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Investigating Latina/o Mathematics Students' Perceptions Of Interpersonal Relationships In College Mathematics

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INVESTIGATING LATINA/O MATHEMATICS STUDENTS' PERCEPTIONS OF INTERPERSONAL RELATIONSHIPS IN COLLEGE MATHEMATICS

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This work is dedicated to my Lord and Savior, Jesus Christ,

who gave me life and all that I have.

For by him were all things created, that are in heaven, and that are in earth,

visible and invisible, whether they be thrones, or dominions, or principalities, or powers:

all things were created by him, and for him:

And he is before all things, and by him all things consist.

~ Colossians 1:16-17 ~

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TABLE OF CONTENTS

Page

Page

Page

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

Latina/o – (Latina and Latino) Term used to refer to citizens of the United States with origins in Latin America or the Iberian Peninsula. The use of “Latina/o” as opposed to “Latino” (usually used to refer to a group of both males and females or just a group of males) replaces the masculine nature of the Spanish language with a more gender neutral term. “Latina/o” is sometimes used interchangeably with “Hispanic.”

ABSTRACT

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It is known that interpersonal relationships are significant to the success of the Latina/o mathematics learner. Unfortunately, interpersonal relationships in mathematics are understudied. For this reason, this study seeks to answer the following question: How do Latina/o mathematics students perceive their interpersonal relationships with their mathematics professors, peers in mathematics, and families with respect to mathematics? To explore the role of such relationships in Latinas/os experiences in mathematics, I define a meaningful relationship in mathematics education (MRIME) as interactions between two parties in which one party acknowledges the other party as a sociocultural being and fosters their mathematics identity. This definition draws from research on care, mathematics identity and mathematics students as sociocultural beings.

This study was done using case studies. Four Latina/o students who were mathematics majors or had a bachelor's degree in mathematics were recruited using a Facebook page. The data collection took place over a period of one year. Three hour-long telephone interviews were conducted with each participant. Analysis of the interviews was based on identifying evidence of components of MRIME including the fostering of

the participants mathematics identity and acknowledgement of the participant as social and cultural beings.

The results showed that the participants felt that their relationships with their mathematics professors and peers in mathematics with the most meaningful while their relationships with their families were the least meaningful when the focus was on mathematics. The results also showed that the interpersonal relationships that the participants had were the weakest when it came to the sociocultural element of MRIME.

The results of this study imply that there exist factors, which are possibly connected to mathematics students' perceptions of interpersonal relationships, which may contribute to persistence in mathematics. The data also suggest that further research should be conducted on interpersonal relationships in mathematics educational settings.

CHAPTER 1. INTRODUCTION

Long before Galileo and Copernicus, Latina/os were creating and doing mathematics. The Mayans in Mexico had a sophisticated mathematical knowledge that allowed them to calculate astronomical events thousands of years in advance. Before the Mayans, the Olmecs, in the same region, had created a complex mathematical system out of their own numerical system that included the number zero (Ortiz-Franco, 1993). Most of the work that was done by this population was destroyed during the conquest of the Europeans. Archeologists still do not know the extent of the mathematical understanding and creativity that these Latina/os possessed (Ortiz-Franco, 1993).

1.1 Latinas/os and Mathematics Today

Today, a very different story is being told. While approximately 16% of the United States population is Latina/o (Ennis, Rios-Vargas, & Albert, 2011), in 2009, Latina/o U.S. citizens and permanent residents earned only 5.2% of the total bachelor's and master's degrees in mathematics and only 2.3% of the doctorate's degrees in mathematics (National Science Foundation & Division of Science Resources Statistics, 2010, 2011a, 2011b). The underrepresentation of the Latina/o population in the field of mathematics is a reflection of what is happening at all grade levels, starting with elementary education.

1.2 Mathematics and Equity

There are several reasons to focus on equity in mathematics education. First, mathematics is vital to the understanding of our world and it is essential that we prepare our students to understand our world through mathematics (Gutstein, 2003, 2006; Moses & Cobb, 2001). Understanding our world through mathematics is equivalent to being able to read and write, in that it is a basic human right (Moses & Cobb, 2001). Second, mathematics is integrated into all sciences, including the social sciences, and failing to adequately prepare all students for success in these fields is not equitable. This does not imply that all students must go into these fields, but they must be prepared if they desired to do so. Third, mathematics as a field would benefit from all students being mathematically literate. It would be a tragedy to all of academia (and society in general) if the mathematical knowledge and creativity of minority subgroups, like Latinas/os, was hidden because of inadequate preparation (Freire, D'Ambrosio, & Mendonça, 1997).

Some may argue advanced mathematics beyond Algebra I is not always necessary to have successful careers. Such thinking is fallacious in that mathematics plays a role as a gatekeeper (Stinson, 2004), effectively eliminating possibilities for advanced study. Hence, the fourth reason to focus on equity is because mathematics is a fundamental pre-requisite for one to be "successful" in this society. In school, children with low mathematics achievement are tracked into mathematics classes focused on basic skills. These students are not ready for college when they graduate from high school (Mosqueda, 2010). Scores on college entrance exams which test mathematical comprehension and skills can determine acceptance, funding, and field of study for students.

Fifth, high paying professions, like engineering, require a strong mathematics background, as do other high status professions such as those in the government and military. A person with a degree in mathematics has the potential to make an income well above the average. For example, in 2009 the median starting salary for a person with a PhD in mathematics working in industry was about $90,000 (American Mathematical Society, 2010). In that same year the median household income of the entire Hispanic population in the United States was $38,000 (DeNavas-Walt, D.Proctor, & Smith, 2010). Therefore, the potential financial effect of mathematical competence on the life of an individual can be significantly positive.

1.3 Latinas/os and Interpersonal Relationships

The dilemma of the underrepresentation of Latinas/os in mathematics in the United States has more recently been studied by only a handful of mathematics education researchers (Civil, 2007; Gonzalez, Andrade, Civil, & Moll, 2001; Gutierrez, 1999; Gutierrez & Irving, 2012; Gutstein, 2006; Mosqueda, 2010). The situation is very complex because factors including language, socioeconomic status, and citizenship play a role in the everyday lives of Latina/o students and their success in mathematics. Therefore, it is crucial that mathematics educational research be conducted in order to gain insight into how Latina/o build mathematical proficiency.

