book smart, but not street smart" in other, non-school settings.

identity construction. In this example, constructing one's identity as naturally intelligent might have different implications for speech and action than, say, discursively constructing one's identity as smart. In the former view, one's identity is given and little, perhaps nothing can change intelligence. In the latter view, changes in action and speech might impact how one is viewed as intelligent.

The Role of Context

Another salient feature of Gee's definition of identity that is important to this study is context. This idea is important not only because the definition includes a reference to "a given context" but also because of the broader sociocultural conceptualization of what is meant by identity. Specifically, if identity is seen as fluid over time and space, and is constructed and reconstructed through interactions with others, it is important to account for the contexts in which that construction happens. What is meant by *context*, though, requires some explanation. According to Gee (2011),

> Context includes the physical setting in which a communication takes place and everything in it; the bodies, eye gaze, gestures, and movements of those present; what has previously been said and done by those involved in the communication; any shared knowledge those involved have, including shared cultural knowledge. However, context is both something "already there" and created by the way we talk. What speakers say keys people to construe the context in certain ways while, at the same time, people use how they view the context to interpret what is said. We called this the "reflexive property" of language and context. Listeners use only what they deem the relevant parts of context to interpret what was said. (p. 203)

As such, context is not limited to physical space, but is extended to include discursive space. By discursive space, we mean all of those contextual factors (like setting, body language, common referents, and shared cultural knowledge) that mediate discursive interactions. When Gee refers to context, then, he describes all of the elements relevant to meaning making within such social interactions. Because context includes "the physical setting in which a communication takes place and *everything* in it" (emphasis added), it becomes clear very quickly that one cannot possibly attend to all aspects of context when attempting to communicate. As such, which aspects of context become relevant are strongly situated.

As defined, the concept of context reflects local level (e.g., eye gaze) through global level (e.g., historical setting) factors. Within the context of a research study about the identities and experiences of women mathematics majors, for example, context might be constituted by the immediate interview environment and the verbal and non-verbal interactions that take place in that setting (e.g., the interactions between a mathematics education researcher, who has earned advanced degrees in mathematics, and comes from a working class background and community, and the student she is interviewing). It might also extend to include the institutional cultural of a liberal arts college and the local neighborhood culture of a LGBT friendly, predominately middle-class, White, liberal neighborhood. Even more, the social, historical, and political setting may be a relevant part of the context. In this example, it may include the histories around women's-only education, or the broader social narratives about gender equality, or schooling and meritocracy. Again, it may be the case that any part of the context may become more or less salient within a social interaction. The point here, though, is that all elements of the context serve to frame that interaction. That is, the physical and discursive space in which the communication takes place is constituted by the context at each level.

In order to explain what is meant by context and how relevant elements of context are related to one another, I have developed an illustration (see Figure 2). Specifically, I unpack which elements of context are relevant by looking at four different grain-sizes: *the global context*, *the institutional context*, *the local context*, and *the immediate communication context*. These different grain sizes do not explicitly come from another source. Based on my prior work and investigations into situated, sociocultural studies in mathematics education, these four grain-sizes have emerged. That is, looking across the relevant literature, attention has been given to context at each of these levels.

At the global level, we have the social, historical, and political contexts (e.g., the contexts of Post-Sputnik STEM Education, the media's narrative that the gender-gap is now closed, and gender and marriage equality in the United States). Within that broader context, we have a slightly more localized context of the institution (e.g., a mathematics department, a liberal arts college). Within that institution, there are certain cultures and particular policies. Here, I am primarily concerned with structural context. In addition to institutional contexts, there are local contexts, which include those elements of context that reflect the practices of local people. A specific example might be a neighborhood in which the local context is reflected in practices and norms, and the backgrounds, experiences, and cultures of participants in that neighborhood. Lastly, at the local level, context is also made up of the immediate communication setting. At this level, aspects of context include the physical setting (e.g., a clinical interview) and the verbal (e.g., passive tone) and non-verbal communication (e.g., tense body language) taking place.

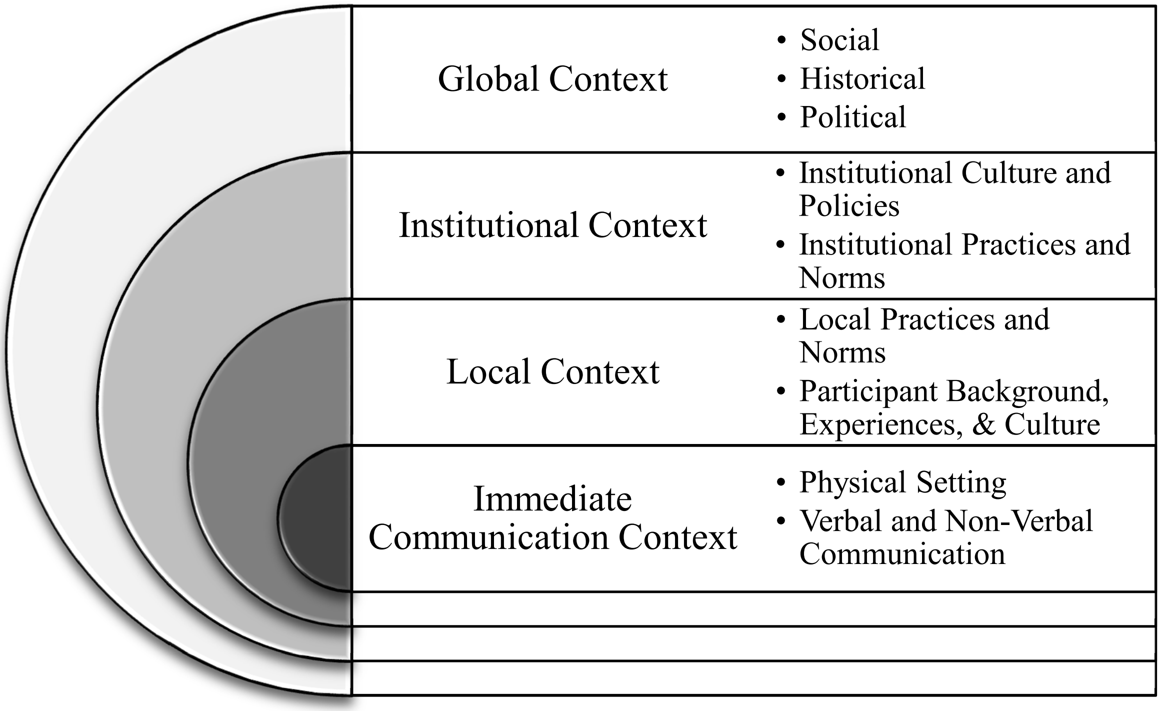

Figure 2. Grain-Sizes for Context

Taken together, these four levels of context provide a theoretical and interpretive foundation for understanding identity. Because any instance of discourse can be contextualized at each level, it is important to be aware of, to be able to account for, and to move fluidly between each grain size.

Discourses and Figured Worlds

So far, I have made only theoretical considerations for "what is" without describing "what should be." Said another way, we have only considered states of affairs–e.g., whether someone *is* or *is not* a doctor–and have refrained from talking about evaluation–e.g., what a doctor *should* do, say, and look like. Based on our experiences with doctors, we each develop theories about what characteristics a "normal" or "typical" doctor possesses and, relatedly, what a "normal" or "typical" visit to the doctor's office might entail. As such, we all build models about who becomes a doctor, what it means to be a doctor, what interactions with a doctor should look like, and so on. Also called a "cultural model" or "discourse model," Gee (2011, 2014) has most recently used the concept of figured worlds to describe such models. Drawing on the work of Holland and colleagues (1998), Gee defined a *figured world* as follows: "a theory, story, model, or image of a simplified world that captures what is taken to be typical or normal about people, practices (activities), things, or interactions" (2011, p. 205)[6]. Of course, what is taken to be "normal" or "typical" is contextually dependent.

Gee argued that it is these figured worlds that allow us to assign significance and give value to identities and practices. Figured worlds inform our evaluations of other people, thereby allowing us to recognize someone as a certain kind of person (e.g., a "typical" lawyer). Further, figured worlds provide the lens through which we view situations, activities, and interactions (e.g., determining if it is a "normal" college party or not). In short, figured worlds allow us to make evaluations because they give us reference for what is appropriate, normal, or typical based on our experiences. Because we continue to have new experiences and, are therefore are challenged to adjust our assumptions over time, figured worlds are subject to change. As Gee, argued, however, these models tend to be persistent, even when confronted with other possibilities. For example, more and more students are having experiences in "reform classes"; yet, when asked to think about a "typical mathematics class," the following picture is likely to come to mind (Wilson, 2003):

[6] According to Bialostock (2002): cultural models are "socially constructed cognitive schemas of thoughts and feelings that mediate the interpretation of ongoing experiences and the reconstruction of memory. These models, widely shared among specific social and cultural groups, are tacit theories (and not necessarily logically consistent) that depict prototypical events (which we take to be "normal" events) in a simplified world. As such, cultural models are highly motivating and thus guide our actions. They not only label and describe the world, but also set forth conscious and unconscious goals that elicit and include desires." (p. 348)

> Classroom talk is highly predictable, tightly controlled. Students raise their hands, the teacher acknowledges the student and the question, directing the answer back to the questioning student. Students typically don't talk among themselves (unless they are misbehaving). The teacher and text are the center of attention. Midway through class, the teacher assigns homework problems (often the ones that don't have answers in the back of the book). Students sit quietly, scratching out answers. The teacher sits, also quietly, reviewing homework papers, helping students with specific problems. Mathematics in these classrooms is presented as a collection of facts and procedures; learning mathematics is a process of practice and memorization. (p. 7)

He argued that although people may be able to articulate perfectly normal, "other" visions of learning when prompted (e.g., reform teaching and learning), it is unlikely that their figured world of mathematics learning would be strongly modified to account for such scenarios.

Discourses, with a capital "D," is used by Gee (2000) "for ways of combining and integrating language, actions, interactions, ways of thinking, believing, valuing, and using various symbols, tools, and objects to enact a particular sort of socially recognizable identity" (p. 201). At its core, then, Discourses are the ways of being or doing that allow an individual to be recognized as a particular kind of person. As such, Discourses are the essence of identity. In order to be recognized as a mathematics teacher, I must walk, talk, act, and do like a mathematics teacher walks, talks, acts, and does.

Pragmatically, figured worlds are different from Gee's better-known concept of Big "D" discourse because figured worlds are about *perception and evaluation* whereas Discourses are about *enactment*. These concepts are inextricably linked, however, because anytime we enact a Discourse, we are drawing on our figured worlds. That is, my assumptions about what a good or typical mathematics student looks like, acts like, and talk like (figured worlds) informs how I enact the identity of mathematics student (which Discourses I enact). That said, it is possible for individuals to bid for identities that may not reflect their assumed figured world. Within this study, in fact, it may be possible for students to intentionally invoke multiple Discourses (e.g., being a woman *and* being a mathematician) or other Discourses (e.g., being a non-nerdy mathematician) in order to challenge current conceptions of mathematical identity.

Mathematical figured worlds and Discourses. Within mathematics, mathematical figured worlds are those figured worlds that account for mathematical people or mathematical practices. Specifically, a *mathematical figured world* is "a theory, story, model, or image of a simplified world that captures what is taken to be typical or normal about [mathematical] people, [mathematical] practices (activities), [mathematical] things, or [mathematical] interactions" (additions in brackets). Specific example might include contexts or communities like the mathematics classrooms, mathematics colloquia or study groups, professional mathematicians' communities of practice, and so on. Mathematical figured worlds also provide us with a way to think and talk about people–a "model" mathematics student, mathematics teacher, a research mathematician, and so on. Similarly, *mathematical Discourses* are "ways of combining and integrating language, actions, interactions, ways of thinking, believing, valuing, and using various symbols, tools, and objects to enact a [mathematical] identity" (Gee, 2011, p. 201). In other words, mathematics Discourses are ways of enacting a mathematical identity.

Figured worlds, Discourse, and context. Thus far, I have introduced three new terms, which are relevant to identity–context, figured worlds, and Discourses. The relationship between these terms is complicated, as they are all broad, multi-level theoretical constructs. Based on their accompanying definitions, *context* can be understood as the physical and discursive setting in which communication take place; *figured worlds* can be understood as models for perceiving and evaluating those context (e.g., people, practices, and tools); and *Discourses* are ways of enacting a particular identity. Within this study, a *context* might be a mathematics classroom (as housed within a department, within a college). The *figured world* by which that context is evaluated as being normal, good, and so on, may be the figured world of a traditional classroom, of a reform classroom, or of a classroom at an all-women's college. Lastly, the *Discourses* in this scenario might include all of the ways of talking, doing, and being in a mathematics classroom. This might include enacting mathematical identities like "being a topologist" or "being logical," or non-mathematical ones like "being funny," "being a leader," or "being girly."

The Discursive Construction of Gender in Mathematics

Having clarified what is meant by identity and the related constructs of context, figured worlds, and discourses, it is now important to consider the role of gender in this study. Just as Martin (2000, 2009) argued that race is a central feature of identity that researchers must attend to when engaging in identity work, I argue that gender is significant. Further, in the same way that his framework accounts for students' racial identities and attends to the ways they negotiate a path through mathematics *as black youth*, my study attends to the ways in which my participants negotiate a path through the undergraduate mathematics *as women*. Due to the fact that I work with a group of individuals who all attended a *women's* college and are speaking to their experiences as women in mathematics, what is meant by "woman" must be clarified and I do so below. Specifically, I state my own meaning of the term gender in this work and explore its' relationship to identity, as I have defined it.

Although gender is clearly related to identity, it is also the case the gender is linked to context, to figured worlds, and to Discourses. That is, a context can be gendered based on the practices and discourses engaged in within that context. Figured worlds and Discourses can also be gendered in the sense that our models of the world include gendered ways of being and doing. Because mathematics itself has been described as a gendered practice, I complete this chapter with an overview of the Discourses surrounding mathematics and gender. Overall, the goal of this overview is to more clearly articulate Gee's framework to make it more specific to the particular Discourses and figured worlds I investigate in this study.

Gender and Identity

Like identity, the concept of gender has been unfailingly difficult to define (Damarin & Erchick, 2010; Glasser & Smith, 2008). Broadly, the stance I take with respect to gender is that, like other aspects of identity, it is socially constructed and dynamic. Consistent with the proposed theoretical framings, my conception of gender is discursive. This means that my perception of gender

> focuses attention on the [language and] *actions* of gender-constructing persons within the "regime" or institutions and culture. Gender is a performance that is constantly in flux. Instead of being a product of natural "identity," gender performances actively create the individual's identity (Glasser & Smith, 2008, p. 349).

That is, genders, like other identities, are socially constructed and enacted. Further, how this identity is enacted is likely to differ from one individual to the next. That is, how an individual enacts the identity of woman is likely to vary across time and space, and to differ across individuals.

Specifically returning to Gee's original definition of identity, a gendered identity, or gender, might be understood as "being recognized as a gendered person within a given context"; however, this conceptualization of a "gendered person" is just as ambiguous. In some sense, however, I am not interested in developing an objective or concrete definition of "gender" or of "woman." Rather, I am concerned with each individual's sense of how she constructs and enacts her gender and how this relates to the ways in which she constructs and enacts her mathematical identity. That is, I wish to gain insight into how "being recognized as a mathematical person" may relate to "being recognized as a woman." As such, I focus on an individual's gender within this study to the degree that she deems it salient to her college mathematics experiences. To better understand what is meant by "being recognized as a woman," and relatedly, how I attend to gender within the confines of my study, I return to Gee's aforementioned types of identity. Specifically, I consider *woman* as a nature-identity and as a discourse-identity, and how those conceptions may differ.[7] I present these views of gender identity not as an endorsement for any one, but as a way to describe possibilities of interpretation. That is, "being recognized as a woman" means different things to different people in different contexts, and, as such, it is important to understand each type.

Woman as a nature- or discourse-identity? Recalling the definition of nature-identity as "a state developed from forces in nature," gender can be framed as something innate or natural. Such a view of gender is consistent with *biological essentialism*, "which presupposes two sexes–male and female–[and] views gender as a direct progression from an individual's biological sex. According to this perspective, "masculine" or "feminine" behavior is decided by biology and fixed in nature" (Glasser & Smith, 2008, p. 346). That is, within this framing, *sex*–understood as dichotomously constructed biological categories of "male" and "female"–determines *gender*–understood as behavior, over which individuals have little agency. Within this framing, "being recognized as a woman" happens when an individual engages in those behaviors expected of women and when that individual fits the appropriate biological category.

Alternatively, framing gender as a discourse-identity–"an individual trait recognized in the discourse/dialogue or/with 'rational' individuals"–gender is instead understood as a discursive construction. This second framing of gender is consistent with social constructivist

[7] Although one might also investigate how gender might be understood as an institution-identity or an affinity-identity, these two views were not foregrounded in here because they were not as prevalent in the ways my participants talked about gender or in the Discourses framing what it means to be a woman in mathematics.

theories of gender, which focus on "the enactment of gender in discourse and action" (Glasser & Smith, 2008, p. 346). In this view, "gender is more a doing than being" (Damarin & Erchick, 2010, p. 318). That is, gender is understood as a *performance* (Butler, 1999, 2004) wherein individuals have agency to draw upon gendered Discourses to enact particular gendered identities. These performances are subject to change over time, space, and context. Within this framing, gender is understood as a socially situated identity that is discursively enacted. In other words, "being recognized as a woman" means that others endorse an individual's speech and actions as if she were a woman. Once again returning to a quotation by Gee (2011, p. 103), "It is only because other people treat, talk about, and interact with my friend as a woman that she is one."

Although I adopt the latter framing of gender (as a discourse-identity), I am aware that the perception of gender as a nature-identity cannot be disregarded. In two different analyses of recent mathematics education literature and science education literature, respectively, Damarin and Erchick (2010) and Glasser and Smith (2010) concluded that educational researchers often conflate *sex* and *gender*. Even in instances where gender was described as something more than or different from sex, authors were not able to specify "the mechanism of gender construction" (Glasser & Smith, 2008, p. 346). As such, understanding gender as directly linked to sex is a common (mis)conception not only within the research literature, but also in broader discourses about gender.

Gendered Mathematics Discourses and Figured Worlds

Many scholars focused on the role of sex or gender in mathematics have argued that mathematics is a male domain (Burton, 2004; Damarin, 2000; Frade, Acioly-Regnier, & Jun, 2013; Mendick, 2005, 2006). This perception can be seen not only in the public's view of the model mathematician being male (Picker & Berry, 2000; Rensaa, 2006; Wong, 1995), and the large proportion of males in mathematics at the most advanced levels, but also in the history of women's roles in mathematics. In order to understand what that roles is and how it may have changed over time, Rogers and Kaiser (1995, p. 3) described the role of women in mathematics in five discernable phases:

Table 2

Five Phases of Women in Mathematics, Rogers & Kaiser (1995)

Phase Number	Description of Phase
One	Womanless mathematics
Two	Women in mathematics
Three	Women as a problem in mathematics
Four	Women as central to mathematics
Five	Mathematics reconstructed

Although it is true that it is more culturally acceptable for women in many countries to learn mathematics beyond arithmetic (Cohen, 2003) and that women are participating in mathematics in greater numbers, I would argue that there are still many ways in which women are seen as a problem in mathematics. This means that even though women are *in* mathematics, they are still often viewed in deficit to their male counterparts and are not understood to be essential to the advancement of the discipline of mathematics.

Rogers and Kaiser (1995) posited that we are currently in a transition phase between phase three and four, and are therefore coming to see women as being central to the creation of mathematics. The difficulty of gaining traction with this argument, however, lies in the discursive construction of mathematics itself. Although similar arguments have been made within the science education communities —namely, that the absence of women in biological and physical sciences has lead to inherent biases within those fields (Harding, 1991)—few have been able to successfully articulate the ways in which mathematics itself has been impacted by an underrepresentation or exclusion of women. This is a result of "real mathematics" being viewed as "a universal truth" and, therefore, removed from human creation (Damarin, 2008; Hottinger, 2016). If mathematics itself is characterized by objectivity and independence from people, then the inclusion or exclusion of women does not or could not matter to its advancement. This means that arguments about women's place within mathematics and, resultantly, how mathematics might be changed for the better upon inclusion of women within it, have yet to be articulated by the field. Damarin (2008) argued that these dominant conceptions and the corresponding gendered Discourses of mathematics as an objective rationality "form a barrier to feminist work" (p. 116). As a result of this special status afforded mathematics, it has been difficult for scholars to make an argument about the role of feminism within mathematics and, resultantly, how to describe the current role of women in mathematics.

Understanding that women and girls are often still seen as a problem in mathematics, scholars have begun to engage in research that attends to the structures which produce a conception of women as a problem in mathematics (Rogers & Kaiser, 1995; Burton, 2004). Specifically, these scholars have worked to illuminate and, at times, to challenge the discursive construction of women in mathematics.

One such longitudinal study of children aged 4 to 15 in 39 classrooms over several years, conducted by Walkerdine and colleagues in 1989, found that student performance was interpreted differently by teachers, depending on the gender of the student. Specifically, Walkerdine found that boys were consistently praised for their natural ability and, even in instances when they "underperformed," teachers described their male students as "having potential." Girls, in contrast, were primarily described by their teachers as hard workers and were usually only praised for their ability to follow rules rather than for innovating thinking (Walkerdine, 1989):

> No matter how well girls were said to perform, their performance was always downgraded or dismissed in one way or another. These pejorative remarks usually related to the idea that girls' performance was based on hard work or rule-following rather than brains or brilliance (in others words what was supposed to underlie real mathematical performance). This reading of girls' performance was consistent across schools and the age-range. (p. 268)

Walkerdine (1989) argued that difference in teachers' perceptions of girls and boys reflected the discursive construction of mathematics itself. That is, teachers may have been unable to perceive their female students as being successful in mathematics because of the ways in which Discourses about being a girl or woman are incompatible with those Discourses associated with being a good mathematics student. She argued that "The discursive production of femininity [is seen] as antithetical to masculine rationality to such an extent that femininity is *equated* with poor performance, even when the girl or woman in question is performing well [italics original]" (p. 268). Hottinger (2016) further articulated this gendered construction of the discipline of mathematics itself:

> A close association exists between masculinity and reason, such that traits considered central to the activity or reasoning—logic, neutrality, a lack of emotional connection, and a separation between the knower and the object of knowledge—are also stereotypical traits of masculinity. Thus, reason can also be seen as a flight from traits stereotypically considered feminine—empathy, creativity, intuition, embodiment, and connection. (p. 15).

The incompatibility of femininity and mathematical subjectivity can be seen not only in the ways that teachers talk about female students, but also in the ways that females students talk about themselves. In a study of 43 undergraduate mathematics majors in England, Mendick (2005) found that female students were unable to see themselves as "good" at mathematics and not a single one of them described themselves as mathematicians (even the highest performing female students). Rodd and Bartholomew (2006), through a longitudinal study of male and female undergraduate mathematics students, similarly found that participants saw mathematical ability as contradictory to femininity. Specifically, they showed that female students described themselves during interviews in ways that rendered themselves as either "special" or "invisible." In the case of being "special," female students explained away their mathematics ability or talent by describing themselves as either having a mathematics gene or indicating that they had always been good at mathematics. Their specialness, Rodd and Bartholomew argued, derived from their status as both mathematically competent while at the same time being female: "These very academically successful students have polished their respective childhood images of being mathematically special, which is part of how they achieve being mathematical women" (p. 42). In other instances, they found that female participants seemed to "retreat into stereotypically feminine roles for self protection" (p. 45). Such students spoke up much less than their male peers and, in the few occasions when they did say something during lecture, seemed embarrassed and actively downplayed their contributions. For both types of responses, it seemed that female students were responding to the contradictions inherent in Discourses of being a woman and being mathematically competent by choosing either to embrace one part of their identity, while downplaying the other.

Together, these studies help us to understand the ways in which mathematics itself is gendered and that being "mathematically able" is an inherently complex and complicated position for women to inhabit. They also make visible the particular Discourses that produce gendered binaries, as Mendick (2005) articulates below:

> 'Real mathematics' is different from other subjects; it is certain and rational; 'real mathematicians' are different from other people; they combine the flattering character of geniuses and heroes with the unflattering character of 'nerds'. These discourses are oppositional and gendered; they inscribe mathematics as masculine, and so it is more

> difficult for girls and women to feel talented at and comfortable with mathematics and so to choose it and to do well at it. (p. 217)

Gendered Activities and Teaching Practices

Many scholars have argued that these Discourses which "inscribe mathematics as masculine" play out in current teaching practices and classroom norms which favor masculine ways of knowing. In response, some have proposed teaching practices and environmental supports which may be seen as more "female-friendly" (Burton, 1995; Fennema, 2000; Morrow & Morrow, 1995). Building on *Women's Ways of Knowing* (Belenky, Clinchy, Goldberger, & Tarule, 1988), these scholars have indicated that such practices include (a) engaging in inquiry based on belief, rather than doubt; (b) allowing risk-taking behaviors in young women rather than rescuing them at the first sign of struggle, but to do so with support; (c) encouraging group work and assigning roles that make expectations for participation explicit; (d) discouraging competitiveness, and lastly; (e) emphasizing mathematical processes over product.

Some would argue that these practices are just good practices, which reflect current mathematics education policy shifts toward "making sense of problems" and "constructing viable arguments and critiquing the reasoning of others" (Common Core State Standards Initiative, 2010; National Council of Teachers of Mathematics, 2000). Fennema (2000) argued, though, that it may not be the goal to find practices that "will enable all students to learn in an equitable fashion" due to the fact that teachers beliefs often play bigger roles than observable classroom practice. Instead, the goal might be to find practices that expressly focus on the success of girls and women in mathematics.

Research Questions

The purpose of this qualitative study is to gain insight into the mathematical identities of senior women mathematics majors, to understand their assumptions about what it means to know and do mathematics, and to describe the role that an all-women's context might play in their descriptions of themselves or of mathematics. As such, I focus on *identity, context,* and *Discourses*. The concept of a *mathematical identity*–being recognized as a mathematical person in a given context–is central to this study. To this end, I pose the following research questions:

- *What language do senior women mathematics majors at an all-women's college use to describe their mathematical identity development?*
- *How might the context of an all-women's mathematics department be described as relevant to students' identity development? Specifically, what activities do mathematics majors at an all-women's college describe as significant to their experience and how do they describe their relationship to others within that context?*
- *What mathematical Discourses do senior women mathematics majors at an all-women's college know, assume, question, or reject? What seems to be the relationship between their identities and those Discourses?*

The first research question focuses on identity development and recognition, that is, how student's discourse describes their mathematical identity development and other related identities. The second set of questions focuses on description of the particular all-women's context of Metcalf, particularly the community practices and relationships. The third set of questions focuses on developing and understanding participants' interpretive and evaluative models–specifically, about what it means to know and do mathematics as a woman. Overall, my aim is threefold: I aim to be able to say something meaningful about (a) who these women are, (b) what meaning is ascribed to knowing / doing mathematics by these women, and (c) how the context of an all-women's college seemed to shape their relationship with mathematics.

Figure 3, below, illustrates how I see the various research topics being interconnected and overlapping. In order to understand mathematical identity development for these young women, I believe that it is necessary to (a) explore their identities, both inside and outside of the context of Metcalf, and aspects of their identity that might not be distinctly "mathematical"; (b) better understand the many Discourses which create images of mathematicians, mathematics majors, mathematical people, and women; and (c) gain insight into the history and purposes of an all-women's context.

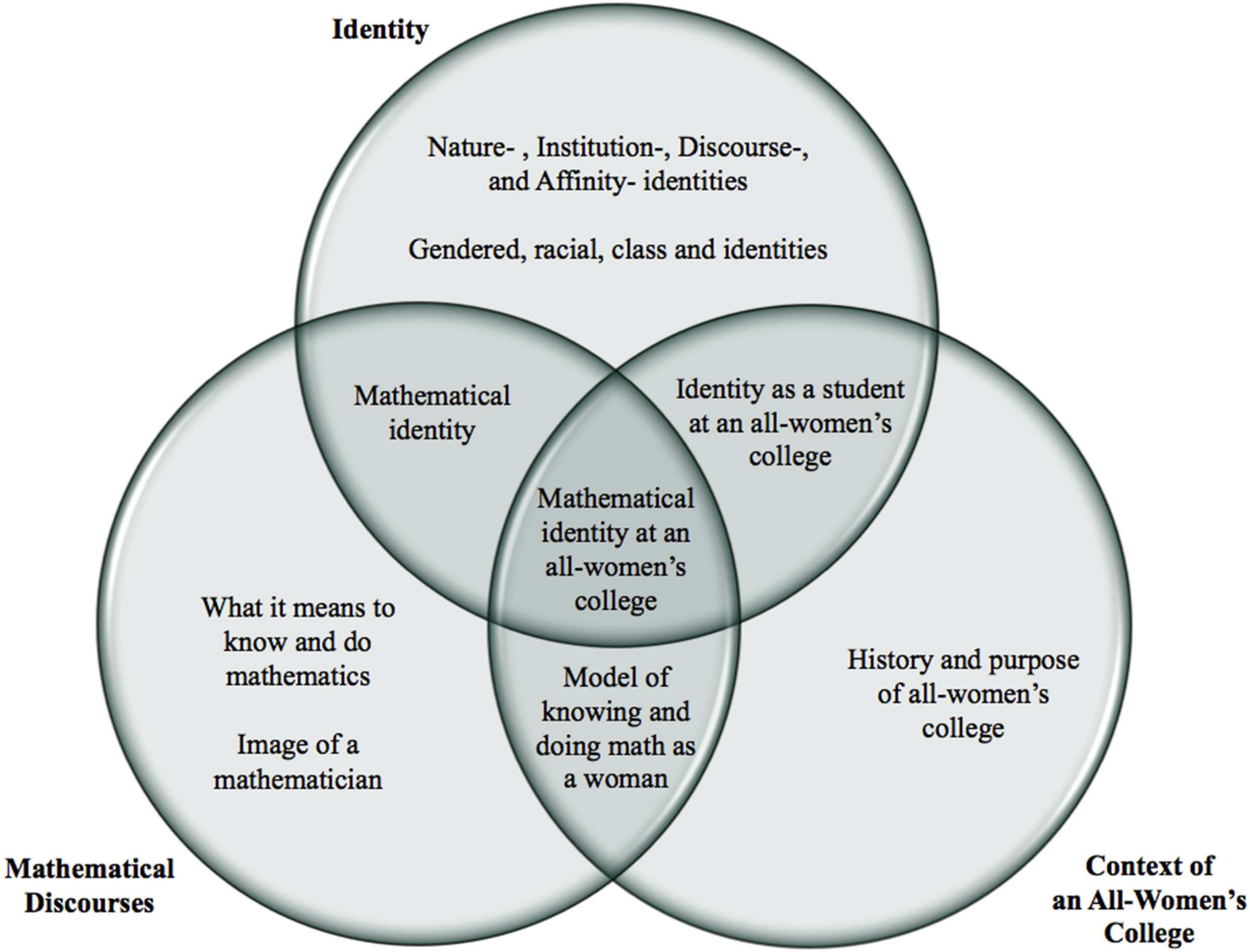

Figure 3. Research Topics Venn Diagram

CHAPTER THREE: RESEARCH DESIGN, METHODS, SETTING, AND PARTICIPANTS

Study Design Overview

Creswell (2007) conceptualized *exploratory studies* as those that "investigate a phenomenon little understood" and *descriptive studies* as those that "describe the phenomenon" (p. 107). As such, the purpose of my study is to *explore* and *describe* the identities of senior women mathematics majors, their assumptions about what it means to know and do mathematics, and the nature of learning mathematics at an all-women's college. In the following sections, I describe and justify the research methods I intend to employ to explore and describe the identities of women mathematics majors in an all-women's college. I begin by explicating my epistemological perspective and providing an overview of the guiding strategies of inquiry. Following, I give relevant details about the settings and participants, and also discuss my role as the researcher. This will be followed by a description of my analytic procedures. A summary table of my data collection and analysis can be found in APPENDIX G: Data Collection and Analysis Summary.

Epistemological Perspective

Consistent with the theoretical framings of this study, the epistemological perspective guiding this work is situated and sociocultural. Similar to other central concepts in this study, though, what is meant by a situated, sociocultural view is not self-evident. "There is no one accepted situated/sociocultural view, but rather a variety of different perspectives developed in work using different disciplinary lenses from areas like the learning sciences, cognitive science, sociolinguistics, and cognitive anthropology" (Gee, 2008, p. 81). Broadly, this view shifts attention from the individual mind–formerly front and center within the cognitive paradigm–to participation within social practices. According to Gee (2008):

> A situated/sociocultural viewpoint looks at knowledge and learning not primarily in terms of representations in the head, although there is no need to deny that such representations exist and play an important role. Rather, it looks at knowledge and learning in terms of a *relationship* between an individual with both a mind and a body and an environment in which the individual thinks, feels, acts, and interacts. (p. 81)

Adopting this epistemological stance necessitates attention to social practices and context.

The adoption of situated, sociocultural theories by some mathematics education researchers has signified a particularly important paradigmatic shift within mathematics education research. This "social turn" in mathematics education indicated "the emergence into the mathematics education research community of theories that see meaning, thinking, and reasoning as products of social activity" (Lerman, 2000, p. 23). Through this perspective, learning mathematics can be viewed as a process of enculturation in the practices of the mathematics community (e.g., a classroom, study group, or mathematics department). Within the context of mathematics education research, those who subscribe to a situated, sociocultural perspective would argue that the learning of mathematics "can be understood in general as talking and acting in the ways that mathematically competent people talk and act when talking about mathematics" (Moschkovich, 2002, p. 199). In this way, learning mathematics *is* learning how to participate within a mathematics community like the classroom, a mathematics colloquium, or a mathematics study group and, therefore, is inextricably linked with mathematical identity development.

Strategies of Inquiry

As indicated by the above research questions, my goal is to gain insight into the identities of senior women mathematics majors, to understand their assumptions about what it means to know and do mathematics, and to describe the Discourses shaped in and by their experience in mathematics. This means that I must attend to three analytic grain sizes: (a) individuals, (b) a group of individuals who have shared experiences, and (c) the broader practices (activities) and Discourses. Due to the multifaceted nature of this study, I chose to employ multiple qualitative strategies. Specifically, I look to sociolinguistic and ethnographic traditions for guidance, which I now consider in turn.

Although Gee provides great detail about how to interrogate a piece of language, he does not explicitly justify which types of data he collects or his original purpose in collecting that data. His reliance on interview methodologies–which are sometimes supported by language captured in non-interview, social settings–can be explained by his association with sociolinguistics. According to Juzwik (2006), "despite the interdisciplinary range of his scholarship, Gee's method of discourse analysis emerged from and contributed to a well-established tradition of sociolinguistic study. And the work derives much of its credibility from these shoulders on which it stands" (p. 19). This means that Gee work is built on the premise that language use and its implications are of central interest. In Gee's (2011) words, his theory fundamentally concerns "how we use language to say things, do things, and be things. It is concerned, as well, with a method of how to study saying, doing, and being in language" (p. 2). In order to gather information about how people use language to say things, do things, and be things, Gee, like other sociolinguists, relies primarily on sociolinguistic interview as a primary data source (De Fina, Schiffrin, Bamberg, 2006). This supports my choice to focus specifically on the data from the interviews I conducted.

Although Gee's framework attends to the role of context, it does not prescribe data collection methods for understanding context, culture, or practices. Therefore, as the name would suggest, *ethno*[8]*-graphy* is the study of people and practices. According to Guest, Namey, and Mitchell (2013), this qualitative approach is "oriented toward studying shared meanings and practices" (p. 8). Subscribing to such an approach necessitates that I ask questions about and seek to observe social and cultural processes and to investigate shared meanings. This means that, in addition to my focus on individual descriptions as the unit of analysis, I also worked to understand group practices and the shared meanings developed in that culture-sharing group. Ethnographic inquiries traditionally rely on participant observation and extended fieldwork, both of which I take up within my study; however the role of this data, as I described in more detail below, was to inform the types of questions I asked during individual interviews. I say more about the particular data collection and analytic strategies below.

Data Collection

Data Sources

Overall, I collected three types of data: (a) interview audio and video (three individual interviews with each participant and one focal group interview); (b) observation field notes, written documentation, and college media sources; and (c) participant questionnaires and feedback. In this section, I justify my choices for gathering these types of qualitative data and then describe, in specific detail, how the collection of and selection of particular pieces of data from this larger pool of data allowed me to answer the research questions for the present study.

Identity. The investigation of my first research question–*How do senior women mathematics majors at an all-women's college use language to describe their mathematical identity development*?–relied on individual participant interviews (the protocol for these interviews is provided in APPENDIX E). There are two reasons I chose to use interview data as

[8] *ethno*: word-forming element meaning "race, culture," from Greek *ethnos* "people, nation, class, caste, tribe; a number of people accustomed to live together"

my primary data source when focusing on identity: First, and most simply, there is precedence for mathematics education researchers who are interested in issues of identity to rely on interviews. This is because "this method allows one to examine the personal narratives of adolescents and adults and relate them to identity formation" (Yamakawa et al., 2009, p. 20). Current studies using Gee's theory of identity also primarily rely on interview (e.g., Gee, Allen, Clinton, 2001; Piatek-Jimenez, 2008). Second, in the tradition of feminist and equity-minded research in which scholars attend to and valorize the voice and experiential knowledge of participants, I argue that it is important to acknowledge and amplify the voices of female students within the discipline of mathematics. In the case of school mathematics, I would argue that women mathematics major's double minority status as women and mathematicians (in-training) brings with it a presumed competence to speak about gender, mathematics, and their intersection. Interview, then, allowed me to hear participant's perspectives and to acknowledge such competencies.

Given the relationship between identity (as I have defined it) and context, I also believed that it was necessary to look at identity construction and recognition in other (i.e., non-interview) contexts. Because there may be differences between how an individual recognizes herself and how she is recognized by others (including me), it was worthwhile to vary the contexts within which identity is investigated. This is not to say that their identity construction within an interview setting is any less valid or "true." Instead, I posited that gathering information about stated and enacted identities simultaneously might help to develop a richer picture than if I relied solely on individual interview data. Further, as I anticipated that there might be perceived inconsistencies between identity construction in different contexts–discursively constructed identities within an interview setting and those constructed in a another given social context–I believed that having empirical information about their enacted identities helped me to interrogate those differences during the one-on-one interview. That is, having witnessed any discrepancies between how a participant described herself during an interview with how others seemed to perceive her in class or another setting, I was able to ask about those. Therefore, in addition to interviewing, I also engaged in observations of participants socially situated, or enacted, identities. These settings varied from nightly mathematics help room sessions, faculty office hours, peer homework groups, departmental gatherings, to classroom sessions.

Identity and context. As my second research question– *How might the context of an all-women's mathematics department be described as relevant to students' identity development? Specifically, what activities do mathematics majors at an all-women's college describe as significant to their experience and how do they describe their relationship to others within that context?*–focuses on participants mathematical identities in relation to practices and relationships at Metcalf, I relied on field observations, college and departmental materials like mathematics/statistics major statistics in order to inform the types of questions I asked during the interview. The difference when gathering data about context as opposed to mathematical figured world or Discourses is that I attended to enactment and engagement in practices in light of participants' perceptions. That is, I used what my participants said to interpret my observations of community practices and aspects of culture.

Mathematical Discourses and figured worlds. In order to address my third research question–i.e., *What mathematical Discourses do senior women mathematics majors at an all-women's college know, assume, question, or reject? What seems to be the relationship between their identities and those Discourses?*–I also relied on individual interviews. Other researchers interested in constructs like Discourses, cultural models, and figured worlds have similarly relied on interview (Gee, 2011), Solomon (2009, 2012); Boaler & Greeno, 2000), some of whom supplement those findings with observational data (Urrieta, 2007; Calabrese-Barton, Kang, Tan, O'Neill, Bautista-Guerra & Brecklin, 2012; Horn, 2008). "Often, interviewing people is a good way to uncover figured worlds (e.g., people's assumptions about what typical schools and schooling look like)" (Gee, 2011, p. 178).

When using a figured worlds framework, scholars look to learn more about students assumptions about the following: "(a) rules and norms, (b) tools and resources, (c) practices, (d) division of labor, and (e) object of the work" (Calabrese-Barton et al., 2012, p. 12). Specified within a mathematics context, this means that social and mathematical practices and norms are of particular interest (Cobb, Stephan, McClain, & Gravemeijer, 2001; Cobb & Hodge, 2007). The aspects to which I attended when investigating participants' figured worlds are listed in Table 3, below.

Table 3

Aspects of Mathematical Figured Worlds and Discourses

Social Practices and Norms (Cobb et. al, 2001)	Ways of explaining and justifying reason
	Ways of listening to and attempting to understand others' explanations
	Ways of indicating confusion
	Ways of indicating and giving reasons for disagreement with an invalid solution
Mathematical Practices and Norms (Cobb and Hodge, 2007)	Ways of determining what counts as an acceptable mathematical argument
	Ways of reasoning with tools and written symbols
	Ways of determining what counts as mathematical understanding
	Ways of motivating engagement in mathematical activity

By social practices and norms, I am referring to ways of acting and speaking that may not be specific to mathematical activity–one would expect students to explain their reasons in other classes, for example. Those practices and norms that are specifically mathematical, according to Cobb and Hodge (2007), are those practices that would be specific to mathematics communities of practice.

As described previously, figured worlds and Discourses do not belong strictly to any one individual. Instead, Gee argued that "…they are partially in our heads and partly out in the world in books and other media and in other people's heads, people we can talk to" (2011, p. 72). Therefore, to develop a rich picture of the cultural models of mathematics and of mathematicians, I used public documentation (e.g., school or department brochures or calendars), departmental documentation (e.g., departmental statistics and email sent to majors), school websites (e.g., college website or departmental website), and interactive media (e.g., participants' Facebook posts or blogs) to augment and specify my interview research questions as needed. For example, seeing something on a departments' Facebook page would allow me to ask pointed questions about what students were talking about or to ask participating about anticipated upcoming events.

Gendered identity, Discourses, and figured worlds. In order to gain insight into how the discursive construction of gender within mathematics plays out within the present study, I specifically attended to how participants talked about issues of gender—for example, being a woman in mathematics, including popular conceptions of women who engage in mathematics. I also took special notice of times when participants talked about things like feminism, patriarchy, or explicitly attended to the differences between men and women or between single-sexed and co-educational settings. Beyond specific investigation into descriptions specifically about their gendered experience, I also kept an eye out for descriptions that seemed to draw upon the binary gendered Discourses from the relevant known literature. Mendick (2005) found that undergraduate mathematics majors' identities were constituted through a series of interrelated binaries including math people/non-math people, fast/slow, competitive/collaborative, independent/dependent, reason/calculation, and naturally able/hardworking. Mendick argued that, in each of these discursive pairings, the first term is more highly valued and constitutes our understanding of what it means to do "real mathematics." Further, the first term in each pairing was associated with masculinity, where as the second term was associated with femininity. Therefore, in my analysis, I looked for instances when participants drew upon gendered binaries such as these and how they positioned themselves within those Discourses. Based on the findings from both Mendick (2005) and Rodd and Bartholomew's (2006) indicating that female students did rarely described themselves as "good" at mathematics and none described themselves as mathematicians, I also attended to how participants talk about themselves in this respect.

In addition to investigating how participants talked about gender broadly and about the aforementioned gendered binaries, I also paid close attention to the ways that participants talked about activities, practices, and norms at an all-women's college. In light of the teaching practices designed to embrace women's ways of knowing I (described in chapter 2), I wanted to know if these female-friendly practices were part of the culture at an all-women's college. Therefore, I looked for evidence of such practices in participants' descriptions of their experience at an all-women's college.

Data Collection Procedures

The study consisted of four overlapping phases, which began in the fall semester of 2013: (a) gaining access, initial observations, and relationship building; (b) participant selection and consent; (c) interviews, observations, and initial analysis; and (e) data analysis and additional analysis. This study structure reflected the fact that data collection and analysis were iterative and respected the need for emergent design.

Individual interviews. Each of the four women in this study participated in four semi-structured interviews–three of which were individual, one of which was a group interview. Each interview was audio- and video-taped. Interviews were conducted in a variety of places. Typically I met with participants in the centrally-located meeting space for the mathematics department. Other times, we met at an on-campus coffee shop or in a small study room space in the library.

Each individual interview maintained a slightly different focus, although there were definitely reoccurring topics. The first individual interview concentrated on each participant's pre-college histories and experiences (See APPENDIX E.1: Interview One – Background for the interview protocol). Topics like the students' socio-economic status, their community, and their parents were central. I asked participants about their personal mathematics history (e.g., K-12 schooling, mathematical interests and hobbies, experiences with former mathematics teachers or courses, etc.). The second individual interview primarily focused on students' post-secondary experiences (See APPENDIX E.2: Interview Two – College Mathematics Experiences for the interview protocol). I asked participants about their social and mathematical experiences in college. This ranged from classroom experiences, meeting and working with others in the mathematics department, to declaring a major in mathematics. The third individual interview focused on their future and their beliefs about mathematics and gender (See APPENDIX E.3: Interview Three – Beliefs About Math and Gender, Future for the interview protocol). In this interview, I asked about career trajectories, beliefs about mathematics, and anticipated roles and obligations as a woman mathematician out in the "real world."

Focal group interview. At the conclusion of the term, I met with the participants as a whole group. I had intended this meeting to be a whole-group interview, which would serve as a way to learn more about their interactions with each other and to see if any additional themes would arise. Although this session allowed me to ask a few remaining questions of the group and to observe how they interacted with one another, this session was not particularly generative of new data. I believe that there were a few factors impacting the nature of this meeting. First, we met at a restaurant, which made it feel more relaxed than some of the previous interview settings. Second, I scheduled the meeting during the last week of the term when participants were simultaneously feeling pressure to study and were also feeling anxious about their post-graduation life. All of them were moving off campus at the end of the term. Some were moving to a new city to start a new job or internship. At the time, I felt that asking questions in an interview-style did not match what students' expectations were for the meeting. Ultimately, this session ended up being more social and relaxed than initially intended and, as a result, did not serve as particularly meaningful data source for this analysis.

Observations. Barring holidays or school closings, I visited Metcalf every Tuesday and Thursday throughout the academic year. Over the academic school year, I observed multiple classes, math learning center help room sessions, office hours, departmental events, colloquium talks, and so on. Further, in Fall term, I attended a conference focused on supporting women in mathematics. In the Spring term, I completed a half-day campus tour and attended the Senior Symposium where students presented their senior projects or theses. As Metcalf was conducting a search for a tenure-track faculty member, I also had the opportunity to attend multiple jobs talks. As I got to know my participants more, they began to do things like text me to let me know when impromptu homework sessions are happening and to invite me to join vie email or text.

Primarily, my decisions about what to observe was informed by what my participants named as interesting or important or what seemed to be an important aspect of the mathematics department culture. For example, if a participant thought that I should accompany her to class, I did. If an email went out to the mathematics and statistics majors describing an upcoming event, I went. Overall, I conducted observations of everyday departmental or campus activities in order to better understand aspects of the context influencing student experience. I did not collect observational data as a primary data source to analyze directly. Instead, the goal of conducting observations and collecting observational data was, primarily, to allow me to ask more informed questions of my participants during interviews and, secondly, to start to be seen as a legitimate member of the community.

During observations, I recorded handwritten field notes in a journal. Primarily, these field notes consisted of real-time descriptions. During these observations, I intentionally attempted to defer interpretation and only reported on what I saw and, perhaps, some questions that I considered based on observations. After observations were finished, I read through my field notes and added reflective notes on the things that I noticed and wondered. Generally, the focus of these notes focused on social and mathematical practices.

Data Analysis

Data Management and Processing

At the end of my data collection, I had two primary types of data to process for analysis. First, as a result of conducting semi-structured interviews, I had audio recordings, which were transcribed in their entirety. Second, as a result of my observations, I had field notes that contained descriptive notes collected throughout the observation, and additional reflective notes written in a reflective journal at the conclusion of each observation.

Once interviews were completed, I transcribed each interview using the conventions presented in Table 4. Transcription was done verbatim. Because English was a second language for some of my participants, transcription was not always grammatically conventional. I specifically chose not to alter the participants' words in these instances or to use the convention of demarcating the text with a [sic] following any unconventional grammar because I believe that doing so had the potential to undermine their voices.

The vast majority of audio data was transcribed using two pieces of software simultaneously: f5, a transcription software, and Dragon Dictate, a dictation software. The only audio data excluded from transcription were those that I deemed to be off-topic, e.g., discussions about the weather. Any sections of audio not transcribed were noted with a short descriptor (e.g., [Discussion About the Weather]).

Table 4

Transcription Conventions

Symbol	**Use**
--,	Self interruption
…	Brief pause
word	Emphasized or stressed speech
(…)	Omitted speech
[??]	Inaudible / unintelligible speech
[ ]	Modified text
[[action / sound]]	Description of action or sound

Three interviews from each of four participants resulted in 463 pages of transcript. These transcripts, and their corresponding audio and video files, were entered into the qualitative analysis software NVivo 11.

Discourse and Inductive Thematic Analysis

Because language is such an important aspect of this work, I drew primarily on discourse analysis. Put simply, *discourse analysis* is "the study of language in use" (Gee, 2011, p. 8). Such studies typically take into account both the content and form of language in use. This means that discourse analysis focuses on the issues or themes of verbal and non-verbal language, as well as the structure of the language (i.e., grammar). Data analysis for this study, then, consisted of two types of analyses. First, I conducted an *inductive thematic analysis,* which focused on content of language (see Glaser & Strauss, 1967; Guest, MacQueen, & Namey, 2012; Saldana, 2009). This type of analysis consisted of reading and re-reading the data, developing codes or categories, and engaging in analytic reflection. To a lesser extent, I also engaged in *linguistic analysis*, which focused on the structure of the language (see Jaworski & Coupland, 2006; Rogers, 2011). This second type of analysis was focused more particularly on the linguistic, grammatical aspects of what participants say (e.g., nouns, verbs, inflections, metaphors, etc.)

Gee's (2011) discourse analytic methods, specifically, were relevant to my analysis. His methods are particularly appropriate for the two reasons: First, and very simply, I am relying on Gee's theory of identity and his related constructs of Big "D" Discourse and figured worlds. Therefore, adopting his analytic methods allows for consistency across theoretical and analytic frameworks. Second, discourse analysis can be conducted at multiple levels. Specifically, discourse analytic methods can give attention to smallest instance of language in use, while simultaneously attending to larger social, political, and historical meanings. Because sociocultural inquires rely on “multiple intertwined levels of analysis,” discourse analysis is an ideal method (Nasir & Hand, 2006, p. 463).

Overall, I engaged in a process called inductive thematic analysis. This means that I read and re-read the data in order to identify and code emergent themes within the data. This process, according to Guest and colleagues (2012) can be described as follows:

> Systematically reviewing units of text (often line-by-line, but units can be words, paragraphs, or larger units of text) as they are collected, creating emergent codes for those units, and writing memos that expand on created codes and the relationships between codes. (p. 13)

As this process was far from linear, I kept an analytic memo. This allowed me to track the evolution of the analysis and to attend to my methodological process and rationale.

Some initial analysis began before the transcription process. This analysis took the form of field notes that I generated during the interview, which reflected what I noticed and wondered during the interview. At times, this directly influenced the types of questions I asked at the next interview or what I would choose to observe at my next visit. In other instances, these reflective notes were the beginnings of my coding scheme.

I conducted the next stage of analysis while transcribing the data. Specifically, the particular way that I chose to transcribe allowed me to process the data in two important ways. First, I was able to listen to the interviews in their entirety. But, because I also used dictation software, I was also afforded the opportunity to say every word of each interview in its entirety. Therefore, this stage of analysis allowed for a deeper level of engagement with not only the content, but the specific language that participants and I used. Similar to the reflective notes I wrote while conducting the interview, I generated handwritten notes on what I noticed and wondered.

After the completion of transcription, I entered the interview transcripts into a qualitative analysis software. I then analyzed units of text at the sentence level, generating themes primarily around the topic of conversation. As these topics were loosely related to the types of questions I asked based on my interview protocol, the initial coding was shaped by these question categories and, therefore, by the research questions driving this study. Since the interviews were semi-structured, there were of course times when we deviated from the interview protocol. As a result, the codes I generated reflected both the topics I intended to specifically ask about within the interviews, as well as the spontaneous topics of conversation generated during our times together.

In instances where a single unit of text reflected multiple codes, I would assign it multiple codes. For example, all participants talked about their classroom experiences at Metcalf. But, within one turn, participants' descriptions might reflect the content or curriculum in addition to focusing on their relationships with a faculty member. Therefore, that description would be coded in such a way as to reflect both.

When I started to make connections between codes, I would generate a larger theme heading and categorize those codes within that larger category. For example, each participant talked about things like why they chose to come to an all-women's college, why they chose a liberal arts college, what their intended major was when they came to college. In each of these instances, these codes seemed to be more about what they anticipated college might be like and reflected their experience in the transitional phase between high school and college. Therefore, instead of grouping these in the larger theme of "college," I decided to group them together under the header "transition to college."

There were times, however, when a theme was subsumed it into another category or, in instances when the theme became too broad, I made the choice to break it down into two or more categories. This occurrence was much more frequent, as I began to see the ways in which seemingly similar utterances highlighted different themes. Ultimately, I generated even top-level codes, each of which contained many subcodes: demographics and background, K-12 history, transition to college, college, identity, gender, and mathematics (see APPENDIX F: Nvivo Nodes).

Identity. In order to gain insight into being "a certain kind of person," I started the next stage of analysis by generating "identity portraits" for each participant. I focused on descriptions of participants and on what I perceived to be important identity stories. Although this analysis was generative and interesting, I found that the content was structured around themes from the interview (my questions), rather than reflecting what the participants' themselves had to say about what was important to them. Further, my initial findings were disconnected from the theoretical framework I was using.

In order to better represent the identities named by participants and to tie the theory, I returned to all of the quotations I had coded as being related to "identity." Reading and rereading those codes, I looked for evidence of Gee's four views on identity: (a) a *nature-identity* (N-Identity), which is "a state developed from forces in nature"; (b) an *institution-identity* (I-identity), which is "a position authorized by authorities within institutions"; (c) a *discourse-identity* (D-identity), which is "an individual trait recognized in the discourse/dialogue or/with 'rational' individuals"; and, lastly, (d) an *affinity-identity* (A-Identity), which reflects "experiences shared in the practice of 'affinity groups'" (Gee, 2000). Using these views of identity, I exported all of the relevant quotations into one document and began coding/grouping the interview data into these four types of identities, with an eye toward the identity development *process*, the identifying agent or *power*, and the *source of that power*.

Here, I found that the attempt to capture only those identity stories that fit within one of these four identity types felt artificial, at times. I found that naming these identities as being one of four types was not, in and of itself, the most interesting or representative way to reflect participants stories about their mathematical identity development. Whereas the first analysis was focused on themes from the interview questions, this analysis seemed to focus almost exclusively on theoretical constructs and, therefore, seemed disconnected from how participants were talking about or thinking about things. In order to engage in an analysis that seemed focused on what participants had to say about their own experiences, I decided to use the Gee lens with more nuance. That is, I still used the four identity types, but rather than structuring my findings specifically around each of the four identity types, I used participants descriptions of what seemed to be important about their experiences and used the Gee framework to highlight the interplay of these types of identity.

As Gee (2000) argued, "Each person has had a unique trajectory through 'Discourse space.' That is, … she has, through time, in a certain order, had specific experiences within specific Discourses (i.e., been recognized at a time and place, one way and not another), some recurring and others not." This means that, in some ways, I weighed those identities that were recurring as being more important. This is because, when attempting to develop any sort of theme, I looked to participants' descriptions for queues like repetition of types of bids for a certain type of identity and longer quotations that seemed to emphasize their investment in the building of that identity. The identity-building stories I share and analyze reflect my interpretation of some facets of participants' identities and are, in no way, definitive proof of some greater truth about who these women are. Instead, the exploration and interpretations I provide highlight the many facets of mathematical identity development and the various factors they named as shaping how that identity was built.

Context. Identity, as I conceptualize it, is context-dependent. Throughout the identity analysis I described above, I found it difficult to limit participants' descriptions of themselves as mathematical people to the Metcalf context, as this did not capture important elements of their story. They all talked about the importance of multiple contexts in shaping their mathematical identity development; their stories reflected their experiences with family, in primary and secondary school, within their communities and with their friends and significant others. In order to address my second research question, then, I specifically focused on the ways that participants specifically talked about Metcalf. Therefore, my goal in this part of the analysis was to look for participants' descriptions of the practices at Metcalf, as well as the relationships they named as being important to their mathematical identity development.

Gendered and mathematical figured worlds and Discourses. When engaging in thematic analysis focused on answering my third research question, I used the social and mathematical practices and norms from Table 3 above, as well as the gendered Discourses described by Mendick (2005). That is, I specifically looked at the data with an eye toward participants' assumptions about what it means to know and do mathematics as a woman. To do so, I looked at their descriptions about the ways that mathematical people do–*or should do*–when doing things like explaining and justifying reasons in a mathematics class or why people are motivated to do mathematics. I also took special notice of times when participants talked about well-known Discourses related to women in mathematics—those related to natural ability and hard work, feminism, masculinities and patriarchy. I also specifically attended to the ways participants described the differences between men and women or between single-sexed and co-educational settings.

In the case of interviews, participants made direct assertions of normality or abnormality (e.g., “But, it's *typical* when you are first coming in and you don't really know what you're doing”; “I didn't feel that at all, like, it was totally normal”; or “They *never* talk about math for fun.”) and more implicit ones (e.g., “I thought it would be a little bit *strange*” or “the LGBTQ activism was a good *surprise*”). They also described senses of obligation or implicit assumptions made by others (e.g., “My mother was not supportive of that” or “So it's kind of always been assumed we'll do that”). Often the sense of typical or normal that is captured in a figured world connects to a notion of what is “appropriate” or “good” (Gee, 2011, p. 178). As such, assertions of normality (or abnormality) or unquestioned assumptions of “appropriateness” or “goodness,” were specifically attended to within the figured worlds analysis.

Quality of the Research

Whereas good quantitative research is marked by characteristics like validity, reliability, generalizability, or “objectivity,” determining how to characterize high quality qualitative research has historically been challenging and politically fraught (Denzin & Giardina, 2008; Lincoln & Guba, 1985; Tracy, 2010). Validity, according to Gee (2011), is conceptualized differently within discourse analytic traditions:

> Validity is not constituted by arguing that a discourse analysis “reflects reality” in any simple way. This is so for at least two reasons. First, humans interpret the world, they do not have access to it “just as it is.” They must use some language or some other symbol system with which to interpret it and thereby render it meaningful in certain ways. A discourse analysis is itself an interpretation, an interpretation of the interpretive work people have done in specific contexts. It is, in that sense, an interpretation of an interpretation. These two considerations do not mean that discourse analyses are “subjective,” that they are just the analyst’s “opinion.” I take validity to be something that different analyses can have more or less of, that is, some analyses are more or less valid than others. Furthermore, validity is never “once and for all.” All analyses are open to

> further discussion and dispute, and their status can go up or down with time as work goes on in the field. (p. 122)

As Gee describes here, the findings in the following chapters are "interpretations of an interpretation." I have worked to ensure that the data I present reflects, to the best of my ability, my interpretations of what have said about how participants interpret the world.

Tracy (2010) argued that there are eight criteria which mark high quality qualitative research: (a) worthy topic, (b) rich rigor, (c) sincerity, (d) credibility, (e) resonance, (f) significant contribution, (g) ethics, and (h) meaningful coherence (p. 839). Below, I specifically address a few of these characteristics as I believe they are reflected within my work.

Based on my introduction and theoretical framework, I hope to have convinced the reader that this work is "relevant, timely, significant and interesting," and, thus is a "worthy topic." I return to this idea in Chapter 7 in order to make a case for the contributions of this work. Tracy (2010) contended that achieving rich rigor should be judged by data collection and analysis procedures. For interviews, in particular, rich rigor can be characterized in the following way:

> In terms of interviewing, demonstrations of rigor include the number and length of interviews, the appropriateness and breadth of the interview sample given the goals of the study, the types of questions asked, the level of transcription detail, the practices taken to ensure transcript accuracy, and the resultant number of pages of interview transcripts. (p. 841)

In the present study, I conducted multiple interviews with each participant (most of which lasted between one and one and a half hours) over an academic year. Transcription was done verbatim and there were great care given to ensure accuracy of what participants said. In total, there were over 450 pages of resultant text. As is true of all semi-structured interviews, the types of questions varied from person to person and from one interview to the next; however, it was the case that asked similar types of questions across interviews to increase continuity. Further, by because I worked with these participants over the academic year, I was able to looked specifically for instances where statements from prior interviews, in my opinion, seemed to conflict or did not resonate with what they had done outside the interview setting or did not seem to match what they were currently describing. In such instances, I was able to articulate that dissonance and ask participants to talk about it.

I worked toward increasing the sincerity of my findings by making explicit, as much as possible, my positionality as a researcher. I am aware that my personal experiences as a female student earning an advanced degree in mathematics at a predominately male institution shapes how I interpret and evaluate what I see. As Weber (1949) argued, there is no such thing as eliminating such biases. In fact, I argue that it is through my subjective experiences that this study has personal significance. Some researchers argue that the researcher should attempt to "bracket" his or her experiences (Moustakas, 1994). Although I believe that it is impossible to fully achieve such bracketing, I will attempt to make clear which characteristics and experiences I believe are relevant to–and may potentially bias–my analysis. In doing so, the reader may have a better understanding of my position within the study and of my reasons for conducting it. In terms of transparency (a subset of sincerity, as described by Tracy), I also worked to create an "audit trail" of both the data collection and analytic process and to make the details of that trail visible to the reader.

In order to make my research as "credible" as possible, I took the following measures: First, by drawing on ethnographic methods, I am able to achieve a greater degree of trustworthiness. That is, because I engaged in prolonged observation and engagement, I am well positioned to provide "rich, thick descriptions" of the setting and participants (Geertz, 1973) and attempt to do so in the findings when appropriate. Further, by interacting with individuals over the year, I believe was able to "[build] trust with participants, [learn] from the culture, and [check] for misinformation" (Creswell, 2007, p. 207). In this way, I feel confident that the findings I report are as credible as possible, given the capacity in which I knew participants. Second, I think that my findings are more credible because a large part of my analytic process consisted of eliciting feedback from other mathematics education researchers on my interpretations of participant quotations. Specifically, when attempting to articulate themes or interpretations of participants' words, I provided complete quotations and surrounding text to readers of my work to see if others were confirming what it was that I was seeing in the larger quotation before editing out text. In this way, I was able to gauge the degree to which my analysis was "plausible and persuasive" to another educational researcher (Tracy, 2010, 842). In instances where I received feedback that seemed to question or disagree with the interpretation I provided, I specifically investigated that text in more detail and looked across all of the relevant interviews for confirming or disconfirming evidence.

Role of the Researcher

Attending to the social and contextual nature of meaning-making within my research compels me to attend to my role as a researcher. By participating within the very community I intended to explore and describe, I remained aware that I was necessarily changing the study's context. In some ways, I am similar to those individuals I wish to study: For example, I am also a female and am formally educated in mathematics. But, I also differ from them in potentially meaningful ways: I am older, did not live and work on campus, and am experienced in mathematics, mathematics education, and research. Further–based on statistics available about students enrolled at all-women's colleges which indicate that such students are more likely to come from highly educated, middle-class family backgrounds–it was likely that our experiences and perspectives might differ with respect to class. That is, because I come from a working class family, what I attend to during observation and how I interpret and evaluate what I hear and see may differ from participants. Lastly, our goals for being in these spaces are different. Simply, they are there to earn a degree and I am there to engage in research.

Therefore, I played the dual roles of insider and outsider. I believe that my insider-ness helped me to develop rapport with others in this space. I suspect that my outsider-ness provided me with a unique perspective. At the same time, I must recognize that my position as an outsider shaped the kinds of relationships I was able to build and, resultantly, the types of observations I was able to make.

Recognizing that a lack of engagement or participation could have negatively impacted my ability to develop meaningful relationships, and that complete participation might not be feasible as I am not a genuine member of the community, I took the role of *participant-as-observer* (Gold, 1958). Therefore, I took a limited active role at first. As Gold (1958) noted, "the participant-as-observer role differs significantly in that both field worker and informant are aware that theirs is a field relationship. This mutual awareness tends to minimize problems of role-pretending" (p. 220). Due to the fact that I conducted semi-structured interviews with participants and that my role as a data collector will be evident to others, I felt that it was important not to "pretend" otherwise. This stance was more honest in the sense that I acknowledged, to some extent, my purpose as a researcher.

Over time, my role evolved. As is the case with ethnographic inquiries, I progressed from a participant-as-observer role to a fuller participant role. This means that over the academic year, participants came to see me as a more legitimate, if temporary, member of the community. This was evidences by things like participants texting me to inform me that they were about to have a study session, being included in department email and events, as well as being invited by students and faculty to attend classes and office hours aside students.

My Positionality as a Researcher

Feminist researchers (Devault, 1990; Sprague, 2016) have long pointed to the importance of developing a relationship with one's participants. Developing rapport, they have argued, is easier to accomplish when the researcher and the participants share common experiences and characteristics. I hold a bachelor's degree in mathematics from a United States college. Like two of my participants, I completed all of my K-12 schooling in the United States schooling system. I am also a young woman, somewhat close in age to my participants. At the time I conducted interviews, I was also engaged in finding my first post-graduation job. Like my participants, I was wrapping up a particularly important part of my educational journey and was looking forward to what the next chapter of my life might be. Together, we all experienced the excitement and, frankly, the anxiety of the upcoming transitions.

There were also ways I was different from my participants. In particular, I am white and English is my first language. As such, conversations with two of my participants who grew up outside the United States and for whom English was not a first language, were colored by this difference. Most vivid, perhaps, was the way that these participants talked about their experiences as a "cultural" one. That is, in order to help me understand their experiences, they frequently re-read their experiences within an American cultural frame. From small instances when participants stopped to explain what a "head girl" was, to longer explanations about how women are viewed in "their cultures," there was an extra burden placed on those participants to try to help me develop a better picture of practices, setting, and norms outside of the United States context.

Further, I had already completed both a bachelor's degree and a master's degree in mathematics. Therefore, my participants may have seen me as a mathematics expert. As a result, they may have been reticent about sharing stories that might cast them, for example, as someone who struggled or had doubts about their choice to study mathematics.

All together, though, my experiences with participants felt genuine. Interviews always lasted longer than the time we had allotted. Sometimes tired from staying up late at night finishing that homework set, other times, excited about an upcoming event, I was there to see these women in their daily ups and downs of college life. Even though two participants described themselves as painfully shy in large group settings, all seemed eager to tell me about their experiences—where they had come from, where they hoped to go. In the few instances when she did not understand the question I had asked, a participant was quick to ask me to rephrase my question. If she did not know an answer or could not recall something, she told me so. Frequently, I would rephrase what I thought I had heard a participant say, to ensure my interpretation was as accurate as possible. Sometimes, my interpretation was not correct and none of my participants hesitated to tell me so if this was the case. In short, I think that our common experience, our positive interactions, and our joint interest in learning about women in mathematics meant that our time together felt important and authentic.

Setting

Setting Selection

Since each woman's college or university bears a unique social and historical context, it is necessary for me to put forth some criteria to narrow down the list of potential sites for my study. When selecting a site, I implement three reduction criteria–two of which are necessary, and one of which is discretionary. First, due to the fact that some historically women's colleges have since converted to co-educational institutions, I only considered those colleges and universities currently committed to women's-only education. According to the Women's College Coalition, there are currently 47 active women's colleges in the United States. Of these programs, only 38 colleges and universities offer degrees in mathematics.

Within this group, there are five institutions known for specifically supporting women in mathematics. As noted earlier, these "five-women's colleges accounted for 43% of the math doctorates…earned by women in the 1970s and 1980s" (Unger, 2007, p. 480). Of those remaining instructions, I chose Metcalf College[9] as the site for my study. Although this institution was selected in part for convenience, it has a number of distinctive characteristics that makes it particularly relevant settings. Of the three kinds of women's colleges–Roman Catholic institutions, southern women's colleges, and independent women's colleges– Metcalf is classified as independent women's colleges. Moreover, it is a member of the Seven Sisters–an association of seven liberal arts colleges in the Northwestern United States that have historically educated women. Another essential aspect of Metcalf's history is that each of the Seven Sisters has historically served as a companion school to one of the seven predominately-male Ivy League schools. That is, they were founded in response to an inability for women to enroll in the oldest and most prestigious male schools like Massachusetts Institute of Technology, Yale, Harvard, Columbia, and Princeton, which were–and arguably still are–mathematical powerhouses.

Metcalf College school history and description. Metcalf is a small, private, nondenominational, residential liberal arts college located in the Northeastern United States. Founded in the early 19^{th} century, Metcalf College is one of five colleges remaining within the

[9] Mecalf is a pseudonym. I chose this pseudonym in honor or Ida Metcalf, the first American woman to earn a Ph.D. in mathematics.

group referred to as the Seven Sisters. Historically, approximately 80% of Metcalf graduates enroll in a graduate or professional program within ten years of graduating. Class sizes at Metcalf were small. The student to faculty ratio is 10:1, with just over 70% of classes enrolling 20 students or less. At the time of the study, 55% of the faculty members across the university were women and 22% were faculty of color.

Metcalf campus description. The campus was beautiful. Large cathedral windows and ornately carved wooden ceiling beams made the library sitting room feel like something from the world of Harry Potter. Other buildings were much more modern, with high-tech computer labs and furniture with bold patterns and sleek lines. Century old trees, some planted by a faculty botanist in the early years of the college, others by some of the earliest graduating classes, dotted the campus. The hard sciences building where mathematics was housed was rather unextraordinary, however. Built in the 1920s, the interior was somewhat outdated. The stairwells contained artifacts from years past—detailed environmental dioramas seemingly from the 1980's, as well as collections of rocks, minerals, and fossils.

The floor where mathematics faculty offices and some classrooms were located looked much like the other floors of the building. The floors and walls were some variation of a neutral brown and the air smelled similar to that of an older library. What did make the math hall stand out, though, were the artifacts posted on the walls. Posters about upcoming REUs or graduate programs were posted every few feet. Projects and presentations from current and former students, as well as posters of women mathematicians and their contributions to the field, covered the walls. Display cases were filled with student work and with origami artwork from one faculty member. In the center of the main hall, one wall proudly displayed pictures and information about current math majors and minors. On it were pictures of all the mathematics majors, with each student's favorite mathematical theorem. Next to that poster hung a colorful display providing information about things like math / stat clubs, the evening help schedule, scholarship information, and the upcoming Putnam exam (see Figure 4).

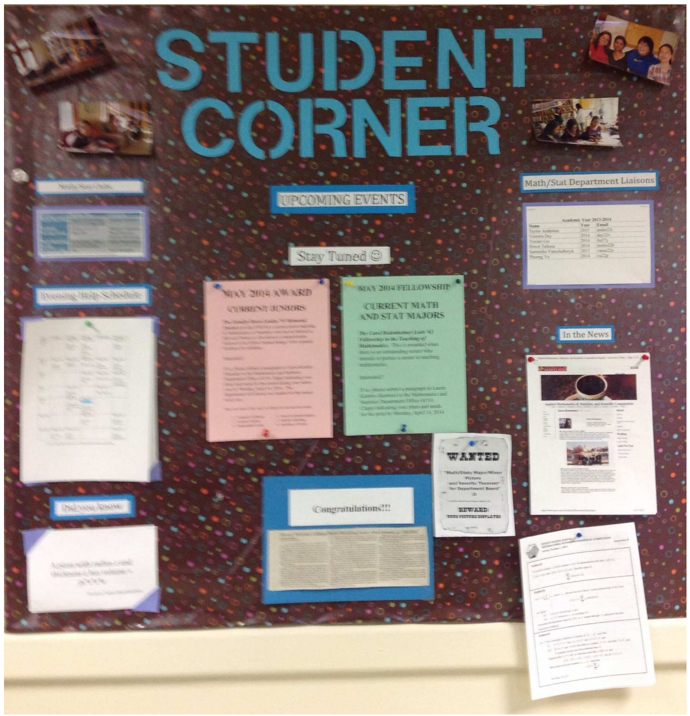

Figure 4. Student Corner Display at Metcalf

Metcalf mathematics department. The number of mathematics majors at Metcalf has steadily increased from 15 in 2013 to 32 currently. Over the past ten years, mathematics majors have made up about 3.5% graduates awarded a Bachelor's degree, while statistics majors have made up almost 1%. Ranking 11th on the major frequency list, mathematics is not exactly at the top of the list in terms of popularity. When one examines minors, though, these numbers change quite drastically. Mathematics moves up the list to the third most popular minor across the last ten years. This means that in the last ten years, much of the student population has been affiliated with the mathematics department in a substantial way. This, of course, does not take into account the number of young women who have studied mathematics as part of their STEM coursework.

At the time of the study, almost two-thirds of the mathematics and statistics faculty were women. The chair of the department was also a woman. Of those faculty members awarded tenure, half of them were women—far exceeding the national average for four-year colleges of 21% (Blair et al., 2013). Multiple faculty members in the department were recognized for their teaching, as evidenced by the teaching-related awards they had received.

Metcalf has history of rich mathematics course offerings, given its size, and of supporting its students in engaging in mathematics research. In terms of student outcomes, as stated previously, the vast majority of students eventually attend graduate or professional school. It is evident that Metcalf is successful in supporting women in mathematics, specifically, as it was one of five all-women's colleges whose graduates went on to earn almost half of mathematics doctorates in the 1970s and 1980s (Unger, 2007, p. 480). As such, Metcalf might be described as a best-case scenario. As I am interested in learning about cultures that may be particularly empowering or supportive to women mathematics majors, I believe that I am justified in choosing to look at one institution that has such a history.

Participants

Participant Overview

The participants in this study were undergraduate mathematics majors in their senior year. Although multiple researchers have noted the importance of transitions as particularly rich formative contexts for students (e.g., Hoyles, Newmann, & Noss, 2001; Jansen, Edgerton, Schielack, & Seeley, 2012; Solomon, 2007), there has been little research focused on the transitions of university senior mathematics majors into the future–for most, either graduate school or a career. It was my belief that, as seniors, these students were in an optimal position to be able to comment on their past experiences of being a mathematics major while also being attentive to their future. Further, as seniors, these students had already experienced "being a math major." As such, they should have had the most insight into being an undergraduate mathematics major at their institution possible. Moreover, since they were on-track to graduate, each participant had some external validation by their institution—a stamp of approval that they are ready to go out into the world and do math. This is important because I believe, as I will explain in more detail below, it is necessary to focus on "successful" cases and one important measure of mathematical success would be the awarding of a degree in mathematics by an institution.

Participant Recruitment and Selection

According to the mathematics and statistics department administrative assistant, there were 24 senior mathematics majors at Metcalf College at the time that this study began. The goal for recruitment was to recruit four focal participants with whom I could work the entire academic year. After spending time attending departmental events, attending mathematics help sessions, asking to meet with faculty, and generally spending time introducing myself to whomever would be willing to meet with me, I received permission from the department chair to send out a recruitment email. The chair of the department actually offered to send out the email on my behalf, thinking that the response rate would be better (see APPENDIX C). Of the 24 eligible students, 10 students responded to the request with a completed questionnaire. A few of these students indicated in their questionnaire response that although they were supportive of the work I was doing, they felt that they did not have enough time to commit to the project.

Of the remaining students, I narrowed my choices down to four individuals using the following methods: First, I chose to include one student, Mai, based on my previous interactions with her. Having met her at a mathematics department event and watching her tutor during mathematics help room sessions, it became evident to me that Mai was particularly excited about mathematics and was very passionate about helping her fellow students in their studies. She also displayed a great deal of confidence when doing mathematics during these sessions. Therefore, when the call for focal research participants went out, I specifically encouraged Mai to participate. Of the group, she was the only one I specifically pursued.

The others were chosen based on two criteria: The first was the length and diversity of responses. Specifically, there were a couple of students who responded to the questionnaire, yet did not offer any justifications or explanations to accompany their responses (e.g., responding "yes" to the question "Are you satisfied with your choice to be a mathematics major at an all-women's college?" without any further explanation as to why). I hypothesized, correctly or incorrectly, that brevity of these written questionnaire responses might predict brevity in responses during interview sessions and, as a result, weighed this against those individuals when choosing focal participants. Second, I chose participants to reflect the diversity of the Metcalf student population and, specifically, the mathematics department. According to public documentation, the most historically represented group on campus is White women from the New England area, coming from a middle-class family, who have an alumni relative. In recent years, however, the demographic make-up has changed markedly and as of the 2013-2014 academic year, international students from East or Southeast Asia represent almost the same percentage. Therefore, I wanted to choose two students from the United States and two international students.

Further, it was important to me to choose participants representing the degree make-up of the department. Because the largest population of students in the program is pursuing degrees in mathematics and economics, I chose two participants who are finishing degrees in that area. As computer science is a growing group on campus, I also chose a participant who is finishing a dual major in mathematics and computer science. Lastly, the department is made up of both mathematics and statistics majors. As a result, I wanted to ensure that the applied or statistics group was represented.

I would like to make clear that in developing such a selection criteria, I am by no means attempting to generate a stratified sample for the purposes of comparison or generalization. As such, I am not claiming that a student would represent all students of the same demographic. Instead, I am looking for diversification of classed, gendered, raced, and mathematical experiences because I believed that this would increase the likelihood of diverse findings and lead to a rich picture.

Participant Descriptions and Backgrounds

All participants were mathematics majors at Metcalf College. Two participants had begun their senior year in the fall, while the other two, by earning additional course credits before the end of their third year, gained senior status in the spring term. In Table 5, the participants' programs of study and basic background information are briefly outlined.

Table 5

Participant Information

	Lauren	**Mai**	**Omna**	**Prianca**
Gender Pronoun	Feminine	Feminine	Feminine	Feminine
Racial / Ethnic Group	Caucasian	Vietnamese	Nepali	Indian-American
English as a First Language	Yes	No	Yes	Yes
Graduation Year	2015	2014	2014	2015
Degree Program	Statistics Major/ Complex Organizations Minor	Math and Economics Special Major	Math and Computer Science Dual Major	Math and Economics Special Major
First Generation College Student	No	Yes	Yes	No
Post College Plans	Go to graduate school for either an MBA or a Master's in statistics. Work for a marketing research company or doing business analysis.	Work for several years, then maybe earn an MBA or a PhD in Economics or Mathematics.	Work in an Investment Bank or get a Phd in Computer Science.	Work as an Actuary.
Actual Post-College Occupation	Studies Applied Mathematics at a private co-educational research university on the East Coast.	Senior Analyst at an asset management firm on the East Coast.	Business Analyst at a large internet company on the West Coast.	Actuarial Associate at a finance company on the East Coast.

Lauren's family and community background. Growing up in the Midwest, Lauren is the eldest sibling, with two brothers and multiple stepsiblings. Like her brothers, Lauren went to co-educational schools for elementary and middle school, and attended a Catholic single-sexed high school.

In a word, Lauren described her family life as "confusing." Her parents, now divorced and remarried, were in and out of Lauren's life growing up. Moving out of her mother's house because of tensions with her mother's new husband, Lauren moved in with her father during the first part of high school. In her senior year, she decided to move in with her grandparents because her father was having difficulty raising three children and finding a new career, while trying to date again.

While her parent's careers and personal lives fluctuated, her grandparents provided much needed stability for Lauren. Her grandfather, a polymath electrical engineer, and her grandmother, a nurse, both supported her in school and in extracurricular activities like Celtic harp and Irish dance. During the summers, she recalls traveling with her grandparents to Ireland.

Lauren's educational background. When she was in third grade, Lauren's family moved and, as a result, she changed schools. After that transition, her parents decided to get her a tutor because she wasn't performing well in school:

> As soon as I switch schools my parents were like, 'You are going to need more help than you're getting because you're not doing fantastic in school. School just isn't your thing' [[laughing]], which is what I was being told and I was this really ADHD child that just wanted to go out and play. So I was very active. I was like the kid that could climb up anything.

As a child with ADHD, Lauren found it difficult to focus in school and explained that she had general organizational issues. After working with the tutor, however, Lauren was able to find techniques that made her more successful in school:

> I would go over tests and all that sort of stuff with her. And she just helped me with organization and all that sort of thing. You could just see a huge improvement within, like, the first semester that I was seeing her.

Lauren worked with her tutor from fourth grade through graduation, seeing her less over time:

> Throughout high school, I stopped seeing her as much and I would see her for maybe, like, one test per semester. It was great. So she was like 'Yay! You're kind of doing your thing.' That sort of thing. So she was just really supportive of me moving on from needing to see her every week or multiple times a week.

Lauren recalls her time with this tutor fondly, as someone who supported her to pursue her interests and to develop skills that allowed her to be successful in school.

Overall, high school was not a positive experience for Lauren. She said that she "kind of went from friend group to friend group throughout high school" and, consequently, thought that "high school was pretty awful, actually." Although she did not think highly of her social experiences, she generally had positive memories of her teachers. One teacher, Lauren recalled, was known for being the "grumpy" teacher and was generally disliked by her peers. Lauren, however, had a positive relationship with this teacher, as she describes here:

> But I really liked her. A lot of people didn't. So I, for some reason, just clicked with her and she and I just got along really well so we would be making jokes and all that sort of stuff. And she, if she found a math joke, she'd share it with me, which I thought was great.

Overall, Lauren described herself as a good student who generally had positive relationships with her high school teachers.

Mai's family and community background. Mai is the second eldest in a large family, which includes two sisters and two brothers. Originally from the countryside of central Vietnam, Mai and her family moved to a larger Vietnamese city when she was in secondary school. She remained there until moving to the United States at the age of twenty-one.