In the Latina/o culture, strong interpersonal relationships are fundamental. This is evident by the fact that Latinas/os have a tendency to favor collectivism over individualism (Raeff, Greenfield, & Quiroz, 2000). For example, it has been reported that most Cuban and Mexican immigrants greatly use family connections for survival when they come to the United States (Vega, 1990). Even outside of the home, Latina/os carry a

sense of family to the surrounding community by embracing other relationships. These relationships are cultivated when individuals connect to one another regarding matters such as family background, language, family origin and nationality, religion, and occupation. These relationships can also be founded on educational experiences, as is the case for many Hispanic students. Since Latinas/os tend to appreciate interpersonal relationships in their everyday lives, it would make sense that interpersonal relationships can have an effect on the Latina/o mathematics student.

Mathematics is a field in which interpersonal relationships have the potential to facilitate student growth and development as learners and mathematical thinkers (Burton, 1998; Escalante & Dirmann, 1990; Gutierrez, 1999; Gutstein, 2003, 2006; Hackenberg, 2010; Herzig, 2004b). In order to investigate the potential influence that interpersonal relationships have on the Latina/o mathematics student, mathematics educational researchers can look at the interpersonal relationships that these Latina/o mathematics students have with their teachers in mathematics, with their peers in mathematics, and with their families centered on mathematics.

1.4 Undergraduate Students and Interpersonal Relationships

It is essential that we recognize that the low numbers of Latinas/os studying collegiate mathematics and choosing degrees in mathematics is an indication that something has gone wrong along the mathematics pipeline. To examine the situation at the collegiate level, mathematics education researchers can focus on undergraduate mathematics. The undergraduate experience is significant because it can be assumed that it is during this time, or while in study for an advanced degree, that students make the decision to participate in a mathematics doctoral program (Mullen, Goyette, & Soares,

2003). Unfortunately, however, there is little, if any, research focusing on Latinas/os undergraduate mathematics educational experience.

The the research literature on education in general does provide some insight into the undergraduate college experience. Interpersonal relationships in college have been proven to be vital in the persistence and attrition of undergraduate and graduate students (Churukain, 1982; Nora, Cabrera, Hagedorn, & Pascarella, 1996; Pascarella & Terenzini, 1979; Thompson, 2001; Tinto, 1975). One reason that interpersonal relationships are significant is college is not simply an academic experience but also is a cultural experience. Learning in college, and particularly, in the science, technology, engineering, and mathematics (STEM) fields, is not strictly about gaining intellectual knowledge, but also knowledge of how to navigate through a culture—a new culture for some (Cole & Espinoza, 2008). Since it has been shown that students tend to persist as undergraduates and in graduate school when they have interpersonal relationships, it is likely that interpersonal relationships can be just as influential to mathematics students and, particularly, to Latina/o mathematics students.

1.5 Research in Mathematics Education on Interpersonal Relationships

Just as college has its own culture, mathematics also has its own culture (Burton, 2009). Navigating the culture of mathematics can be a difficult experience for some students. Interpersonal relationships can have a significant impact on mathematics students' experiences in college mathematics. There exist only a few research reports that overtly speak to interpersonal relationships in mathematics educational settings (for example see Black, Mendick, & Solomon, 2009; and Hackenberg, 2010). Because they are important to college students and Latina/o students, and because they are

understudied, mathematics educational researchers must draw their attention to interpersonal relationships in mathematics. The relationships that need to be studied are those that are most influential to all mathematics students, their relationships with their professors, peers, and family centered on mathematics.

1.6 The Potential Influence of Interpersonal Relationships with Mathematics Professors, Peers in Mathematics, and Family Concerning Mathematics

Education in mathematics should focus on educating the whole student, especially Latina/o students (B. D'Ambrosio et al., 2013). Mathematics students do not exist in a vacuum in some isolated classroom, but they exist in communities in and outside of mathematics. Mathematics students have interpersonal relationships that exist all around them. For that reason, mathematics educators should recognize the interpersonal relationships that undergraduate mathematics students have with their mathematics professors, peers in mathematics, and families concerning mathematics.

1.6.1 The Potential Influence of Mathematics Professors

For an undergraduate student, a mathematics professor can be perceived as a friend or as an enemy. The professor, like any mathematics teacher, is the person that presents the mathematics to the students, assigns tasks, sets the tone of the class, sets the classroom norms, assigns grades, and is a representative of mathematics as a field of study. The culture of traditional mathematics classrooms promotes individual learning and competition, in contrast to the Latina/o culture, which tends to favor the collective (Raeff et al., 2000). Because of this cultural clash, Latina/o mathematics students may have a sense of dissonance when learning mathematics, which could enhance the feeling of a disconnect to mathematics.

Nevertheless, mathematics students need to learn how to navigate through the culture of mathematics and successfully participate in the community of practice. Wenger (2000) mentions that *competence* in a community of practice is measured by the ability to navigate and contribute to the *joint enterprise*, *mutuality*, and *shared repertoire* that is established by the community. Thus, for one to be competent, according to members of the mathematics community, one would need to know how to navigate through the community successfully. This would also mean that they would have to develop the knowledge of the norms and practices of mathematics. To gain knowledge the student would have to have interpersonal relationships that support the development of this knowledge. Since mathematics professors are well versed in the culture and community of mathematics, they are the best resources for students.