Growing up, her parents worked together running a construction business. Her father ordered materials and did the heavy lifting, while her mother managed the books and the employees. Mai describes her mother as an important role model; simultaneously a strong woman and a thoughtful, fair employer:

> My mom is really, really strong woman and she's doing business and she has her own store and she's doing managing things (…) She treat people really well and the employees really, really respect my mom (…) My mom create a good connection with the employees. So that they can work really hard for the business (…) She always, like, treat people really well compared to other businesses (…) Really, really make me feel like I want to be the woman like that.

As Mai indicated in this quotation, she thought very highly of her mother's ability to command respect and to treat others well. Though she did not specifically use the phrase "role model" to describe her mother, it was clear from our conversations that she saw her mother as a model for the type of woman she hoped to be.

Although the family business had grown to be successful, the family faced difficult financial times. Mai recalled that her mother, in particular, was the one to ensure that the family business provided for the family:

> Like, she has been doing, like, many things that other women they would not be able to do it. Like, she went through many difficult time that's like the peak of a mountain that we would fall. But, she didn't fall. She stay there. So, I…really admire her.

Mai's educational background. Being successful business owners meant that Mai and her siblings had more money and resources for their education. Without her mother's hard work and business savvy, Mai believed that she would not have had the educational opportunities that she was afforded growing up.

Overall, Mai described herself as a good student who was liked by her teachers. She received good grades and worked hard in her studies. When Mai was in eighth grade, her parents moved to a major city Vietnam in search of new opportunities for their construction business. This meant that she lived apart from her parents while she was still in middle school, reconnecting with them after completing tenth grade. Around the time her parents moved, Mai started working with a private tutor. This connection was important for two reasons. First, it was important for her to have a female care for her well-being "So, she was, she was the person I felt like close. Like, oh my god, my mom's left. So, now you my mom [[laughing]]." Secondly, Mai indicated that this particular tutor was the one with whom only the top students got to work. Therefore, Mai felt that the opportunity to work with this tutor made her feel special and served to recognize her status as a good student.

As a first-generation college student, Mai was the first in her family to pursue a secondary education and the only one of her siblings to study abroad. After three years of post-secondary schooling in business, she moved to the east cost of the United State without friends or familial connections. In preparation for the move, she began to learn English during the three-year time span between graduating from high school and moving to the United States. After coming to the United States, she first earned a business degree at a technologically-focused community college. From there, she applied and was accepted to business schools in the area, with the intent of earning a bachelor's in business.

During the summer break after completing her associate's degree, Mai attended a selective five-week program at a local university specifically designed to support students transitioning from local community colleges to a four-year universities. During that time, she took classes in multiple disciplines, including a class on gender issues, and learned more about a liberal arts education. Those experiences sparked new educational interests, as well as convinced her that business alone was not a valuable direction. As such, she decided to pursue a liberal arts education, where she intended to study economics with a minor in mathematics, which I will discuss in later chapters.

Omna's family and community background. Omna grew up in Nepal and lived there though high school. She is the third eldest of four sisters. When she was younger, her father traveled frequently in order to secure construction contracts from the government and to complete affiliated projects.

> My father had a construction business, he had to go all--, everywhere. Because he took contracts from government to, say, build a hospital or a road or something like that. So my father wasn't really there at home much. But he was really supportive and everything.

As such, her childhood memories are predominately of her mother and sisters, with whom she has strong and mutually supportive relationships.

Repeatedly, Omna described the important role that her sisters had played in her identity and experience growing up. Omna said that she felt that her sisters' ability to be straightforward and honest and to be non-wavering in their support of each other made these relationships so important. Despite being separated by continents, they still talked with each other regularly.

> Yeah, we actually, we talk a lot and we don't really hold our opinions and there is no hierarchy. And we don't talk about--, I guess, we, when we are together, we are together as a team. So, they never talk about each other. We talk about either other people or other ideas. There is never a competition.

As members of this "team," Omna said she and her sisters consistently provided each other with various types of support. Beyond emotional support, they also helped each other to prepare for difficult tasks, like interviewing or applying to colleges:

> Whenever like somebody has an interview or some other stuff, we always like, you know, give tips. Even like my first two years of college here, my sister supported the family--, the parent - family contribution. So, my parents didn't pay anything after I came here. So, for the first two years, it was my sister. So, and, uh, my younger sister, I will be supporting some after I graduate.

Here, Omna describes how she and her sisters actually created a financial support system, wherein no sister had to take on the financial burden of paying for her own education. Although Omna's parents provided monetary and educational support for their daughters throughout primary and secondary school, the sisters took on and distributed that burden amongst themselves, post-high school, and worked to financially support one another. So, at the time of her senior year, Omna was committed to helping her younger sister pay for college.

Omna's educational background. Omna described herself as a good student throughout primary and secondary school. In fact, she described being a good student as her "brand." Student rankings were very visible at her school and, according to Omna, she was at the top of her class: "I always used to be on top, so I always had high scores." In addition to her good academic performance, Omna was involved with many extracurricular activities at school, like model UN. Reflecting this, Omna was made head girl at her school, where she served as an assistant to teachers and administrators, while representing her fellow students. She was proud of the fact that the top students at her school were female, as this was not the case at other local high schools: "most of the top students in our school were women."

Her mother, Omna recalled, worked hard to establish a supportive yet demanding learning environment. Because she didn't have many educational opportunities as a young woman, she wanted to ensure that her daughters had what she didn't: "She wasn't educated, but she was really--, she is really, I guess, a stubborn woman but she knew the value of education." Her mother established an environment of "healthy competition," where she encouraged her daughters to work on homework notebooks in addition to their regular schoolwork: "My mother used to bring like these notebooks, all these notebooks that she would, she would tell us to finish those notebooks by practicing on them or whatever."

Prianca's family and community background. Prianca grew up on the East Coast of the United States. Her mother, a high school science teacher, and her father, an IT specialist at a major university, moved from India to the United States when Prianca was a baby.

When Prianca and younger sister were both little, her mother stayed home full time. Later, when both girls were enrolled in school full time, their mother began substitute teaching. Her mother later enrolled in a Master's program in order to gain her state teaching certification and now teaches chemistry and biology. Prianca recalled watching her mother study for the teaching certification test and studying for her graduate school courses.

> I think when I was like ten or eleven she was taking like MTEL test. Like, it was really obvious, she would be like, 'This is my studying time. I need you to leave me alone and, like, just let me do work.' Or, when I was at school and my sister was at school, that's when she would do a lot of her studying. Um, but yeah, I was--, I could, like, I was able to visualize, like, her work ethic. I would see her studying a lot.

This experience was important to Prianca because it provided her with a model for being a hard working mother and student.

Prianca's educational background. Overall, Prianca described her parents as being "big on education." As such, Prianca's parents fostered a supportive educational environment for Prianca and her sister by providing both time and resources: "I had support, too, especially, like, from my family… like getting tutors, if I need help. And I had that."

Prianca's attended a small, public, co-educational high school. She explained that her school was particularly competitive environment, as many of the students were children of the nearby university's faculty and staff. This meant that the school itself had plenty of resources and that many parents had the means to supplement their children's education with aids like tutors and high stakes test prep.

Even within this competitive schooling environment, Prianca was a good student, recalling that she earned all A's and B's throughout school. In addition to taking advanced courses like AP psychology and AP Biology, Prianca was on the swim team and served as a chief editor for the school newspaper. In her sophomore year of high school, she became a member of the feminist alliance on campus.

CHAPTER FOUR: BUILDING MATHEMATICAL IDENTITIES

Alex: *Would you call yourself a mathematician?*

Omna: *... Myself? Yes. Um, I mean, uh, uh, um, so I'm thinking about the way I should be defining terms in--, other people's perceptions or in my own definition?*

At the time of her senior year of college, each participant described herself as someone who was "good" at mathematics; however, each participant's stories of becoming someone who was good at mathematics varied from person to person. Some described themselves as someone who had always been good at mathematics, whereas others described themselves as someone who struggled with mathematics in the past and had substantial shifts in how they viewed their mathematical competency over time.

In this chapter, I explore participants' descriptions of themselves as students of mathematics and how those descriptions seemed to reflect the context of their mathematical identity-building stories. Here, I address my first research question: *What language do senior women mathematics majors at an all-women's college use to describe their mathematical identity development?*

Recall that I define mathematical identity as "being recognized by oneself or others as a *mathematical person* in a given context." At times, I choose to use the phrase "mathematical person" or "mathematical people" at times, rather than mathematical identities because, as one might expect, my participants did not talk about their experience as identities or identity work. Instead, they talked about themselves as being a mathematics student, being a member of the mathematical modeling club, or being a "math person" or "STEM person." Therefore, by mathematical people, I mean the broader category of socially recognizable ways of being a person who engages with mathematics. This might include being a mathematics student, being an actuary, or simply being the person who calculates the server's tip at dinner.

Because there are many ways to be a mathematical person, I focus more narrowly on two mathematical identities: someone who is good at mathematics and someone who is bad at mathematics. I do so because these identities were evident in the ways that each participant talked about competency, success, engagement, motivation and performance in mathematics. These aspects of their experience seemed to be tied up in how they described themselves as either being good or bad at mathematics. Therefore, I chose to focus on being good or bad at mathematics because these ideas were strongly represented in each of the participants' descriptions of her experiences in mathematics. The second reason I chose to focus on these two identities is because, in the next chapter, I focus more specifically on the experiences of two participants who described major shifts in the ways that they described themselves as mathematical people. Specifically, I focus on those participants who described themselves as formerly being bad at mathematics and who had become good at mathematics.

Though participants did actually use phrases like "I was terrible at mathematics" or "I've always been good with numbers," I understand that it the labels "good" or "bad" are likely overly simplistic and may be perceived as static. Nonetheless, I chose to use these labels for two reasons. First, I do so for ease of reference and clarity for both myself and the reader. Second, and more importantly, these labels seemed to be consistent with how participants talked about being a mathematics student. These labels are not intended to describe Truths about participants. That is, I am not saying that they are definitively good or bad at mathematics. Instead, these identities of being good or bad at mathematics are characterized in this way because of their social recognizability and the ways that participants seemed to recognize themselves as being this kind of person through language.

While focusing on these two identities, I explore the nuances of those identities depending on person and context. Of course, reflecting the non-static nature identity development, the identities participants enacted or described shifted from story to story. Participants emphasized different facets of that identity depending on the context framing participants' descriptions. As such, this investigation necessarily focuses on unpacking the role that context seems to play in the ways that participants described their mathematical identity development.

In this chapter, I focus first on participants whose views of their own ability in mathematics were generally positive over time (those who have "always been good at mathematics") and, then, on participants whose view of their own mathematical ability have improved or changed over time (those who "used to be bad at math"). The goal of this exploration is to better understand how these stories point to particular types of mathematical identities and how individuals who view themselves as successful in mathematics view the experiences that shaped that identity.

Someone Who is Good at Mathematics

Of the group, only Mai consistently described herself as someone who was always good at mathematics. Throughout primary and secondary school, and all through college, Mai described herself as maintaining this identity. Despite this, what Mai meant when she said that she was good at mathematics changed from description to description and was multifaceted.

Access to Tutoring and Endorsement of Identity by Others at School

Mai indicated that success in school, generally, and in mathematics, specifically, was shaped by multiple factors. She described private tutoring as perhaps the most important aspect of her schooling:

> Honestly, I think that the roles of the private tutors are more important than the role of the public education I got officially at the school. Even though those people come from the same school, same department. Because they --, we study a lot more. We do a lot more homework. We do a lot more complicated homeworks, complicated problems. Um, than the private school. I guess because private school, we don't have that much time, first things. And second things, it is really, really, um, take, uh--, mix, like, the levels, education level, like in the level of, like, math levels or basic levels, really mixed in the public, like, the official class. But for the private part, it is usually, like, um, they can

> divide into, like, a better group. A group A, B, C. And then A would be the best and there would be harder problems. And then many more problems. And then B would be like a little bit less or they would --, so that like, depend on what group the professor or the teacher would explain, like, spend a lot more time to explain things. But a lot less time to explain because the better group would have a better understanding and, like, easier to get things. So it was like, go, go, go, go.

Here, Mai describes tutoring as being important to her experience in two primary ways. First, having access to tutoring meant that she had more structured time specifically devoted to studying mathematics because her regular classes did not have enough time for working on problems and for the teacher to explain things in enough detail. As such, Mai linked her success in mathematics to the opportunity to practice it more than she would have otherwise been able to do had she not been enrolled in tutoring. This means that becoming and being someone who is good at mathematics is a process realized through practice. Further, she hints at the sense of urgency felt by this group in that they had to "go, go, go, go" all the time when learning mathematics.

In addition to simply devoting more time to mathematics, Mai also felt that she was good at mathematics because she understood it more quickly than her peers—she was "easier to get things." Because she and others in the A group had a "better understanding," she explained that she was able to work on hard or "complicated" homework that was not accessible to her peers outside this group. By describing herself in this way, Mai built an identity as someone who was good at mathematics by naming herself as belonging to the A group, students known at her school to be the best at mathematics. In Gee's (2011, 2014) terms, this identity is being built by drawing on the affinity identity of being a good student because she was a member of this group. Specifically, by describing the roles and practices of that A group, she positioned herself not only as someone who also spent a great deal of time practicing mathematics, but as someone who "got" mathematical concepts quickly as compared to the majority of her classmates.

Mai indicated that this identity was recognized and supported outside of tutoring sessions. She said that others—peers and teachers—endorsed this identity. As she described here, Mai was the student expected to work difficult problems at the board in order to help her classmates:

> So, I went to the board and write out the homework problem, like, the hard problem that I solved at home. And other people couldn't solve it. So, I could solve that on the board so that people could ask me question, if they do. Or they could just copy it. Um, and also, a lot of, like, other friends that they don't understand the problems and they would come to me and ask, uh, the question.

In this quotation, Mai described herself was someone who is good at mathematics because she was able to solve problems that her peers were not able to solve. Implicit in this quotation, yet made explicit in our conversations at other times, was the fact that her teachers endorsed this identity with the expectation that Mai would come to the board to explain her work to her peers. Notice that in the above quotation, she did not say that she was asked to come to the board. Instead, she said that she did and that she, not the teacher, was expected to field questions from peers. In this way, her description positioned her in a teacher role in these moments, possibly unlike her peers. Further, her indication that she, not the teacher, was the primary actor may reflect her belief that she had both the skill and the agency to perform this task with minimal bidding or oversight from the teacher. By copying down her work and asking questions directly of Mai, her peers further supported her belief that she was good at mathematics and was a leader amongst her peers. Therefore, Mai's description framed "being good at mathematics" as a discourse identity, one that was endorsed and made real by others in her school.

In this quotation, she also describes herself as a consistently capable student and, in doing so, seemed to set herself apart from peers who "couldn't solve it" and who needed additional support. In this way, she positioned herself as being more capable than others who were possibly seen as struggling or, at the very least, had not gotten things quickly. At other times, she extended this difference in ability between herself and others in the A group, saying that she was quicker to get things than even her peers within the top performing group. An implication, here, was that she was different from almost all of her classmates and, more importantly, that she was viewed as someone who was especially good at mathematics, even amongst the top students.

Interestingly, Mai's descriptions of "getting things" more quickly than her peers in class were rarely connected to her tutoring experiences. That is, she did not seem to directly link her success in class to the fact that she had seen the material, at times, months before her peers did and in much more depth within a more personalized learning environment. After some pushing on my part about the role that tutoring played in her experience and how it specifically set her up to be more confident in mathematics and provided her with opportunities that her peers who did not have access to tutoring may have not had, she considered the notion that some educational inequities may have existed:

> Mai: I never thought of, like, inequality back then. But, now looking at it and talking about it, it's like, maybe yes, there is some. Because I got a private education on side. Instead of just the public education. And that's make me, like different, like, make me be a different person and have a higher education, like, have higher background compared to them. Uh, but at the same time, mmm, some of them also went to the private, um, tutor--
>
> Alex: They had the same experience as you did, but you--,
>
> Mai: Yes, some of them have the same experience.
>
> Alex: You still felt more confident in mathematics?
>
> Mai: Yeah, um-hm.

Here, Mai said that having a private education actually made her a "different" person, compared to her peers. Specifically, she had a higher background compared to her peers who did not have similar educational opportunities. At the beginning of the first quotation, it seemed that Mai could have made a connection between inequity of access to resources and the impact this may have on her own performance in school mathematics. Yet, she responded by reinforcing her belief that, even given the academic advantage of having a tutor, she was still more confident than her peers. Even amongst the students who had access to a tutor and who purportedly worked as long and hard as Mai, she described herself as still outperforming them. In doing so, she seemed to be building an identity as someone whose skill in mathematics was not a function of the tutoring she received. Although tutoring may have enhanced her performance, her identity was built on personal characteristics or capabilities that allow her to understand things more quickly than her peers.

Overall, she seemed to describe herself as being particularly good at mathematics because of the speed with which she could grasp the content, her potential for solving problems that her peers could not, and her ability to perform well on assessments—all of which, arguably, would have been impacted by her early and repeated exposure to the material. Instead, the way that she described herself as someone who consistently outperformed her peers explicitly and implicitly built being good at mathematics a nature identity. Namely, she was good at mathematics because of natural ability—a state developed from forces in nature.

These schooling experiences in tutoring and in her regular public school classes supported Mai in building the identity of someone who was good at mathematics. Here, having had access to tutoring opportunities and endorsement of this identity by peers and teachers alike shaped how Mai talked about and thought about herself as a student of mathematics. Therefore, her descriptions of these experiences also reflected personal actions and beliefs, which I will return to below.

Supportive Family and Culture

Mai described her family as being particularly supportive in that they provided her with access to resources like tutoring in mathematics throughout primary and secondary school. Mai said that her parents supported her mathematics endeavors specifically because they understood that success in school, and in life, was linked to success in mathematics. As Mai indicated in the following quotation, Vietnamese culture places great emphasis on mathematics performance. A person's success in school was reflected mostly in their success in mathematics, and social mobility was heavily influenced by this performance:

> Math can help you to be successful and everything, can change your life. Because most of the national exam that you have to take to get into university in Vietnam is math. And if you could build a good background and there's a good chance you will get into a good school. Um, so they really, like, started building my education background, especially in math, when really, really young. Um, and I think it's maybe a part of it because I was in--, math was easy for me.

Because of her family's valuation of mathematics and the fact that future schooling opportunities are tied almost exclusively to performance on the mathematics portion of the national exams, Mai and her parents understood the importance of doing well in mathematics. Mai said that her parents, who had worked very hard their whole lives to be able to provide for themselves and their children, understood how difficult life could be without access to education:

> In my family--, because--, my dad and my mom didn't have college degree. Um, so, even, like, [they] had a business and they were well respected. But, I knew that they are not as well respected as a [??] or as someone who has a college degree. They, um, so, they always, like, it's something they didn't want to happen to their children. They want to--, their children to have a much better, well-respected life.

Here, Mai described her parents' desire to provide educational opportunities for their children so that they might "do differently." For Mai, this specifically meant that her parents paid for mathematics tutoring for her from first grade on. In addition, Mai's father used to teach Mai mathematics at home:

> As far as I could remember, my dad always think that I'm good at math. And I would get up in the morning, like around four A.M. in the morning or five A.M. in the morning and then my dad would cook and then [he] would teach me math. And, so, I was prepared from an early time and I think that helped me a lot in term of develop my background in math because of the really concrete background.

This quotation stands out for two reasons. First, it connects her success in mathematics to these early experiences with her father. It exemplifies how her father supported her in learning mathematics content. Perhaps more subtle, here, was how her father supported her in learning to value mathematics. Mai and her father woke up early to study mathematics. This was the first activity of the day and, therefore seemed to provide evidence of mathematics being a priority to Mai and her father.

The second reason this quotation is highlighted is that Mai began by noting that her father always thought she was good at mathematics. In fact, at another point in our interview she said, "my dad was really good with math. So, he believes that because he's good for math, so we all get the good gene for math." This is important because it illustrated how her father's beliefs about her mathematical ability impacted her entire experience with mathematics. His belief that she was more genetically inclined to be good at mathematics meant that he treated her as someone who is naturally capable or good at mathematics. Therefore, at least part of her mathematical experiences and identity development were impacted by her father's beliefs and consequent actions about her natural ability.

Performance and Ability

Mai also described the impact that her family's support had on her beliefs about herself: "And especially in my family, where they support me so much study math, then I always feel confidence. […] I had all the support I wanted." As she states here, she felt that her confidence in mathematics was due, at least in part, to the supports that her family provided her. This pointed to the ways in which her family impacted how Mai viewed herself as a mathematical person. Specifically, her confidence in her mathematical endeavors was stemmed in continual support from her parents.

In addition to the aforementioned familial and cultural influences, Mai linked being good at mathematics to her own abilities, beliefs, and actions. First and foremost, Mai said that she knew she was good at mathematics because of her ability to perform in her classes. Specifically, her ability to consistently earn high scores on homework assignments and assessments in mathematics and the hard sciences served as evidence of her success throughout: “My focus was math, chemistry, biology, and physics. So they are the four subjects that I had to focus. And the four subjects that I had the highest scores. And the four subjects that I studied most.” Here, Mai directly coupled success in mathematics or other content areas with spending time studying that subject. In this way, Mai’s identity as someone who was good at mathematics was founded in hard work and many hours dedicated to specifically studying mathematics.

Many times, Mai named hard work and dedication as the factors that allowed her to be someone who was good at mathematics. In some instances, she indicated that part of identity may be a natural or given talent. Mai indicated that she often “got” things more quickly than her peers. And, as mentioned earlier, Mai’s father believed that his children were good at mathematics because he had been good at mathematics himself and thought that he had passed the “math gene” on to his children. And though Mai described her father as maintaining this belief, it seemed to be reflected in Mai’s descriptions of herself getting things more quickly and more easily than her peers. Being positioned in this way by her father may have led Mai to talk about her success in mathematics being both a product of hard work and something for which she may have had a genetic advantage.

Motivation – For Individual Educational and Career Opportunities

Mai indicated that she had strong motivations for working hard to succeed in mathematics. The first motivation seemed to be rooted in Discourses on the importance of mathematics versus other subject areas. Specifically, Mai said that she valued mathematics because it opened doors for better educational and career options later in life, as mathematics had a unique status in Vietnam, as compared to other subjects. She explained that it might be entirely possible to fail the literature or history portions of the national exam and still gain entry to the top colleges and universities in Vietnam as long as one's mathematics scores were high enough: "Those schools, they don't care how much, how bad, how awful other [non-math] grades are. They don't care about your GPA either. As long as you get a good score [on the mathematics portion] for the national exam, you are good to go." As such, it became clear to Mai at an early age that mathematics was the means to a bright future:

> Math can help you to be successful and everything, can change your life. Because most of the national exam that you have to take to get into university in Vietnam is math. And if you could build a good background and there's a good chance you will get into a good school.

Driven by a desire to get into the top universities after secondary school and to have career options later, Mai devoted her efforts almost exclusively to studying mathematics, chemistry, biology, and physics throughout school.

Motivation – To Earn Family Respect and for Social Mobility

As I mentioned earlier, Mai's parents worked hard to support her specifically in her mathematics endeavors because they understood the privileged role that mathematics played in Vietnamese culture and society. This means that these beliefs had been adopted by and acted upon by her parents. As such, Mai's motivation to be good at mathematics also reflected her family's values. As mentioned earlier, Mai described her parents as being keenly aware of the ways that access to education, generally, and to mathematics, specifically, could shape someone's life:

> Because they couldn't go to school, didn't have a chance to go to school, they didn't have the privileges or whatever in the past. And they want us to have that chance to help to change our life. To, you know, do differently…

She described her parents as lacking the educational opportunities that she and her siblings had growing up and, resultantly, her parents' desire to provide their children with all of the opportunities they did not have. As such, it seemed that Mai and her family believed that education was an important tool for social mobility. When asked if having educational opportunities that her parents did not placed any extra pressure on her to be a good student, she said that she did not feel that way:

> I don't feel the other way. I don't feel that. Like, I just know that my mom and dad are supporting me and it's just wonderful to have the parents like that. I never thought of it as a pressure. Yeah, I only thought of it as a support. And I always thought I was really lucky to have that, to have support from them like that.

As evidenced in this quotation, Mai repeatedly described her parents as being extremely supportive rather than a source of pressure and, in doing so, links her success to the continual support of her family.

In addition to viewing mathematics as a tool for her own or her family's social mobility, Mai also described the ways in which her success in mathematics reflected positively on her family. She said that by earning a degree in mathematics, her family would earn more respect from others in the community: "They'd say, oh my god, that family, they have five children, all of them go to college. That family is really well respected. Or, like, oh yeah, she went to college. That persons is well respected." By performing well in mathematics, she felt that she was not only advancing herself, but also enhancing her family's status and respect within their community. As such, it seemed that she had internalized these community expectations and, in turn, was motivated to bring respect to her family.

Motivation – To Change Community or Break Barriers

In addition to being driven to change her family's status, Mai also described wanting to change Vietnamese cultural perspectives of women. Specifically, she felt that the community she grew up in had not only different, but often lower expectations of a woman's potential. As she described below, Mai was bothered by this and was motivated to study mathematics in order to positively contribute to changing cultural expectations of women:

> Women are not, like, respected the way that they deserve. It's not all, but, still. Like, some idea. And say, they only think of woman should stay at home to take care of the kids. And just --, to be in the house, not doing anything that outside society and change something [??] like that. So I, I --, because the, the environment I grow up and, like, how I would grow up in the family that my mom is a really strong woman. But how others in the society and how they don't consider women should be strong. Like, they don't think that woman should be successful. And that really, really bothered me a lot. And after only thinking, like, of woman --, we are woman does not mean that we have to be submissive and passive and follow what the men say. Or we have to do housework, or whatever. Like, we, we are also human being and there's no thing to say that --, no rule to say that we are lesser than men in term of ability. And I see that a lot of, like, what, the things that when I went to schools and everything, I was always the, like, around like top or second students in the, the class. So, a lot of other boys that come to me and asked me questions about math, was like, so, why do they think that woman not --, should not be that good? So, like, in consideration of all that, I'm always thinking of how to help women in my country to have a better understanding or, like, have a better perspective.

Here, Mai specifically called into question the gender roles imposed by Vietnamese society, but also described her strong motivation to counter those prevalent beliefs about gender roles. Specifically, she made an argument for equality of treatment by stating that there is "no rule" that would position women as less successful or less able than men. In fact, by drawing on her own experience being the top student in class, sometimes over male peers, she positioned herself as someone who might be able to serve as an example of being successful in mathematics, despite these expectations.

Motivation – For Enjoyment

At many points throughout our time together, she described the importance and value of mathematics. Primarily, she illustrated this by describing how hard she worked when studying mathematics and, at times, the degree to which she chose to spend time on mathematics over other subjects or extracurricular activities. In this way, she consistently described mathematics as being valuable. She also described herself as someone who enjoyed mathematics. In these instances, however, she linked her excitement for doing mathematics with her good performance in the subject. Simply, she liked mathematics because she was good at it. When I asked Mai if she and her friends in the A group liked studying mathematics, she paused before replying:

> We [she and her grade-school friends] work on math, work on math together. But, it was like, 'Oh yeah, we are good at the subject.' We didn't think, 'Oh yeah, we love the subject.' We didn't think it that way.

Here, Mai indicated that enjoyment was not their primary motivation for studying mathematics, at least in primary and secondary school. Perhaps a more appropriate description is that Mai thought that learning mathematics could be rewarding. She did describe being excited when she was able to figure out a particularly challenging problem or when she was able to get something faster than one of her friends.

Although she described her early mathematics experiences in terms of obligation and hard work, Mai did use affective language to describe her current feelings toward mathematics—describing herself as "loving" mathematics or having a passion for the subject. For example, she said: "I love studying with math. So, maybe, that's why, like, I can get things faster or that I can, like, if in the class of, like, twenty students, if I don't get it, then other people don't get it." In this quotation, Mai described herself as someone who "gets things faster" than her peers—in this case, I believe she was comparing herself to others at the college level. Further, she described herself as someone who was able to understand difficult mathematics problems that her peers had not understood or could not understand. Mai described this ability as being a result of her love of the subject. Consequently, this description positioned her peers who were not able to "get things" quickly as being less passionate about the subject. As such, Mai seemed to have believed that being good at mathematics necessitated hard work. But, being particularly skilled seemed to require (or at least benefited from) enjoying that work.

Mai did not explicitly describe the events or experiences that led her to start enjoying mathematics. Having always been "good" at mathematics seemed to help facilitate this. Yet, she did not talk about enjoying mathematics until she came to college. This seemed to point to changes in motivations to study mathematics over time. Specifically, her early motivations were grounded in a desire to get into a top college. She did not explicitly desire to study mathematics in college, but instead to study business. At the point when she decided to change majors and chose to study mathematics, interest in the subject became a primary motivator. In addition to being good at mathematics, she realized that she also liked doing mathematics.

Summary

Mai described herself as someone who was always good at mathematics. She built this identity by telling three types of narratives: descriptions of performance or ability, descriptions of her motivation to do mathematics, and descriptions of her evaluation or enjoyment of the subject. Mai's identity as someone who was good at mathematics was built by providing two types of descriptions: First, she felt that her natural ability and her enjoyment of the subject made her more inclined to be successful in mathematics. When telling me about these experiences, she framed her success in mathematics as something that came naturally to her. She repeatedly said things like, "math was easy for me." As such, she endorsed this identity by naming success in mathematics as something that came easily or naturally for her. At other times, she described this relationship in terms of hard work and dedication, and, at times, sacrifice. In fact, as I will describe in a later chapter, she was a strong advocate for hard work being the primary factor separating students who did well in mathematics from those who did not. In this way, she framed being good at mathematics as something over which she had agency and control.

These descriptions depict the complicated nature of identity development—at times, her success in mathematics was due to her ability. Simply, she was good at mathematics because in her experience, she got things quickly—more quickly than other people she believed to be good at mathematics. At other times, it was because of her hard work and determination, coupled with the various supports and resources she had. Of course these narratives are not contradictory, merely different facets of her mathematical identity development.

Someone Who Used to Be Bad at Math

The descriptions provided by the other three participants about their experiences in mathematics differed from Mai's in many ways, primarily in the way that Lauren, Omna, and Prianca described their early experiences in mathematics as diverging from their later experiences. Although Mai maintained an identity of someone who was competent in mathematics across her schooling experiences, Lauren, Omna, and Prianca all told mathematical identity-building stories that shifted substantially over time and context.

A recurring theme for both Lauren and Prianca was the difference between their current and past mathematical selves. Specifically, Prianca and Lauren described themselves as people who used to struggle in mathematics, due to their personal shortcomings. Further, things like a lack of teacher or family support served to limit their development of a productive mathematical identity early on. But, with various resources and supports, accompanied by changes about their own perceptions of themselves as students of mathematics, both Lauren and Prianca felt that they had become competent and successful. Both could point to particular events, experiences, or relationships, which acted as a catalyst for this major shift in how they described their mathematical identities. Omna's description of her own mathematical identity development did not have such clear signposts in her story. There were times when she described herself as someone who was successful in mathematics and as someone at the top of her class. These stories featured events from both secondary school and university. At other times, she insisted that she was not mathematically gifted and, at times, downplayed her mathematical achievements. Again, these stories seemed to reflect beliefs about herself from across her life.

Below, I explore the ways in which Lauren, Omna, and Prianca described their mathematical identity development. For Lauren and Prianca, I focused on the descriptions they provided which contrasted their former and current mathematical identities. Further, I specifically explore the mechanisms they named in these change narratives. For Omna, I examine and unpack the ways she talks about herself as a mathematical person and how these descriptions seemed connected to the context framing those descriptions.

Being Bad at Mathematics

Seven minutes into our first meeting, Lauren began to tell me about her former mathematical identity: "I actually was horrible at math for a long time and until --, until like ninth, tenth grade, I was so bad that I was like, 'This is the worst thing.' I wanted to go into English [[laughing]]." In this quotation, Lauren builds an identity of someone who had been bad at mathematics "for a long time." Further, she shifted from a statement about her ability—"I was bad"—to "this is the worst thing." In doing so, made a strong connection between performance and enjoyment. Feeling that she was "horrible" at mathematics translated into mathematics itself being the "worst" subject. She also bolstered this identity by making visible her performance in or enjoyment of English. As I will discuss in a later chapter, participants at various times all created this dichotomy between mathematics and English. In this way, they positioned mathematics as a field that was starkly contrasted from English. More importantly, though, it highlighted an underlying belief that people generally fall into one of two categories: those who are Math people, and those who are English people. In her early schooling, Lauren positioned herself in the latter camp.

Like Lauren, Prianca said that she did not always enjoy or perform well in mathematics. In contrast to her other schooling experiences, Prianca used terms like "frustrating" and "disheartening" when describing her pre-college mathematics experiences. High school proved to be a particularly difficult time for Prianca specifically because of her experience with mathematics, as she described here: "I remember I, like, hit a low point in my junior year when--, actually, in pre-calc, when I got, like, my first C. Which was, like, very disheartening." Prianca described the experience of receiving this one grade as a low point in her high school career. She described this moment as being something from which she had difficulty recovering, as it shook her confidence in her herself and, further, her ability to get into a good college after high school.

Prianca said that, generally, she was a good student and that she earned good grades. Therefore, having earned her first C in this class was fresh in her memory and was representative of her lack of success despite her continued efforts. In the same way that grades were used as a rationale for Mai's identity as someone who is good at mathematics, both Lauren and Prianca felt that they used to be bad at mathematics because they did not earn top marks in mathematics.

Being Tracked

Prianca's high school tracked its students within mathematics and she was placed in the advanced track. Being placed in this track proved frustrating for Prianca, though, because she felt as if she was always performing at the lowest end of her mathematics classes. Her high school mathematics classes moved quickly and Prianca usually felt like she did not understand all of the material:

> I wanted to take Calculus and I wanted to take, like, higher levels. Cause I just felt like math was something that's really useful and I didn't--, I didn't want to, like, stop my math education. It was just that I felt I wasn't very good at it.

Here, Prianca noted that she understood the value of mathematics and, resultantly, that she was motivated to perform well; however, her consistent struggle to keep up with her advanced track classmates negatively impacted how she thought about her capabilities as a mathematics student. Specifically, she built this identity as a struggling mathematics student by contrasting her performance with others in her cohort who seemed to perform better.

She described herself as being "stuck" in the advanced track because she knew that she wanted to go to college and the expectation of college-bound students was that they would take advanced mathematics through senior year. Prianca recalled how students in the lower track were positioned by peers and teachers alike as unmotivated and less capable than their advanced track peers. Positioning the lower-tracked group in this way was not only problematic for those students, but also had negative consequences for members of the higher-tracked group. That is, students like Prianca–who were enrolled in advanced mathematics yet not performing at the top of the class–felt like they did not quite belong in either group. Prianca described this feeling when she was told by teachers that she could always move to the lower track if she could not handle the workload.

> That was one of the reasons why I didn't want to be in that lower-level because the way that my pre-calc teacher would just, like, talk about us. She would always say how it's pre-calc honors and we're the brightest students and that, you know, if you don't want to do this, then you can go down to pre-calc CP [college prep] and that's perfectly fine. I remember she would tell me all the time, 'Maybe you should think about [moving to CP].' And I would be so mad. I was like, 'You always diss these kids and say that they're not really serious about their, like, careers, if they're taking CP. And now you're telling <u>me</u> that I should think about it.' That's so rude.

Overall, as someone who intended to go to college, Prianca felt pressured to persist with the advanced track despite how poorly she felt about the content and her ability in mathematics.

Disengaged Teachers and Differences Between Teacher and Student Expectations

Prianca named multiple factors that negatively impacted her mathematics identity development. For example, she said her teachers used mathematics textbooks that were "older than [she] was" and, consequently, mathematics was not taught in a way that felt modern or relevant. She also thought that some of her high school teachers lacked a passion for teaching mathematics. She said that her Pre-Calculus teacher, in particular, did not put a lot of effort into teaching because it had become so "routine" for her. Moreover, this teacher insisted that students advocate for themselves in ways that Prianca did not feel comfortable with:

> She felt like we were kind of at the age where we should be able to figure it out for ourselves--, like, advocate. I remember, she was super huge on, like, advocating. Do it for yourself. Whereas I think I needed a little bit more support from her specifically. Like, maybe reaching out to me and asking me if I needed help. I think even that much would have, like, gone a long way.

In this quotation, Prianca pointed to differing expectations between her teacher and herself. At a time when the content had started to become particularly difficult for Prianca, her new teacher adopted and communicated expectations about the level of agency or advocacy students could or should have. When describing this experience, Prianca seemed to waiver about the degree to which this was the fault of the teacher or herself. As I will discuss in more detail below, Prianca thought that this shift in expectation was particularly difficult for her as a shy student and as a female in a majority male class. As such, she seemed to look back on this experience with some frustration aimed at herself for not having been more vocal in her needs while, at the same time, describing this teacher's policy as unnecessarily rigid and, ultimately, detrimental to her success and confidence. Essentially, Prianca said that she interpreted this expectation that students advocate for themselves as her teacher not being sensitive to the needs of her students and even as withholding help from students who "needed help."

Differing Familial Expectations

Although Prianca named multiple inhibiting factors, Lauren's descriptions of her experiences did not clearly point to specific negative instances or events. Instead, she focused on her own perceived shortcomings when describing her former mathematical identity. The only instance when she mentioned negative (or non-positive) factors was when she described her relationship with her parents and, accordingly, her familial expectations, as I will describe in more detail below.

Even though her grandparents were generally supportive of her educational and recreational endeavors, Lauren described her parents as being, at times, discouraging of her mathematical pursuits. Although her parents never explicitly linked their disapproval of her interest with her gender, she said that they held tacit beliefs that each gender was more suited to certain areas. While her brothers were supported to engage in mathematics and science, Lauren was encouraged to pursue music and caregiving. Her mother, in particular, discouraged Lauren from pursuing mathematics: "So they're always like, 'Oh, no. You shouldn't even, like, consider math. You shouldn't do this sort of thing.' So, I just never got help in that area." Her mother, who was a massage therapist, instead encouraged her to be something more suitable for women: "So she's like, 'Yeah, you should be like the healer type person, like a nurse.'" In many ways, Lauren described her later success in mathematics, and in her studies more broadly, as something achieved despite her mother's lack of support.

Personal Characteristics

Outside of describing her struggle to earn good grades in mathematics early on, Lauren did not specifically state why she was "horrible at math a long time." She talked about herself as being a "bad" student, generally, because of her difficulties organizing her time and work:

> I was really awful and I ended up getting a tutor to help me. And throughout that I worked on like organizational issues that I had. I was very ADHD when I was younger so I had issues with that too. Which I was like I don't get it. I'm not gonna focus on this. I'm going to skip it.

In this quotation, Lauren supports a former identity as a struggling mathematics student by describing personal attributes. Specifically, she "had issues" early on with knowing how to study and, relatedly, with her persistence. In some ways, she frames this identity as a natural state, a nature identity, linked to being "very ADHD." As such, Lauren's experience in mathematics and, perhaps in school more broadly, was impacted by her experience as a child with ADHD. In the first sentence of this quotation, Lauren also described the need for a tutor in order to overcome her "organizational issues." As such, Lauren's experience in overcoming this identity as someone who is bad at mathematics because of her natural state requires an outside force.

Similarly, Prianca attributed her lack of success in mathematics to personal characteristics or factors. Specifically, as mentioned earlier, she thought that being shy might have inhibited her from speaking up in class when she had questions and, therefore, negatively impacted her learning. She said:

> It's like, if you're left behind, then you're left behind. There's no point in trying, like, to help you get up. Unless you are very--, unless you advocate for it. And that's my fault that I didn't, like, try to advocate and be like "slow down. I really have no idea what

> you're talking about." But, I was also shy and I think that might, um, lead to whole co-ed thing. I was kind of, like, too shy to ask and a whole class of boys and being like one of the only few girls, like, asking questions over and over again.

In this quotation, Prianca describes feeling helpless. She underscored the enduring nature of an identity as someone who has fallen behind. Namely, that no matter what she did, she was going to be "left behind." The specific definitive language she used here—"there's no point in trying, like, to help you get up"—was spoken as if it was coming from the teacher's perspective. This seemed to reflect not only her feeling of helplessness, but also underscored Prianca's belief that her teacher thought that she was beyond assistance.

At the same time, she also seemed to struggle with her role in contributing to this identity. In the above quotation, she describes herself as shy and lacking the will or ability to advocate for herself. She immediately provided a justification, however, about why the context itself made it difficult, if not impossible, for her to do this. Being in a predominately male environment made the prospect of speaking up stressful. Perhaps more subtle here was that the learning environment framed students who asked questions in a non-favorable light. Prianca seemed to describe a social expectation where only those students who are lost ask questions. Therefore, the act of asking a question was likely to be interpreted by others as reinforcing her status as a struggling student. Ultimately, it seemed that Prianca did not absolve her teacher or the environment from negatively impacting her experiences and, therefore, her developing mathematical identity. Although she was willing to reflect on what she might have done to improve the situation in Pre-Calculus, her later experiences in predominantly female classes and in classes where questions are valued by her teacher and her peers led her to affirm the position that these factors like her teacher, the classroom norms, and student expectations outweighed her agency to improve the situation.

Upon graduation from high school, Prianca described herself as lacking “passion” for any one subject. Although she liked psychology, she did not think that she wanted to pursue it as a career. She had hoped to have a positive experience in mathematics or science that left her excited about studying something in STEM after high school. Instead, Prianca’s experiences in mathematics left her with an unproductive mathematical identity and feeling disenchanted with mathematics as a field:

> Looking back, I, I kind of feel angry that, like, I wish--, er I had support, too, especially, like, from my family. Like, my family is really big on education and, like, getting tutors if I need help. And I had that. I just felt like I didn't, I didn't really get taught the way, like, in a way that I could fully understand exactly what's going on. Like, I could understand certain problems, but I don't--, I don't really know what it was that--, maybe it was, like, lack of practice, er something. But, I think that if I had a stronger background in high school, like, earlier, then I would have realized that I liked it a lot earlier rather than coming to school and then realizing, like, after ‘oh, actually, I like the subject that I thought I hated.’

This quotation illustrates many of the themes present in Prianca’s descriptions of her mathematical identity development. First, she begins the quotation by describing her anger. At times, she seemed partially angry with herself for not practicing enough or for not working hard enough to find her “passions.” But, mostly she was angry at the teachers and the schooling contexts that did not help her to see her potential. As someone who, at the time of our interview, enjoyed mathematics and planned to pursue a career in mathematics, she was angry that mathematics had been taught by her former teachers in ways that did not give her access, did not help her to make sense of the material, and did not support her to gain confidence in her mathematical pursuits.

Overall, these experiences led Lauren and Prianca to build identities as someone who struggled in mathematics. For Lauren, this identity was explicitly endorsed by her parents who told her that school “wasn’t her thing” overall and specifically discouraged her from pursuing mathematics. Early on, this identity also originated from her position as a child with ADHD, who faced difficulties with organization. In this way, being a person who struggled with mathematics was affirmed by institutional measures of performance like grades, endorsement by her parents, and lack of focus or organization. That is, Lauren's description of her mathematics experiences reflected both nature and discourse identities.

For Prianca, identifying as a struggling mathematics student also reflected many factors. Specifically, she was shy and, at times, thought that she lacked the motivation or passion needed to succeed. When describing her experiences as a shy student, she built a discourse identity—an individual trait recognized by others—and also framed her shyness as a nature identity. In addition, her experiences as a lower-performing student in the advanced track were exacerbated by having a Pre-Calculus teacher who insisted students advocate for themselves without providing them the support that Prianca felt that she needed. Therefore, Prianca's framed her experience in mathematics as an institution identity, implicitly endorsed by her teachers and peers.

Someone Who Became Good at Mathematics

Both Lauren and Prianca pointed to specific events and relationships that positively shifted how they thought about themselves as mathematical people. Importantly, both named teachers as playing a significant role in reifying this identity. In Lauren's case, this teacher was her sophomore geometry teacher. Lauren thought that she had always been bad at mathematics, and that with tutoring and supports, she improved some, but still considered herself to be awful at mathematics. Lauren described the process of becoming someone who is good at mathematics as being a straightforward and sudden event as she described here:

> Yeah, I was sitting thinking that and then I started realizing that I was actually doing well. And I got hundred percent on a math exam - I think it was geometry. And the teacher's

> like, ‘Actually, you're good at this. Will you actually consider more of this sort of thing? We’re trying to do a computer science program the following year and it's kind of mathy. Maybe it's your thing.’ So I tried that. I was like, ‘Oh, this is great. I'm going to go into computer science or engineering.’

In this quotation, Lauren frames becoming a “math person” as sudden and even surprising—as if this shift in identity was something that happened to her, rather than something over which she had knowledge or agency. Important in this quotation is the role that both grades and her teacher played in affirming this identity. Again, Lauren’s description served to link being good at math with earning high grades on assessments. Lauren did not further explain if this was the first time she had been able to earn such a high score on a mathematics exam. It was still clear, however, that this achievement served to endorse her identity as a good mathematics student. Further, Lauren’s shift in how she viewed herself as a mathematical person seemed to be recognized and endorsed by her geometry teacher. It was through her teacher’s recognition of her capabilities and an invitation to pursue other “mathy” things that Lauren permited herself to believe that she could be successful in mathematics. After this experience in her sophomore geometry class, she seemed to consistently identify herself as both mathematically competent and as someone who generally enjoyed studying mathematics.

From positive experiences in her sophomore geometry class to AP Statistics in her senior year, Lauren developed an interest in Computer Science and Statistics, as she said here, “I took Statistics and I adored it…I was like this is where I want to be.” Lauren described her experience in mathematics in very strict terms before and after; there was a sudden and dramatic change in the way that she described herself as now being good at mathematics.

Prianca did not use such simple and straightforward terms to describe her shift in mathematical identity. For her, it took time and repeated positive experiences in mathematics to overcome this identity as someone who struggled in mathematics. In her senior year, Prianca took AP Calculus and recalled that her teacher that year was both knowledgeable and, at times, very motivating:

> There were certain concepts I felt like I really got in calc. Um, and it was like a good experience learning from her. And she was also very knowledgeable about it. Um, and, like, she studied math in college and when--, she went to grad school for math. So, she, like, knew a lot about it in general rather than just the stuff we need to know in the class (…) I think that was kind of a good memory or good experience for, like, certain topics where--, or like certain times where I felt very motivated to do well.

Despite this, her lack of confidence from her Pre-Calculus experiences endured throughout her senior year and after. Although Prianca described her Calculus teacher as being substantially better than her Pre-Calculus teacher, she felt that, in some ways, it was already too late to change her perceptions about herself as a student of mathematics for the better: “It's like at the point, I just didn't even want to do [math] anymore. And it's like, you’re a senior and you're almost graduating anyway, so you already don't feel that. But it definitely did leave a mark.”

Unlike Lauren, Prianca left high school convinced that she would never be interested in studying mathematics and that she would not be a person who could be successful in mathematics. As I discuss in detail in the next chapter, it was not until Prianca came to college that she changed her perspective on this and began to (re-)build an identity as someone who could be good at mathematics.

Being Someone Who Enjoys Mathematics and Is (Sometimes) Good at It

Despite earning almost exclusively A’s in her mathematics classes, Omna thought that she was not the strongest mathematics student in school: “I was not the best math student. But I always got above --, I was straight A’s, though, especially in math. I always got A's, 90 and above.” Omna’s descriptions of herself as a student of mathematics felt qualitatively different from the descriptions provided by the other participants. Whereas others endorsed their identities as mathematically competent by talking about earning high grades, Omna believed that this alone was not sufficient for being good at mathematics. Instead, Omna described being good at mathematics as requiring "originality of thought." In other words, she thought that truly gifted individuals were capable of mathematical innovation, of adding something to the current understanding of the field. Because Omna did not view herself in this way, she described herself as "a follower and a practicer" when it came to mathematics. She also repeatedly said that because she enjoyed mathematics, she took an interest in it. Therefore, she attributed her success in mathematics to interest and hard work.

Not Being the "Brains of the Family"

Omna explained that her high grades reflected "persistence" in mathematics, rather than some "natural" mathematical talent. As she described it, her "brand" was being a good, hardworking student who was involved in many projects and school clubs. In contrast to herself, Omna believed that her older sister possessed such talent, as she describes here:

> Yeah, they thought I was a good student, but my identity or brand, you might say, was more like a --, from other places. Not for my mathematical, you know, genius--, genius or whatever. But my sister, she was known for like her outstanding brain or whatever. Like she's still the model student in my school [[laughing]]. Yeah, so, in my family, we say all our brains [went] to her.

Omna said that her sister had been labeled the "brains of the family." By describing her sister in this way, Omna builds an identity for her sister as being genetically or naturally talented in mathematics. According to Omna, their family, their community, and even international organizations and schools recognized this talent. By describing her sister as the one who got all the brains, Omna simultaneously built a peripheral, if not inferior, identity for herself as not being the brains of the family or not "the model" mathematics student from her school.

When describing her sister's accomplishments, Omna seemed happy for her. In fact she spoke about the pride she felt that all of her siblings (except for the youngest who had yet to graduate from secondary school) had attended top schools in Nepal and throughout the world to study STEM disciplines. Omna described how much it meant to her being one of four sisters to all pursue difficult majors at universities and colleges around the world. She described her sisters as being her best friends and repeatedly said that there was no competition amongst them. As such, Omna did not express animosity or jealousy toward her sisters. It seemed, however, that the role she played as a younger sibling to someone who had been identified as "one of the top girls in the country" meant that she had a deferential perspective of her own ability and accomplishments. That is, she had not been nationally recognized in the same way that her sister had and saw the difference in their achievements. She said, "I guess it's because I've seen so many people who are naturally gifted in mathematics. So, yeah, I guess I find myself comparative --, comparing to them, so." As such, she described herself as lacking the natural ability she had witnessed in others.

Changing Contexts and Changing Status

Like other participants, Omna's schooling experiences also played a big role in shaping her mathematical identity development. Although Omna generally thought highly of her school teachers, she recalled having mixed experiences in her high school mathematics classes. Mostly, she linked any difficulties in her mathematics classes with changes in context. Her earlier experiences in Algebra were positive, as she described below, because she was in a familiar schooling setting and she was already established as a top student in her school:

> The time in my life, it was such that I had a great stability and I liked my school. I liked my friends. I liked the teachers. I was one of the top students and then --, and then I liked working and I like practicing the stuff. As I worked more, I understood more, and I enjoyed it more. So that's why I have, I have a better experience with [Algebra] (…) With Calculus, I feel a little bit insecure, I guess.

As she highlights at the end of this quotation, Omna contrasted her positive experiences in Algebra with relative difficulties in Calculus. When asked why she felt insecure in Calculus, she indicated that affective factors, rather than difficulties with the content per se, made a difference in her confidence with Calculus material. Specifically, she believed that this difference in her Algebra and Calculus experiences was influenced by her status and her comfort within the school environment, which was similar to Prianca's interpretation of her pre-Calculus experience. She explained that, while enrolled in Calculus, she experienced some disconnect because of a recent transition: "I came across Calculus only in my A-level part [of school] and because I changed my school for the first time then, I had a difficult time adjusting to the school." Adjusting to the new environment and to her status as a new kid in school was difficult for Omna and seemed to be a factor in her achievement and, resultantly, how she talked about herself as a mathematics student. The way that Omna described her transition to a new school seemed to play a large role in the renegotiation of her own identity. As you may recall from earlier, Omna had described being a good student as her "brand" prior to changing schools. In this new environment and as the new kid, this brand had to be reestablished, as it may not have been self-evident to her new classmates.

Interestingly, Omna linked these high school mathematics experiences to her engagement with and ability to perform in each of these subjects at the college level. That is, Omna believed that her positive experience in Algebra led her to be confident and to enjoy abstract Algebra as a mathematics majors, whereas Calculus still felt like a weak spot for her.

Being Excluded from an All-Boys Computer Science Club

At various points in our time together, Omna talked about the ways in which a young woman's experiences in school mathematics left lasting "impressions" on what she was willing and able to do in mathematics as an adult: "I definitely think the elementary school environment plays a big role in a girl's decision to [pursue mathematics]--, especially when they're young. Like, the impressions that are made. I think, yeah, that's really important." Although Omna said that she had difficulty recalling early memories of such experiences, she did share with me a story from high school, which seemed to impress upon her a lack of confidence in computer science and related to her reservations about her own ability in mathematics. In high school, a peer started a boys-only computer science club. As a result of this no-girls policy, Omna was prevented from joining this club even though she had wanted to:

> At that moment, I guess--, well, I was new to the school, first of all. I didn't really know the teachers and the management. And, at the same time, I mean, I always thought of myself as a feminist. Even then, I guess I just didn't think that I wanted to be in that club that much. You know? I thought I wasn't too interested. So, I didn't really try to--, and, actually the guy and I, we used to talk. So, he was kind of my acquaintance and almost a friend. But, still--, I never thought--, I didn't think that I wanted to join in the first place that much.

This description highlights Omna's struggle to reconcile two conflicting Discourses. On the one hand, identifying as a life-long feminist, Omna had always been a confident young woman and student. On the other hand, she did not push the issue of not being able to participate because, as she said that she believed herself to be of lower status as a new student and because of her belief that the person running the club was a friend. Ultimately, she convinced herself of two things: one, that she really had not wanted to join and, two, that computer science was just too hard, as she described here:

> I guess that kind of deterred me from computer science as a subject… And even--, yeah, I didn't try computer science until my sophomore year [of college] because I thought that computer science was really hard.

Based on this experience, Omna believed that computer science was too challenging to pursue and, ultimately, was not for her. As I describe in Chapter 5, this experience had such a lasting impact on Omna that it was not until her sophomore year of college that she decided to enroll in a computer science class. Similarly, her insecurities from high school Calculus seemed to follow her to the university and shaped her early decisions about which subjects she thought she could or should pursue.

Although this experience was not specifically about mathematics, it was an important part of Omna's identity and how she viewed her own ability in mathematics through a lens fashioned, in part, by others. Despite her many achievements in high school—being head girl, being one of two students in her graduating class to go to college immediately out of high school, and earning top grades—Omna seemed to believe (and to some extent still believed, as of her senior year) that her ability in mathematics and computer science was not as strong as others whom she identified as being gifted in those subjects.

Chapter Summary and Discussion

In this chapter, I explored the ways in which mathematics majors at all-women's colleges talked about themselves as mathematical people and the influencing factors or experiences that seemed to inform the development of those descriptions of themselves. This exploration was driven by my first set of research questions: *What language do senior women mathematics majors at an all-women's college use to describe their mathematical identity development.* The difficulty of addressing these questions in any meaningful way lies in the fact that the descriptions provided by participants varied across multiple dimensions. Not surprisingly, and aligned with much of the research on identity, participants' views of themselves and their relationship to mathematics changed over time. Further, each participant told stories from their perspective, but also recounted events from other people's perspectives. As such, the vantage point for any one identity-building description shaped and was shaped by those involved.

Participants' descriptions of themselves were always filtered through the lens of the context of their experience. This means that the stories they told to build their mathematical identities reflect the social, historical, political context of their experience they recalled, as well as the individuals with whom they interacted during their experience. Even within one socially recognizable identity—being a mathematical person—there were (and are) many ways to frame and interpret a participants' descriptions of themselves. One goal of this chapter was to better understand how the development of a mathematical identity reflected participant's description of the development *process*, the identifying agent or *power*, and the *source of that power*. In some instances, identity-building stories told by participants positioned themselves as the identifying agent and source of that power. In others, participants positioned others as having that power.

Looking across Mai's descriptions of herself as a mathematical person, developing and maintaining an identity as someone who is good at mathematics seemed to be built around three things: (1) being gifted or genetically inclined; (2) supports like access to educational resources and recognition by parents, teachers, and peers; and (3) hard work and motivation. In describing her mathematical identity as someone who is (and has always been) good at mathematics, Mai named all of these factors. Mai's descriptions of herself as a hard working and motivated person were consistent with the findings from other studies. As described earlier, other scholars have found that (Mendick, 2005; Rodd & Bartholomew, 2006) female students are quick to highlight the ways in which their success in mathematics can be attributed to hard work. Further, her acknowledgement of the role of outside resources and familial supports was consistent with the discursive construction of successful women in mathematics. Mai's description of herself as a mathematics student was different from what other research has found in that she did describe herself as naturally able, but always described that alongside her hard work. Rodd and

Bartholomew (2006) found that a few (high achieving) female mathematics majors described themselves as being naturally talented. Yet, the particular way students framed this identity was by describing themselves as "strange" or "different." The authors argued that it was through claims of abnormality that these young women had built identities as being "special." If Mai thought of herself as special, she did not describe herself in that way. Instead, she seemed to believe that—special or not—the only way to get ahead was through hard work. As such, Mai's identity as a successful mathematics student seemed to be discourse-identity—produced by a process over which she had agency, rather than contingent solely upon a nature-identity as someone who was naturally gifted at mathematics.

When describing identities as people who used to be bad at mathematics, Lauren, Omna, and Prianca named themselves as the primary powers in inhibiting their success. And, in Lauren and Prianca's case, the process of becoming someone who was good at mathematics seemed hinged upon an external power. With Lauren, she claimed that she was terrible at mathematics and always had been, and had linked that to having difficulties concentrating and organizing. She was told by her parents that school and mathematics "just wasn't her thing" and she seemed to believe it herself. Yet, as she described it, something happened in her sophomore geometry class wherein she decided that she loved mathematics and was, from that point forward, a "Math Person." This event marked a shift away from the nature-identity of being a child with ADHD and being "horrible at math." Instead, she became a person who was—quite suddenly—not only mathematically capable, but also enjoyed mathematics.

As I stated earlier, Lauren's description of this event highlighted two things: first, her high score on a mathematics test. Second, but just as important, is the role that she described her teacher as playing. Lauren said that her geometry teacher pointed out how well she had been doing in class and invited her to do more "mathy" things in the future. As such, I think that Lauren's description underscored her teacher's authority in build or, in the very least, naming this identity. The teacher's recognition and validation of Lauren as someone who could be good at mathematics seemed to an important, if not necessary, to reforming her mathematical identity story.

In Prianca's case, she described herself as lacking the passion needed to be successful in her high school mathematics class. Further, she said that her shyness was an inhibiting factor to being able to ask questions and to get the help that she needed. And it seemed that her negative experience in Pre-Calculus reinforced the way that she had viewed herself. Yet, as I will describe in detail in the next chapter, Prianca described a shift in her mathematical identity resulting from an experience with a professor who recognized and named Prianca's mathematical potential. In this way, both Lauren's and Prianca's respective mathematical identity shifts seemed to both be heavily influenced, if not contingent upon, an external authority reifying this identity. As such, participants' descriptions seemed to point to the importance of others (especially mathematics teachers) in facilitating or authorizing the process of becoming someone who was good at mathematics. Therefore, it seemed that Lauren and Prianca perceived their mathematical development in terms of a discourse-identity in which the primary source of that power was "rational others" rather than themselves. In Chapter 7, I return specifically to this idea in order to situate these findings within the known literature focused on women's experiences in school mathematics.

Throughout this chapter, I focused on how participants talked about their mathematical identities and how these identities shifted over time. I did not specifically highlight the role of context in participants' descriptions. In the next chapter, I focus specifically on the role of the

Metcalf context in shaping these young women's descriptions of their mathematical identity development.

CHAPTER FIVE: INVESTIGATING THE ROLE OF CONTEXT IN MATHEMATICAL IDENTITY DEVELOPMENT

As I discuss in Chapter 3, none of the participants came to Metcalf with the intent of studying mathematics specifically. Mai, having had positive experiences in mathematics throughout school, and Lauren, who developed an interest and confidence in mathematics much later while in high school, both considered pursuing degrees in a STEM field, though not mathematics specifically. Mai was set on studying economics, while Lauren was not committed to a particular area, instead wanting to try economics, computer science, or another related field. In contrast, Prianca and Omna left high school with low confidence in mathematics and did not think highly of their experiences in mathematics. Resultantly, each had all but ruled out studying mathematics when applying to colleges. Prianca and Omna explicitly said that they did not intend to study anything in STEM at the beginning of their college career. Yet, each ended up choosing mathematics as her major course of study and, reportedly, did so with confidence.

As "being a mathematics major" is one socially identifiable identity and is, therefore, a fundamental aspect of the ways participants describe their mathematical identities, I wanted to better understand what aspects of the context influenced their decisions to pursue mathematics—especially for Omna and Prianca. The purpose of this chapter is to investigate the role of the context in shaping the mathematical identities of these young women.

Because context, as envisioned by Gee, is an all-encompassing concept–from the immediate physical setting and aspects of communication, like gesture and intonation, to the social, historical, and political Discourses influencing how communicators interpret what is done or said–I necessarily narrow the lens of my analysis to focus on two aspects of context: *activities (practices),* "socially recognized and institutionally or culturally supported endeavors" and *relationships*, relationships among the participant, "other people, social groups, and /or institutions" (Gee, 2011, pp. 17-18). That is, I focus on what mathematics majors at Metcalf do and on the relationships they deemed meaningful. I do so because these aspects of context were reflected in each participant's descriptions of her experiences at Metcalf and, for some participants, were the most salient factors they reported shaping their mathematical identity development.

In this chapter, I address my second set of research questions: *How might the context of an all-women's mathematics department be described as relevant to students' identity development? Specifically, what activities do mathematics majors at an all-women's college describe as significant to their experience and how do they describe their relationship to others within that context?* In the first part of this chapter, I focus on the various institutional practices participants named as being relevant to their experience at Metcalf. Specifically, I consider the role and impact of the degree structure itself, as well as the options for majors and specializations, which were the norm at Metcalf. I explore these aspects of context first, as they seemed to be important to all participants' choices to be mathematics majors.

In the second part of this chapter, I look across participants' descriptions of activities, like attending class or office hours, and of their relationships with peers, with faculty, and with the institution in order to gain insight into the ways that the context shaped their experience. It is not surprising that mathematics majors would describe the activity of going to class as being a representative part of her experience as a mathematics major. Nor would it be surprising for participants to name the development of interpersonal relationships with their teachers or peers as important. Instead, the value in this exploration lies in that it illuminates what it means to know and do mathematics at the all-women's context of Metcalf because, together, these descriptions will help me characterize the context as participants perceived it which will allow me to explore the role of context in shaping these participants mathematics identities. Therefore, this chapter is not a collection of events and people, but rather a focused exploration of the specific nature of these activities and relationships and how these aspects of context shaped the ways participants recognize themselves as mathematical people. As such, this chapter concludes with a focus on the implications for students' mathematical identity development. That is, I explore how the activities and relationships named by participants point to a specific way of what it means to know and do mathematics; and, therefore, points to specific ways of being a mathematical person.

Institutional Practices

One important variable participants identified with respect to their experience with mathematics at Metcalf was that of institutional practices. Institutional practices refer to those practices (activities) at Metcalf which are not specific to the mathematics department. Such practices included school-wide policies and expectations for all students like completing school distribution requirements, and enrolling and finishing a dual major or degree specialization. Below, I focus on how these activities shaped participants' experiences and, correspondingly, seek to understand how students' seemed to be impacted by the institutional policies that encouraged such activities.

Distribution Requirements

Reflective of the degree structure of many liberal arts colleges, all degrees at Metcalf included something called a distribution requirement. As the name suggests, students were required to take courses in various content areas distributed across the curriculum—physical education, a foreign language, something in each of the hard sciences, humanities, and social sciences. The degree structure meant that students were not just encouraged but required to explore different subjects. For students like Prianca–who "like, literally, had no idea of what [she] wanted to study"–this meant that they were afforded the opportunity to investigate new areas without having to commit to any one subject area early on. As Prianca said,

> And I think that, like, distribution requirements and just coming to Metcalf in general kind of, like, takes that away [the stress of feeling like you are not a 'math person'] and it gave me, like, an opportunity to try it out.

Because of the structure of the degree, students were provided space to explore. According to participants, being able to do this was important in helping them make an informed decision when declaring a major. Although all of them deviated from their initial degree path, Prianca's story, in particular, points to the importance of encouraging students to try out different subject matters:

> I remember I, like, originally took calc [Calculus] two cause I wanted to get rid of the distribution requirement. And then, I just fell in love with the subject after and just kept- decided to take more math classes until I ended up being a math major.

Were it not for this distribution requirement and subsequent positive experience in mathematics early on in her degree, Prianca might likely have never finished a degree in mathematics.

Minors and Degree Specializations

In addition to having distribution requirements, participants explained that there were multiple minor and degree specializations at Metcalf.[10] In fact, every participant in the study was either enrolled in a special program, was completing a dual degree in mathematics and another subject, or was had a minor in another discipline. According to participants, many

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[10] Approximately 65% of students in the mathematics or statistics major had a minor, specialty, or secondary major in another department. Of those students, economics was the most popular, while biology came in at a close second. Looking across the 2014 and 2015 class list, there were students pursuing minors in everything from Art to International Relations. Looking at aggregate school data, enrollment in a minor or academic specialization outside of the department was reflective of standard at Metcalf – approximately two-thirds of students declare a minor, specialty, or secondary major.

students at Metcalf enroll in a degree specialization or minor. This norm was important for two reasons: First, enrollment in a minor led some students to eventually declare a major in that area, as Mai described here:

> Originally, I thought of having a major in economics and a minor in math. But, I, I was always interested--, like, you know, how I like math. I like, like, working with numbers and how I feel, like, good working with numbers.

Despite always being interested in mathematics, as Mai described here, she did not initially enroll in a mathematics major, instead opting for a minor in math. By enrolling in a minor early on, though, Mai had a smoother transition into her final program, a dual degree in mathematics and economics.

Now, Mai came into the program with a solid mathematics background and felt very confident in her ability to succeed in mathematics. For other students who do not have this initial passion or confidence, enrollment in a minor seemed to serve as a way to test out the area without the pressure of having to finish an entire bachelor's degree. For some of the study's participants, a minor did eventually turn into a major. This was true for Omna, as she had tried out computer science, declared computer science as a minor, and eventually decided in her sophomore year to change her degree path toward a dual major in mathematics and computer science.

Based on the experiences of some participants, it seemed that enrollment in a minor or academic specialty broadened students' academic horizons in that it provided them with an opportunity to try out a new discipline. This was particularly true for Lauren, who upon taking an introductory economics class, decided that she hated it; yet, Lauren's initial pursuit of economics allowed to her test out that area and, while it did not lead to a major in economics, she said that it did eventually lead her to a minor in a related area, complex organizations, as she indicates here:

> Yeah, I'd never taken an economics class. I just thought the idea of how people behave financially is really interesting. And I still find that very fascinating. In particular, behavioral economics, which I know would be more of a graduate level type stuff that you would study, but. I always found a really fascinating. And then I came here and took the intro class that we have and was like, "This is awful. I hate it." Which is funny now, because I'm taking micro theory. But that's so I can take econometrics. Because that's Statistics based. (…) Yeah. So my minor is Complex Organizations, which is through the economics department but it's kind of like business, leadership, Econ that sort of thing.

Providing a structure that encouraged students to pursue multiple options or a secondary course of study for a minor or specialization, ultimately seemed to give participants the ability to explore different subjects that they might not otherwise have.

Activities at Metcalf

When describing their experiences in college, all of the participants told stories about being in class. Generally, participants thought highly of their teachers and valued attending class. Omna was the only participant to question the value of attending some classes, indicating that, at times, some lectures were not worth attending, as she could always grab notes from a friend after class. The other three participants said that most students attended classes regularly and, based on their descriptions, attending class was a typical activity and was representative of the experience of being a mathematics major.

Descriptions of classes varied by participant, as did participants' evaluations of the content, instructor, and pedagogy. Although Mai enthusiastically said "the professor here is awesome" and felt equally excited about her coursework, other participants described their in-class experiences as varying based on either the content or the instructor. Reflected in the descriptions of participants of their classroom experience, however, were two common student activities: participating in class and experiencing/interpreting instructors' pedagogical strategies.

Participants' descriptions of these activities were important in that these practices matched their cultural models of what "school math" should be. As such, being a mathematics student meant engaging in mathematics in particular ways, some of which were normal (or even possible) within the context of Metcalf. I discuss these ideas in the following sections.

Participating in Class

According to participants, classroom discussions, group work, and so forth were not the norm at Metcalf. In fact, when asked about class discussions, some participants asked for clarification about what I meant when I said discussion—an indication that discussions were not part of their general mathematics experience at Metcalf. Participants said that instructors encouraged student participation in that some grading schemes from their math classes included five percent allotted for participation; however, the bar for what faculty counted as participation in some classes, according to participants, was rather low. Specifically, they said that participation, in many cases, stood as a proxy for attendance. This was reinforced by how all participants described their passive role as a student in classes. The exception being Mai, who, at times, described herself as being a very active participant in her (earlier) mathematics classes, an idea to which I will return below.

Omna said that she could not remember taking a single mathematics course at Metcalf in which group work or student collaboration was an expectation for students. Some participants recalled one to two instances across their entire college career wherein they completed a worksheet in groups or were asked to present something at the board in their mathematics classes. Not all participants had this experience, though, as this sort of student classroom participation and activities seemed to be instructor- and content-dependent. As such lack of discussion seemed to be a salient part of participants' experience. Omna said,

> It wasn't like, 'Okay, let's have a group discussion,' you know. We did have, um, presentations on topics. Yeah, individual presentations. But, um, I think of Emmy, also, what she makes us do is--, she gives us problems and each of us go to the blackboard and just do it. Yeah, but um, I remember that there is no such thing as in, okay, you go to--, go and into a work group or something.

In this quotation, Omna describes only one teacher who expected students to share their strategies with classmates during class. And, even in this case, it was only due to prompting by the professor who "makes us do it," rather than a student expectation or desire to participate in this way.

Although participants said students were generally comfortable asking a question or making a contribution in class, it was rare for students to do so. They said that they, themselves, were not anxious or stressed about speaking up and that, except for some shy or reserved peers, their friends would be equally comfortable talking in front of the whole class. Despite this, the norm was for students to remain fairly quiet in mathematics class.

Overall, participants reported feeling content with these classroom participation norms. Only Mai expressed some concern about the engagement of her peers and about the students' role in class. In fact, Mai described how she actually participated less in her classes in her senior year than she used to when she first came to college:

> Yeah, like after my first semester, I was like, oh my god. Like, my first semester in my economic class, I was asking so many question. I ask so many question sometimes it felt like I was the only person asking question every day in class. And talking to my professors. And kind of like having conversation even with my professor when--, while other people just, like, are sitting there and listening… After a while. Like, at first, I thought I would change the environment. But after a while, I was changed by the environment.

Mai described the social norms that shaped her engagement and, in this case, they had done so in a subtle way. That is, "after a while," she realized that she was not speaking up in class. Although she referenced her economics classes in the above quotation, she said that her experience reflected mathematics classrooms also. The way that Mai talks about herself in this quotation was interesting in that she positioned herself alongside the professors as the only individuals attempting to make change in the discursive patterns of class. Despite being a student, she believed that she had the agency to "change the environment." Ultimately, she found that her concerted efforts to support conversation with the instructors did not alter these deeply rooted mathematics classroom participation norms. Resultantly, the environment ultimately "changed" her.

Mai said that she did not have a clear understanding of why she spoke up less in her mathematics classes. She only knew that it was rare for other students to participate in class and that she, as a result, felt uncomfortable speaking up in class as much as she used to when she first came to Metcalf. When asked why she thought that her peers did not talk in class, she guessed that it might be out of fear of being seen as "silly" or "not smart," but said she was not sure. This points, perhaps, to a cultural norm related to doing "school mathematics"; namely, that being a student in a mathematics class, at least in the United States, was characterized by limited participation.

Barring being in a "big class" (i.e., a large-lecture style class, which was rare on campus), other participants said that they felt completely comfortable speaking up in class. And, for the most part, they were confident that their peers did also. They indicated, however, that people just chose not to. Instead, students were much more likely to write down their question and to seek resources outside of class to answer that question, reflecting a cultural norm of individuality and non-collaboration. Lauren said that, for herself, she was unlikely to ask a question of her instructor during class:

> Not unless I'm completely confused and have absolutely no idea like what is trying to happen. For the most part, I just try to copy it down and understand it as it's going. If not, then I go to the professor later or ask my friend.

In this quotation, Lauren describes her role in class as passive. Her job as a student was to take good notes and to do her best to keep up with the material as "it's going," as if the class was something Lauren witnessed rather than something she might actively contribute to. For Lauren and others, their experience in mathematics class was primarily one of information gathering and, as Omna described it, to "absorb" as much as possible during class.

Experiencing or Interpreting Instructors' Pedagogical Strategies

Related to classroom participation wherein students primarily played the role of note-taker, participants described Metcalf mathematics faculty as generally using lecture-based instructional strategies. Prianca said that there were instructors who, depending on what the kinds of content they were teaching, attempted to implement projects, student presentations, use non-standard assessments, or have students engage in classroom discussion. The other participants said that group work, student-to-student discussions and so forth were not the norm, as evidenced by the conversation excerpt below:

> Alex: So, in class, have you had classes where group work was a component of, like something that you did in class?
>
> Omna: Umm... we'll no, not really.
>
> Alex: Really? Okay.
>
> Omna: Yeah.
>
> Alex: What about classroom discussions? Like is that something that was done in a math class here?
>
> Omna: Um, classroom participation is like five percent of your score. But, um... it wasn't like, okay, let's have a group discussion, you know. We did have, um, presentations on topics.

Alex: Individual presentations?

Omna: Yeah, individual presentations. But, um, I think of Margaret, also, what she makes us do is--, she gives us problems and each of us go to the blackboard and just do it. Yeah, but um, I remember that there is no such thing as in, okay, you go to--, go and into a work group or something.

As evidenced by this last turn by Omna, in instances where students are expected to give individual presentations, the instructor "makes" them do it.

Prianca was the only one who described having the experience of being in a "non-traditional" mathematics class. According to her, those students who had experienced student-centered teaching or were asked to complete "non-traditional" activities or assessments responded negatively, as she describes below:

> This is kind of just me, but I felt like, like there are new, like, innovative ways of teaching, like teaching through inquiry and just, overall, nontraditional teaching and I feel like I just don't click as much with that. Like, I'm taking differential equations right now and instead of having tests, we are having these five-minute demos in his office, where, like, he'll give us a question and we have to, like--, the first few demos, he give us a question and we have to express it in Matlab and solve it in Matlab. And the other one is like, he's going to give us a separation by variables question. And you just have to solve it. And I just feel like that's very different from, like, every other test that I've had. Or, like, we have to give a presentation in the class, um, that's pretty different from what I've done. I don't know--, it's like very less--, it's not as much lecture, it's more group work. But, I feel like for--, like, that works a lot for other disciplines. But, just for math, it's kind of hard. It feels like you are, like, teaching--, or, like, you are learning the answer by yourself rather than, like, getting lectured. Which, I know it's supposed to be, like, a better way to learn, but I don't really like it [[laughing]].

Here, Prianca describes a class she was taking where the teacher attempted to teach "through inquiry," which she described as a novel experience at Metcalf. Enacting pedagogical strategies, such as making group work a standard part of class, as Prianca described, put the responsibility of learning material on the student in a way that she found uncomfortable, at least when it came to mathematics. As Prianca indicates in this quotation, she believed that mathematics was different from other disciplines in that it is harder to make sense of in the moment. Therefore, when an instructor used pedagogical strategies that asked more of the student, this positioned students as being forced to "learn the answer by yourself." Further, the idea of having an assessment in which a student would be asked to solve a new applied problem in a one-on-one setting was not representative of her mathematics experiences.

For Prianca, the ability to participate in a group discussion in a higher-level mathematics class was restricted by her lack of prior exposure to the content:

> I feel like professors… they, like, ask questions and then ask us to talk with our partner about it. But, I just don't feel like I have enough background to start talking about this. Like, I need more from you [the professor].

In this way, Prianca described herself and other mathematics students as being at a disadvantage when asked to have a discussion about a topic with which she was unfamiliar. The language she uses in this quotation is interesting, as she used a tone almost bordering on pleading, one that positioned the instructor as a person with the answers and who was intentionally withholding them from the students.

Although Mai described her classroom experiences as traditional teacher-centered lecture, she said that some of her instructors were trying to find ways to encourage students to participant. In these instances, though, Mai said her peers found it difficult to speak up because her instructors seemed to be looking for the "right answer," as she describes below:

> And not just, like, if the professors, like, talking and talking and talking and, you know, sometimes asking question here and there, but kind of, like, not --, kind of, like, looking for the right answer. And that kind of freak people out. Like, if you are looking for the answer but kind of freely let people explain, let people, like, express their, um, thoughts then it would be easier for them to talk about it. But if you are looking for only one answer, then it could be hard.

Because some of the instructors seemed to ask questions that had only one right answer, Mai felt that her peers might "freak out" about trying to anticipate what the instructor wants, which she contrasts with "freely letting people explain." As such, Mai seemed to believe that attempts at encouraging students to speak up might translate into "guess what the instructor is thinking."

This sentiment was echoed by other participants when talking about their in-class experiences; namely, that the instructor's role was to be helpful and that asking students to play a more active role felt not only uncomfortable, but actually acted as an inhibitor to learning. Prianca continued, describing her peers' reactions to course structures like this:

> Well, I know that class was, specifically--, that they don't really like it. Or, it just--, I've talked to a lot of people in that class and they just feel like they aren't really getting anywhere. Like they're just not--, like, myself included, don't feel like they are learning... enough.

Overall, classroom norms at Metcalf positioned instructors as the experts who, through lecture and thoughtful explanations, were able to provide students with the tools needed to make sense of new content. The role of the instructor, then, was to provide clear explanations and to ensure that assessments were "fair" in that they align with what students had seen in class. Being recognized as a mathematics student, then, means engaging in these behaviors—showing up to class, taking thorough notes, and "absorbing" as much of what the instructor presents as possible. This evokes and perpetuates a banking metaphor for learning, wherein learning is characterized by "receiving, filing and storing deposits . . . bestowed by those who consider themselves knowledgeable upon those whom they consider know nothing" (Freire, 1970, p. 46).
As such, participants seemed to mostly describe their identities as mathematics students in passive terms.

Relationships

In addition to their experiences in the classroom, participants described other activities or practices that were important to their experience at Metcalf—for example, going to office hours, being part of a study group, attending Math Club meetings, or being a teaching assistant. The way that they framed these activities, however, focused on the interpersonal interactions or relationships built with others while engaging in those activities, rather than on the significance of the activity itself. In other words, participants gave these activities importance because they served as a context for developing meaningful relationships with peers and with faculty. As such, I return to the activities outlined in the previous sections below, with a focus on how they acted as contexts for developing and maintaining relationships with others at Metcalf.

Relationships with Peers

Participants uniformly agreed that the climate in the mathematics department, and at the college more broadly, was highly cooperative and that they had supportive relationships with their peers. This support took two forms: first, participants said that their peers were supportive of them generally in pursuing their passions. For Lauren, in particular, who had never been supported in pursuing mathematics prior to coming to Metcalf, she described how college was the first time that she had received such support from friends and faculty. Lauren said, "Yeah, no, I never really had somebody that's like, 'yeah, that's great go do that.' Until I got here and had friends and professors saying, 'yeah, that's great, go do that.'" Therefore, one aspect of feeling supported and being a part of this cooperative peer culture was that peers encouraged one another to do whatever made them happy, academically. Being surrounded by other individuals who also valued and enjoyed studying mathematics made for a generally supportive and cooperative peer culture.

The second aspect of this cooperative peer culture, as described by participants, came from a general lack of competition. This supportive rather than competitive learning environment was evidenced by their experience working in groups with their friends outside of class. That is, when describing their work in study groups, participants felt that every study group member generally had something to bring to the table and that there was never a race to determine who could figure out something the quickest. As Mai describes below, participants supported their study group mates and expected that support in return:

> I think we are support each other. Like, if you are in math, then you know other people, like, people who also study math in your course, you would support the person and you support, like, you support the person at the same time that you support yourself in terms of what you are doing.

In addition to describing their out-of-class experiences, participants also pointed to classroom experiences when providing evidence of the non-competitive peer environment. Rather than explicitly describing what happens in Metcalf mathematics classes, though, most participants contrasted their experiences to those from high school or to those of friends at other competitive co-educational or all-women's college environments. Competition manifested itself in different behaviors from classmates. That is, many participants described how competitive environments were often linked with students talking over one another and attempting to get an answer quicker than one's peers. Examples of such situations were often within the context of a co-educational classroom, in which participants felt that men dominated the conversation. Lauren, having taken co-educational classes at a nearby institution experienced this first-hand:

> I have men in my class at Edgerton right now, which is really interesting. And I've had men in my Econ classes that I've taken here….And they're always the ones that sit and talk. They sit and talk while the professors talking, quite often. Or they sit and talk at the professor. Or they just feel the need to have the attention on them. It comes across as that way to me in every single situation. Like they always talk, even if they're wrong, they're gonna talk.

In this quotation, she describes her male peers as engaging in dominant, even rude, discursive actions; speaking out of turn, engaging in attention-seeking behaviors, talking over peers and the professor, even speaking up when they have nothing of value to contribute. Prianca similarly said:

> I remember in high school how they would be, like, very dominating over the conversation, or like the lecture and they'd constantly--, it's not like the questions annoyed me. But, they--, I guess it's just like their, their attitude towards, like, knowing everything and thinking they already know it.

Other participants described similar experiences of male peers acting as if they "already know it" and "dominating the conversation"—either recalled from their K-12 schooling, through secondhand reports of friends attending co-educational experiences, or first-hand experience in the college setting. Omna similarly said that the effect of having dominant male personalities in class was that her peers became "less outspoken" and participated less.