1.6.2 The Potential Influence of Peers in Mathematics

Meaningful relationships with peers in mathematics are also important to mathematics students. Valverde (1984) claims that Latina/o mathematics students are *field-dependant* learners, which means that they "view their environment as unified and having an inherent order," where as *field-independent* learners "view situations in distinct parts and apply structure even when no order is readily apparent" (1984, p. 127). Field-dependent learners tend to thrive in group learning environments with minimal competition. The work of Gonzalez, Andrade, Civil, and Moll (2001) highlights the idea that Latina/os are field-dependent learners, especially in mathematics. By exploring the lives of Hispanic families, in particular Hispanic women, Civil became aware of the rich funds of mathematical knowledge held by the women (Gonzalez et al., 2001). Civil spent time with a group of Latina women who were involved in a dress making class run by

one of the women in the community. This course was heavy in mathematics, especially geometry. Civil observed that group learning and field-dependency are a valid way to describe how Latina/os learn math:

> Further, the collective knowledge and experience of the group on the topic of sewing and the mathematics of clothing (as learned through the scrutiny practiced in purchasing various types and styles of clothing) allowed a dialogue of sophisticated meanings to be constructed. Throughout the lesson, the repeated "ahs" from the group demonstrated that Señora María's explanations facilitated understanding. (p. 124)

Since Latina/os seem to thrive in group settings that have little competition, it would make sense that mathematicians and mathematics educators should encourage the development of such groups, where everyone contributes and is valued for their input. Treisman (1992) built on one such group and proved that community learning is not unique to Latina/o students. Group learning is weaved into the curriculum of the Emerging Scholars Program (ESP). Guidance from instructors was another program component and is another trait of field-dependent learning. ESP is so successful at supporting students of color in learning advanced mathematics that universities across the country implement the program in their departments. In the middle grades, Gutstein (2006) has incorporated group learning into his work to build "dominant mathematics" understanding while also supporting the emergence of perspectives on social justice for Latina/os. The work of Treisman and Gutstein are but two examples of the potential

power of collaboration and community, including student interpersonal relationships, to build mathematical knowledge and success.

1.6.3 The Potential Influence of Family

Investigating students' relationships with their mathematics professors and their peers in mathematics provides a focus on the in-school experience of the students. Since mathematics students have relationships out of school that are sometimes centered on mathematics, investigating those relationships is important. In fact, it is not uncommon for students to have a mathematics background that is brought from home – it just may not be what mathematics educators would expect or quickly recognize. The experience that Civil had with the dress-making class depicts this clearly:

> Marta Civil, the mathematics educator in our group, often felt that her lack of knowledge with the practice itself (e.g., sewing) made it harder to "visualize" the mathematics, and that her training in academic and school math made it harder to see other forms of mathematics…Constructing the circles (or quarter of a circle) as [the instructor] did certainly show the circle as the geometric locus of points equidistant from a given point. This is the formal definition of a circle. Yet we wonder how many children experience this in school mathematics…Even more we wonder how many children are aware that this knowledge about circles may reside in their households (p. 125).

The above statements elaborate that there are *funds of mathematical knowledge* students possess that have no relation to school (Gonzalez et al., 2001). This existing knowledge comes from their everyday life, more specifically, their home life. "The

historically accumulated bodies of knowledge and skills essential for household functioning and well-being" (Gonzalez et al., 2001, p. 116) are called *funds of knowledge*. Households have "extensive knowledge about construction, repairs, carpentry, household management, folk medicine, [and] farming" (Civil, 2007, p. 3). Whole communities can have funds of knowledge as well. Acknowledging that students may have sources of mathematical intelligence to draw form that comes from their home life could be significant in teaching them.

1.7 The Purpose of this Study

The interpersonal relationships that undergraduate mathematics students have with their professors and mathematics, peers in mathematics, and families centered on mathematics can potentially influence how they come to know mathematics. Because the issue of equity in the mathematics pipeline is negatively affecting minority subgroups, such as Latinas/os, a focus on the interpersonal relationships in such a subgroup can have a threefold impact on mathematics education. First, mathematics educators and mathematics education researchers can gain a deeper understanding of the uniqueness of this subgroup. Having a better understanding of Latinas/os will equip researchers to conduct further research and will equip educators to better educate students of this subgroup. Second, focusing on interpersonal relationships will provide mathematics educators and mathematics education researchers some knowledge about mathematics students in general. Third, focusing on the experiences of individual Latinas/os allows for different voices to be heard and different perspectives to be taken into consideration. This allows for a much more equitable approach to research in mathematics education

(Gutierrez, 2002) and the results of this study can help mathematics educators build equity practices.

Since interpersonal relationships are perceived by each member of the relationship differently, it is necessary to focus on how such relationships are perceived by individuals. For this reason, the purpose of this study is to answer the following question: *How do Latina/o mathematics students perceive their interpersonal relationships with their mathematics professors, peers in mathematics, and families with respect to mathematics?*

CHAPTER 2. LITERATURE REVIEW AND ANALYTICAL FRAMEWORK

Mathematics students can have a number of types of interpersonal relationships, including romantic, friendly, platonic, and professional. It is essential to study the type of interpersonal relationships that directly impact students in their study of mathematics. Hence, we have to look at relationships that are meaningful to students in mathematics educational settings. I define a *meaningful relationship in mathematics education* (MRIME) as interactions between two people in a mathematics educational setting where, at least, one person, through their care for the other person, fosters that person's mathematics identity and acknowledges that person as a sociocultural being. I constructed this definition through a careful analysis of the research literature on mathematics pedagogy for Latina/o mathematics students (Gutierrez, 1999; Gutierrez & Irving, 2012), mathematics identity (Martin, 2000), and the ethic of care (Hackenberg, 2010; Noddings, 1988).

Because this study only focuses on the perspectives that Latina/o students have about their relationships with their mathematics professors, peers in mathematics, and families, this framework will illuminate the *perceived* meaningful relationship in mathematics education. By acknowledging the fact that these interpersonal relationships have the potential to be perceived in different ways by different members of the relationship, we eliminate the risk of speaking for the other members and creating a false

description of the relationship. Nevertheless, the purpose of this study is to begin to understand how individual Latina/o mathematics students perceive their interpersonal relationships. As human beings, it is from our own perceptions of our experiences in life that we make judgments, take positions, and make decisions. Thus, it is not necessary to examine the perspectives of the other members of these students' interpersonal relationships.

2.1 The Perceived Meaningful Relationship in Mathematics Education

2.1.1 Perception of Care in the MRIME

The definition of a *meaningful relationship* hinges on the care that one person has for another person. An interpersonal relationship cannot be perceived as meaningful if it does not have a foundation of care. According to Noddings (1988), in the caring relation:

> The first member of the relational dyad (the carer or the "one caring") responds to the needs, wants, and initiations of the second. Her mode of response is characterized by the *engrossment* (total presence to the other for the duration of the caring interval) and *displacement of motivation* (her motive energy flows in the direction of the others needs and projects). She feels with the other and acts in his behalf. The second member (the one cared for) contributes to the relation by recognizing and responding to the caring (p.219-220).