Participants' descriptions of being in a co-educational space serve as a stark contrast to their experiences in single-sexed spaces. Omna noted the difference between how women engage in the conversation in an all-women's class as opposed to a co-educational class:

> I've noticed that in a women's college, women are more outspoken in classes. As far as in coed classes, guys are more outspoken, I guess, in class. Yeah. Yeah, in terms of class participation, I expected a lot of class participation from my peers [at Metcalf] and I got that, yeah. (…) I used to remember like my [high school] class and some of my guy classmates being really obnoxious and looking down on girls and that sort of thing. There wasn't that kind of provocation here. So, that would be the best part [of being at an all-woman's college.] [[laughing]]. You know, no guys that --, there were no guys who would, like, look down on you. You wouldn't have to think, "Oh, what would --, like, would the guy think that --, will the guys think that I'm stupid or something?" So, there was all that kind of suspicion or doubt. You, you, like, you knew that your friends or your other women wouldn't judge you however stupid question you ask.

These descriptions served to distance themselves from male peers and to align participants with other women, who, at least at Metcalf, would not participate in this way. As such, participants' descriptions sometimes seemed to other male students and, correspondingly, male-dominated interactions: both the ways in which they were unlike women in that they quickly assumed they were right and in they ways that they seemed to "judge" or cast "doubt" on women.

Although some women may have participated less in class in a co-educational setting, Omna described herself as becoming more outspoken in a co-educational environment and said that she was encouraged to participate more: “If there's a guy in the class, I get really competitive and I don't want to be like --, I don't want the guy to get high scores. So that actually increases my effort in the class.” What Omna said here is in stark contrast to how she generally described herself as a student. Repeatedly, she said that she was very uncompetitive with her sisters and peers and that she generally was not an active member of classroom discussion (sometimes bordering on being “lazy”). The change of context to include male peers, however, shaped Omna’s description of her attitude toward learning and engagement in classroom conversation in powerful ways. This is important as it underscores the ways in which her identity—as a student, as a contributor to the classroom conversation—is contextually dependent and that a major contributing factor for Omna and for others was the individuals who occupy that space.

Whether participants felt encouraged or discouraged from speaking up in a co-educational class, they uniformly agreed that a male presence impacted how they participated in class and, ultimately, generated a competitive atmosphere that many found unappealing. For participants, this meant that having a positive, supportive relationship with peers was an essential element for productive, thoughtful discourse patterns at Metcalf. And the development of these positive, supporting relationships was far from guaranteed when the other individual(s) were male.

Relationships with Faculty

When asked about who or what supported them to be successful in mathematics, participants consistently told stories about their relationships with faculty members. Omna said, second only to her ability to earn high grades, the support offered by faculty members and their ability to create a comfortable classroom environment was of the utmost importance. Reflecting the overall supportive atmosphere, participants felt that the faculty members were invested in student success and that many of them were always available to help. A positive relationship with faculty members was marked by a few different things. First, participants described certain faculty members as "caring" individuals who were "accessible." For students, part of being cared for meant that a faculty member made time for his or her students, which was demonstrated through having an open-door policy in which students could come in throughout the day to get help. For example, Prianca said:

> I really liked how much attention I was getting from my professors. Like, it exceeded my expectations. Especially with office hours, just being able to talk to them one-on-one. And they know what to ask for help so easily. Like, I remember my math professor, even if he didn't have office hours, like, his door was always open. And I, like, I really appreciated that.

Further, participants said that these faculty members consistently demonstrated interest in students as people. That is, these faculty members' interest in students went beyond classroom performance, to include a desire to know their students as a whole. Lauren explained that such faculty members worked to develop positive relationships like these with her and other students:

> I do have faculty, like, asking what I'm doing for the summer and how my classes are going and if I'm having any problems with anything. What classes I'm looking forward to taking. And they might recommend something. It's the people that will --, that I can go up to and I know that I can talk to about just anything I'm doing. Or just show them something random.

As this quotation illustrates, Lauren felt that they had positive relationships with the faculty that extended beyond caring solely about performance in their class. Because many of the faculty members took a vested interest in students' well-being, even asking about "random" aspects of students' lives (i.e., non-mathematics content), Lauren felt like the faculty knew her better and, resultantly, knew how to support her better. In this way, the idea seemed to extend to the university. Lauren thought that developing these sorts of relationships with her instructors at Metcalf led to greater success and was part of the reason she was excited to work with the same faculty members across semesters. That is, she felt that getting to know faculty members on a personal level improved her experience in mathematics and served to support her success in mathematics. Prianca described her Calculus II professor in similar terms: “I would, like, go to him for advice all the time. But, no, he was not my formal advisor.” As such, this professor made time for her even after she was no longer enrolled in his class, despite the fact that she was not his advisee.

Although participants shared stories about many different faculty members, every participant had stories about their relationship with one professor. Emmy, the department chair, made a concerted effort to get to know students and to make herself accessible. Lauren said that one of her peers, who had never taken a class with Emmy and was not assigned as her advisee, met with Emmy regularly to get help with homework and advice about courses.

Participants all agreed that Emmy had not only a passion for a subject, but also a passion for teaching and inspiring others to make connections between mathematics and their everyday lives. Mai exclaimed that Emmy was the “best” and provided the following reasoning:

> The thing is, she show her passion for math in the class. Like, you could see when she teaching, you can see that she is just so into it. It's like, oh, she was talking about math as, like, a, an author talking about her book. Like, like, you know, that feeling of just absolutely into it. And that is really, really, really inspiring.

In this quotation, Mai likens Emmy to an author sharing her work with others. In doing so, Mai positioned Emmy as a creator of mathematics, as an authority over the text of mathematics. As such, Emmy was clearly seen by Mai and others as a mathematical expert. But, it was not just that Emmy was excited about her work; more importantly, it was in the act of expressing that excitement with her students and encouraging them to feel “absolutely into it” that made Mai and others think so highly of Emmy. That is, Emmy’s passion for the subject served as a way to motivate and excite her own students. Participants described Emmy’s relationship with mathematics as inspiring and some of them expressed a desire to enjoy their future profession as much as Emmy did.

Participants said that Emmy was able to engage her students by encouraging dialogue about the purpose of mathematics and by highlighting the contributions made by mathematicians historically, as Omna describes here:

> She always tells us, think about the content and, like, think beyond the curriculum or the college setting. And, even in her lectures, she talks about those mathematicians who, who, like, discovered some, some thing. Yeah, that definitely made her classes interesting to me.

As Omna indicated, participants appreciated Emmy's effort to support students in making connections with their coursework and the world outside. Further, by telling stories about mathematicians and their contributions to society, Emmy helped students to see mathematics as a human endeavor and connected to the experiences of real people.

Participants each had faculty members with whom they had built meaningful relationships. Although the individual faculty member differed from person to person, story to story, there were commonalities across student-faculty relationships worth noting. First, all participants referred to faculty members by their first names (at least when talking with me about them). On the one hand, this might just say something about the institutional social norms and the degree of formality assumed by faculty and students. On the other, I believe that this reflects the familiarity between students and faculty. That is, students actually knew the faculty members as more than their "faculty member" identity because they had developed relationships with them that were less formal than a faculty-student relationship that may be some undergraduate students' experiences. This type of relationship was further reflected in the detailed knowledge that participants had of faculty members' lives, which exceeded knowledge of their research and professional background. In passing, Lauren described an experience working with one professor who "never showed up on time" and connected his tardiness to the professor having three kids, one of which was a new baby. Prianca referenced one of her former instructors who was not able to stay on as a permanent faculty member because his wife was also an academic and she found a tenure-track position somewhere else. Knowing these sorts of details is evident that, one, students cared to learn this information about the faculty and, two that faculty willingly shared personal information with students.

Second, there were commonalities in the types of faculty support students sought and valued. In addition to getting help on homework or figuring out which courses to take, students additionally talked to faculty members about possible careers. But, more than providing advice, faculty members actively sought to support students in networking—for research opportunities (REUs), internships, teaching assistantships, and other professional activities. Lauren said that a prestigious internship she had secured for the summer was the result of a relationship she developed with a former statistics professor at Metcalf:

> She had recommended just go talk to these people. It's kind of the business thing that you were looking at. Just ask them what they do. I think you'd find it interesting…And I was like, yeah!...Yeah, I find there's a lot of help with that and if I go and ask the professor, 'Oh, I'm looking for this sort of thing, what do you recommend?' 'Well, if you go talk to this person, this person, and this person, here's their emails. Just tell them I sent you.

Here, Lauren describes her professor as being a well-connected person and it was through those connections that she applied and was chosen for a summer internship at a nearby lab. Prianca and Mai described having had similar experiences with both teaching assistantships and internships. Omna was the only one who did not have a similar story:

> I guess the only missing part of it, an undergraduate math experience, has been a research or an independent study. But, um, I don't--, I mean, I didn't reach out to a professor to do something like that. And, and my advisors really haven't been pushing me to, towards that either.

As Omna noticed, it was through these faculty-student relationships that many academic and career opportunities became available. At another point in our conversation, Omna even noted that students who received awards in the mathematics department were the ones noticed by faculty members and that a student was unlikely to be noticed if she did not have a meaningful relationship with a faculty member.

Omna indicated that she had some regrets about not making a concerted effort to develop such a relationship with a faculty member, as she thought that this may have resulted in her having fewer opportunities. Interestingly, by choosing not to "reach out to a professor," she seemed to put the onus on herself for not having developed such a relationship with faculty member. But, in the other cases, participants described the faculty member as being the initiating member of the relationship. That is, participants made it sound as if faculty members sought them out and encouraged them to pursue certain opportunities. There may be many reasons for this (for example, Omna was much more reserved and not as visibly excitable as some of the others). Either way, it seemed that participants experienced different types and depth of interaction with faculty members. And in some instances, if students did not make a concerted effort to develop such relationships, they were likely to miss out on academic opportunities and recognition.

In summary, participants' relationships with faculty were significant in many ways. First, faculty members made students feel cared for as people, not just as students. Second, some faculty members' passion for teaching and learning mathematics bred excitement and engagement in their students. By modeling a positive relationship with mathematics, faculty members like Emmy were able to shape their students engagement with the subject and to inspire them to find the joy in mathematics. Lastly, it was through positive relationships with faculty that students were supported in making degree and career choices, as well as finding opportunities to engage in mathematics in new ways. Through opportunities like internships or teaching assistantships, participants were able to gain experience teaching, working in a lab, working as an actuary in ways that are not only significant in that it supported participants in figuring out what they would like to do after graduation, but also in gaining an edge when applying for jobs in the future.

How Aspects of the Metcalf Context Shaped Students' Mathematical Identities

Although Lauren and Mai came to Metcalf with strong and productive mathematical identities, this was not the case for Omna and Prianca. Prianca, especially, had developed an aversion to and lacked confidence in mathematics. Even though Omna did not come to Metcalf with the same level of disinclination toward mathematics, she was reluctant to try mathematics or computer science based on the perceptions that she had about her own ability.

Given that Prianca finished a degree in mathematics and Omna completed a dual-degree in both mathematics and computer science, I wanted to learn more about the shifts that occurred—either in terms of how they viewed themselves or how they viewed the discipline of mathematics. Having explored the various activities and relationships described as important to participants' experience at Metcalf, I now shift to focus on how those aspects of context specifically seemed to influence participants' identity development. In this section, I describe how Omna's and Prianca's relationship with mathematics changed and how this shaped their mathematical identities. Specifically, I consider how their relationship to the subject evolved and how their relationships with other individuals at Metcalf supported this.

Prianca's Mathematical Identity Development as Related to Context

Prianca's experiences at Metcalf influenced how she thought about her own mathematical identity and ability, as well as her engagement in the discipline. Previously, I described how Prianca's Calculus Two professor supported her to develop an interest in mathematics during her first semester. Although Prianca had many positive things to say about her Calculus Two professor and named multiple factors influencing her decision to be a mathematics major, she repeatedly came back to one idea - the desire to find a life-long passion and to find a career that matched that passion. By building a relationship with a professor who emphasized the applicability of mathematics and who convinced Prianca that being an actuary would be a smart career move for her, Prianca was supported to think about mathematics as a tool for her future success.

Reflecting her desire to engage with mathematics as a tool for her future success, Prianca primarily took applied mathematics classes and participated in extracurricular activities within the mathematics department that connected mathematics and business or industry. For example, Prianca was an officer in the actuarial club. This is important, as these experiences simultaneously shape and are shaped by Prianca's desire to be a person who can use mathematics in her career. What started as a discourse identity (as someone who is good at mathematics and could have a career in mathematics) endorsed by her Calculus professor, seemed to develop into an affinity identity (officer of the actuary club) and, ultimately, to the status of an institutional identity (a graduate of an applied mathematics program, a person with an actuarial internship, a person who has passed the first two actuarial exams, and so on).

In addition to being encouraged to consider mathematics as a major and future career, Prianca said that her experience in her Calculus Two class shaped how she thought about participating in classroom discussions and, therefore, increased her confidence as a student of mathematics. Specifically, the expectations for participation set by her Calculus Two professor were more conducive to her needs. Prianca said, "He was just like very easy-going and was very easy to ask questions. And I did ask a lot of questions!" She said her Calculus Two professor established a practice of valuing questions as something one should take seriously and engage with.

Her experience in college was in stark contrast to her Pre-Calculus experience in high school, where Prianca felt that her teacher and peers viewed students who asked questions as being "totally lost" or someone who needed help. Instead of valuing questions, as her Calculus Two instructor did, her Pre-Calculus teacher valued answers. And, as I describe below, it was frequently her male peers who were to first to provide those answers. Prianca's initial statements about her high school Pre-Calculus class highlighted the difficulty of building an identity as a competent mathematics student in an environment that places value on characteristics Prianca felt that she did not possess. She described her experience in this Pre-Calculus class as a "low point" in her high school career and described herself as being "disheartened" at this time, and the tone of her responses reflected that. She positioned herself as a student who was failing to keep up and, as you may recall, was convinced that asking questions would not help her to "get back up." She then blamed her situation, at least partially, on her inability to advocate for herself. In this way, Prianca took perceived failure as an internal problem—not advocating for herself or being "too shy" to speak up was the reason for "being left behind." Although being shy is an internal state, Prianca seemed conflicted about the degree to which the onus of this problem belonged solely to her. Being in a class that was primarily male—as was the case in her high school math and science classes—meant that being shy was warranted. Further, as she indicated here by saying "one of the only girls" to ask questions, it seemed that her female peers also remained quiet in class. Therefore, she seemed to feel that the co-educational classroom culture played a substantial role in her lack of participation, as has been well-documented within the literature (Kasier & Rogers, 1995; Rodd & Bartholomew, 2006).

In contrast, the culture at Metcalf was different in that professors generally encouraged and valued student questions. Prianca said, repeatedly, that she thought it unlikely that she would have chosen to be a mathematics major outside of the context of an all-women's college were it not for such encouragement and support from faculty.

> I just think I wouldn't feel that way if I went, like, to a co-ed school. I wouldn't feel like I really had that chance. I would--, I think I, myself, might have boxed myself in after high school that, 'Oh, I'm not a math person anyway.'

Prianca felt strongly that the context of an all-women's college influenced her to pursue mathematics and to support her in challenging her former identity of "not a math person."

Prianca's experience in mathematics—her willingness to try math beyond Calculus Two, her decision to be a math major, her plan to become an actuary—were strongly influenced by the relationship she built with her Calculus Two professor early in her academic career. Further, she explicitly named classroom and institutional practices as important factors in her desire to pursue mathematics and her eventual success in finishing a mathematics degree. For example, she explained that she would likely not have even attempted a mathematics major at a co-educational school. As such, a strong case can be made that Prianca's mathematical identity was fundamentally shaped by both the practices at an all-women's college and, perhaps to a greater extent, the relationships she built with others within that context. At the end of this chapter, I will explicitly return to this idea to show how Prianca's experience at an all-women's college shaped how she recognizes herself as a mathematical person. Before I do that, I would like to return to Omna to gain a better understanding of her experience because her descriptions of the context—the activities she engaged in or the relationships she built with others—did not make for such a nice, neat causal narrative.

Omna's Mathematical Identity Development as Related to Context

Like Prianca, Omna ultimately chose to be a mathematics major after initially expressing interest in other non-STEM fields. And similar to Prianca, Omna had a complicated history with mathematics and, subsequently had entered college with concerns about her ability and expressed a lack of interest in studying mathematics. Yet, unlike Prianca, Omna did not appear to have a fundamental, consistent shift in the way that she described her mathematical identity. When describing herself, she often maintained an identity of someone who was not particularly mathematically competent and of someone who, when compared to others, was not mathematically gifted: "I've seen so many people who are naturally gifted in mathematics. So, yeah, I guess I find myself comparative--, comparing to them, so."

Other participants may have told stories about their experiences prior to college in which they lacked confidence or felt like they did not have what it took to be good at mathematics. But, those stories were always told in past tense. That is, participants who had those negative (or less than positive) views of their mathematical identities prior to college revised those stories to later describe someone who was confident and able to do mathematics. Similar to Prianca's case, such stories maintained fairly clear and consistent descriptions of their pre-college mathematics identity as being distinct from their college / post-college identity. Further, the ways in which they identified with mathematics or identified themselves later in life were more favorable in that they were more confident, had developed the right skills to be productive in mathematics, or came to see mathematics as something different than what they used to think and saw themselves now as more knowledgeable about how to be successful in mathematics. This was not the case, however, for Omna.

There did not seem to be one event or aspect of the context that, by itself, made a significant difference in Omna's mathematical identity development. Although she named many factors as contributing to her success (e.g., supportive faculty, a non-competitive environment, and an ability to study the content she found interesting), none of them seemed to be pivotal in her mathematical identity development. She did not have a single class or instructor she found to be inspirational. She never named a person at Metcalf as being a role model of hers. She did not explicitly link her beliefs about herself or mathematics as being significantly impacted by one aspect of the context or by one practice or event.

Despite this, through our time together, I began to understand the ways in which Omna's experiences at Metcalf, in contrast to her prior schooling and family experiences in Nepal, played a fundamental, albeit subtle role in her mathematical identity development. Specifically, her experiences at Metcalf made possible other identity narratives for Omna, which I describe in more detail below.

When describing herself in comparison to other mathematics majors or to her sister, Omna's mathematical identity remained self-effacing and generally static. Omna's beliefs about her mathematical ability (a "practicer" rather being "gifted") did not fundamentally change. Her experiences at Metcalf did noticeably alter her perceptions about the accessibility of computer science, however. And it was almost exclusively within the context of her computer science classes that Omna described herself in different, more competent terms. Specifically, outside of the context of her mathematics classes and outside the context of her familial comparisons, she sometimes described herself as being mathematically talented. Predominately, when comparing herself to non-math majors, she used a more confident tone and her language shifted to reflect this confidence.

Below, I explore Omna's identity development relative to her experience in computer science. I do so for two reasons: first, the stories she told about herself based on her experience in computer science at Metcalf reflected a substantial change in how she viewed herself as a computer scientist from what she thought was possible in high school. As such, it is, perhaps, easier to see how the context of Metcalf shaped her identity development in this area. Second, and most importantly, her computer science identity acted as a conduit for shifts in her mathematical identity development.

Omna's computer science identity. As I described in Chapter 4, Omna's experience of being excluded from the computer science club at her high school had deterred her from trying computer science. Worse, it actually had convinced her that computer science was something that would be too difficult for her to even attempt in the future. Yet, by the time she graduated from Metcalf, Omna had completed a dual major in mathematics and computer science. Pinpointing exactly what fostered that transition was challenging. Omna thought that her decision to try computer science, and ultimately to pursue a dual major in that area, was based on a fondness for "structured" disciplines, as well as her preference for out-of-class learning. Describing herself as "not a classroom person," Omna said that she preferred to engage in a subject on her own terms:

> I mean, I can talk and I do the readings, but I would say going to classes makes me less interested in the subject. I would, I mean --, what I like to do is I like to get a book and study it myself. And then explore more in my own ways.

Omna indicated that her computer science classes allowed her to do this—she was able to skip classes and, instead, learn the material by herself at home. The practices within the computer science program allowed for this. As she hints at in this quotation, Omna described herself as somewhat solitary: more interested in getting her homework done, or getting an extra hour of sleep, than spending time socializing. Influenced by her relationship with her sisters, she also frequently downplayed the role of friendships in her life. Specifically, having a group of sisters meant that she always part of a group, one that stuck with each other across time (and across continents). According to Omna, this strong familial bond rendered most college friendships trivial. As such, Omna put less stock in making friends than did many of her peers.

Seemingly in contrast to this, Omna, at other times, emphasized the meaningful role her peers played in her schooling experience. As she describes below, the supportive relationship she had with others in the larger STEM cohort was a formative part of her experience at Metcalf:

> I think we are a supportive group. Especially in computer science, I feel the affinity in the bond in computer science more. Mostly because…they are more of a group. Like you can do that [programming] in a group.

In contrast to mathematics, Omna felt that computer science was a discipline that lent itself to group work. Perhaps more interesting is that she seemed excited about the prospect of working with others when many times previously she had described a strong desire to work alone on assignments. She went on to say that, after the group had finished their assignments, they could engage in computer science activities for fun:

> My involvement has been more in the computer science club. Maybe, maybe it's because our activities that we conduct are more, um, they are less academic, I guess. For example, we have game jam, where we just code and try to make games.

Here, Omna described her place within a cohort and highlighted the ways in which being around other people who enjoy doing the same things she enjoyed enhanced her experience at Metcalf. As such, Omna may have bought into the collaborative culture here because of the social component and the ability to do something less academic and more focused on games. Whatever the particular mechanism, her engagement with the subject seemed to be positively impacted by relationships with her peers.

Interest in trying a new subject drove her to take her first computer science class. If there were specific factors beyond interest that influenced Omna to try computer science in the first place, she did not share them with me explicitly. Although there were factors that she named as important to her experience, overall, which reasonably may have shaped her schooling trajectory. For example, Omna indicated that a supportive rather than competitive peer culture was part of what made Metcalf so great. Overall, Omna's experience at Metcalf was defined, in many ways, by engaging in the content and practices of mathematics and computer science, as well as developing mutually supportive relationships with other STEM majors. Exposure to proof and higher-level mathematical content and the opportunity to try computer science after years of apprehension allowed her to develop genuine interests in those fields. And the development of supportive relationships allowed her to become more fully enculturated into the STEM group.

How Omna's computer science identity reflected changes in her mathematical identity. More importantly, I might suggest, is the ways in which exposure to different peer groups impacted Omna's descriptions of herself. By shifting the context for comparison to computer science people, Omna's identity stories shifted. Specifically, she said that confidence in her ability to do the mathematics necessitated by computer programming shaped her decision to stay in computer science. That is, computer science, as a discipline, is highly dependent on mathematics. And because Omna had such a strong background and ability in mathematics, she was well-positioned to succeed in computer science. This was the only time when Omna described herself as being particularly competent in mathematics—when comparing herself to peers from computer science.

I argue that by telling stories within the context of her computer science experience that served to build her mathematical identity, she was permitted to identify as a mathematically competent person in a way that she had not done previously. Namely, that removing herself from her family context in which her sister was the mathematical brains of the family, or distancing herself from her high school experiences in which her male peers intentionally excluded her from activities that were "too hard" for girls, gave Omna the space to tell a new type of identity narrative. In this way, I argue that the differences in context—a family or schooling context wherein she was positioned as second-best as opposed to an all-women's context, in which she was supported by faculty and peers to try out something without the competitive baggage from her past—served to shape Omna's mathematical identity development.

Chapter Summary and Discussion

In this chapter, I described the activities and relationships described by participants as being relevant to their experiences as a mathematics major at Metcalf and, subsequently, the role that the context may have played in the identity development of these young women. The purpose of this chapter was to address my second set of research questions: *How might the context of an all-women's mathematics department be described as relevant to students' identity development? Specifically, what activities do mathematics majors at an all-women's college describe as significant to their experience and how do they describe their relationship to others within that context?* To do so, I looked across participants' descriptions of their experiences at Metcalf and specifically investigated those aspects of context which were, first, common to all participants and, second, had the most significant impact on participants' identity development.

My findings were, in some instances, in alignment with the literature on women's education and, therefore, were not necessarily surprising. For example, as has been shown in the literature on why women persist or leave STEM majors (Seymour & Hewitt, 2007), participants placed a great deal of importance on the relationships built with faculty. Namely, students felt that their success in choosing a mathematics major, staying with the major, or in successfully finishing their degree was, at least in part, due to positive, supportive relationships they had built with faculty members. Some of the activities described by students, however, did surprise me. It was my expectation that classroom practices at all-women's colleges would look substantively different than classes in other spaces with which I am more familiar in that classes at Metcalf would have been student-centered and reflective of the "feminized" practices I described in Chapter 2. As such, I expected that practices associated with "doing school mathematics" or ways "being a mathematics student" might look different from the practices and identities developed in many of the traditional learning environments across the nation.

As I described in this chapter, though, participants agreed that in most classes, students played a passive role in their classes. Mai even explained that she actually participated less than she used to when she first came to college. Therefore, I was left wondering how these positive shifts in identity development for many of the participants might have occurred. Given the fairly traditional classroom environments at Metcalf described by participants, which emphasized passive student roles and individual, non-collaborative engagement patterns, I wanted to know more about why the classroom participation and discourse practices may look as they did.

Below, I specifically explore possibilities for a lack of student participation in the classroom—two of which I argue were reflected implicitly and explicitly in participants' descriptions. I posit that, although students' participation norms may look similar to those of women in a co-educational space, students' interpretations of why they participated in this way was more complex than what is oftentimes described in the literature about women's participation in the mathematics classroom.

After, I explore themes that seemed to be entirely absent from participants' descriptions. Specifically, even though participants did not talk about non-traditional, student-centered, or feminist practices, they did exist. There were spaces where students discussed, shared, and debated about mathematics. In these spaces, faculty engaged in practices like describing mathematics a human endeavor and supported their students in meaningful, student-centered problem solving. I specifically explore why these practices or activities might not have been visible to participants. This exploration raises questions about what role these spaces might play in supporting women to engage with mathematics or to think about themselves or the discipline differently.

Gendered Discourse Practices

Women's discourse patterns have been well-documented in co-educational spaces, wherein women have a tendency to say less and to be less confident in their contributions than their male counterparts (Boaler, 1997; Rodd & Bartholomew, 2006). And although participants described comparably low levels of female participation in single-sexed classrooms, the interpretation and evaluation behind these observations seemed to be more complicated that what is described in the literature on women's participation in co-educational environments. By this, I mean that the majority of students did not speak up during class; yet, participants maintained that students could speak up if they wanted to. They just chose not to. Participants described themselves and their peers as feeling confident, capable, and supported, even encouraged by instructors to speak in class. Most, on a typical day, in a typical mathematics class, did not.

In this section, I explain and hypothesize that the reasons behind the lack of student discourse were multiple, none of which reflected negatively on the agency of the student or on the enthusiasm or encouragement of the faculty members.

First, participants held tacit beliefs that talking too much meant that they were dominating the conversation. That is, speaking up in class could easily be interpreted as being a "know-it-all" or talking over others. As such, most students at Metcalf chose to listen and to process rather than speak up, which reinforced classroom norms in which students did not speak up frequently. Therefore, listening and really hearing what the professor had to say, as opposed to contributing to the classroom discussion, was an important part of what it meant to be a good student at Metcalf.

It is important to acknowledge the ways in which participants' perceptions about being a good mathematics student were clearly gendered. That is, each participant described experiences wherein students spoke up in class and how they perceived this behavior as being rude, inconsiderate, or domineering; however, these characterizations were exclusively limited to male students. No participant described female peers as speaking up too frequently or out of turn, nor did they describe women as participating in an inappropriate way. Being a "bad" mathematics student, then, seemed to be characterized by speaking up during lecture or participating in a way that was not conscientious of others, and was described entirely as a masculine behavior. Similar to Lauren's above description of male classmates, Prianca described certain male discourse patterns as being problematic:

> I remember in high school how they [male classmates] would be, like, very dominating over the conversation, or like the lecture and they'd constantly--, it's not like the questions annoyed me. But, they--, I guess it's just like their, their attitude towards, like, knowing everything and thinking they already know it.

Choosing not to speak up in class—co-educational or single-sexed—may result from participants' conscientious objection to traditionally masculine ways of being a student and a desire to embrace feminine ways of being in a mathematics classroom.

This argument is similar to one made by Rodd and Bartholomew (2006). Finding that women in co-educational classes in England did not participate at rates comparable to male students and actively downplayed their contributions in class during interviews, similarly posited that women are not necessarily lacking agency when they choose not to speak up during class. Instead, it might be the case that women actively and intentionally choose to participate in a different way:

> Our point is that one of the ways the women students can be different is in the way they come close to knowledge: quietly and in control, rather than in the (patriarchal) constructivist ideal of an interacting neophyte engaging with the knowledge of his mathematical family by gazing, questioning and being a replica of the teacher/father. We are arguing that a learning persona does not have to be an imitation of the masculine model. These women students' invisibility is not biddable. It is intentional. (p. 49)

In this quotation, Rodd and Bartholomew (2006) question the privileging of a masculine model of learning as being the only way to engage in mathematics. Further, they underline the possibility that some women may choose to be "invisible" not because they are lacking agency, but because they are actively rejecting a narrow, masculine model of being a mathematics student. This is important, I argue, because it challenges the assumptions that many mathematics education researchers (including myself) have been making; namely, that student engagement and participation is essentially measured by how much students talk. Therefore, a logical conclusion would be to then think that lack of student talk necessarily reflects a lack of student interest or agency. Especially in co-educational settings, where teachers and researchers continue to focus their attention on how to get girls and women to talk more, we might begin to ask ourselves the ways in which this privileges the masculine model of engagement and excludes other ways to engage. Further, in addition to attending to how much women and girls talk in class, we might also be concerned with which sort of prompts and classroom norms encourage facilitate meaningful participation from women and girls. Research by Jansen (2008) showed that some students participated because they wanted to help another student. Such students were reluctant to participate in the discussion, however, because expectations related to things like engaging in mathematical argumentation, which is arguably a more patriarchal or masculine reason for participating. Similarly, asking or answering questions to get attention, might be a more masculine reason for participating (as the participants in the present study seemed to believe). I think that, in addition to calling attention to why women talk less, it is also of particular interest which kinds of talk may draw them into classroom discussions more. As Rodd and Bartholomew (2006) wrote, we "want to posit a positive female–mathematical and celebrate some of the distinctively feminine ways in which these women negotiate the demands of undergraduate mathematics" (p. 47) rather than focus, again, on the ways in which women are not doing what men are doing.

Perceptions of "Doing" Mathematics

This, alone, might not account for the lack of student talking in class, as some participants indicated that small- and whole-group conversations were the norm in their non-STEM classes. Further, as I have mentioned previously, Mai described the ways in which she talked less in class than she did when she first came to college. Therefore, I posit that a second piece contributing to these participation and discourse practices could be participants' perceptions of the nature of learning mathematics. Recalling Prianca's earlier description of mathematics being hard in comparison to other subjects, some participants indicated that students chose not to speak up in class because they felt that they were in need of additional processing time and that this was particularly true for mathematics. Each participant described the experience of just trying to keep up in mathematics class, and taking notes as best as possible so that they had one complete resource to return to when studying or completing homework. All participants described mathematics coursework as not only being more difficult than the work in their other classes, but also felt like the barrier to entry for new content was much higher than with other content areas. That is, participants seemed to believe that learning a new topic in mathematics was further removed from their background and, therefore, it was harder to gain traction with new content as it was introduced in class. As such, students anticipated needing additional supports bridging the gap between their prior knowledge and the new content. This meant that the students' role, at least during class, was to watch the expert do mathematics and to attempt to follow along. This perpetuated a particular cultural model or Figured World about what it means to do "school mathematics" in which students are passive receivers of knowledge (Boaler & Greeno, 2000). Overall, participants' descriptions of their in-class mathematics experiences positioned students as lacking the tools, or perhaps the processing power, to be able to both follow the presentation of the material and to contribute to said lecture.

Relatedly, the lack of discussion with peers in class may reflect beliefs held by participants about the value of what other students had to contribute. In other words, they did not see their peers as experts and, therefore, preferred to hear from the professor about the "correct" way to do something. Participants explained that they all indicated that group work could be beneficial, but was typically reserved for times when a student wanted to check their solution with a classmate or when someone was "stuck." As Omna described, the purpose of working with others was to check in, after having completed the assignment:

> …mostly answer-checking. You know. It's not like we are all solving a problem together. It's usually, okay, I've finished my homework. You've finished your homework. Let's cross-check our answers. And there's a--,if, if her answer if different than mine, then, then we go deep into the problem. And if it's similar, then we don't, we don't bother, um, discussing about it.

As such, participants believed that discussions about mathematics were generally reserved for situations when a student needed help from another student. Engaging in discussions when being newly introduced to an idea, mid-class, did not fit their conception of the purpose of class time. And, at best, was seen as a luxury in that participants often felt pressed for time and did not always feel as though working in groups was the most efficient or beneficial use of their time.

I believe that it is important to note these descriptions were specific to mathematics. Participants talked about working in groups during class and discussing ideas in more dynamic ways during study sessions for their non-mathematics courses like sociology or economics. This, perhaps, points to a perception held by participants about the specific nature of learning mathematics—that it was difficult because it did not draw on student's intuitive knowledge and prior experience, the instructor was the mathematical authority and purveyor of knowledge, and it was best learned or practiced in isolation unless one becomes "stuck." These perceptions seemed to be consistent with Becker's description of mathematics as a field wherein *separate knowing* is practiced and valued over *connected knowing*.

Drawing on *Women's Ways of Knowing* (1986), Becker described the differences between these two types of knowledge (see Table 6) in order to make a case for how separate knowing has been traditionally prioritized over connected knowing—both in mathematics teaching and learning.

Table 6

Separate and Connected Knowing, Becker (1995)

Separate Knowing	Connected Knowing
Logic	Intuition
Rigor	Creativity
Abstraction	Hypothesizing
Rationality	Conjecture
Axiomatics	Experience
Certainty	Relativism
Deduction	Induction
Completeness	Incompleteness
Absolute truth	Personal process tied to cultural environment
Power and control	
Algorithmic approach	Contextual
Structure and formality	

Characterized by intuition and creativity, and based in experiential knowledge, connected knowing seemed to be viewed by participants as being worthwhile in their non-mathematics classes. When describing themselves as learners in a mathematics context, though, the focus seemed to be on the development of separate knowledge. Relatedly, what participants highlighted in their descriptions of classroom dynamics seemed to promote a separate rather than connected view of the content, teaching, and learning of mathematics.

Availability of "Other" Spaces

So far in this chapter, I have focused on participants' descriptions of their experience at Metcalf. I did not highlight my experience observing classes, attending help room sessions or office hours, or attending departmental events. But, I think that it is important to provide more detail on my observations, as there were things that I noticed in my field experience that could add to these hypotheses related to why participants may have described normative mathematics practices in the way that they did. In particular, I found that students' participation and the ways they engaged with the content and each other were fundamentally different in some other spaces outside of class. That is, those “feminized” practices I mentioned earlier—(a) engaging in inquiry based on belief, rather than doubt; (b) allowing risk-taking behaviors in young women rather than rescuing them at the first sign of struggle, but to do so with support; (c) encouraging group work and assigning roles that make expectations for participation explicit; (d) discouraging competitiveness, and lastly; (e) emphasizing mathematical processes over product—those practices may not have been evident in participants descriptions or in my observations of classes, but were prominent during group homework sessions and, more interestingly, during faculty office hours.

On many occasions, faculty office hours were so well attended that they had to move to a classroom to accommodate all of the students. When observing these office hours, I noticed that faculty members were more likely to be sitting down at a desk or table, quietly observing while students worked at the board. At one office hour, held by Emmy, there were six Analysis students present when office hours started (during that term, just over twenty students were enrolled in that class). The session started with Emmy writing a problem on the board, and then handing a piece of chalk to one of the students. Throughout the session there were multiple students, chalk in hand, writing down what their peers said on the board and contributing to the conversation. Ten minutes into office hours, every single student present had contributed something to the conversation.

Early in the session, Emmy sat down and primarily listened, allowing students to struggle with the content at times. Students talked with one another, asked each other questions, and helped each other to develop justifications for their thinking. The experience of students speaking up, not being afraid to be wrong, supporting each other when they were-- these were all normative aspects of group work outside of class. I saw this weekly in the mathematics help room sessions where students gathered to work together on homework sets with the help and guidance of a more senior mathematics student.

In addition to seeing students engage in mathematics in a fundamentally different way than they had in class, there were other aspects to their experience that seemed to be absent from their descriptions. For example, I observed that multiple mathematics instructors offered tea to both students and myself. I found this gesture meaningful because it seemed to be an invitation to come and stay in their office for an extended period of time: the duration of a cup of tea. This seemed to exemplify the culture at Metcalf, where students were welcomed guests in the mathematics professors' offices and that they could expect to have an extended period of time to converse with the instructor. Yet, this occurrence was entirely absent from participants' descriptions. Further, it seemed that some faculty members did engage in feminist practice during class, but participants rarely attended to them. The only notably example of this happening was when, as you may recall from earlier in this chapter, Omna described Emmy's desire to have her students "think beyond the curriculum" and to talk about the mathematicians behind the mathematics they were learning. In this way, Emmy seemed to be encouraging her students to learn mathematics in a more "connected" way—by highlighting first-hand experience, by attending to people as creators of mathematics, and by providing contextual reasons for studying mathematics (Becker, 1995). Though others did describe Emmy as an excellent teacher, they did not attend to this aspect of her teaching, instead highlighting her expertise and, at times, her passion for the subject.

Feminized or connected practices existed on campus, just not necessarily where I had anticipated seeing them. For me, this raises questions about why these practices during office hours or during mathematics help room sessions were mostly absent from participants' descriptions of their mathematics experiences at Metcalf. Although I am not able to determine these reasons based on the data I collected and analyzed, I am left wondering if the common thread here is the discursive construction of "real mathematics." That is, dominant perceptions about what it means to know and do mathematics leads to a privileging of *separate* knowledge over *connected* knowledge. Therefore, when I asked participants to describe their experiences in mathematics, they may be only describing those experiences which would be easily recognized as such: namely, those aspects of their experience which model separate (masculine) ways of knowing because this is the dominant perceptions about what it means to know and do mathematics. Likewise, if their perceptions about things like group work, drawing on experiential knowledge, or building intuitive understanding (all characteristic of women's ways of knowing) are incompatible with their perceptions of "real mathematics," it might not be surprising that participants would neglect to recognize them as a meaningful aspect of their mathematics experiences.

Overall, this meant that participants may have acted or said things in a particular way during mathematics class, and that, on the surface, these behaviors or discourse patterns were consistent with discourse patterns found in co-educational settings where female participants felt shut out, talked over, or discouraged from speaking up. Yet, as I hope I have demonstrated in this chapter, the reasons behind these behaviors or classroom discourse patterns were multiple and complex. Further, they may or may not have matched those beliefs and behaviors of women in co-educational environments. And, at least within the context of a mathematics classroom at Metcalf, there was little evidence from participants that students' lack of participation had anything to do with an oppressive or exclusive atmosphere that specifically discouraged women from speaking up. Instead, these young women may have chosen not to speak up in class based on a multitude of reasons: gendered discourse culture or practices, based on perceptions about the field of mathematics or how one learns mathematics, or due to the availability of other spaces which allowed for student participation and engagement.

CHAPTER SIX: GLOBAL, INSTITUTIONAL, AND LOCAL DISCOURSES OF BEING A WOMAN AND BEING A "MATH PERSON"

In Chapter 3, I explored participants' descriptions of their experiences in mathematics with the goal of better understanding their mathematical identity development. Because mathematical identities are multiple and shift over time, I chose to focus more narrowly on how participants talked about being "good" or "bad" at mathematics and how these descriptions changed over time and as a reflection of context. In this chapter, I broaden the focus of that exploration to include experiences outside of this dichotomy in order to the better understand some of the more nuanced Discourses and figured worlds shaping (and shaped by) their experiences.

You may recall from Chapter 2, that *Discourses*, with a capital "D," is used to describe "ways of combining and integrating language, actions, interactions, ways of thinking, believing, valuing, and using various symbols, tools, and objects to enact a particular sort of socially recognizable identity" (Gee, 2011, p. 201). At its core, then, Discourses are the ways of being or doing that allow an individual to be recognized as a particular kind of person. In order to be recognized as a mathematical person, one must walk, talk, act, and do like a mathematical person walks, talks, acts, and does. Of course, determining what "counts" as a "recognizable" act (and what does not) depends entirely on context and is inherently subjective.

Yet, some of the ways of being a certain type of person described by participants–about what it means to be a woman, a student, or a mathematician–are prevalent and persistent. Individuals "through time, in a certain order, have specific experiences within specific Discourses (i.e., being recognized, at a time and place, one way and not another), some recurring and others not" (Gee, 2000, p. 111). These recurring Discourses are powerful not only in the ways that participants some to see themselves as mathematical people, but also in the ways in which these mathematical identities interact with the various tacit models about mathematics and mathematical people. You may recall from Chapter 2, that *figured worlds* are tacit, taken-for-granted theories about a simplified world. They model and capture people's assumptions about what is typical or normal about people, events, practices, interactions, and things (Gee, 2011, 2014). Because they describe what is typical, normal, or even possible when it comes to being recognized as a certain type of person, they are inextricably tied up in mathematical identity and the Discourses one might draw upon when recognizing someone as a mathematical person, as Gee describes below:

> When people "figure" a world, that is, imagine what the world looks like from a certain perspective of what is "normal" or "typical," they are imaging pictures of Discourses or aspects of Discourses at work in the world. They are imaging typical identities and activities within typical environments. (2011b, p. 43)

In this chapter, I specifically focus on exploring and attempting to name the various Discourses evoked by participants' within descriptions of their experiences. Then,

In order to establish some boundaries about what I describe as a Discourse

Guiding this exploration are my third set of research questions: *What mathematical Discourses do senior women mathematics majors at an all-women's college know, assume, question, or reject? What seems to be the relationship between their identities and those Discourses?* Of course, these Discourses are too numerous and too nebulous to be "captured" in their entirety. As some of these Discourses seemed to be more pressing and relevant when it came to these participants' mathematical identity development, however, I have chosen to narrow my focus on participants' primary conceptions of what it means to know and do mathematics as a woman.

In Chapter 2, I named four different grain-sizes used to describe context: *the global context*, *the institutional context, the local context,* and *the immediate communication context*.

The first goal of this chapter is to unpack the global Discourses I believe to be inherent in participants' experiences. To do so, I start with an examination of participants' descriptions of their experiences outside of Metcalf with the intent of revealing and unpacking the global Discourses they may signify. Overall, I build a case for two primary Discourses: one, which describes a normal or typical woman, and another, which captures what is taken to be typical or normal about mathematical people.

Following, I proceed to examine participants' descriptions of their experiences specifically at Metcalf with the intent of revealing and unpacking the institutional Discourses they may signify. Specifically, I focus on the Metcalf school-wide Discourses, which simultaneously build a socially recognizable conception of mathematics, as well as those who engage in mathematics. Overall, these global and institutional Discourses seem to reflect figured worlds that people hold about mathematics and those who know and do mathematics.

Not all of the stories told by participants reflected their own personal beliefs or assumptions about what it means to know and do mathematics, though. In fact, participants' stories reflected the Discourses and figured worlds brought forth and seemingly acted upon by their instructors, peers, friends and family, and the media instead. In many instances, participants' perceptions of what it means to know and do mathematics differed substantially from these dominant figured worlds. Together, the participants pointed to alternative ways one would or could view the field of mathematics and those who do mathematics. Whether challenging a Discourse or embracing it, each participant seemed to have her own view of mathematics and of women who do mathematics. Therefore, the next goal of this chapter is to specifically explore the ways in which participants assume or counter such Discourses and, in instances when they seemed to reject a Discourse, how they countered it in implicit and explicit ways.

As Gee (2014) noted, "Discourses are not units or tight boxes with neat boundaries" (p. 184). In fact, any Discourse is complex in the ways in which it can change over time and how it is sometimes tangled up with other Discourses. The last goal of this chapter is to focus on the interplay of Discourses as reflected in participants' descriptions. I do so because participants seemed to be drawing on each of these Discourses in complex, even seemingly contradictory ways. Therefore, this sort of analysis serves to complexify the way these Discourses are identified, named, and understood.

Global Discourses

In this section, I examine two Discourses I believe were reflected in participants' descriptions of their experiences a woman in mathematics. First, I focus on the descriptions provided by participants about being a woman, specifically focusing on gender roles. I then investigate those descriptions that seem to reflect an image of a typical or normal mathematics major or "math person."

Being a Woman

Lauren, Mai, and Omna all described the ways in which friends, family, and their communities held and acted upon beliefs about women. The stories that they shared varied from person to person. Yet, common to each participant were the stories they told about which career and educational paths were presumed to be acceptable or desirable for women. For example, each talked about the people in their lives making assumptions and suggestions about which career and educational paths would be appropriate for women to take. Taken together, the descriptions provided by participants reflect the various Discourses of "being a woman."

Mai described Vietnam as a "patriarchal society," one in which "women are not, like, respected the way that they deserve. It's not all, but…they only think of woman should stay at home to take care of the kids…not doing anything that outside society and change something." Here, Mai seemed to be noting two important aspects of the gender roles influencing her upbringing. First, women are viewed as being responsible for specific domestic roles, like childcare and housekeeping. Second, women are discouraged from attempting to make decisions or to try to change society.

Mai said that some women, out of fear of disapproval from their husbands or being perceived as too educated, sought out alternative educational paths. In particular, she said that some women in the community in which she grew up chose to take classes at local community centers rather than with an accredited institution like a college or university:

> Other men in Vietnam, like, like when they get married a woman, they don't want their woman to go to schools so much. They can --, the woman can--, can just like graduate from undergrad. Then if that woman got married, then the man would not want her to go, like, MBA or PhD or masters or whatever. Higher education. So, some woman --, I know some woman they, like, they want to do something. So they have to do it different way. Instead of going to schools officially.

This quotation serves to underscore the beliefs by others that professional and career advancement is regarded as unimportant, even problematic, for women. Yet, because women realize the value of education, they seek it in ways that are accessible to them and are more socially acceptable.

Despite this pervasive Discourse, Mai described her father's continual belief in her ability and support in pursing a higher education. She described her father as being "different from other men in Vietnam" because of his unwavering support:

> The thing is, my father, he is --, has some patriarchal idea. But, at the same time, he's really ambitious and, compared to my mom, honestly, my mom, she's really strong but she still has some idea, like, some ideas that women should not be studying so much. But

> she was like, oh yeah, study your bachelor degree or, um, you know, you have a bachelor degree. You are good. You don't have to go to master degree, PhD, or anything. But, my dad is like, oh yeah, just go study PhD, whatever you want. Like, my dad was supportive so much.

In this quotation, Mai described her parents differing perspectives on her continued education—namely, that despite being a male in this highly patriarchal society, her father was actually more supportive of Mai pursuing a higher education than Mai's mother.

Similarly, Omna explained that Nepalese society is "highly patriarchal" and continues to provide few educational opportunities for women.[11] Omna described her situation as fortunate, one in which multiple factors came together to support her educational path. In contrast to her cousins, who were her same age, Omna had many educational opportunities and was able to make her own educational, professional, and career decisions. She said:

> I have a cousin who is younger than me by one year, but she already has two children. So, if they [my parents] had stayed within their own family circle, or traditions, then--, I think they had envisioned us to be like our cousins. But they moved to Kathmandu and then they were in a new society and then, at the same time, their business was growing. And even the school, the high school that I talked about, it was a really small school. As we grew up, it became bigger and bigger. Now, it's a very good private school there. So, I think it was just kind of was a luck as well that we--, the, the environment got set up really good. I mean, it was a very good set up. It just grew to be a good set up.

Here, Omna names factors like her family's newfound wealth and status as serendipitously shaping her path and allowing her to pursue the career and life of her choosing. Important in this quotation is the degree to which she feels like she escaped this reality experienced by many young Nepalese women. Omna, who described herself as very career-driven and generally interested in exploring and changing the world went on to say, "I never plan to marry, actually. I don't want to have children, either." She saw her cousin's circumstance—being married and having children at such a young age—as something that she had narrowly (and happily) avoided.

[11] According to UNESCO 2011 data, fewer than 50% of adult women are literate, compared to 72% of adult men.

Omna went on to say that she thought that this cousin had wanted to continue her education but was not able to, due to family obligations and expectations. Omna's above quotation underscores the level of choice that she was afforded as a result of her family's circumstances and her concern that her cousin, another Nepalese woman of the same age, had not been afforded those choices.

In Chapter 4, I wrote about how Lauren "never got help" or encouragement in science or mathematics because her parents thought that she should be a "healer-type person." Lauren was encouraged to pursue music and caregiving, while her brothers' were supported in pursuing their interests in mathematics and science. She said that her father and grandparents never explicitly linked their disapproval of her STEM interests with her gender. Instead, this positioning by her family was subtler. Rather than saying that she should not pursue something based on her gender, Lauren's family acted on beliefs that she was more suited to certain non-STEM disciplines. Therefore, she was encouraged to pursue hobbies and studies that they thought were more suited to her gender, without explicitly acknowledging that her gender may have influenced their encouragement. Specifically, her mother actively discouraged Lauren from pursuing mathematics and, instead, encouraged her to pursue something more suitable for women, like a career in nursing.

These descriptions point to a particular model of what career and educational paths are typical, reasonable, or viable, for these young women. I believe that that the degree of support offered to—or, in Lauren's case, withheld from—these young women in pursuing higher education or specifically wanting to study mathematics reflects the values and beliefs of the people in their lives and, therefore, the Discourses they assume. Specifically, within these patriarchal Discourses, I would characterize participants collective descriptions about "being a woman" by the following:

- Women should not be the primary decision makers and should not attempt to change or reform their world;
- A woman's education, career, and professional goals are deemed unimportant, even problematic;
- In the instance that a woman is to be educated, she should not too educated;
- Child-rearing, child care, and housekeeping, are the primary roles of women; and
- Because women are more inclined to be healers and caretakers, they should pursue jobs consistent with that role.

Although participants encountered patriarchal Discourses in different ways and to differing degrees, it is clear that each was aware of them. Further, in Lauren, Mai, and Omna's cases, they felt a sense of obligation to pursue their educational and professional goals despite the Discourses surrounding them, which I will return to in a later section.

Being a Mathematics Major or a "Math Person"

Just as participants evoked and described Discourses that positioned women in particular ways, so did they enact Discourses to identify those who do mathematics in particular ways. As I describe in detail below, each participant shared stories about times when peers made assumptions about them because of their interest in mathematics or their status as mathematics majors. In some instances, these assumptions were fairly neutral. Prianca joked that, as a math major, her friends could always count on her to have a pencil, which she seemed to insinuate was true of "math people." In other instances, these assumptions were evaluative and, oftentimes, had implications for these participants' identity development.

Mathematical people are generally intelligent. When telling someone that she was a mathematics major, Omna found that others were quick to make assumptions about her intelligence. She said,

> Most of them automatically assume that I'm smart. Yeah, especially when I say I'm a math and computer science major. And I told you like last time, I don't think of myself as exceptionally smart. Maybe like in a common sense smart, yes. But, um, yeah they seem to assume that I'm a living calculator [[laughing]] Right?... Like, no… I didn't major in calculations.

Omna's quotation highlights two ideas I believe to be important. First, it calls attention to something "others" associate with the Discourse of mathematicians—that mathematicians calculate things all day. Echoed by others' stories, there was a frustration about how others mischaracterized what mathematicians do as number crunching rather than careful problem solving[12]. Second, and perhaps more importantly, Omna's above quotation highlights the connection between mathematical competence and presumptions about overall intelligence. Specifically, people assume that if someone is good at mathematics, they must be highly intelligent. Yet, as evident in this description, Omna seemed to distinguish between "common sense smart" and an academic intelligence (i.e., "book smarts"). As such, Omna seemed to be drawing on the construction of mathematical intelligence as being a very specific type of intelligence, which could be sharply contrasted with "common sense" intelligence.

Each participant described the ways in which others linked mathematical ability with being "smart" more generally. Each recalled being told that they must be smart or a genius after revealing that they studied mathematics to another person. In some instances, being viewed as

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[12] "To be thought of as calculating is not complementary. Calculating is often what the other is: women; scheming; wheeling and dealing bargainers. The refined mind reasons, but does not calculate. Indeed, witness the oft-told joke that mathematicians cannot add up" (Walkerdine, 1997, p. 57 as cited by Mendick, 2005).

highly intelligent was framed positively—that being good at mathematics and, resultantly, being smart was something to be admired. Participants described how assumptions about intelligence were sometimes cast in a negative light by others, however—there was something different and alienating about being a mathematically intelligent person. For example, Prianca said that others often respected her for pursuing mathematics, while at the same time found it hard to relate to her because of her interest in mathematics:

> People either think that it's really hard, so they--, I feel like they respect me for it [[laughing]] um, or they just think that, like, I am--, like I'm not on their level. (…) Just, like, a different kind of smart than like--, not, I don't know if that necessarily means, like, you are too--, you're smarter than we are. It's that you can't--, they can't really relate.

The assumption that Prianca is "on another level," means that she was positioned as being different in some way by others. Similarly, Lauren said that people are oftentimes "intimidated" by mathematically competent people because mathematicians "think in a very different way." Notice that the word "different" shows up in both Prianca's and Lauren's descriptions of mathematical people. It seemed, perhaps, like they are trying to reframe being "smarter" with "different kind of smart" or that being good at mathematics supports you think at a "different level" instead of a "higher" one. In doing so, it seemed like they downplayed others' framing in hierarchical ways. I think this was an important observation, given that girls/women are more likely to be socialized to downplay their abilities than boys/men are. I will return to this idea in Chapter 7.

Mathematical people are smart in some ways…but not others. Each participant had experienced being told that they must be a genius or very smart to be a mathematics major and, mostly, this type of intelligence seemed to be viewed by others as desirable and impressive. At the same time, participants all could recall experiences wherein mathematical people were positioned in deficit ways. That is, in addition to having presuppositions about mathematical people's intelligence, participants said that others also assumed that mathematically competent people typically lacked in other areas, like social skills and awareness of political and culture issues.

The existence of these presumptions became evident to participants by the level of surprise exhibited by peers when learning that they were mathematics majors. For example, Omna said that people were frequently surprised to learn that she was a mathematics major because she was known by her peers to be a politically active person:

> And most people, when I tell them my major, they don't --, I thought you were some sort of political science major. Maybe it's because I kind of speak more than, I guess, a normal math major--, than, I guess, what they think a normal, ordinary math major. Yeah, they definitely --, sometimes they seem surprised. Because I'm also well aware of other political and other thoughts and other cultural things.

This quotation is interesting because it evokes an image of what Omna thinks others associate with a "normal, ordinary math major" who is generally unaware of societal, cultural, or political matters. In this way, this description partially built the identity of a mathematician as someone who is smart in a singular sense and who lacks a social intelligence or ability. Other participants similarly described "being smart" in this way signified a lack of ability or intelligence in other areas like being sociable, articulate, glamorous, or funny.

As I will return to below, I believe that this characterization was important because it not only said something about the Discourses reflecting and shaping constructions of mathematical people—that they may be smart in some ways, but were clearly deficient in others—but also about Omna's ability to enact or be recognized as a mathematical person.

Metcalf School-Wide (Institutional) Mathematical Discourses

So far, I have focused on those global Discourses named by participants, which seemed to be reflective of their collective experiences. In addition to these Discourses, participants' descriptions also seemed to draw upon institutional Discourses at Metcalf. That is, they told stories about their experience as a mathematics major wherein others at Metcalf shared their beliefs or made assumptions about what it meant to know and do mathematics or about mathematical people. By institutional Discourses, I mean those Discourses developed by students at Metcalf, not necessarily in the institutional policies and documentation like the school's website or its mission statement.

These stories reflected three pervasive school-wide Discourses surrounding mathematics:

(1) Mathematics is disliked by many and is too hard;

(2) It is socially acceptable not to be good at mathematics; and

(3) Individuals are either mathematically-inclined or English/language/art-inclined (but not both).

Below, I explore these three institutional Discourses in detail, with the goal of better understanding how the Metcalf institutional context seemed to inform and shape the mathematical identity development of these four mathematics majors. I do so because being a certain type of person—in this case, each young woman was a mathematics major at an all-women's college—was reflected in and reflective of the Discourses enacted and assumed by people within that context. Overall, I underscore the ways that these Discourses are polarizing in that they build or reinforce beliefs that mathematics is for some people, but not others. Building on this, I work to illuminate the ways in which these Discourses, together, build an image of a mathematician as being different from other, "normal" people.

Mathematics is "Gross" and "Too Hard"

Within the mathematics department, participants had generally positive things to say about being a mathematics major, as well as the value and appeal of mathematics, which I return to below. In contrast, participants described their peers outside of STEM as viewing mathematics as difficult, inaccessible, and unpleasant. When talking about mathematics to her "non-math" friends at Metcalf, Prianca had been told, " 'That's gross' [[laughing]]. That's like what everybody says. They just think it's so hard." Other participants, unprompted, used that exact phrase–"that's gross"–when recalling peers feelings on the subject of mathematics or statistics.

Prianca said that even Metcalf faculty members outside of mathematics had expressed their aversion toward mathematics. She recalled a time talking with her former religious studies instructor when the topic of mathematics came up: "She was telling me how she's, like, never taken a math class before. Um, and she was, like, saying how math is so hard and stuff." This description was representative of the view of mathematics held by some individuals outside of the mathematics department—namely, that mathematics was too hard for even the most educated and accomplished people. Prianca went on to say that the professor said that she had taken very little mathematics (as this was not a requirement at her undergraduate institution) and, therefore, had little exposure to the discipline. Yet, Prianca recalled the certainty and ease with which this professor said that mathematics was difficult and inaccessible.

Like Prianca, Lauren similarly recalled her peers' reactions to hearing that she was a statistics major:

> I think there's a lot of majors that require Stats courses. So then everybody is like, "Oh yeah, I remember having to take that. It was awful. I hated it." And a lot of people --, either you like it or you don't like it-- is what I've seen. So, and just a lot of people that aren't in this area, they just didn't like it.

In this quotation, Lauren described how she believed that mathematics was a particularly divisive subject; there are those who love it and those who hate it. This sentiment was reflected in stories told by each of the participants. Some people had always hated math and would continue to do so. At times, both the participants and their peers described this identity in fairly static terms.

Yet, as we know from Chapter 4, some participants changed their opinions about mathematics in substantial ways. For example, Lauren had thought that mathematics "was horrible" when she was a child, but later grew to love it. And when reflecting on their own experiences, participants described preferences for certain content areas within mathematics over others. For example, Omna did not enjoy Calculus, but enjoyed more advanced, proof-based mathematics. Lauren had a preference for statistics over other areas. Mai enjoyed Analysis more than other subject areas. Therefore, their affinity for mathematics was not simply buying into "mathematics" as a subject. Rather, each participant preferred aspects of their mathematics coursework to others. For many of their non-mathematics major friends, however, the label used by participants to describe peers or the label peers used to describe themselves seemed much more permanent. Based on all the participant's descriptions, peers generally thought that math was "too hard" and "just didn't like it." And these opinions, participants thought, were unlikely to change.

It is Socially Acceptable Not to be Good at Mathematics

Relatedly, participants said that their peers outside of mathematics not only disliked mathematics, but were also freely admitted that they were "not good" at mathematics. In this way, one of the pervasive Discourses on campus was the social acceptability of being "bad at math." Participants thought that their peers seemed unabashed about saying so, as Omna stated here:

> I mean [I hear that] more here than back in Nepal… I think it's seen as a --, some people are proud, not exactly proud, but some people it's like an okay thing to say or sometimes like, I hear some sense of pride in it. Not exactly pride, but, um, because --, it, among

> math majors, obviously not… But in other classes, yeah. 'I'm not good in maths.' That's what I --, I hear that a lot.

Omna pointed to the fact that it was socially acceptable for her peers to declare that that they were just not good at math; that these declarations about not being a math person bordered on pride. Further, based on this quotation, it seemed that Omna recognized when the Discourse was acceptable to enact and when it was not; in a mathematics class or amongst mathematics majors, this discourse would "obviously not" be acceptable. Yet, according to participants, this language was prevalent amongst individuals outside of the mathematics department context. As I explore in more detail below, the justification in such a stance may lie in Discourses surrounding mathematically competent people; namely, that mathematicians or people who were good at mathematics were socially inept, nerdy, and not relatable to most. Therefore, creating some distance between oneself and this image could be warranted, even desirable.

Individuals are Either Mathematically-Inclined or English/Language/Art-Inclined

Every participant shared stories that drew on a Figured World or cultural model: some people are "English people" whereas others are "Math people." For example, Mai described a college friend's experience being a "qualitative" person: "If I talk to a friend who study international relation, then she would say, 'Oh my god, I am not good at math. But, you know, I'm good at writing.' …She would value qualitative more than quantitative [reasoning]." Reflecting her friend's perspective, it seemed that being a "qualitative" person means being good at writing and valuing a certain type of reasoning. I would go further to say that her friend's identity seemed to be almost reinforced by her anxiety about quantitative reasoning. In other words, a lack of quantitative skill—being "not good at math"—served to bolster her friend's identity as a qualitative person. In this quotation, it was not entirely clear whether Mai bought into the identity that her friend was building for herself as a qualitative (not quantitative) person.

Prianca similarly said that her high school friends were inclined to talk about themselves as being either a "math person" or a "humanities person":

> They already, like, boxed themselves into just wanting to take--, like, limiting themselves to humanities classes and being like "Oh, I'm not a math person. So I'm not even gonna try." And then when it comes to college, it's like they didn't--, they didn't care about math in the first place, so it's not even really an option.

Here, Prianca described her friends who "tended to take more humanities AP classes" than classes in STEM in high school. Because such friends had "limited" themselves to taking humanities classes, they had decided that they were not a "math person." In addition to making this dichotomy evident, this quotation is also important in the way Prianca framed the longer-term consequences of being a "non-math" person. Namely, because they had not had the experience of taking mathematics classes beyond the minimum high school requirements, these friends entered college with limitations about which college majors might be feasible. That is, by being a "non-math" person in high school meant that it was highly unlikely that these students would pursue math in college. Therefore, Prianca seemed to be saying that these students were set on a trajectory to continue being "non-math" people in college.

Mathematical Figured Worlds: Mathematics is Not for Everyone and Mathematical People are Different From Others

So far, I pointed to three persistent institutional Discourses about the discipline of mathematics that were perpetuated outside of the mathematics department at Metcalf; namely, that (1) mathematics was disliked by many and thought to be too hard; (2) it was socially acceptable not to be good at mathematics; and (3) individuals were either mathematically-inclined or English/language/art-inclined, but not both. Prior to this, I unpacked some of the prevalent global Discourses about mathematical people named by participants. Specifically, I emphasized those descriptions wherein mathematically competent people are assumed to be intimidatingly smart, while, at the same time, are assumed to lack social skills and awareness of social issues. In Chapter 7, I specifically return to these findings in order to explore the ways in which these Discourses speak to issues of gender and patriarchy in mathematics.

Taken together, these Discourses seem to capture a figured world wherein mathematics is a field that is not accessible to everyone. Further, the descriptions provided by participants served to create a fairly narrow image of a "typical" or "normal mathematician," which is generally unrelatable and unflattering. As such, participants seemed to draw upon Discourses which built a normative identity for mathematical people as being not only different from other (normal) people, but as being deficient in other areas like social awareness and common sense intelligence. Overall, I believe these Discourses reflected a figured world which assumed that mathematics was not for everyone and that mathematical people were different from others.

The perceptions of mathematics and mathematicians by peers outside of the department, sometimes generated, reinforced, and perpetuated by the media's portrayal of mathematicians, were part of the global and institutional Discourses impacting mathematics majors at this all-women's colleges. These Discourses about who does mathematics and why ultimately positioned mathematics majors in tacit ways, which I will return to below.

Local Discourses

Having explored the prevalent global and institutions Discourses about mathematics and mathematically competent people, I now move to an exploration of participants' own perspectives on mathematics and mathematical people. As these are the Discourses reflected in participants' experiences as members of a mathematics group at a particular women's college, I will characterize these Discourses as "local." Specifically, I aim to better understand which

Discourses they questioned, rejected, or worked to redefine and, then, which Discourses participants themselves created or assumed.

Questioning, Rejecting, and Reframing Global Discourses

Below, I consider the impact of the aforementioned global and institutional Discourses on mathematics majors and the ways in which they constructed their own Discourses about mathematics and mathematically competent people. I begin by focusing on those Discourses participants questioned or actively contested, with the goal of better understanding the types of identities that these four mathematics majors were attempting to build for themselves.

Questioning or rejecting patriarchal Discourses. Although all participants talked about themselves as people who were capable of changing the world, Prianca and Mai expressed this notion most frequently and passionately. Mai passionately talked about the importance of education for women and for changes in the ways that women were viewed in society. She described Metcalf as a space where she was able to meet other women who also desired to change their world:

> Woman at Metcalf College are really focused and they, they carry their dreams and they are here for a reason. Like, they, they want to be something. They want to achieve something. They want to make a difference. Maybe not all of them, but a lot of them are like that. And they want to bring the equality. They want to empower other woman to do different things.

Making a difference, bringing about gender equality, empowering other women: these were aspirations held by Mai and she thought that others at Metcalf held them also.

For Mai, making a difference in this way was possible only through more and higher levels of education. She said that she intended to earn a PhD in economics, as well as an MBA. This motivation might be founded in the aforementioned Discourses about women and education; that a women's education, career, and professional goals are deemed unimportant, and that a woman should not be too educated. Therefore, in order to change the world–and to speak back to patriarchal Discourses that would position her as someone who, based on her gender, was not able to advocate for change–Mai may have felt compelled to pursue the highest levels of education.

Prianca similarly talked about being motivated to change her world. Specifically, she said that she was driven by a desire to "break professional barriers." For Prianca, being able to do so meant that she needed access specifically to mathematics. She said that her desire to pursue a degree in mathematics could be traced back to her earlier experiences in her high school feminist alliance club. She said,

> I remember, like, the beginning of my sophomore year, I read, I read a book--, and I don't even, I don't even remember, like, how they had to do with feminism at all, but it really change my thinking and just like made me very--, feel like--, I felt like I wanted to be very active in feminism (…) And, like, how there weren't that many women in math or science, how that was something I wanted to do.

Admittedly, Prianca said that she came to college having "no idea" what content she intended to study; however, she was motivated to find a major that would allow her to be "active in feminism," as she said in the above quotation. Specifically, having learned that there were so few women in mathematics and science at the most advanced levels, Prianca felt more compelled to study something in STEM in order to change perceptions about what fields were accessible to women. In addition to pursing something in STEM, Prianca built on this commitment to say that her long-term goal was to become a high-powered executive and to break the proverbial glass ceiling:

> I think, eventually, I want to be, in the very long run, like, a CFO or, like, a very high management position. That's, like, my main goal. I feel like part of the reason I decided to study math is, like, yes, because it's something I really wanted to do, but it's also that, like, the reason--, partly, the reason also why I wanted to go to, like, a women's college was because I wanted to, like, breaking professional barriers. In, like, the--, it is, like--, data, it shows that, like, there are very few percentage of women that are in those high-

> level positions and that's really, really what I want to be in the future, like, one of those high-level positions.

Here, Prianca explicitly linked her ability to make changes in the professional world to her access to mathematics. Namely, she felt compelled to study mathematics, at least in part, in order to make these personal career advancements and to work toward changing perspectives on what women should and can do in the workplace.

Rejecting, questioning, or reframing mathematical Discourses. In addition to questioning, rejecting, or actively working to undermine certain Discourses about being a woman, participants also did so with Discourses surrounding mathematics and mathematical people. The first way some of them did this was to question or reject the existence of a typical or normal mathematician. The second way they did this was either to distance themselves from or to reframe some stereotypes about mathematical people.

Rejecting the notion of a (stereo-)typical mathematician or math major. Like other participants, Lauren contested the idea of a typical or normal mathematician or mathematics major. When asked if she thought there was a typical math major, she replied:

> I don't think so. I think there's a lot of different fields of thought or whatever you --, what's that called? Schools of thought? Yeah. I think there's a lot [of schools of thought] that people can fall under and that really would diversify the people that are there and their beliefs.

Here, Lauren noted that mathematics majors were diverse simply because people were diverse. Most participants responded in a similar way; knowing a diverse group of students who all do mathematics served as an example for all the ways one can be a mathematician or mathematics major.

Prianca similarly agreed that there was not a (stereo-)typical math major, but went further to acknowledge the gender component inherent in this stereotype:

> Yeah, I remember reading, like, on the Metcalf website somewhere, where someone was--, I think--, I don't remember, like, specifically, but someone was talking about how it's so normal to them that, like, all of the physics majors they know are girls. And it was something like that, like, that was what I really wanted, to know a lot of women who are in these, like, underrepresented fields, other than just know a lot of guys that are. Um, and I felt like I was really able to get that, especially with math or physics. Like, when I think about it, all the math majors I know are girls. I don't know any male math majors, which is something very different to say to someone that goes to, like, a coed school.

In this quotation, Prianca specifically describes the importance of the Metcalf all-women's context in shaping her conceptions about "math people." Unlike someone going to a "coed school," Prianca had the experience of working with a diverse group of women mathematics majors. Being surrounded by male mathematics majors was genuinely not representative of her experience. Instead, all the mathematics majors she knew were girls. By virtue of being surrounded by many women in mathematics—having almost exclusively female students and women comprising about half of the mathematics faculty—her concept of "math major" or "mathematician" seemed to almost entirely be built upon her experiences with women.

When asked if she thought there was such a thing as a "typical mathematician," Omna also said that she did not think so:

> Uh... I mean, we're made to believe so... But, no. I don't think so. One of my professors is a highly glamorous professor [[laughing]] and she defies like all the nerdy, um, that's out in the media. So, and even I --, people don't expect me to be a math major because of my other interests, so. I don't think there is a typical math major.

Omna said that the media's portrayal of a nerdy mathematician did not reflect her experience. Through this description of her professor, a legitimate member of the community of mathematicians, Omna seemed to be able to support her own identity as a "non-nerdy" woman who was a mathematics major. Knowing a "glamorous" woman who was also an expert in mathematics meant that Omna had a counterexample to prevalent negative Discourses about people who know and do mathematics. Lauren's, Prianca's, and Omna's descriptions all seemed to point to the importance of having peer and faculty models who did not fit these negative stereotypes in order to question or reject the notion of a typical mathematician or mathematics major.

Also visible in Omna's quotation above is the role of the media in creating or perpetuating stereotypes about mathematical people. Therefore, while questioning the existence of a normative mathematical identity at all, participants still were aware of popular stereotypical representations of mathematicians, mathematics teachers, and mathematics majors. And, in some instances, participants felt compelled to address these stereotypes.

Rejecting stereotypes about mathematical people. Prianca said that she was well aware of the stereotypes about mathematical people and outright rejected that label for herself. She said,

> I think they don't think that I fit, like, a stereotypical math student. I don't know… I think they think…that like math--, mathematicians are really nerdy. Like, 'You don't look like you would spend hours doing problem sets.' [[whispers]] *But I do*. [[laughs]]

Here, Prianca was bringing to light two important perceptions she seemed to think others had about mathematicians: first, stereotypical mathematicians were nerdy and, relatedly, that this nerdiness was linked to a desire to sit around completing problem sets. This perceptions, perhaps, explained why others thought that mathematics majors knew nothing else: they spent all of their time doing problem sets rather that learning about culture and politics or engaging in social activities. Prianca's aversion to being labeled a nerd meant that she did not affiliate with this stereotype. Omna similarly said that this stereotype was "untrue" for her.

Reframing stereotypes about mathematical people. Others responded to these negative stereotypes in another way: by changing how people talked about being nerdy. For example, Lauren differentiated between nerdy and geeky and indicated that recent cultural trends distinguished between these two in a significant way. Although the term nerd maintained a derogatory connotation–describing "kind of the glasses, and the sweater, and walking around with your books, hunched-over type" or "I wouldn't go hang out with her type"–the term geek seemed to have taken a new, positive, and socially-acceptable meaning in recent years. To illustrate the difference between nerdy and geeky, Lauren compared two characters from the popular TV show "Big Bang Theory"; explaining that Bernadette would be geeky, while Amy would be nerdy.

Omna described her confusion about the difference between the two, yet had the vague conception that being geeky was preferable to being nerdy: "Yeah, and I think Katie Perry has this video… like the sense that I get is that geeky is better. Because I wasn't raised here, I don't really get the difference between nerdy and geeky." Here, Omna is referencing Katy Perry, a pop singer whose video "Last Friday Night" features her hosting a party while dressed up as a geek—with overly large glasses, a stonewashed jean jumper, and headgear. Dubbed "geek-sheik," this trend was referenced by participants as something that changed how young people talked about people who might have formerly been labeled nerds.

Instead of listing the particular characteristics that differentiate one label from another, the larger point here was that the media now offered alternative ways of being a math or science person. Through the media's portrayal of some individuals who could simultaneously be "mathy" AND socially acceptable, the Discourses around what it meant to know and do mathematics were opened up to be more inclusive. In short, according to these participants, Discourses about mathematical people were becoming more varied—to include women, to include people who were social, or endearing, or funny. Omna said:

> I think, like, smart is the new sexy kind of thing, you know. People, I think, they like to project that they are smart. So, if you're like a software engineer or something, people

> look at you in a good way, unlike what the media suggests. The media suggests that they are nerdy, awkward and everything. I think in--, especially here, I think, if you're doing a really hard major and doing something really, like, good research, then I think people admire you and like, against those, you know, nerdy and socially awkward stereotypes.

Lauren similarly said that that being geeky could be compatible with being "sexy."

Bolstered by students' relationships with friends who identified as "geeky," these popular media depictions seemed to have impacted students' affiliation with that identity. As the following quotation indicated, being nerdy or geeky could be acceptable identities, according to participants. Mai said:

> I'm nerdy [[laughing]]. Um, because I think I like many things in science…Not just in math, also, like, in econ even. Like, I like following news that what the Fed is doing. And then, um, about stock market. And about, um, um, other natural phenomena. It doesn't have to be math. But, um, you know, the curiosity to learn more about things, about science that make people think that I'm nerdy (…) And I, you know--, I embrace that.

Although Lauren and Mai were confident in this identity, Prianca maintained some distance from this nerd brand. Although she liked being a mathematics major and had many friends in mathematics, she thought that the buy-in from some of the mathematics majors in relationship to this culture was beyond her comfort level. She thought that this stereotypical nerdy mathematician was exemplified by some of the students who study for and take the Putnam Exam[13], as she described here:

> Or just, like, thinking these must be, these must be the nerdiest people around [[laughing]]. To come in, like, on a Saturday or whatever it is and take a test for six hours and then talk about it…Not that it's bad, it's, it's good. But, it would just be awkward [[laughing]].

[13] The William Lowell Putnam Mathematical Competition, often abbreviated to Putnam Competition or Putnam Exam, is an annual mathematics competition for undergraduate college students enrolled at institutions of higher learning in the United States and Canada.

Prianca seemed to be caught between two Discourses—one which said that people who willingly work on hard mathematics problems on the weekend are nerdy and awkward and another which admired hard work and a commitment to mathematics.

(Re-)Defining What it Means to be a Mathematical Person

Mathematical People are Analytic

As I described above, participants thought that people generally view mathematicians as "different." Although participants sometimes disagreed with this framing (especially when it was a negative one), they seemed to agree about one thing with respect to being different—namely, that working on problem solving meant that mathematicians viewed the world differently. Amongst STEM majors, mathematics was seen not only as a tool to accomplish a given task, but also as a means for developing important analytic skills. This led participants to believe that mathematics majors were more analytic and critical in their thinking than some other people. Having developed analytic skills meant that math majors were particularly good at problem solving in mathematics, but also in general. As Mai described,

> I think math is not only about, like, oh yeah, how you add or how you minus or how you, you, you do things, but also how you think of things. And when you think of math and you, you have to think of problem, how to solve that problem and that really make your brain, all the nerves connect together and that's how it develop your mind.

Here, Mai referenced her belief that developing mathematical knowledge actually impacts brain development and changes the way that an individual thinks about solving problems more generally. By contrast, then, it seemed that she was implicitly saying that people who do not study math do not have the same number of connections in their brains. This, in turn, might complicate the previous descriptions of how others think of mathematics majors as being smart or geniuses. Here, it seemed that Mai might they think of herself as being 'smarter', but may not have wanted to name it as such.

Lauren similarly noted this, saying that mathematics and statistics majors seemed to think differently from others and, specifically, were very critical in their thinking:

> I think how they analyze things is very different than other fields, I guess. I mean, there's still diversity within how we do that. So you see like the pure math versus the applied and that sort of thing (…) I think that people who are mathematicians/statisticians think of it [analysis] very critically.

Participants felt that being different in this way was seen as a desirable skill, something that employers would be interested in, as Prianca indicated here,

> I think, like, overall, thinking critically and analytically is very important, like, especially for, um, the actuarial science stuff I want to do… like, the job description and in just, like, talking to actuaries, they would say that, like, a very important characteristic for actuaries is being able to think critically and analytically.

Across participants' descriptions, it seemed that being good at mathematics meant being "analytic" and a "critical thinker." Overall, participants described mathematicians as good problem solvers. As they finished their degrees in mathematics, they all said that the primary skills they had developed were "thinking critically" and "analytically."

When asked what characteristics defined a successful mathematics major, though, none of these skills were mentioned. In other words, being a critical or analytic thinker was not a necessary requirement to begin a mathematics major and, instead, participants described it as the outcome of finishing a mathematics degree—earned through the process of completing their coursework. Alternately, participants agreed on two characteristics necessary to being a successful mathematics major—being interested in math and being a "hard worker."

Mathematical People are Hard Working

Participants generally thought that hard work and interest played significant roles in succeeding in mathematics. In fact, every participant named hard work as the primary factor leading to their own success in mathematics. In addition to being hard working, participants used similar self-descriptors: Omna and Mai said they were both “persistent,” Lauren repeatedly talked about being “stubborn,” and Prianca described herself as “driven.” All together, participants believed that being motivated and hard working seemed to be the keystone to success in mathematics.

Working hard, though, appeared to be simultaneously a source of pride as well as frustration for mathematics majors. Although participants’ hard work seemed to unify mathematics majors and other hard science majors, workload simultaneously served as a divider between STEM and non-STEM students, as Prianca described here:

> I don't know, I just feel like with my friends that aren't, that don't fit into those categories of, like, math, Econ, or, like, hard sciences, I just, like, don't tend to get along with them as much, just because I feel like--, you have a lot of this free time. (…) So, it's like I almost feel like they don't have as much work as me, which makes me feel annoyed.

Prianca thought that her non-STEM peers seemed to have an easier workload than STEM students. Prianca went on to say that having classes on Fridays, and oftentimes examinations on Fridays, meant that she and the other STEM students often missed out on going out with some of non-STEM friends on Thursday nights. Prianca and others told similar stories about the sacrifices unique to the mathematics and other STEM students.

Related to working hard, a common theme for all participants, was a description of the fundamental lack of time associated with it—time to complete all of their coursework and, perhaps more prominent, time to pursue activities other than studying. For example, Mai talked about seeing a movie as a “luxury.” For some, a lack of time also meant not being able to explore other academic interests. For example, Lauren described how being a STEM major meant not be able to take more art classes because of her tight schedule. For others, this meant not being able to participate in extracurricular activities. Omna thought that math majors were less likely to participate in such activities because of their school workload: “I do think the math majors are less engaged with the outside activities." This is important because a lack of engagement with extracurricular activities, arguably, may have reinforced stereotypes about mathematics majors being antisocial or socially awkward.

In fact, each participant had been a member of at least one of the mathematics clubs on campus at some point, but described how she was either less involved in these clubs or had left entirely because of a lack of time. Mai, having participated in the mathematical modeling club early on, decided to drop because of time restrictions, as she described here:

> At the beginning of second semester because I, I think I was taking, like, five classes at that time, and I, uh, so, like the group started again to meet and, um, prepare for the competition, uh, but at that time, I felt like, Oh my god, I don't know if I all be able to have enough time every time to, like, spend with my team, you know, to work on it. And I would not want to say I, I want to be in the team and then I would not commit into team. If I say I am in the team, it means that I am totally committed. You know? Like, it's the way, like, I don't want to, like, reverse my promise.

Being a mathematics major seemed to come hand-in-hand with being busy. Mai even had to justify taking time to complete the interviews for this study by claiming that our time together had been her "fun time" for the day. She said, "No, I mean, like, today is Friday, so I usually leave my time on Friday to be able to enjoy myself. It's a lot of effort. But, even though, you know, um, I feel guilty every time." Mai's quotation underlines an additional issue. Not only did participants feel that they were typically spread thin, but said that this also led to guilt, at times, about spending time doing anything outside of their coursework.

Together, participants' descriptions teetered between pride and frustration: pride at proving how hard she could work and, as a result, what she could accomplish; frustration about the amount of work she had to do and the sacrifice involved in being a mathematics major.

The prevalence of this "hard work" discourse shaped participants' view of mathematics and what it took to be successful in mathematics in two important ways: First, participants indicated that there were a number of sacrifices they had to make in order to successfully finish a degree in mathematics. Second, participants were faced with competing Discourses about the role of hard work versus innate intelligence relative to success in mathematics. I explore this in more detail below.