While Noddings' (1988) definition describes care in general, Hackenberg (2010) builds from Noddings' theory to define *mathematical caring relations* as "a quality of interaction between [two parties] that conjoins affective and cognitive realms in the process of aiming for mathematical learning (Hackenberg, 2005c)" (p. 237). She argues

that *cognitive decentering* is "a crucial part of establishing a caring relation that is mathematical" (p. 239). Cognitive decentering is the act of setting aside one's own thoughts and perspectives and attempting to think and perceive the way a student thinks and perceives and using that to interact with the student (2010). Like Noddings (1988), Hackenberg (2010) claims that the one cared for recognizes and responds to the caring through *subjective vitality*. Subjective vitality is "a psychological experience of energy and aliveness, characterized by feelings of enthusiasm and vigor (Nix, Ryan, Manly, & Deci, 1999; Ryan & Deci, 2008; Ryan & Frederick, 1997) or calm alertness (Thayer, 2001)" (p. 241). According to Hackenberg, a caring teacher would create lessons that build from students' existing ways of thinking mathematically and challenge the student to further develop their ways of thinking mathematically. During a mathematics lesson, the teacher would cognitively decenter herself, check for subjective vitality, and readjust instruction on a moment-to-moment basis.

Both theories are important in that they provide two similar, but distinct definitions of care. Noddings' and Hackenberg's theories begin with the perspective of the "carer". Since the focus of this study begins with the perspective of the "one cared for," it is necessary to modify these theories. If a student *perceives* that the other member of the relationship cares for him or her in general, then they feel that the other member responds to their "needs, wants, and initiations," regardless of the actual motivation of the other member. In the perceived MRIME it is not necessary that the "carer" actually cares. What matters is what is perceived by the one being cared for.

2.1.2 Acknowledgement as a Sociocultural Being and Fostering a Mathematics Identity

In the perceived meaningful relationship in mathematics education, the perception of general care and mathematical care would be the reasons that a student would also perceive that the "carer" acknowledges them as a sociocultural being and fosters their mathematics identity. The general care that the carer is perceived to have would force him (or perceive to force him) to acknowledge the other member as a sociocultural being. The mathematical care that the carer is perceived to have would cause him (or perceive to cause him) to foster the other member's mathematics identity.

2.1.2.1 Acknowledgement as a sociocultural being

The perceived meaningful relationship in mathematics education would, through a *general care*, acknowledge the student as a sociocultural being. The National Council of Teachers of Mathematics's (NCTM) (2008) position on equity in mathematics states that mathematics should be taught in culturally relevant ways that acknowledge and incorporate students' cultures. Gutierrez (1999; 2012) argues that teachers need to get to know their students as cultural beings. Teachers should get to know their students' cultures and embrace their culture so much so that it is actually a part of the classroom experience (Gutierrez & Irving, 2012; Gutstein, 2006; Ladson-Billings, 1995, 2009). In the perceived MRIME, the caring member of the relationship would be perceived as not only acknowledging the cultural background of the one being cared for, but also as attempting to incorporate their culture as a part of the relationship. For example, the carer might show an interest in learning the language of the one being cared for. In the field of mathematics, it has been shown that recognizing one's cultural background can

leave a positive mark on the field of mathematics. This was the case for Dr. David Blackwell who was the first African-American inducted into the National Academy of Sciences and the first black tenured faculty at the University of California, Berkeley. Dr. Blackwell stated:

> My blackness was a plus for [Jerzy] Neyman. He had a tremendous amount of sympathy for anyone who had been oppressed or mistreated in any way. He always favored the underdog. It would have given him a special pleasure to appoint me just because I was black (Albers, 1985a, p. 29).

Dr. Blackwell was referring to the first time he applied for a position at the University of California, Berkeley in 1942 but did not get hired. Twelve years later, however, he was hired as a visiting professor by Dr. Jerzy Neyman, the chairman of the Department of statistics. Later, he himself became the chairman of the department. Dr. Neyman's recognition of Dr. Blackwell as a cultural being enabled contributions to the field of mathematics and statistics in the form of textbook writing and game theory. Equally important was the fact that Dr. Blackwell paved the way for other Black and minority mathematicians to contribute to mathematics in a similar fashion.

In addition to the carer being perceived as acknowledging the one cared for as a cultural being, it is essential that the carer is perceived as being aware that the other member is a social being (Gutierrez, 1999). As humans, we are social beings and mathematics education is very much a social activity (Burton, 2009; Gutierrez & Irving, 2012). For that reason, the perception of acknowledgement of one member of the MRIME as a social being by the other member is important. This perceived

acknowledgement as a social being can be expressed through the carer participating in non-academic activities with the one being cared for or by the perception that the carer encourages "community" between the one cared for and others (Gutierrez, 1999; Gutierrez & Irving, 2012; Ladson-Billings, 2009).

If a student perceives that members of the MRIME cares about them as a sociocultural being, then he or she may be more likely to choose to learn mathematics from those other members. Kohl (1992) argues that some students choose to learn and to not-learn due directly to the perception of acknowledgement (or lack thereof) of the student as a sociocultural being. Those students who choose to not-learn are viewed as "stupid" or as failures, but in reality they "[accept] the failing grades [not-learning] produce[s] in exchange for the passive defense of their personal and cultural integrity" (p. 18). In the perceived MRIME, a student would choose to learn mathematics from another member of the relationship if they viewed that person as acknowledging them as a sociocultural being.

2.1.2.2 Fostering a positive mathematics identity

As stated above, the ideal perceived meaningful relationship in mathematics education would, through mathematical care, foster a student's mathematics identity. Mathematics identity is defined by Martin (2000) as "the participants beliefs about (a) their ability to perform in mathematics contexts, (b) the instrumental importance of mathematical knowledge, (c) constraints and opportunities in mathematical contexts, and (d) the resulting motivations and strategies used to obtain mathematics knowledge" (p.19). A well-developed positive mathematics identity is crucial to any student studying in the

field of mathematics (Gutierrez & Irving, 2012). Therefore, the perception that the student has about how other members of the relationship help or hinder the development of their positive mathematics identity can impact the student's decision to progress in their mathematical studies.