The Interplay of Mathematical Discourses

Identifying and unpacking any Discourse is inherently difficult in that Discourses are fluid. They can "change, hybridize with other Discourses, and they can even die" (Gee, 2014, p. 184). Further, when "we speak, we not only speak out of a given Discourse but also say or imply things about other, sometimes competing Discourses" (p. 187). The last goal of this chapter is to focus on the interplay of Discourses participants seemed to draw upon. I do this so that I might complexify the way these Discourses are identified, named, and understood. I first investigate the interplay between intelligence and hard work Discourses and, following, look into the ways that participants themselves talked about being a "math person." Throughout, I aim to illuminate possible relationships between these Discourses and participants' mathematical identity development.

Intelligence and Hard Work Discourses

Previously, I described how participants consistently agreed with their peers that mathematics was hard and that success in mathematics necessitated concerted and persistent effort; however, participants' views of mathematics and who can or cannot do mathematics differed in important ways from their peers'. For example, as I began to describe above, participants generally felt that "being bad at math" or thinking that mathematics was "too hard" was more of a choice or an attitude rather than an innate ability. Mai, as someone who had a great deal of experience tutoring peers at Metcalf, found this phenomenon to be very frustrating:

> I really, like, not really accepted it. I think and I, I was surprised because I know that they are smart, too. It's just that they consider themselves as not good in that specific subject. And, so, it really limit their, their, um, let's see, um, the effort they put in it. Or limit their enjoyment or the feeling for the subject.

Mai's description pointed to something that most of the participants noted; namely, that having a negative attitude toward mathematics learning and lacking experience in mathematics were cyclically related. That is, according to Mai, peers' beliefs that they were not good at mathematics ultimately led to putting in less effort. Without effort and experience, Mai and other participants felt that people become less proficient at mathematics, therefore reinforcing their belief that they are not good at mathematics. In this way, she seemed to be moving away from descriptions of mathematics as something different and inaccessible to others toward a more inclusive discourse wherein more people could access mathematics if they did not "limit their enjoyment" of mathematics.

Likewise, when asked what separated successful math majors from those who switched out of the major, Omna said:

> Oh, I guess, persistence would be something. I mean, it also depends on whether you're interested in the topic, right? I guess, it's a cycle, you know. Persistence and interest in the topic. Um... I don't really--, because, I don't want to offend, you know. I don't think of dropouts as unsuccessful math majors. So, it--, for me, it's just personality type and what the interest--, I mean, it's molded by their other experiences inside and outside the classroom. So, I don't really think of them as unsuccessful.

Here, Omna names persistence, interest, and personality type as being the factors impacting a student's decision to pursue mathematics. Interestingly, Omna also seemed to question or reject the notion of a student being unsuccessful in mathematics should she leave the major. Instead of it seemed that she preferred to think of this in terms of a student choosing a different, more interesting path, according to personal preferences.

When describing their peers, participants consistently said hard work and interest—rather than intelligence—were the primary factors determining whether or not someone pursued and finished a degree in mathematics. When describing their own experience in mathematics, however, there seemed to be inconsistencies, even tensions, between hard work and natural ability Discourses. That is, although all participants named persistence and hard work as being absolutely necessary to their success in mathematics, some participants seemed to hold conflicting beliefs about the role of intelligence in that process.

At times, some participants explicitly downplayed or even outright rejected intelligence as a factor in their mathematics success. Omna exemplified this, repeatedly saying that she was not particularly good at math. In the following quotation, she described why she did not initially declare a major in mathematics in her first year of college:

> I think I knew that I wasn't very mathematically gifted. I was interested, but I, I thought I wasn't very gifted and I don't think that's...you know, that's--, like people say, that's what women do; they underestimate themselves. I don't think that's unreasonable [assessment of myself]. I just--, that's just a valid evaluation [of my ability].

Recognizing that women are more likely to undervalue their accomplishments, Omna still insisted that she was not finishing a degree in mathematics because of natural mathematical "gifts" or ability. Instead, she maintained that success in mathematics was due entirely to her interest in the field and, more importantly, her persistence. This theme was echoed throughout others' descriptions of their own mathematical achievement.

How ability or intelligence was framed within and across participants' stories, however, was complex and sometimes inconsistent. I found that these stories reflected two primary Discourses: one framed mathematical ability as a natural trait; something that one was born with. The other framed mathematical ability as something that is earned through hard work. The first of these Discourses, framing intelligence as natural, was subtle and arose almost exclusively when participants compared their mathematical ability to those whom they perceived to be more naturally talented. For example, you may recall that in Chapter 4, I explored how Omna described her sister's mathematical competence in contrast to her own:

> Yeah, they thought I was a good student, but my identity or brand, you might say, was more like a --, from other places. Not for my mathematical, you know, genius--, genius or whatever. But my sister, she was known for like her outstanding brain or whatever. Like she's still the model student in my school. [[laughing]] Yeah, so, in my family, we say all our brains [went] to her.

Previously, I described how this quotation framed Omna's sister's success in mathematics to natural ability. Omna repeatedly linked her own success in mathematics to hard work and interest in the subject, whereas her sister's success in mathematics and sciences was ascribed to her natural genius.

As mentioned previously, across my conversations with Omna, two Discourses seemed to be at play: One framed mathematical ability as a natural state while the other indicated that mathematical ability was earned through hard work. This distinction was complicated by an evaluative Discourse, however—one where natural ability was deemed more valuable than ability earned through hard work. Being head girl in high school, not only finishing a degree in mathematics and computer science, but finishing at the top 15% of her class at Metcalf—these seemed to be indicators of something beyond hard work. When I pressed her to say more about why she appeared to value natural genius over hard work, however, she insisted that interest and hard work were the only factors impacting her success:

> I don't know…Anybody can be interested in mathematics. It's not an exclusive subject. So you can be interested in mathematics. I think that's what I am, I'm interested in mathematics. But whether I'm good in mathematics or not, I think that's really subjective.

Here, Omna noted that being "good" in mathematics was a subjective measure. At times and in certain contests, she stated that she was good at mathematics. At others, she said that she was not. Of course, this could reflect some ambiguity in what it means to be “good” in mathematics. Further, as each participant had experienced the full range of content in mathematics, it seemed that they had a more nuanced understanding of being good at mathematics. Being good at Algebra I was, perhaps, different than being good at Abstract Algebra I. Yet, it seemed that being good at mathematics, at least for Omna, was almost exclusively linked to natural or given ability.

The interplay of these two Discourses was visible in others’ descriptions. For Mai, mathematical ability as a result of hard work seemed to be the dominant Discourse, especially in instances where she described her frustrations about some of her peers claiming that “they just aren’t math people.” At other times, though, Mai described herself and family members as being naturally talented. She said that her brother was naturally talented in mathematics and particularly so for his age; “he just naturally develop interest in, like, just naturally be good at math. Just naturally be, like, score really high in math as compared to literature.” This, almost in direct conflict with other comments she made which explicitly challenged the dichotomy of being either good at math or literature, led me to ask her about these two different ability narratives. In response to my inquiry, Mai indicated that both natural ability and hard work were important factors in mathematical ability:

> I think the naturally is, has a little bit part of it, but the upbringing has a bigger part of it…Like, my dad was really good with math. So, he believes that because he's good for math, so we all get the good gene for math. But, I do believe that it's … not only the gene, but also, like, environment has a bigger part. And my mom believe in the environment.

In this quotation, Mai seemed to be drawing on family Discourses about being a good mathematics student. She clearly stated that her mother believed that the environment was the greater factor, whereas her father believed that mathematical talent was inherent. Seeming to have adopted some aspects of each belief, Mai said that being good at mathematics was largely dependent on the educational environment and experiences with mathematics. But, she thought that mathematical competence was also linked, perhaps to a lesser degree, to natural mathematical ability: a "good gene for math."

Similar to others, Lauren talked about her own success in mathematics as being shaped primarily by her "stubbornness" and hard work. Yet, at other times, she indicated that she believed that natural ability played into her success:

> Yeah, I think I'm naturally inclined somewhat to understand this [mathematics and statistics] more than some people might be. Cause I don't understand all of the economics theories. But some people get that in a snap. And I'm just like, I have no clue what's going on.

Here, Lauren seemed to be linking understanding concepts quickly, with a natural ability, rather than an earned one. Specifically, she said that she is more naturally inclined to understand mathematical concepts and that her ability in mathematics seemed to parallel peers' ability to get economics concepts "in a snap."

Overall, the prevalence of "hard work" narratives was deeply embedded in participants' descriptions. Yet, even if they were subtler, natural ability Discourses emerged, too. It is important to note that these natural ability Discourses seemed to come up almost exclusively when making comparisons between individuals outside the context of the institution. That is, participants did not talk about their mathematics department peers as being more or less smart. When describing members of their study groups, participants talked about how each member had something to contribute. Further, they described how members of their study group all rotated between being the person who, as Lauren described, "got it right away" and the person who is "totally lost." In doing so, they seemed to acknowledge that there are more nuanced ways of knowing and doing mathematics: it is not simply that people either "get it" or they "don't."

Instead, everyone experiences times when they get it "in a snap" and other times where they struggle.

Being a Math Person or a Non-Math Person

Similar to the interplay between hard work and intelligence Discourses, participants also seemed to draw upon two identity Discourses, which appeared to be at odds with one another. That is, when describing others and themselves as mathematical people, they seemed to draw upon different–perhaps competing–Discourses. Above, I described an institutional Discourse that seemed to be prevalent at Metcalf: that individuals were either mathematically-inclined or English/language/art-inclined (but not both). I return to this Discourse specifically because there were times when participants seemed to buy into the conception that there were two types of people: math people and non-math people. Yet, at other times, participants directly challenged this notion.

Many of the quotations I provided earlier seemed to reflect participants' perceptions about English / humanities / social science people; namely that such people identified in this way by their own choosing. Participants seemed to indicate that peers adopted these identities because of their values and dispositions, as well as their affinity for subjects other than mathematics. Perhaps only implicit in these previous quotations, though, participants sometimes explicitly differentiated between math and non-math people in ways that seemed to reflect their personal beliefs about being a mathematical person. For example, when describing her secondary school experience, Omna said, "I mean, there were people who were good in math and there were not. But, we didn't really had, um--, one of my other best friends, she was more of a social science person, a humanities person." In this instance, Omna's description felt somewhat static and inherent: reflective of her friend essentially being one type of person as opposed to another. Instead of choosing not to pursue mathematics, it seemed these friends might be signifying that they saw themselves as a “non-math person.”

The descriptions were not always of other people. Instead, there were instances when participants seemed to regard this distinction as truth about themselves. For example, Mai talked about herself as having always been good at mathematics, whereas she had been “not good at writing” (i.e., had always struggled in her Vietnamese literature classes). Lauren talked about herself as being “creative” and “artsy,” at times, *despite* being a mathematics major.

At other times, those same participants took issue with this division and explicitly challenged the notion of being one type of person or another. For example, Mai said:

> … A lot of my friends who come from other countries, they were good at math before. And when they came here, and they study, study all the writings and they forgot about math. And then they started taking math again, they have problem. And they started, they started feeling, “Oh my god, I'm not good at math.” And the society to support for that. And just like, “Oh yeah, you were good at writing, you are not good at math. You are good at math, you are not good at writing.” And I don't agree with that. If you good at math, you could do the writing. If you're good at writing, you can do the math. As long as you put the time into it.

This description is interesting for a few reasons. First, it illustrates the changes in attitude toward mathematics from fellow international students as they were exposed to mathematical ability narratives and beliefs in the United States over time; namely, that students who previously were successful in mathematics and formerly believed that being good at mathematics was linked to hard work began to change both their beliefs about mathematics and about their own mathematical identities. Second, this quotation highlights the aforementioned belief that mathematical ability is distinct from—if not in conflict with—ability in reading and writing. Interestingly, Mai described herself in these very terms at other times: being naturally good at mathematics and struggling with literature and writing.

Although participants sometimes directly challenged the notion that people are either mathematics or English people, there were other instances where participants drew upon Discourses that implicitly reinforced this split. That is, participants sometimes described people as being either mathematically-inclined or English/language/art-inclined. And this either/or Discourse seemed to be reflected in the identities of both math and non-math people.

According to participants, their friends who did not identity as "math people" generally highlighted their own ability in writing or social sciences. And, at times, when bolstering their own identities as mathematically competent people, participants sometimes downplayed or even rejected their ability in English, language, or art. This, perhaps, is most evident in the way that Lauren described her early experiences in mathematics: "I actually was horrible at math for a long time and until --, until like ninth, tenth grade I was so bad that I was like, 'This is the worst thing.' I wanted to go into English. [[laughing]]" Based on this quotation, it seemed that her desire to pursue English at this time in her life was entirely a function of her own perceived inability in mathematics. That is, the reason she wanted to "go into English" seemed to be rooted in her dislike and lack of success in mathematics. This was the only instance when Lauren mentioned liking English or having any desire to pursue something in the humanities.

Chapter Summary and Discussion

Throughout our time together, each participant in the study shared descriptions of being a mathematical person—a student of mathematics, a mathematics major, a mathematician, and so on. Together, these descriptions captured what was assumed to be normal or typical about mathematics and about people who engage in mathematics. Naming the Discourses that served to build participants' conceptions of a "math person" is an inherently difficult task because of the amorphous nature of Discourses. Discourses do not "belong" to any one person. They may shift over time. And individuals may draw upon multiple Discourses in competing or contradictory ways. At times, participants' descriptions seemed to illuminate their own conceptions about who does mathematics, what it means to know and do mathematics, and why people engage in mathematics. Some of these descriptions did not seem to reflect their personal beliefs, evaluations, or presumptions, though. Instead, they were reflective of (and reflected in) the broader mathematical Discourses assumed by others. That is, the descriptions provided by participants about their experiences in mathematics seemed to reflect the Discourses assumed by their instructors, peers, friends and family, and the media.

In this chapter, I sought to name and unpack the Discourses that seemed to frame participants' descriptions. I began with an investigation of the global Discourses about being a woman and about being a "math person." I then proceeded to investigate participants' descriptions of their experiences at Metcalf specifically, with the goal of identifying and examining various institutional mathematical Discourses. Taken together, I argued that these Discourses give rise to the conception that mathematics is not for everyone and mathematical people are different from others.

Because participants' conceptions of mathematics and of what it means to know and do mathematics sometimes differed in substantial ways from the prevalent Discourses, I then explored those global and institutional Discourses participants seemed to reject, question, or had worked to reframe. Building on this, I then unpacked the Discourses that seemed to be reflective of participant's own perspectives. Using these local Discourses, I made a case for re-defining what it means to know and do mathematics as a woman based on participants' perceptions.

I believe that all of the aforementioned Discourses, be they positive or negative, ultimately shaped participants perspectives about what it means to know and do mathematics.

Further, and perhaps more important, I argued that these Discourses reflect which socially recognizable mathematical identities seemed to persist and possibilities for changes to those identities. When "using language, as well as ways of acting, interacting, believing, valuing, dressing, and using various objects, tools, and technologies… to enact a specific social recognizable identity," an individual is inherently drawing on these Discourses (Gee, 2014, p. 181). Therefore understanding what is typical, normal, or even possible when it comes to being recognized as a mathematical person is inherently tied up in these Discourses.

In this Chapter, I investigated two Discourses, which produce different perceptions about what it takes to be good at mathematics: one that framed mathematical ability as a natural trait; something that one was born with. The other Discourse framed mathematical ability as something that is earned through hard work. I explored the tensions I saw as inherent when participants seemed to draw upon these two Discourses. Rather than resolve those tensions in any definitive way, I am left with further questions. Specifically, might the adoption of "hard work" Discourses, as is often championed by the "mindset" scholars (Dweck, 2006), be more complicated than meets the eye? All of the participants in this study described hard work as THE way to be "good" at mathematics. Yet, this rationale did not seem to support all of the participants in consistently describing *themselves* as being good at mathematics. As you may recall, Omna in particular maintained that she was not particularly "gifted" or "able" in mathematics. Further, when she did describe someone who was "good at mathematics," she characterized that person by their natural ability. It seemed that participants had generally embraced "hard work" Discourses for others and for themselves. Yet, "hard work" still seemed to be perceived as less valuable than natural mathematical ability, at times. Succinctly described by Mendick (2005), it seems that "'hard work' is the province of the 'less intelligent' and opposed to 'effortless achievement'" (Mendick, 2005, p. 209).

In addition to gaining more insight into the ways that "hard work" may be linked with "less intelligence," I am also left wondering about the ways that "hard work" Discourses may be gendered. As I described in Chapter 2, Walkerdine (1990) found that grade-school teachers praised female students for their hard work in mathematics, instead of their intelligence or natural aptitude. Yet these same teachers described male students as being naturally adept and treated them as such during classes. Consistent with this, Mendick (2005) and Rodd and Bartholomew (2006) found that the young women in their studies engaged in "denials of intelligence," instead highlighting how hard they had to work to navigate their undergraduate mathematics degrees. Therefore, it seems that "hard work" might not only be characterized as necessary for less intelligent or less capable people, but also as a feminine trait.

Within this all-women's context, it was difficult to untangle the Discourses of hard work and natural intelligence. At Metcalf, it might be that conceptions of "hard work" were more universally accepted because notions of "natural intelligence" were not as visible or valued. Was this due to a de-coupling of the gendered binary, which links hard work with femininities and natural ability with masculinities? That is, in a male-less environment, might "hard work" Discourse be more readily accepted because masculine notions of success are not visible or are outright rejected?

CHAPTER SEVEN: CONCLUSIONS, LESSONS LEARNED, AND IMPLICATIONS FOR FUTURE RESEARCH

Overview of the Dissertation Study, Purpose, and Goals

The purpose of this qualitative study was to gain insight into the mathematical identities of senior women mathematics majors, to understand their assumptions about what it means to know and do mathematics, and to describe the role that an all-women's content might play in their descriptions of themselves or of mathematics. As such, I focused on the constructs of *identity, context,* and *Discourses*. In Chapters 4, 5, and 6, I addressed each of the following research questions, respectively:

- *What language do senior women mathematics majors at an all-women's college use to describe their mathematical identity development?*
- *How might the context of an all-women's mathematics department be described as relevant to students' identity development? Specifically, what activities do mathematics majors at an all-women's college describe as significant to their experience and how do they describe their relationship to others within that context?*
- *What mathematical Discourses do senior women mathematics majors at an all-women's college know, assume, question, or reject? What seems to be the relationship between their identities and those Discourses?*

The first research question focused on identity development and recognition, that is, how participants' discourse described their mathematical identity development and other related identities. The second set of questions focused on description of the particular all-women's context of Metcalf, particularly the community practices and relationships. The third set of questions focused on developing and understanding participants' interpretive and evaluative models–specifically, about what it means to know and do mathematics as a woman. Overall, my aim was threefold: to say something meaningful about (a) who these women are, (b) what meaning is ascribed to knowing / doing mathematics by these women, and (c) how the context of an all-women's college seemed to shape their relationship with mathematics.

Framing the Study

Below, I return to my findings from my results chapters in order to talk back to existing literature and to raise questions about what the field has said about women in mathematics, mathematics identity development, and the construction of mathematics as a masculine discipline.

Research on Why Women Choose to Study Mathematics

In this section, I specifically reconsider the findings from Chapter 4 on participant's mathematical identities in order to speak to the known literature about women's engagement and persistence in mathematics. Since identities, as I have used the term, are built upon the three following interconnected ideas, I reconsider the exploration from Chapter 4 of students' descriptions of "being good / bad at mathematics" can be interpreted with an eye toward the development *process*, the identifying agent or *power*, and the *source of that power* (Gee, 2000).

Although the theoretical framing I employ in this study does not lend itself to making claims about internal states per se, participants' descriptions of themselves oftentimes included statements about internal states: personal beliefs, motivations, and actions. That is, when describing herself as a mathematical person, it seemed as though there were times when each participant described herself either as the identifying agent or named the locus of power as being internal. As such, the process or the identifying agent in that identity was herself. There were also times when participants seemed to tie her success in mathematics to external factors: her family, her tutor, or her community. In these cases, participants seemed to describe the source or power as lying outside the participants themselves and, therefore, could be interpreted as "external factors" through a psychological lens.

Of course, as is the case with identity-building stories investigated from a sociocultural perspective, the distinction between internal and external is arguably artificial, as each description potentially reflected both types of factors (or neither). For example, having a supportive family might be external in the sense that her family's actions impacted her in particular ways. Yet, it is also the case that a participant's role within the family shapes and is shaped by her own beliefs and actions. As a member of a family, and various social groups, cultural, and institutional groups, each participant's mathematical identities stories were shaped by her relationships with others.

Reframing the various facets of mathematical identity I name in Chapter 4 as "internal" or "external" factors shaping her mathematical identity development may help to illuminate connections to this larger body of literature, which generally focuses on psychological or sociological interpretations of women's experience in STEM (Hall, 2008; Sax, Kanny, Riggers-Piehl, Whang & Paulson, 2015; Shapiro, & Eagan, 2011; Seymour & Hewitt, 1997; Shapiro & Sax, 2011). From this perspective, I believe that an important finding from Chapter 4 relates to the different roles that internal and external factors seemed to play in shifting identities. In particular, when describing identities as people who used to be bad at mathematics, Omna, Lauren, and Prianca named themselves as the primary powers in inhibiting their success. Whether it was a personal characteristic like "being shy" or "being very ADHD" or it was a lack of passion or motivation to learn mathematics, each named factors about themselves shaping their identity as someone who was not good at mathematics. As such, this identity seemed to reflect internal states or factors. The phenomenon of women internalizing perceived failure, or having poor "self-concept" or lower self-confidence than men, is well documented within the psychological and sociological research on women in mathematics (Bressoud, 2014; Shapiro & Sax, 2011). Yet, it was also the case that Omna, Lauren, and Prianca described teachers or family members as playing a negative role in their mathematical identity development. Therefore, it is not a clear distinction between internalizing failures and externalizing successes, as is sometimes assumed to be true within the psychological literature on gender in mathematics.

More significant, I might argue is that, for both Lauren and Prianca, the process of becoming someone who was good at mathematics seemed hinged upon an external power. That is, both Lauren and Prianca's process of becoming a person who was good at mathematics seemed, at least in part, to originate from the endorsement of a teacher. In this way, both Lauren's and Prianca's respective mathematical identity shifts seem to both be heavily influenced, if not contingent upon, an external authority reifying this identity. As such, participants' descriptions seem to point to the importance of others (especially mathematics teachers) in facilitating or authorizing the process of becoming someone who is good at mathematics. I believe that there is also evidence in Mai's descriptions that her parents' reinforcement of her being good at mathematics seemed to reinforce, even helped to build, this positive mathematical identity. Overall, my findings indicate the women in my study perceived others in playing a large role in either identifying or maintaining an identity as someone who was good at mathematics.

My findings focus specifically on the role that others seemed to play in shifting some of my participants' mathematical identity stories. These findings speak to what is already documented within the literature focused on students' decisions to study STEM disciplines and the documented reasons why women, in particular, choose to study mathematics (Hall, 2008;

Seymour & Hewitt, 1997; Zeldin & Pajares, 2000). In Seymour and Hewitt's (1997) seminal study on why undergraduates choose to study STEM disciplines (and why they leave), they found that individuals like teachers, parents, and role models played a very important role in undergraduate women's choices to study science, mathematics, or engineering:

> The most marked difference between the sexes documented in this study lies in the reasons for their choice majors. Women were about twice as likely as men to have chosen a S.M.E [science, mathematics, or engineering] major through the active influence of someone significant to them. (p. 77)

Whereas men were much more likely to cite "being good at mathematics and/or science in high school" (p. 77) —arguably a statement about internal factors and personal ability—women were much more likely to describe their decision to be a STEM major as resulting from supportive relationships.

Research on Stereotypes, Discourses, and Images of Mathematical People

In Chapter 6, I explored the Discourses the participants seemed to draw on when describing mathematics or themselves as mathematical people. I named and described three persistent institutional Discourses about the discipline of mathematics that are perpetuated by peers, instructors, friends, and family; namely, that (1) mathematics is disliked by many and thought to be too hard; (2) it is socially acceptable not to be good at mathematics; and (3) individuals are either mathematically-inclined or English/language/art-inclined, but not both. I also unpacked those Discourses that served to create an image of mathematically competent people as being intimidatingly smart, while, at the same time, are assumed to lack social skills and awareness of social issues. When describing the ways in which participants questioned, rejected, or reframed certain mathematical Discourses, I also highlighted some of the stereotypical images of mathematicians conjured by participants; namely, that mathematicians were nerdy, non-glamorous, and asocial. Through this exploration, I made the case that prevalent mathematical Discourses support the notion that mathematics was not for everyone, while simultaneously constructing an image of a mathematician as different from other "normal" people.

The findings from this part of my analysis were consistent with the findings of other studies focused on peoples' perspectives on, beliefs about, cultural models of mathematicians or people who do mathematics (Damarin, 2000; Ernest, 1996; Lim & Ernest, 1999; Picker & Berry, 2000; Mendick, 2005, 2006, 2007; Mendick, Moreau, & Hollingworth, 2008). Below, I specifically compare and contrast my findings with a similar study conducted by Mendick and colleagues (2008). Mendick's large scale, mixed-methods study specifically focused on secondary and university students' images of mathematics and mathematicians as they relate to popular culture and, in turn, how these images seemed to influence these students' relationship to mathematics. Although her participants consisted of both STEM majors and humanities majors, and the study itself was focused specifically on describing the effects of popular culture on students' understanding of and engagement with mathematics, the findings from that study were consistent in many ways with the findings from the present study. Based on surveys from 556 secondary students and 100 undergraduates and on findings from 27 focus groups involving 129 participants, Mendick and colleagues (2008) found that there were fairly consistent and strong images of mathematicians and mathematics, which reflect dominant media representations, as described below:

> The majority of Year 11 students and non-mathematics undergraduates had a view of mathematics dominated by number and calculation, with a strong division between everyday and esoteric mathematics and between mathematics and 'creative' subjects such as English, reiterating discourses identified in popular texts. Nearly all participants, mathematics students included, saw mathematicians as White, male, middle class and old, these are simultaneously positions of power and ones that draw on some common popular culture tropes of obsessiveness, geekiness, madness and social awkwardness. (p. 19)

Through their analysis, Mendick and colleagues concluded that popular images serve to "other" mathematicians and mathematical people from "normal" people (p. 19). Yet, as I found in Chapter 6 with my participants, the mathematics majors in this study had a complex relationship with this image / Discourse. That is, they "showed a critical awareness that the images were clichés and often both used them and distanced themselves from them" (p. 19).

Similar to my findings, Mendick and colleagues found that some mathematics majors "gave positive value to 'geek' status" (p. 21). Mendick found, however, that students who did so were much more likely to be male. More common amongst the mathematics majors in their study, both male and female, was a desire and "considerable" effort to "claim 'normality'" during interviews and focus groups (p. 21). These two ways of conceptualizing and responding to geek Discourse were evident in my participants' responses; namely, that some participants described themselves in ways that affiliated with geek culture, while others disassociated with that image in an attempt to undermine or counter it.

In instances where their participants distanced themselves from popular media images of mathematicians, Mendick and colleagues found that "particular people, be they teachers, peers, family members or characters in media texts, can serve to counter dominant clichés" (p. 20). Mendick's participants named multiple representations of mathematical people in the media—some of which participants admired or connected with, others not. Those media characters described in a positive light by participants were strictly male. A commonly referenced by mathematics majors in Mendick's study was Ian Malcolm from Jurassic Park, whom participants described as being the "first cool mathematician" (p. 21). Her participants indicated that this character served to support them in developing a positive image of being a mathematician. The handful of other positive examples provided by participants in Mendick's study was exclusively male, thereby seeming to reinforce an image of a mathematician as a male figure.

For my participants, people such as their non-nerdy, "glamorous" professors and their female peers provided them with counter examples to "dominant clichés" of mathematicians. Based on my participants' descriptions, however, it seemed clear that there was a dearth of female mathematicians in media texts, much less female characters in the media who might serve as a counter to negative images of mathematical people. You may recall that some of my participants talked about characters from the Big Bang Theory television show and one mentioned a music video featuring Katy Perry, which seemed to celebrate geek culture. In neither of these instances, though, did participants seem to have a strong affiliation with or to give positive value to these media images. Instead, such images seemed to serve illustrative purposes in describing existing images of female "geeks" of which they were aware. Further, neither of these examples are the characters mathematicians; the women from the Big Bang are scientists, while the character in the Katy Perry video is a high school student.

The findings from my study seemed to indicate that participants' resources for "countering dominant clichés" about women who do mathematics were limited to teachers, friends, and family. In lieu of positive and powerful media representations of women in mathematics, it seemed that the role of members of families and communities served as dominant examples of what it meant to know and do mathematics in a way that did not reinforce negative stereotypes about mathematical people. This points, then, to the development and maintenance of spaces that allow for the existence of these resources.

Complexifying Discourses on Women in Mathematics

Drawing on the construct of a "marked category" which "refers to any group of individuals whose bodies are assumed to bear … marks of deviance: women, blacks, people of color, Jews, criminals, homosexuals, or persons of disability," Damarin posited that "mathematically able" is a marked category (2000, p. 80) because being mathematically able is characterized by the following:

1. Members of marked categories are ridiculed and maligned. Also, the application of terms denoting marked category membership are used to tease, harass, and discipline members of the larger society.

2. Members of marked categories are frequently portrayed as incompetent in dealing with daily life.

3. In schools and other institutions which purport to serve the needs of all, the needs of members of marked categories are deferred while the needs of the unmarked are met.

4. Members of marked categories are feared as powerful even as they are marked as powerless.

Three of these characterizations of mathematical peoples were visible in the ways in which my participants described others' presumptions about being a "math person" (1, 2, and 4). That is, to many, math people are "geeks," not "sexy" or "glamorous." They are incompetent when it comes to social and political awareness and social acceptance. They are smart in a way that is "different" and "unrelateable."

Damarin (2000) further contended that by virtue of being a woman—a marked category in its own right—making the choice to affiliate with mathematics as a woman necessitates the adoption of the status of a doubly "marked" person. As such, being a woman in mathematics is complexified by the ways in which Discourses about these two marked categories interact. Therefore, gaining insight into the mathematical identity development of these women seemed to be shaped by two powerful Discourses which served to "mark" both women and the mathematically able.

Damarin (2000) argued that "communities that celebrate mathematics" are the key to developing resources for countering Discourses which "other" mathematically able people:

> For women, already members of a marked category, becoming 'mathematical' means becoming doubly marked, and thus marginalized within each class. Biographies and autobiographies of women mathematicians, together with related accounts of and by women mathematicians indicate that many women who elect mathematics have backgrounds in a family or other small community which celebrates mathematics. Multigenerational, affirming, and genuinely interested in the mathematical accomplishments of its members, such a community counters the larger social discourse of mathematics ability as deviant in several ways: it normalizes the ability, it allows members to experience and enjoy the diversity and humanity of the community, and it can counter directly the totalizing potential of the popular media and discourse. (p. 80).

I believe that the present study serves as an illustration of one such community—a space where diverse groups of women, by virtue of existing and celebrating mathematics, can begin to counter Discourses which frame mathematically able people as deviant or abnormal.

Questions Raised About Current Research on the Role of Feminine Practices in Supporting Women in Mathematics

Some women's mathematics education scholars have argued that traditional "masculine" teaching practices and classroom norms hinder the participation and engagement of girls and women in mathematics (Boaler, 1997; Boaler & Sengupta-Irving, 2006; Eccles, 1987; Fennema 2000). Working from this premise, these scholars have promoted teaching practices they argue are more in line with the "learning styles" of women and girls. As I described in Chapter 2, such practices include things like allowing risk-taking behaviors in young women rather than rescuing them at the first sign of struggle, but to do so with support; and encouraging group work and assigning roles that make expectations for participation explicit (Morrow & Morrow, 1995).

Based on this literature, it was my expectation that participants would describe mathematics classrooms at all-women's colleges as being characterized by these practices.

Within the all-women's context of Metcalf, however, student-centered or "female-friendly" teaching practices were not visible in participants' descriptions of their experiences in the classroom, nor were they described as valuable by participants. As I discussed in Chapter 5, the women in this study described their mathematics classroom experiences as being characterized by lecture, a lack of group work, and limited student talk. The absence of many of these female-friendly practices from participants' descriptions did not correlate with a lack of feeling supported. That is, participants felt well-supported by instructors, both inside and outside of the classroom. Participants said that they generally felt that they were encouraged to speak up and felt that they could if they wanted and, overall, found their mathematics classroom experiences at Metcalf to be meaningful. Looking across their descriptions, it seemed that at least some of the practices that one might characterize as traditional or masculine were not interpreted in this way by participants within the Metcalf context. Further, some participants outright objected to the adoption of student-centered or "inquiry-based" teaching practices, at least in mathematics.

The fact that participants did not describe the practices at Metcalf as being consistent with the practices listed above seems to point to the complexity of capturing or understanding elements that constitute a supportive learning environment for women; namely, that female-friendly practices need to be interpreted within the context in which they are used. Based on participants' descriptions, it seemed that effectively supporting students to pursue mathematics may not be dependent upon the adoption of student-centered or feminist teaching practices in classrooms at Metcalf. Of course, I do not have data to support that the adoption of such teaching practices were harmful in any way to student engagement or success; nor am I claiming this. Student-centered teaching is the cornerstone of my own practice and I believe very strongly in the effectiveness of this type of teaching. Instead, I am claiming that participants, themselves, did not speak about their experience or provide evidence that they valued these types of practices.

Yet, these practices did exist in office hours and during mathematics study sessions. As I explored in Chapter 5, the reasons for this are likely multiple and complex. It could be that dominant Discourses about traditional mathematics teaching and learning are so widespread and deeply rooted, that the concept of student-centered or female-friendly practices seemed to fall outside participants' perceptions of what "real" mathematics teaching could or should look like. It might be that participants did not describe these practices because they were not experts in teaching or curriculum and, therefore, may not be attending to things like teaching practices despite my questions focused on classroom practices and norms. It could be that the all-women's context negated the need for female-friendly practices in the first place; that, by virtue of being in an all-women's context, these women did not feel the need for practices designed to ameliorate gender inequities. Alternatively, it might be the genuine open-door policy and the relationships it mediated.

The question about where these feminist practices did and did not occur, and how they were seen or interpreted by students, necessitates further investigation. Specifically, I am left wondering what the lack of these practices (or, in the vary least, participants' lack of awareness of them) says about supporting women in learning a "masculine" discipline like mathematics. If, within an all-women's context, the practices and culture norms might still be primarily characterized as masculine, is there even a possibility of disrupting gendered binaries in mathematics in any meaningful way? Hottinger (2016) indicated that some feminist scholars have challenged the gendered discursive construction of mathematics through a "rejection of masculinist reason and the creation of a feminine or feminist notion of reason" (p. 15). Similarly, one could argue that if the practices of mathematics are themselves gendered, the creation of feminist practices might be warranted. Based on my participants' descriptions of their mathematics classroom experiences as being very traditional, as well as their perceptions of what it means to be good at "real mathematics," it may be that gaining traction with the idea of a feminist notion of reason or feminist practice may be challenging.

By describing masculinities and femininities in mathematics, I realize that it is easy to slip into essentialist arguments—to reject masculine ways of knowing and to assume that feminist epistemologies or pedagogical practices are to the benefit of all women in mathematics. The question remains, though, whether the women who have been succeeding in mathematics thus far may have done so because they have embraced masculinities in mathematics. That is, might their success within the field stem from being enculturated into hegemonic ways of being in mathematics? Becker (1995) similarly asks

> Are women in mathematics more likely than non-mathematicians to be separate knowers and thus be attracted to the subject because, at least at this early stage, they perceive mathematics to be an objective discipline in which they can find absolute truth? (p. 172)

Resultantly, I think the question of how gendered Discourses within mathematics produce or reproduce mathematical people and notions of success in mathematics has yet to be fully explored.

If mathematics departments or universities establish much more open and agentic spaces than the typical lecture-based classrooms, I am also left wondering, on the one hand, what do those spaces do for young women studying mathematics? Is the development of such spaces important because they might support women in navigating their own participation within the masculine discipline of mathematics—to encourage women to speak up and to participate in more visible ways? Or, would the goal of these open spaces be more about challenging the dominant discursive construction "real mathematics" and to encourage students to embrace more connected ways of knowing? Further, might these goals be compatible in that they are both focused on drawing attention to and challenging students' narrow perceptions about what it means to know and do mathematics as a woman?

On the other hand, this study leaves me wondering how feminist practices or embracing feminine ways of knowing might prepare these students for predominately male educational environments or work environments. Even if accepted or embraced within an all-women's context, it might be that disrupting those Discourses which privileged masculine ways of knowing or which "other" girls and women in mathematics outside of that context may prove exceedingly difficult. Assuming that there is a paradigm shift in certain spaces like all-women's colleges or programs from seeing "women as a problem in mathematics" to "women as central to mathematics" (Rogers & Kaiser, 1995), how might that start to shape the role of women in mathematics outside of these spaces?

Key Lessons from the Study About Conducting Research

Qualitative Research is Not Quantitative Research Nor is it Just High-Quality Journalism

Qualitative research is not quantitative research. Despite my acute awareness of this fact, I found that there were times throughout this work when dominant quantitative research paradigms began to impact how I thought about the goals and the quality of my work. Throughout this process, I felt the challenge of navigating the interplay of Discourses of "real research" (which is characterized by things like "validity" and "reliability" and "replicability") and my own understanding of my work (which was none of those things in the way that they are traditionally conceived). With the help of a few articles which directly asserted the ways in which qualitative research can and should have their own markers of quality (Tracy, 2010), I was able to ameliorate some of those concerns. Throughout my analysis and writing, I found it necessary to consciously understand the ways in which qualitative research is different from quantitative research and that my work was intended for an audience who understood and celebrated what it is that qualitative work offers.

At other times throughout this process, I found that the desire to capture what participants had said in the most sincere way possible meant that I was hesitant to interpret or hypothesize anything. In this way, many initial drafts of this work looked more like high-quality journalism: a collection of nice stories, reflecting the words of participants. The following example, provided by Gee (2014) helped me to understand that my role, as an interpreter of participants words is necessary for work to be research:

> Let's say you, in the United States, had seen lots of white swans and no black ones. You could make the narrow hypothesis: "All swans in the U.S. are white" (or even worse, "All the swans I have seen are white"). Or you could make the broader hypothesis: "All swans are white." This latter hypothesis will turn out to be false and will be shown to be so when someone shows us that there are black swans in Australia (as there are). Now we can retrench to a narrower hypothesis like "All swans outside Australia are white" and see if this can be falsified. Having made the bolder hypothesis we have forced ourselves to learn more about swans by pushing ourselves and others to search more widely for evidence, in this case, to go out and look for black swans well beyond the United States. (p. 30)

First, this quotation highlights the fact that hypothesis is absolutely necessary in research. Second, it helps me to see how this work is not done even after the thesis has been submitted. Discourse analysis is an on-going process of exploration, testing themes by sharing your interpretations with others, questioning and troubling those themes, and modifying these interpretations based on new information or counter evidence.

Sometimes You Have to Kill Your Darlings

Perhaps the most challenging part of this work lies in the fact that qualitative work necessarily excludes the vast majority of the data collected. As someone who revels not only in the complexity of theory, but feels compelled to describe to the best of my ability all that I know about my participants, I found it very difficult to make decisions about what data to exclude. For example, although I conducted a series with another participant at another all-women's college, I chose to exclude this data in the present study because bringing another institutional context into the analysis seemed to introduce too much complexity. Yet, Cassie had wonderful insights and was particularly eloquent about how "math people" are viewed (and the impact that this had on her developing mathematical identity). In particular, one story Cassie shared with me seemed to so beautifully illustrate the themes from my study. Cassie described her frustration when others attribute her success in mathematics to innate intelligence rather than hard work. She felt very strongly that she had earned her ability and that this hard work was often discounted when others around her chalk it up to being the "mathy one." Recognizing that this story was important, but did not have a place in the present study, however, I made the decision to exclude it.

There were also things that I observed during my visits to Metcalf that I found to be exceedingly interesting, yet had difficulty determining how it "fit" into the overall story I was telling. For example, I observed male professors talking to me and to students about their wives and children, which I interpreted as an attempt to make themselves seem safe or relatable to female students. It seemed at times male faculty members made their relationship with their wives or daughters visible to students because it served as evidence that they were invested in relationships with women and, perhaps, that they had been accepted or legitimized by other women. I also noted that a number of job candidates gave talks where they discussed topics like being a new mother, trying to find a work/life balance as a woman, breastfeeding, and even miscarriages. The fact that candidates discussed these topics at their mathematics job talks seemed to clearly reflect those candidates' perceptions about teaching young women mathematics majors.

At an office hour, one female faculty member addressed her students about the importance of sounding confident while talking. After one female student contributed an idea and immediately began to hedge what she had said, this professor jokingly said that it was clear that she was going to have to give them the "feminist office hours speech." This faculty member continued by saying that women often sounded unsure even when they were sure, and provided examples of the use of qualifiers like "maybe" or when the pitch of her voice changes at the end of a sentence, making it sound like she was asking a question. During this session, this faculty member intentionally talked with her students about sounding confident and encouraged them to be confident that they had meaningful contributions to make.