A student's belief about their own ability "to perform in mathematics contexts" can either be beneficial or detrimental to their mathematics identity (Herzig, 2004a, 2004b). If the student has relationships that stimulate a belief that they are capable of performing well in mathematics contexts, then they are developing a positive mathematics identity. The belief that they are mathematically capable can be stimulated by the perception that they have of the mathematical care that another member of a relationship has for them. The experience of Dr. Persi Diaconis, a renowned statistician and magician, is consistent with this view:

> As an undergraduate, I had a very good teacher named Onishi, who loved analytical number theory. I took a course from him, and he was nice and seemed to think I was smart, and that probably made some difference to me, too…. I went back to New York, and I started to think about [the] problem. I got started on it, and then I got Onishi interested. He taught me some stuff, and the two of us hacked out a solution…. Eventually it wound up as a triple paper… It was my first paper… That happened when I was more or less an undergraduate. It was due to a bright, friendly teacher and an older guy who asked a really good question…(Albers, 1985b, p. 74).

Dr. Diaconis perceived that his professor thought that he was smart. As a result, Dr. Diaconis was able to produce his first mathematical paper as an undergraduate.

Like a student's belief about their mathematical capabilities, a mathematics student's belief about "the instrumental importance of mathematical knowledge" is also crucial. It is important that students in general have an understanding of how very useful mathematics is in today's world (U. D'Ambrosio, 2012) but it is more important that our "mathematicians in training," those who are pursuing or have degrees in mathematics, have a better understanding of this. Ma and Kishor (1997) state that a student who has a positive attitude toward mathematics believes that mathematics is useful. In the perceived MRIME, if a student perceives that the other member of the relationship cares for them mathematically, then they may perceive that that person tries to encourage him or her to gain a strong belief that mathematics is a useful tool for understanding the world.

A student's beliefs about "constraints and opportunities in mathematical contexts" are just as important to mathematics students as the first two parts of the mathematics identity. According to Martin (2000) these constraints and opportunities to participate in mathematics can be anything from differential treatment from peers because of mathematics ability to participation in school-wide mathematics competitions. Since mathematics is currently viewed as a subject that is only studied by an elite group of intelligent people (U. D'Ambrosio, 2012), some mathematics students may have trouble fitting into that mold. In fact, they may be looked at as "nerds" from their peers outside of mathematics (Martin, 2000) and as "outsiders" from their peers in mathematics, especially students of color. Considering how difficult mathematics can be as an area of study, interpersonal relationships that address the struggles of being a mathematics

student can be powerful. Likewise, interpersonal relationships that prepare students for opportunities for success in mathematics can be very influential to students' persistence in mathematics. Dr. Garrett Birkhoff, a world-renowned mathematician, stated that his father who was also a mathematician, helped him prepare for a career in mathematics (Alexanderson & Wilde, 1985). There are many examples in which mathematicians have stated that an interpersonal relationship that they have had taught them about the constraints and opportunities of studying mathematics (Albers & Alexanderson, 1985).

The last part of the mathematics identity is the student's motivations to participate in mathematics. Students have different motivations for wanting to learn mathematics, for instance to break a stereo-type, to be successful, or to "resist dominant underachievement norms" (Martin, 2000, p.123). A vital part of the perceived MRIME setting is the perception that a member of the relationship supports the student's current motivations for learning mathematics and helps the student to develop stronger motivations. Here the carer, again, is perceived as decentering himself in order to think like the student.

The reason this last part of the mathematics identity is important to the perceived MRIME is because to continue in the mathematics pipeline, a student needs to have strong non-superficial motivations (Middleton & Jansen, 2011). Students need to perceive that the other members of their mathematical interpersonal relationships are attempting to help them develop healthy reasons for studying mathematics. "The key here is that students' values influence their interests and career choices" (Middleton & Jansen, 2011, p. 57). If a student is motivated to study mathematics, for example, only because he or she wants to be the first person in their family to have a degree in mathematics, then

they value the status that studying mathematics would give them and not necessarily mathematics itself. Eventually, they may lose interest in mathematics and look for other ways to gain status. But, if they perceive that members of their relationships are encouraging them to see the value and utility of mathematics as stated above, then their reasons for studying it may change and they may be more likely to continue in the mathematics pipeline (Herzig, 2004a; Middleton & Jansen, 2011).

The last part of the mathematics identity also includes students' strategies for studying mathematics. Interpersonal relationships can help these strategies develop. Such strategies can be taking the right courses at the right times, study habits, and ways to look at problems. In mathematics, collaboration with one's peers is a common strategy that mathematicians use to grow mathematically and to contribute to the field. Dr. Peter Hilton, a famous mathematician known for his work in algebraic topology and homotopy, stated that collaboration with peers is extremely effective in producing quality mathematics work:

> First I must say that I do enjoy it. I very much enjoy collaborating with friends. Second, I think it is an efficient thing to do because it may very well happen if you are just working on your own that you run out of steam, that the project loses some of its appeal for you. But with two of you, what tends to happen is that when one person begins to feel a flagging interest, the other one then provides that stimulus. In that sense I think it is an efficient procedure.... So very often I do think you get a better product with this type of collaboration, if there is this kind of complementarity between the collaborators….It is very nice to develop that sort of relationship with a colleague (Steen & Alexanderson, 1985, p. 141).

When students have meaningful relationships in mathematics, the members of those relationships can either encourage or be a part of sound strategies for studying, such as collaboration. When professors, for example, encourage their students to work with their peers to solve problems, they are encouraging their students to develop good strategies for studying mathematics. When a student studies with their peers productively, their peers are taking part in helping that student develop good strategies for studying mathematics. Having reliable methods for studying mathematics helps students progress by helping them grow mathematically, belong in the field of mathematics, and can make studying mathematics more enjoyable, as Dr. Peter Hilton stated above.

2.1.3 Results of MRIME: "Choosing" to Grow Mathematically and Enjoy Mathematics, and Feeling Belonging in Mathematics

A student may choose to grow mathematically as a result of the other members of the interpersonal relationships acknowledging them as a sociocultural being and fostering their mathematics identity. By *growing mathematically*, I am referring to students developing their ability to think mathematically. Henningsen and Stein (1997) describe mathematical thinking as "[using] mathematical tools systematically to explore patterns, frame problems, and justify reasoning processes…" (p. 524). Because students choose to learn or not-learn if they feel acknowledged as a sociocultural being (Kohl, 1992), they are choosing to grow mathematically or not-grow mathematically. In order to successfully proceed through the mathematics pipeline one needs to continually grow mathematically. Herzig (2004b) concluded that when female graduate students in mathematics programs have interpersonal relationships that are meaningful to them, they

may choose to complete doctoral degree programs. If students do not perceive that their relationships are meaningful then they may choose to not grow mathematically, in spite of the fact that they may be very mathematically capable. But choosing to grow mathematically may not be enough for the student to make the decision to continue in mathematics. The student may need to choose to value mathematics and feel like they belong in mathematics.

For a student to value mathematics for it utility is a part of the mathematics identity described above (Martin, 2000). Mathematics students should also value mathematics because they enjoy it. Middleton and Jansen (2011) describe *intrinsic value* as how much an individual personally enjoys doing a task. They also refer to *cost* as negative effects of doing the task. If students perceive that they have MRIME then as a result of those relationships they may value mathematics for more than its utility but they will also place high intrinsic values on mathematics. To the student, the cost of doing mathematics should not exceed the values they place on mathematics. Meaningful interpersonal relationships can help students place an intrinsic value on mathematics. Dr. Peter Hilton stated that when he was an undergraduate student, he worked with topologist Dr. Henry Whitehead. Dr. Hilton felt that doing mathematics with Dr. Whitehead was fun but also demanding (which was the cost) and he called it a “marvelous experience” (which showed that he valued mathematics) (Steen & Alexanderson, 1985, p. 135). For Dr. Hilton, the relationship that he had with his professor encouraged him to enjoy mathematics and the fact that doing the mathematics was demanding was a cost that did not exceed his enjoyment. He claimed that he chose to study topology as a result of the relationship that he had with Dr. Whitehead. This is a powerful example of how

interpersonal relationships can affect the student's mathematics identity, particularly their enjoyment of mathematics.

Mathematics is a field that has a culture of its own (Burton, 2009) and like all academic fields, is a *community of practice*. Communities of practice are "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger, 2006, p. 1). Wenger and Snyder (2000) say that "people in communities of practice share their experiences and knowledge in free-flowing, creative ways that foster new approaches to problems" (p. 140). So, for a student to perceive that they *belong in the community of practice of mathematics*, they must perceive that they and other members of their mathematical relationships are exchanging experiences and knowledge in mathematics in free-flowing creative ways. By participating in such exchanges, he or she may feel like those who are involved in the exchange are attempting to develop their mathematical identity through providing them the opportunity to meaningfully participate in mathematics. Thus, he or she feels like an "insider" in the mathematical community and that they belong in mathematics.

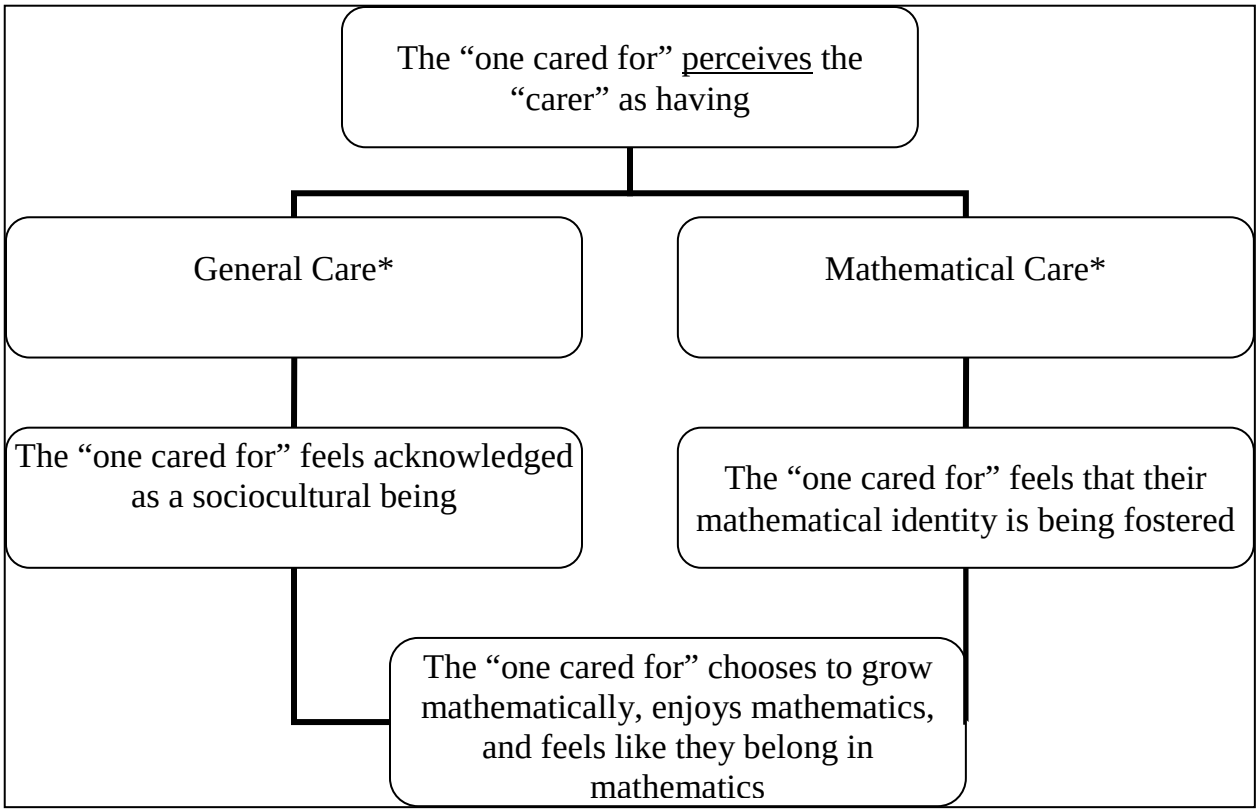

Figure 1: The Structure of MRIME

In this framework, the perception of having meaningful relationships in mathematics educational settings leads to mathematics students possibly making decisions to continue in the pipeline. Ladson-Billings (1995) states that "the trick of culturally relevant teaching is to get students to 'choose' academic excellence" (p. 160). If a student does perceive that he or she has a MRIME, then he or she may "choose" to grow mathematically, enjoy mathematics, and feel like they belong in mathematics, which may ultimately lead them to continue in mathematics. Black, Hendrick, and Solomon (2009) stress the importance of students having positive relationships with mathematics. Any deficiency in the perception of a meaningful relationship could affect the student's

relationship with mathematics and their persistence in the discipline. It is important to note that there may be other factors that contribute to the persistence and attrition of Latina/o students in mathematics, but the existence of such factors are not the focus of this study.