In instances such as these, I found myself faced with a tough decision: to force something into the thesis on the grounds that it was very interesting or to cut something due to its lack of clear connection to a research question. Modifying William Fulkner's words for my own use: Sometimes, "in writing, you have to kill (…) your darlings" in order to address your research questions.

What My Theoretical Framework Did and Did Not Allow Me to See

As with any theory or perspective, there are limitations and affordances of the theories I used, which shaped how I interpreted what participants' said about their experience in mathematics as a women and their mathematical identity development. By using Gee's theory (2000, 2011, 2014), I was able to give more explicit attention to what the participants said and to carefully explore how participants talked about themselves as women and as students of mathematics. Through a careful analysis of what participants said during interviews, I was able to provide a careful look into the particular language they used to build their mathematical identities. Therefore, I think that the use of Gee's theory helped me to see how they perceived themselves and their experiences in mathematics and to develop themes, which reflected what they said in that interview setting.

Gee's theory was, at times, vague about how to manage the participants' identity development across contexts. Instead of developing a picture of how participants' identities may have shifted from the interview to the classroom to a group homework session, I felt that using Gee's theory only helped me to explore the language participants used to build their identities *within an interview setting*. Of course, I would argue that the stories they told in the interview setting is interesting, "valid," and worthwhile. But, I believed that there would still be more left to learn by investigating how participants enacted their mathematical identities outside of this setting and, perhaps, other theories might be more suitable for doing this.

As I wrote previously, Discourses do not have nice neat boundaries. There are always many Discourses that could be shaping participants' words and actions and, in my study, it was rare when participants explicitly described or named a Discourse. Gee's theory is flexible in that it allows the user to consider a piece of language from any theory or perspective. I might have taken a feminist, Marxist, or Foucauldian perspective and still engaged in a discourse analysis as conceived of by Gee. In order to use Gee's framework in a meaningful way, I found it necessary it necessary to name the gendered and mathematical Discourses I attended to within my analysis—whether or not they were explicitly described by participants. Doing so helped me to keep a broader perspective on the role of the gendered construction of mathematics and the ways in which these my participants' descriptions not only reflected Discourses about mathematics, but also about gender. I believe that this was important because, as I described previously, there were times when I felt that gendered Discourses were being enacted, yet were missing from participants' descriptions. In these instances, it was helpful to draw on those gendered Discourses to better understand why participants may have been attending to certain ideas and not others.

Related to this, I felt that adhering to Gee's theory sometimes led to tensions in taking what participants said at face value. Gee's theory places a lot of value on what participants said and, for the most part, assumed that what individuals say was a reflection of what they believed. Yet, there are other theories (e.g., psychoanalytic theory), which may have better prepared me to take a more critical stance on why participants may have said what they did. Rodd and Bartholomew (2006), in their study of undergraduate mathematics majors, faced similar tensions when attempting to understand the role of gendered Discourses in study identity development. As a result, they found that their stance as researcher and the theories upon which they were building their analysis, needed to adapt, as they described here:

> As with the majority of research in the social sciences, our initial analyses grew out of the basic premise that we could take our data at 'face value', yet as we immersed ourselves in the interviews that had been conducted with students we found that often what struck us as most significant was that which was left unsaid, or the contradictions occurring in students' narratives, rather than the face value of what we were being told. It seemed to us that many students were telling us (and themselves) stories to which they were highly committed and which they held to be 'truths' about themselves, and we increasingly viewed ourselves as *interpreters* of the interviews, noting omissions and gestures, rather than *distillers* of truths. (p. 38)

Although Gee acknowledged that researchers are "interpreters of the interviews" rather than "distillers of truths," his theory did not clearly delineate how such interpretations should be made when they are based on things that participants did not say or in what the researcher perceived to be a contradiction.

One goal of this work has been "to document aspects of the female experience of studying mathematics, and in particular, to consider some of the ways in which the young women we studied negotiate a path through undergraduate mathematics *as women*" (Rodd & Bartholomew, 2016, p. 36). In order to address complicated issues of identity, gender, and the discursive construction of mathematics, I necessarily highlighted some aspects of their experience while deemphasizing others. The lens that I chose did not deeply or adequately address issues of diversity among these women in mathematics or *intersectionality* of gender with race, class, age, socio-economic status and other categories of difference (Crenshaw, 1991). I think that further investigation is warranted to better understand the ways in which these young women experience mathematics as individuals with multiple identity markers.

Key Lessons from the Study for Educators

I believe that this study is significant for educators in that it highlights potentially supportive environments and practices for women mathematicians-in-training, thereby contributing to the field's understanding of the ways in which postsecondary institutions can support students in succeeding in mathematics. Throughout this work, I aimed to illuminate students' perspectives on their environment and learn more about what they perceived as supportive programs and practices in their educational experiences. Such data inform decisions for policy and practice at secondary and postsecondary institutions of learning. Specifically, I think that there are two primary implications for various other stakeholders in the education of women in mathematics such as administrators or department chairs of women's colleges, or people who teach in mathematics departments and want to create more supportive contexts for women mathematics majors.

First and, most simply, it is necessary to provide opportunities for students to take college mathematics and to have positive experiences in those classes. Based on Prianca's description of her journey to becoming a mathematics major, having a positive experience in her Calculus 2 class at Metcalf was essential to her decision to become a mathematics major. For Prianca, this seemed to come down to two things: having a supportive and motivating instructor and feeling supported by the environment. Were it not for a professor who was both encouraging and engaging, she said that she might have finished her degree requirements and left mathematics forever. In addition to the role that her professor played, Prianca said that the all-women's context was essential in her decision to be a mathematics major, as I described in Chapter 5:

> I just think I wouldn't feel that way if I went, like, to a co-ed school. I wouldn't feel like I really had that chance. I would--, I think I, myself, might have boxed myself in after high school that, 'Oh, I'm not a math person anyway.'

The lesson for educators, I suggest, is aimed at institutional practices: namely, that colleges and universities need to be putting their best teachers in those early mathematics classrooms. We need people who are going to attend to students' beliefs, perceptions, and mathematical identity development, and who can work to create safe, supportive spaces where students feel like they have an opportunity to be successful, despite their high school background.

Related to this, I indicated in Chapter 5, based on the experiences of some participants, it seemed that enrollment in a minor or academic specialty provided them with entry into a mathematics major. As none of the participants came in as mathematics majors, yet all successfully finished degrees in mathematics, it seemed that enrollment their initial enrollment in a mathematics minor or a dual or specialty major was an important mechanism in their eventual major choice. Therefore, I believe that institutional policy makers should consider offering minors and special major options, as they may lead students to try out mathematics thereby leading to more students engaging in mathematics for longer.

The other important lesson for educators might be that, even in an all-women's space, explicit discussion about women in mathematics is important. Given that women have been exposed to and shaped by Discourses which frame both women and mathematics as "deviant" from the norm, I believe that it is important for educators to talk openly about the ways in which students can distance themselves from clichés and to challenge these norms. Based on this and related research, negotiating and challenging these Discourses seemed to be facilitated by knowing people who do not fit these stereotypes. Therefore, in addition to facilitating conversations about what it means to know and do mathematics as women in ways that challenge pervasive Discourses, I believe that it is necessary to have a mathematics faculty that represents all the various ways of being a mathematical person.

Key Lessons for K-12 and Parents

I believe that the findings from this study might also offer insights for K-12 educators and parents of young girls and women. Specifically, it is clear from Prianca's experience as a "lower performing" student in an advanced track, that more work needs to be done to understand the ways in which tracking might be harming even those students in the most advanced tracks. Especially when popular Discourses continue to characterize mathematics by speed, competition, and natural ability (and that these traits are often linked to masculinities), it is important to be thoughtful about the ways in which tracking may be reinforcing gendered Discourses about what it means to be "good" at mathematics. And, for those students who are placed in the highest track (which arguably might be the most competitive group), these narrow conceptions of mathematically ability might be particularly damaging.

For parents, I think that the biggest take-away might be the importance of serving as a role model for learning. Each participant described her parents as valuing an education and having high expectations for their daughters. Lauren's and Prianca's were life-long learners and had all earned degrees beyond their high school diploma. In Omna's and Mai's cases, their parents had to work very hard to build their respective family businesses and instilled in their daughters the understanding that quality of life was directly linked with educational attainment.

Across participants' descriptions of their experiences in mathematics, it is also clear that each had educational advantages beyond what might have been accessible to her peers. Even though Mai and Omna described their families as lower income, at least early in their lives, both had access to highly qualified tutors. In addition to one-on-one tutoring, Lauren had the opportunity to go a private school. Prianca similarly had tutors and described having access to resources like test prep. Therefore, beyond having positive attitudes toward learning and expecting that their daughters would attend college, it seemed that a common thread, here, was providing their children with time and educational resources like tutoring. I understand that making a recommendation that all parents go out and get their child a mathematics tutor is highly problematic for many reasons—primarily, that such resources are not equitably accessible to parents of all income levels. Further, I realize that I only studied and interviewed students who had successfully made it through the mathematics pipeline. Therefore, tutoring may not be the solution for every student's success in mathematics. Instead, I would offer one key lesson for parents: that providing children opportunities to engage in mathematics with whatever supports they may have access to might play a role in a child's access to mathematics in the future. And, in instances where parents are able to create excitement about mathematics and to encourage their child to be motivated to study mathematics, they should seize that opportunity.

Concluding Remarks and Directions for Future Work

Overall, I argue that this study is significant on two fronts: First, with respect to educational research, I believe that this study informs current conversations about how to conduct identity- and gender-related research. Namely, it serves as an example of research that is *non-comparative* (not boys versus girls, not about differential treatment of the genders or of differences in performance or ability), as well as *non-essentalizing* (does not treat "girls" or "women" as a homogeneous category or view gender as static, as is the case with some research in mathematics education). Relatedly, it illuminates the practices, relationships, and Discourses shaping and being shaped by an all-women's context—a type of setting I believe is severely under investigated by the field.

Second, this work is important in that it embraces the complexity of both students' mathematical identity development and the multiple layers and grain sizes of context. So much of the mathematics education literature focused specifically on classroom practices. Although important, classroom practices make up only one slice of students' experience. Further, as was evidenced by my participants' interpretation of classroom practices being markedly different from my own; namely, what I saw as being lack of student engagement and "traditional" teaching methods in which students had little agency was not seen in this way by participants. Therefore, if I had relied solely on observations of classroom practices, I would have developed a very different picture of what it meant to know and do mathematics at Metcalf. As difficult as it was, at times, to consider all of the layers of participant experience and context, I believe that doing so provided me with a more nuanced picture of the experiences of young women in mathematics and an all-women's context.

As a woman in mathematics and as a first generation college student, I am passionate about finding ways to support students who are traditionally underserved and underrepresented within advanced mathematics. Mathematics in particular has served as a gatekeeper to advanced educational and work opportunities for many students of color and young women. Therefore, my motivation as a mathematics education researcher has been and continues to be providing access to meaningful mathematics experiences for those students. Broadly, my research agenda has focused on access to and participation in mathematics for all students at the undergraduate level. Specifically, the current study centers on student identity, as it relates to educational context. Yet, as I mentioned above, I did not deeply address issues related to intersectionality. In the future, I hope that my work will grow and adapt in order to give more careful attention to the role of other identity markers–such as race, ethnicity, and class–as they inform mathematical identity development.

I see this research as a launching point for a research agenda focused on student access and achievement as it relates to identity in an educational context. In particular, I plan to use what I have learned in this work to, one, better my own teaching by learning how to listen to my students and their unique needs and, two, to extend this research to focus on the experiences of women at my university and other nearby institutions. My goal, here, would be to investigate the roles of existing programs in mathematics recruitment and retention so that the field might learn more about how these institutions support women, students of color, and first-generation college students to successfully complete degrees in mathematics. Specifically, in light of the recent large-scale study MAA National Studies of College Calculus (Bressoud, Mesa, & Rasmussen, 2015), which found that women are 1.5 times more likely to leave the "leakiest part of the STEM pipeline," it seemed that there is much work to be done to better understand not only why some women are not choosing to study mathematics, but to develop more nuanced research methodologies in order to gain insights into students' own perceptions of why they *persist* and *succeed* in mathematics. Additionally, I argue that it is through attention to the stories of those women who do succeed in mathematics that we might begin to understand how to support women in developing positive mathematical identities and to disrupt and dismantle harmful gendered binaries in mathematics.

APPENDICES

APPENDIX A

Research Study Consent Form

Research Study Consent Form

Researchers

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Purpose and Overview

You are being asked to participate in a research study of senior women mathematics majors' experiences and identities at an all-women's college. The goal of this study is to gain a better understanding of the individuals who studies mathematics at an women's college, how they interpret and evaluate their experiences in mathematics, and what they believe about what it means to know and do mathematics. We are looking for mathematics majors (aged 18 years and older) who are currently in their senior year of study at _____ College. Should you consent and be selected to participate, your **total out-of-class time commitment to this project will be approximately five hours** over two semesters.

Upon consent, you will be asked to fill out a **participant questionnaire** where you will provide some personal and background information. In the event that more individuals consent to participate than had been anticipated, the data provided in this participant questionnaire will be used for screening purposes. That is, based on the information provided in this questionnaire, we will pick the four to six participants that provide the greatest diversity of responses to participate in this research.

Should you consent and be selected to participate, you will be asked to participate in three individual **interviews** that will take approximately one hour each. Additionally, you will be asked to participate in a focal group interview, which may take up to one and a half hours. These interviews will take place outside of class time, at your convenience. In these interviews, *you will be asked to describe your background, your educational experiences, your beliefs about mathematics and gender, and your future plans.* This interview will be **videotaped**, **audiotaped,** and transcribed. In order to protect your anonymity, pseudonyms will be used. Again, **you must be at least 18 years old to participate in this research.**

Your Participation and Rights to Say "No" or Withdraw

Participation is voluntary, you may choose not to participate at all, or you may refuse to participate in certain procedures or answer certain questions or discontinue your participation at any time without consequence. Refusal to participate will involve no penalty or loss of benefits to which the subjects is otherwise entitled.

Potential Benefits to You

If you choose to participate, you may gain some additional understanding of yourself as a mathematician and of your college experiences. You may benefit from knowing that this study has the potential to benefit future generations of women mathematicians and that your insights are appreciated and validated by others.

Potential Risks to You

Just as discussing academic experiences can be empowering, discussing negative experiences in mathematics can also be potentially stressful. As part of the purpose of this study, however, we are supportive of students' struggles and hope to help whenever possible. Otherwise, there are no foreseeable risks associated with participation in this study.

Privacy and Confidentiality

Your confidentiality will be protected to the maximum extent allowable by law. The research data will be kept on the campus of Michigan State University (MSU) in a locked file cabinet or password protected computer or external hard drive for 3 years after the close of the research. Only the appointed researchers (Alexandria Theakston and Beth Herbel-Eisenmann) and the Institutional Review Board at MSU will have access to the research data. Your real name will not be associated with any personal information; instead, false names will be used. The results of this study will be published and/or presented at professional meetings, but the identities of all research participants will remain anonymous.

Costs and Compensation

There is **no** financial cost to participate in this study. Similarly, you will **not** receive money for participating in this study. In recognition of the fact that you will have your time to further this research, the researcher will offer participants assistance on applying to graduate school, on writing job applications or materials, or developing a conference presentation or proposal. These supports will be arranged at the convenience of the participant and researcher.

Contact Information for Questions and Concerns

If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher(s) (**Alexandria Theakston Musselman**: theakst1@msu.edu, Michigan State University, East Lansing, MI 48824, 517.242.6994 and **Beth Herbel-Eisenmann**: bhe@msu.edu, 329 Erickson Hall, Michigan State University, East Lansing, MI 48824, 517.432.9607).

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517.355.2180, Fax 517.432.4503, or email irb@msu.edu or regular mail at 207 Olds Hall, MSU, East Lansing, MI 48824.

Please sign your initials if you consent to the following:

________ I give my consent to be video-recorded and audio-recorded during the interview for research purposes only.

Documentation of Informed Consent Your signature below means that you voluntarily agree to participate in this research study. You will be given a copy of this form to keep.

____
Student's Name (Printed)

____ ______________
Student's Signature Date

APPENDIX B

Recruitment Script

Recruitment Script

A brief statement will be read to students before the consent form is distributed:

"Hello. My name is Alex Theakston Musselman; I am a graduate student in mathematics education at Michigan State University. For my dissertation, I am conducting research project that is focused on the experiences that students, like you, have at an all-women's college. Over the upcoming months, I would like to interview a few of you and ask questions about your experiences as a math major at _____. If you are willing to participate, I would like to schedule three one-hour interviews with you, at your convenience.

Know that if you do agree to participate, this project is not connected to your grade. You are free to participate or not participate.

My hope is that the study will help the _____ math department and possibly other programs understand and address the needs of female students interested in mathematics. I think that it is really important for researchers and educators to learn about students' perceptions and evaluations of your college experiences so that institutions of higher education, like this one and others, can be responsive to your needs.

I will pass out consent forms, and if you wouldn't mind participating, please read the form, write your name and e-mail address, initial the lines next to the text, and sign your full name at the bottom.

If you agree to participate, please bring your signed consent form tomorrow and leave it in this envelope. I will come by tomorrow after class to pick it up.

Does anyone have any questions about me or my study?"

After reading the recruitment script, I will then pass out the consent forms. I will then answer any clarifying questions from students. I will leave an envelope out on a front desk at the beginning of class and come by after class to collect them.

APPENDIX C

Recruitment Email from Metcalf Department Chair

Subject: For Math/Stat Majors and Minors

Hi Everyone,

I am writing to let you know that the Metcalf Mathematics and Statistics Department will be serving as a site for an up-coming dissertation study. The name of the person conducting this study is Alexandria Theakston Musselman and she is a doctoral candidate in Mathematics Education from Michigan State University. She is interested in talking with women, like you, about studying mathematics at an all-women's college.

For her dissertation work, she is specifically focusing on the experiences and beliefs of senior women mathematics majors. Therefore, if you are a senior mathematics major, she will likely be contacting you by email soon to see if you are interested in participating in her study.
Overall, she is looking for four or five individuals who would be willing to meet with her for three or four interviews and to be shadowed once or twice a week throughout the school year as they do math-related activities. She is very passionate about finding ways to support women in advanced mathematics study and wants to know more about who you are, what experiences you have had as a math major, and what your beliefs you have about knowing and doing mathematics. She is really looking forward to meeting you. If you have any questions about her, or her study, please feel free to contact her by email at theakst1@msu.edu or by phone at (413)591-8322. Keep an eye out for an email from her and be sure to respond if you are interested in working with her this academic year.

Take good care,
Emmy Noether

APPENDIX D

Participant Questionnaire

Participant Questionnaire

Personal Information and Background

1. What is your name?

2. Do you prefer to use the feminine or masculine pronoun when addressed?

3. With which racial/ethnic group(s) do you identify?

4. Is English your first language?

5. Where did you grow up?

6. Do you have any family members who are alumni here?

Mathematics Background

7. When did you know that you wanted to study mathematics?

8. Are you satisfied with your choice to be a mathematics major at an all-women's college?

9. Do you have another major, minor, or specialty?

10. Are you currently enrolled in any special programs or belong to any clubs related to mathematics?

11. What are your plans after graduation?

12. Is there any other information that you would like to provide?

APPENDIX E

Interview Protocol

Interview One: Background (Identity)

I. Introductions

II. Personal Information
   a. Name
   b. Age
   c. Tell me about the community where you grew up
      i. Income level?
   d. Other places lived?

III. School Experiences
   a. Where did you go to school?
      i. Public or private?
      ii. All-girls' school or coed?
      iii. Size of graduating class? School?
   b. Favorite subject? Least favorite subject?
   c. Grades (GPA)

IV. Math Experiences
   a. Teachers
      i. What were your math teachers like?
      ii. Tell me about your favorite math teacher. Least favorite math teacher?
      iii. Did you have any math teachers that had a particular impact?
      iv. What do you think your math teachers thought about you?

   b. Classes
      i. How would you describe a typical math class in high school?
      ii. Did you have any math classes that had a particular impact?
      iii. Best math class? Worst math class?
   c. Peers
      i. Did your friends have an interest in math?
      ii. Were you open with your peers about your interest in math?
      iii. If so, were they supportive of your interest in math?
      iv. Were you ever treated differently because of your interest in math?
      v. Any gendered experiences?
   d. Extra curricular activities
      i. Math programs or clubs?
      ii. Summer camps?
      iii. Tutoring?
      iv. Enrichment program?

V. Family
   a. Parents (or Guardians)
      i. Parents' (or guardians) occupations?
      ii. Parents' (or guardians) educations?

iii. Parents' (or guardians) feelings about math?
iv. Parents' (or guardians) feelings about college?

b. Siblings
    i. Number of siblings?
    ii. Siblings' occupations?
    iii. Siblings' educations?
    iv. Relationship with siblings?

VI. Role Models / Mentors

a. Did anyone encourage you to do math?
b. Did anyone at home help you in math?
c. Did you have a significant math teacher? One who acted as a mentor?

VII. Personal Characteristics

a. Describe yourself as a person
    i. How do you think your family would describe you?
    ii. How do you think your friends would describe you?
b. Describe yourself as a student
    i. Are you more likely to participate in class or listen?
    ii. Competitive? Determined? Serious academic attitude?

VIII. Future Goals

a. When you graduated from high school, did you think you were going to go into math?
b. Did you think that you were going to go to college? To an all-women's college?

Interview Two: College Mathematics Experiences (Identity and Context)

I. Transition to College
    a. When and why did you decide to go to this college?
    b. Did you know that you wanted to study math here before you came?
    c. Did you come to visit before you decided to go to this college?
        i. If so, was there anything during that visit (or during recruitment) that influenced your decision?
    d. What expectations did you have coming to an all-women's college?
    e. Tell we what it was like to come to an all-women's college
        i. Best part?
        ii. Worst part?
    f. Would you recommend coming to an all-woman's college to study math?

II. Declaring a Major
    a. When and why did you decide to become a math major?
    b. Did you have any doubts about declaring a math major?
    c. Were there any external forces (such as parents, spouse/partner, friends) affecting your decision about your major?
    d. Do you have any minors or specialties?
    e. Are you more interested in applied or theoretical mathematics? Why?

III. Mathematics Experiences
    a. Faculty
        i. What are your math professors like?
        ii. Do you feel supported by the faculty?
        iii. Have you had any math professors that have had a particular impact? Positive? Negative?
        iv. Have you noticed any difference between male and female professors?
        v. How do you think faculty members would describe you?
    b. Classes
        i. What math courses have you taken so far at the college level? Tell me a little bit about them
        ii. Have you had any classes that particularly inspired you?
        iii. Do you feel challenged in math class?
        iv. Can you tell me about any class events that were "abnormal" or different?
        v. Do you feel like you have any influence on how classes are run?
    c. Peers
        i. How have your peers impacted your mathematics experience?
        ii. Do you feel supported by your peers?
        iii. Describe your relationships to your peers
        iv. How do you think your peers would describe you?
        v. Do you feel like you fit in? In the math department? At the school more broadly?
        vi. Do you have non-math major friends?

            1. If so, what do your non-math major friends think about math? Math majors?
            2. What do others on campus think about studying math?

d. Mathematical Activities
    i. Are you a member in any study group?
        1. If so, describe what you do and the dynamic
    ii. Are you or have you been a teaching assistant?
        1. Are you a member of any math clubs or groups? (e.g., Putnam exam, Math / Stat Club, Problem Solving Seminar, Mathematical Modeling Group, GRE Group, Actuarial Club)
    iii. Have you attended any REUs
        1. If so, tell me about that experience
    iv. Other

IV. Norms / Obligations

a. Social Norms / Obligations
    i. Norms for explaining and justifying reason?
        1. What does it mean to justify your solution?
    ii. Normative ways of listening to and attempting to understand others' explanations?
        1. Is it important to work with others in math?
    iii. Norms for indicating confusion?
    iv. Norms for indicating and giving reasons for disagreement with an invalid solution?
    v. What if you contributed an answer during a class discussion and it was incorrect? What would your reaction be?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
When I am asked a mathematics question, it is important that I explain how I did the problem, not just give my solution.	1	2	3	4	5
When doing written work (e.g., a homework assignment or exam), it is important that I explain how I did the problem, not just give my answer.	1	2	3	4	5
It is possible to approach the same math problem in more than one way.	1	2	3	4	5
To work on math problems, I have to be taught the rules and steps, or else I can't solve them.	1	2	3	4	5
When working on math problems, it is important that I work with others.	1	2	3	4	5
It is important to understand the applications of your math work to other disciplines or the real world.	1	2	3	4	5

I am responsible for understanding what others have contributed in class.	1	2	3	4	5
The use of symbols is important in mathematics.	1	2	3	4	5
If I don't understand what my teacher or another student has said or if I think that something that someone said is wrong, it is important that I say something.	1	2	3	4	5

b. Mathematical Norms / Obligations
    i. Norms for what counts as acceptable mathematical argument
    ii. Normative ways of reasoning with tools and written symbols
    iii. Norms for what counts as mathematical understanding
        1. How do you know when you understand a mathematical concept?
    iv. The normative purpose for engaging in mathematical activity

V. Success

a. Do you consider yourself to be successful at college math?
    i. If so, what do you think allowed you to be successful?
    ii. If not, what do you think prevented you from success?

b. Which of your personal characteristics do you feel impacted your mathematics experiences at college?
    i. What personal characteristics do you think helped you?
    ii. What personal characteristics do you think hindered you?

c. Do you know of anyone who began in your program but dropped out or changed fields?
    i. If so, why?
    ii. What characteristics do you feel separate you from other women who don't make it?

Interview Three: Beliefs About Math and Gender, Future (Context and Figured Worlds / Discourse)

I. Mathematics
   a. Is there such a thing as a typical mathematician?
      i. If so, describe one.
   b. Do you consider yourself to be a mathematician-in-training?
   c. Why do you study mathematics?
      i. Do you think this is true of your peers?
   d. How is a mathematical argument different from another type of argument? (in contrast, say, to a science or political science argument)?

II. Mathematics Philosophy
   a. In your own words, how would you define "mathematics"?
   b. In your own words, how would you define "mathematician"?
   c. (Nature of Mathematics Survey)

1. "Mathematics is an objective, absolute, certain, and consistent body of knowledge."	O	O	O	O	O	"Mathematics is a process of inquiry, and a coming to know."
2. "Mathematics rests on human intuition and shared meaning."	O	O	O	O	O	"Mathematics rests on deductive logic/reasoning."
3. "Current mathematical knowledge is not open to future revision and change."	O	O	O	O	O	"Current mathematical knowledge is open to future revision and change."
4. "Mathematics consists of objects and patterns that have no existence outside of the mind.	O	O	O	O	O	"Mathematics consists of objects and patterns that can be seen in real objects and natural phenomena."
5. "As new mathematics arises, its primary value is in furthering yet more mathematics.	O	O	O	O	O	"As new mathematics arises, its primary value is in describing real objects and modeling natural phenomena."
6. "Mathematics is a dynamic and continually expanding field."	O	O	O	O	O	Mathematics is an accumulated set of facts, rules, skills, and procedures."
7. "Mathematics is created/produced."	O	O	O	O	O	"Mathematics is discovered."
8. "The elegance and beauty of mathematics is found mostly when complex problems are solved using symbolic notation, language, and representation."	O	O	O	O	O	"The elegance and beauty of mathematics is found mostly in how it is displayed and found in the patterns of nature."
9. "Mathematical claims are considered to be true when a formal proof is given and accepted by the community of experts."	O	O	O	O	O	"Mathematical claims are considered to be true when sufficient supporting evidence has been found."

III. Teaching and Learning Mathematics

a. Say that your college needed to hire a new professor and you were asked for advice on what would make a good math professor. What would you say?
b. If you were to design a good math exam, what characteristics would it have?
c. (Modified Mathematics Education Survey for Teachers)

10. "I mainly see [the instructors'] role mainly as a facilitator. [The instructor should] try to provide opportunities and resources for [his or her] students to discover or construct concepts for themselves."	O	O	O	O	O	"I mainly see [the instructors'] role as a transmitter of knowledge. [He or she should] try to assist students in arriving at a point of independence and mastery from which they can proceed on their own."
11. "The most important part of instruction is the content of the curriculum. That content is the field's judgment about what students need to be able to know and do."	O	O	O	O	O	"The most important part of instruction is that it encourages 'sense-making' or thinking among students. Content is secondary."
12. "A mathematics instructor's job is to teach students how to calculate and find answers to problems without using technology."	O	O	O	O	O	"Technology, including graphing calculators and computers, is an integral part and an invaluable tool in mathematics instruction in today's math classroom."
13. "It is imperative that students have opportunities to work together with others when solving mathematics problems so that they can learn from one another and learn the mathematics more deeply."	O	O	O	O	O	"When students work with other students in groups it is too difficult to determine what each individual student knows and often one student does most of the work while others benefit from his/her effort."
14. "When preparing mathematics lessons, [instructors seem to] generally follow the textbook and/or the proscribed curriculum.	O	O	O	O	O	"When preparing mathematics lessons, [instructors seem to] generally modify the textbook approach and supplement it with additional problems and/or activities.

IV. Mathematics "Out There…"

a. Do you think that how mathematics is done here is typical? Would most people that you might meet on the street share your experience with mathematics?
b. What do people say when you tell them you are a math major?
c. What do other people think about mathematicians?
d. What do you think it would be like to study mathematics in a coeducational environment?
e. Do you know of any stereotypes…

i. About mathematicians / mathematically competent people?
ii. About women mathematicians?

V. Future
   a. What do you plan to do after you graduate?
   b. What are your thoughts about studying math in graduate school?

APPENDIX F

Nvivo Nodes

Table 7

Nvivo Nodes

Name	Sources	References	Created On	Modified On
1. Demographics and Background	9	551	Jul 11, 2016, 11:41:04 AM	Jul 29, 2016, 4:39:51 PM
College Readiness or Resources	5	7	Jul 12, 2016, 4:35:51 PM	Sep 6, 2016, 10:09:00 AM
Community or Cultural History	5	27	Jul 11, 2016, 11:58:22 AM	Sep 6, 2016, 10:13:06 AM
Family	9	179	Jul 11, 2016, 11:41:28 AM	Sep 23, 2016, 2:53:28 PM
Family Influence and Expectations	8	73	Jul 12, 2016, 2:53:58 PM	Sep 23, 2016, 10:32:15 AM
Parent Career and Education	4	38	Jul 12, 2016, 4:11:19 PM	Jul 29, 2016, 3:15:23 PM
Siblings	5	40	Jul 11, 2016, 11:46:02 AM	Sep 13, 2016, 4:09:04 PM
Significant Other	3	12	Jul 25, 2016, 12:41:44 PM	Sep 5, 2016, 4:40:47 PM
2. K-12 History	8	338	Jul 11, 2016, 11:43:02 AM	Sep 23, 2016, 3:16:26 PM

Table 7 (cont'd)

K-12 Classes	7	46	Jul 11, 2016, 11:44:25 AM	Sep 14, 2016, 5:27:01 PM
K-12 Culture	6	54	Jul 18, 2016, 9:38:02 AM	Sep 6, 2016, 10:41:42 AM
K-12 Curriculum and Pedagogy	4	18	Jul 18, 2016, 12:28:07 PM	Jul 25, 2016, 4:20:01 PM
K-12 Extracurriculars, Tutors, and Resources	4	47	Jul 11, 2016, 11:45:07 AM	Jul 29, 2016, 10:41:07 AM
K-12 Peers	5	34	Jul 12, 2016, 2:51:40 PM	Sep 6, 2016, 10:28:46 AM
K-12 Status	5	41	Jul 11, 2016, 11:56:48 AM	Sep 6, 2016, 10:13:25 AM
K-12 Teachers	5	54	Jul 11, 2016, 11:44:01 AM	Aug 10, 2016, 3:02:19 PM
Mathematics Preparation	5	28	Jul 20, 2016, 6:27:49 PM	Sep 6, 2016, 10:08:34 AM
3. Transition to College	9	166	Jul 13, 2016, 12:32:10 PM	Sep 6, 2016, 10:55:29 AM
Choosing a Liberal Arts School	4	6	Jul 25, 2016, 11:59:23 AM	Sep 14, 2016, 5:52:33 PM

Table 7 (cont'd)

Choosing an All-Women's College	8	36	Jul 11, 2016, 11:50:34 AM	Sep 14, 2016, 5:40:04 PM
Choosing Major	8	27	Jul 18, 2016, 9:42:53 AM	Sep 16, 2016, 5:35:58 PM
Choosing Metcalf	8	62	Jul 12, 2016, 4:17:06 PM	Sep 20, 2016, 10:16:46 AM
College Visits and Research Resources	7	30	Jul 13, 2016, 12:33:35 PM	Sep 14, 2016, 5:33:50 PM
3. College	10	1077	Jul 11, 2016, 11:38:05 AM	Aug 3, 2016, 1:03:59 PM
Assessments or Grades	6	33	Aug 3, 2016, 1:03:59 PM	Sep 23, 2016, 11:13:23 AM
Class Practices and Norms	0	0	Aug 3, 2016, 4:28:36 PM	Aug 3, 2016, 4:44:42 PM
Mathematical Practices and Norms	2	23	Aug 3, 2016, 4:29:33 PM	Sep 13, 2016, 6:41:48 PM
Social Practices and Norms	3	41	Aug 3, 2016, 4:29:15 PM	Sep 13, 2016, 6:26:03 PM
College - Staying or Switching	1	10	Aug 10, 2016, 9:48:40 AM	Aug 10, 2016, 9:53:22 AM

Table 7 (cont'd)

College Advising	4	14	Aug 1, 2016, 11:26:09 AM	Sep 16, 2016, 5:40:43 PM
College Agency	6	28	Aug 3, 2016, 11:06:52 AM	Sep 21, 2016, 10:18:32 AM
College Class Participation	6	94	Aug 3, 2016, 10:45:13 AM	Sep 23, 2016, 11:01:07 AM
College Classes	8	142	Jul 20, 2016, 10:13:12 AM	Sep 23, 2016, 11:13:07 AM
College Curriculum and Pedagogy	7	54	Jul 13, 2016, 12:25:40 PM	Sep 21, 2016, 10:19:11 AM
College Faculty	10	137	Jul 12, 2016, 2:48:45 PM	Sep 23, 2016, 11:16:17 AM
Bad Teaching	1	14	Sep 17, 2016, 10:52:26 AM	Sep 20, 2016, 11:04:17 AM
Good Teaching	2	4	Sep 17, 2016, 10:52:12 AM	Sep 23, 2016, 11:18:24 AM
College Non-Academic Exp	1	3	Aug 1, 2016, 9:54:47 AM	Aug 1, 2016, 9:57:38 AM
College Peers	8	136	Jul 12, 2016, 2:51:17 PM	Sep 23, 2016, 11:02:06 AM

Table 7 (cont'd)

College Status	8	40	Jul 20, 2016, 1:56:18 PM	Sep 23, 2016, 10:39:38 AM
Culture – College	8	59	Jul 13, 2016, 3:57:37 PM	Sep 23, 2016, 11:19:08 AM
Culture – Department	9	80	Jul 13, 2016, 3:56:48 PM	Sep 23, 2016, 11:17:47 AM
Difficulty or Time Shortage	5	20	Aug 10, 2016, 2:11:12 PM	Sep 23, 2016, 11:17:10 AM
Homework and Study Sessions	6	41	Jul 18, 2016, 12:15:56 PM	Sep 23, 2016, 11:09:28 AM
Internships, Clubs, and Extracurriculars	9	85	Jul 18, 2016, 12:14:40 PM	Sep 23, 2016, 11:21:44 AM
Major and Minor	10	34	Jul 12, 2016, 3:56:13 PM	Sep 23, 2016, 9:09:17 AM
Office Hours	5	16	Aug 1, 2016, 11:13:57 AM	Sep 17, 2016, 10:51:54 AM
Resources for Success	10	48	Jul 18, 2016, 11:51:14 AM	Sep 21, 2016, 11:23:04 AM
College Impact on Future	1	3	Sep 16, 2016, 5:25:20 PM	Sep 20, 2016, 4:20:48 PM

Table 7 (cont'd)

4. Identity	10	242	Jul 12, 2016, 2:52:31 PM	Jul 29, 2016, 4:18:15 PM
Ability or Intelligence	10	107	Jul 12, 2016, 9:15:50 AM	Sep 23, 2016, 11:02:39 AM
Changes in Identity or Beliefs	4	13	Aug 10, 2016, 2:26:57 PM	Sep 23, 2016, 9:43:06 AM
Choosing to Study Math	4	9	Aug 10, 2016, 2:28:30 PM	Sep 23, 2016, 11:22:08 AM
Future Career and Education	6	23	Jul 25, 2016, 10:35:49 AM	Sep 23, 2016, 11:20:41 AM
Goals and Motivation to Learn	9	72	Jul 11, 2016, 11:49:14 AM	Sep 23, 2016, 11:23:26 AM
Personal Characteristics	0	0	Jul 11, 2016, 11:47:11 AM	Jul 11, 2016, 11:47:25 AM
Description - Other	9	39	Jul 11, 2016, 11:48:29 AM	Sep 23, 2016, 9:56:31 AM
Description - Self	10	89	Jul 11, 2016, 11:47:37 AM	Sep 23, 2016, 10:37:54 AM
Role Models	4	18	Jul 20, 2016, 9:12:39 AM	Jul 29, 2016, 3:58:40 PM

Table 7 (cont'd)

5. Gender	9	119	Jul 11, 2016, 11:50:05 AM	Sep 13, 2016, 3:46:42 PM
Feminism	6	15	Jul 20, 2016, 9:09:31 AM	Sep 6, 2016, 10:30:55 AM
Gender Roles	6	33	Jul 13, 2016, 4:20:14 PM	Sep 13, 2016, 3:45:44 PM
Male-Dominated Careers or Fields	1	2	Sep 16, 2016, 5:31:19 PM	Sep 16, 2016, 5:32:56 PM
Math and Gender	6	29	Jul 18, 2016, 12:49:57 PM	Aug 3, 2016, 4:57:49 PM
Single-Sex Versus Co-Ed	8	39	Jul 11, 2016, 11:38:20 AM	Sep 16, 2016, 5:32:41 PM
6. Mathematics	10	376	Jul 12, 2016, 2:44:30 PM	Jul 29, 2016, 4:18:33 PM
Being Good at Math or Enjoyment	10	124	Jul 13, 2016, 3:11:07 PM	Sep 23, 2016, 10:31:53 AM
Math and Other Subjects	8	27	Jul 12, 2016, 4:32:09 PM	Sep 23, 2016, 11:08:54 AM
Math or STEM Culture	10	56	Jul 13, 2016, 12:26:19 PM	Sep 23, 2016, 10:48:44 AM

Table 7 (cont'd)

Motivation to Learn Math	8	51	Jul 18, 2016, 9:31:03 AM	Sep 21, 2016, 8:52:24 AM
Perceptions of Math	10	61	Jul 12, 2016, 2:44:41 PM	Sep 23, 2016, 11:00:28 AM
Perceptions of Mathematicians	1	5	Sep 23, 2016, 9:33:01 AM	Sep 23, 2016, 9:52:43 AM
Sacrifice to Study Math	5	17	Jul 19, 2016, 1:05:54 PM	Sep 23, 2016, 9:47:14 AM
Stereotypes	4	11	Jul 13, 2016, 12:26:07 PM	Sep 23, 2016, 9:52:58 AM
Theoretical vs Applied	4	24	Aug 3, 2016, 8:59:25 AM	Sep 20, 2016, 12:26:38 PM
Alex Comments	5	13	Aug 3, 2016, 5:21:29 PM	Sep 23, 2016, 10:52:06 AM

APPENDIX G

Data Collection and Analysis Summary

Table 8

Data Collection and Analysis Summary

	Identity	**Context / Practices**	**Mathematical Discourses / Figured Worlds**
Research Question	What language do senior women mathematics majors at an all-women's college use to describe their mathematical identity development?	How might the context of an all-women's mathematics department be described as relevant to students' identity development? Specifically, what activities do mathematics majors at an all-women's college describe as significant to their experience and how do they describe their relationship to others within that context?	What mathematical Discourses do senior women mathematics majors at an all-women's college know, assume, question, or reject? What seems to be the relationship between their identities and those Discourses?
Type of Task	Identity Recognition	Description of Practices	Interpretative and Evaluative Models
Unit of Analysis	Individual	Individuals Community of Practice	Individuals Group of Individuals Who Have Shared Experiences
Primary Data	Individual Interviews	Individual Interviews	Individual Interviews
Supporting Data	Observation Field Notes	Observation Field Notes Researcher Reflective Journal Public Documents Websites Focal Group Interview	Observation Field Notes Researcher Reflective Journal Public Documents Websites Interactive Multimedia
Thematic Data Analysis	Nature, Institution, Discourse, and Affinity Identities Core Identities Socially Situated Identities	Practices (Social and Mathematical) Participant Relationship to the Context	Norms and Obligations (Social and Mathematical) Agents, Practices, Values Participant Relationship to Mathematics

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