2.3 Conclusion

This framework provides a lens that allows researchers to investigate how students view their interpersonal relationships in mathematics educational settings. It draws from research on care, the influence of recognizing students as sociocultural beings, and mathematics identity. Figure 1 shows the connection between the fostering of the mathematics identity and the recognition of students as sociocultural beings. Without care, the latter two components of the meaningful relationship could not exist. Therefore the meaningful relationship is built on a foundation of care. The sociocultural being - mathematics identity dyad makes up the whole mathematics student and cannot be overlooked when exploring interpersonal relationships. In order to answer the question of how Latina/o mathematics students perceive their interpersonal relationships with their professors, peers, and families, this framework was used as a structure to build understandings about the role of interpersonal relationships on mathematics students' perspectives in the field. It provides insight into how Latina/o mathematics students perceive being recognized as a sociocultural being and having their mathematics identity fostered by the people that they commonly interact with.

CHAPTER 3. METHODS

While the population of Latinas/os continues to increase, they are underrepresented in the field of mathematics. It is known that interpersonal relationships are important in the Latina/o culture (Raeff et al., 2000; Vega, 1990), to undergraduate students and their persistence in college (Churukain, 1982; Nora et al., 1996; Pascarella & Terenzini, 1979; Thompson, 2001; Tinto, 1975), to mathematics students in general (Burton, 1998; Escalante & Dirmann, 1990; Gutierrez, 1999; Gutstein, 2003, 2006; Hackenberg, 2010; Herzig, 2004b), and to Latina/o mathematics students (Gutierrez, 1999; Gutierrez & Irving, 2012; Gutstein, 2006). What is not known, however, is the impact that interpersonal relationships have on Latina/o mathematics students in college. The purpose of this study is to investigate how Latina/o mathematics students who are mathematics majors or have bachelor's degrees in mathematics perceive their interpersonal relationships with their mathematics professors, peers in mathematics, and families concerning mathematics.

This chapter will expound on how the study was designed, the sample was selected, the manner in which the data was collected and analyzed, what steps were taken to ensure the validity and reliability of the results, and what biases I, as the researcher, would have that could potentially influence this study and findings.

3.1 Design of the Study

The *qualitative research paradigm* (or framework) stems from the methodology of sociology and social science research and, unlike the scientific research paradigm, qualitative studies seek to explore how individuals explore their world and their experiences (Ernest, 1997; Merriam, 2009). Because the purpose of this study is to understand how a specific subgroup of mathematics students understand their experiences in a mathematics educational setting, the use of qualitative research is an appropriate tool.

It is important to note that this study also aims to investigate race and culture in mathematical settings and hints at investigating power structures (i.e. the student-professor relationship, peer relationships, and student - family relationships centered on mathematics, as well as Latinas/os navigating mathematics as a space that has a culture that is incongruent to theirs), however, it is not the primary focus of this study, and thus, critical theory would not be the most effective framework to use for this study. For that reason, the foundational framework of this investigation stems social constructivism.

3.1.1 Social Constructivism as a Theoretical Framework

Constructivism in mathematics education was influenced by Jean Piaget, whose focus was on an individual's thinking and cognition in mathematics (Ernest, 1997). Researchers have drawn from the constructivist theory of learning and have developed *social constructivism*. Ernest (1997) describes social constructivism:

> These perspectives are centrally concerned with the social construction of persons, interpersonal relationships, and the types of interpersonal negotiation that underpin everyday roles and functionings, such as those of the teacher in the classroom....What these social constructivist ideas share is the notion that the

> social domain affects the developing individual in some crucial formative way and that the individual constructs or appropriates his or her means in response to his or her experiences in social contexts (pp. 30-31).

It is important to mention that social constructivism "assumes that reality is socially constructed, that is, there is no single, observable reality. Rather, there are multiple realities, or interpretations, of a single event" (Merriam, 2009, p. 8). Social constructivism in mathematics educational research focuses on the learner as a whole person, emphasizing the social context that they operate in (Ernest, 1997). Since this study concentrates on individuals' perspectives of their social interactions, applying social constructivism as the theoretical framework is suitable for this study.

3.1.2 Case Study

In qualitative research, a basic qualitative study could be done using a *qualitative case study*. According to Merriam (2009), a case study is "an in-depth description and analysis of a bounded system" (p. 40). She goes on to say:

> The "what" [is to be studied] is a bounded system, a single entity, a unit around which there are boundaries. I can "fence in" what I am going to study. The case then, could be a single person who is a case example of some phenomenon, a program, a group, institution, community, or a specific policy... (p. 40).

The unit of analysis characterizes a case study. The phenomenon that is being studied must be bounded and the data collection must be finite, meaning that there is a limit to the number of interviews or observations that could be conducted, in order for it to be a

case (Merriam, 2009). A case may be chosen because it is an "instance of some process, issue, or concern" (Merriam, 2009, p. 41).

Case studies are different from other types of qualitative research in that the study focuses on the unit of analysis whereas the other types are characterized by the focus of the study. Ernest (1997) asserts that the purpose of case studies is to use the in-depth investigation of a concrete example to illustrate or describe the general case. He states that this is done "not with the precision of the exact sciences, but suggestively as an illustration of a more general and complex truth" (p. 34).

Because case studies focus on specific incidents of phenomena, like how individual mathematics students perceive their interpersonal relationships, it is appropriate to use this method of inquiry for this particular study. Even more appropriate is the use of a *multi-case study*. Instead of focusing on one particular case, the multi-case study explores multiple cases and will usually have a cross-case analysis that implies possible generalizations (Merriam, 2009). Therefore, this study uses a multi-case approach to investigate particular Latina/o mathematics students' perspectives of their interpersonal relationships with their mathematics professors, peers in mathematics, and families. The experiences of one participant constitute one case and in this study there are four cases. After the description of each of the four cases, I provide a cross-case analysis where I suggest possible generalizations.

3.2 Sample Selection

Due to the fact that the experiences of one participant make up one case in this multi-case study, selecting the right participants was crucial. I, therefore, used a purposeful sampling method to select participants. *Purposeful* sampling involves

choosing participants that will provide the best information on the phenomenon being studied, and more specifically, a *unique sample* is based on unique attributes of the phenomenon (Merriam, 2009). This study seeks to answer the question: How do Latina/o mathematics students perceive their interpersonal relationships with their mathematics professors, peers in mathematics, and families with respect to mathematics? Thus, the criteria for selecting participants were that the participants had to be 18 years old or older, identify as Latina/o, and have a bachelor's degree in mathematics or be a mathematics major. It was important that the participants identify as Latina/o because, as stated in Chapter 1, the main demographic that this study is examining is Latinas/os. The participants needed to be a mathematics major or have a bachelor's degree in mathematics in order to get a clear picture of interpersonal relationships in mathematics at the college level, from the perspective of the participants.

The participants were recruited using a Facebook page that was created for the study (Appendix A). Since there were three parts to this study, I created three Facebook pages to recruit participants to join at anytime of the study. Nevertheless, all of the participants joined at the beginning. Because of the specificity with which the sample was selected, only four of eight potential participants qualified to participate. Of the four potential participants that did not qualify, two were mathematics education majors and two did not continue correspondence after initially showing an interest in participating.

All of the participants identified as Latina/o and were of the appropriate age range. Three of the participants were completing a bachelor's degree in mathematics at the time this study began and one had already completed a bachelor's degree in mathematics and was in the process of completing a master's degree in mathematics. Three participants

were female and one was male. All of the participants were from different areas of the United States — two from the Midwest, one from the Southwest, and one from the Northwest. All of the participants attended research universities that were classified as "high research activity" or "very high research activity" by the Carnegie Foundation for the Advancement of Teaching (2010). The universities that the participants attended served different communities including urban, suburban, and rural. Three of the four participants were born in the United States and one was born in Mexico.

3.3 Data Collection

In case study research, a common method of data collection is conducting *research interviews*. A research interview is a conversation between the researcher and the participant in which the questions that are asked to the participant are specifically about the topic of the research study. Interviewing is used in situations when the researcher cannot observe a particular behavior, feelings, or past events (Merriam, 2009). Interviews can be *person-to-person* and *group* or *collective* interviews. Person-to-person interviews involve the researcher interviewing one person at a time. Group or collective interviews involve the researcher interviewing multiple people at one time. This study was done using person-to-person interviews.

3.3.1 Semistructured Interviews

In order to understand the participants' perspectives of their interpersonal relationships conducting interviews was the best method for data collection. Since the participants were located across the country it was impractical to conduct observations or collect documents in order to gain more information about the individual cases. Instead, I conducted three telephone interviews with each participant. The interviews were

semistructured, meaning there were basic questions that were intended to be asked via an interview protocol, but there was much room for flexibility within the interview. This allowed me to make sure that the interview remained focused on the topic of discussion while still allowing me to dig deeper into specific subtopics that I felt were important to the study. The interview protocol, which is described in the next section, was created using the analytical framework. The interview questions were created with the intention of exploring the participants' perspectives of their interpersonal relationships through the lens of MRIME. To create the questions I explored the research literature in mathematics education that spoke to each component of MRIME. Then, I generated questions that would specifically address each topic based on research literature. The interview questions are presented in the next section.

3.3.2 The Three Interviews

The three telephone interviews that I conducted with each participant took place over the course of one year. The first interview concentrated on getting to know the participants' family backgrounds and their mathematical biographies. The goal of this interview was also to gain an understanding of their perspectives of their relationships with their mathematics professors. The following questions served as the anchor protocol:

1. Which Latina/o subgroup do you most identify with (Mexican-American, Puerto Rican, Cuban, etc)?
2. Did any of your parents graduate from college? If so, which one(s)?
3. How long have you…Been a math major? / Had your bachelors degree in math?/ Been a master's student?/ Had your masters degree?

4. Can you tell me how you became interested in mathematics?
5. Why did you choose to get a degree in mathematics?
6. How would you describe your relationships with your mathematics professors in class? Please give an example.
7. How would you describe your relationships with your mathematics professors outside of class? Please give an example.
8. Do you think you will ever pursue a doctoral degree in mathematics? Why or why not?
9. In what way(s) do you think that your relationships with your mathematics professors have influenced your decision to (not to) pursue a doctoral degree in mathematics? Please give an example.

During the second interview, the participants were asked to discuss their perspectives on their relationships with their peers in mathematics. During this interview the participants were asked the following:

1. How would you describe your relationships with your peers in mathematics classes? Please give an example.
2. How comfortable do you feel discussing mathematics with your peers from your mathematics classes? Please explain
3. Do you feel like you belong in mathematics? Please explain.

4. In what way(s) do you think that your relationships with your mathematics professors and peers have influenced your decision to (not to) pursue a doctoral degree in mathematics? Please give an example.

The final interview focused on the participants views of their relationships centered on mathematics with their families. The participants were asked to answer the following questions:

1. To your knowledge, what is the educational background of your parents or guardians?
2. What type of occupation did your parents or guardians have while you were growing up?
3. Tell me about the mathematics that your parents or guardians did at their place of work.
4. Tell me about some hobbies or interests that members of your family had when you were growing up (eg. sewing, carpentry, cooking, gardening, sports, etc.). Talk about any mathematics that was involved in these activities.
5. Tell me what you think members of your family believe about the importance of mathematics. How does that make you feel?
6. Discuss how members of your family feel about your mathematics ability. How do you know? How does that make you feel?
7. Talk about how you feel when you compare yourself to members of your family when it comes to studying mathematics.

8. Discuss what members of your family believe about how you as an individual can benefit from studying mathematics. Compare that to what you believe. How does that make you feel?
9. Talk about a time when you discussed your reasons for studying mathematics in with members of your family.
10. Tell me about a time that you have talked about your experiences in college mathematics with members of your family.
11. Tell me about a time that members of your family tried to understand your experiences in college mathematics.
12. Talk about a time when you discussed getting a bachelor's degree in mathematics with your members of your family.
13. Talk about a time when you discussed getting a doctoral degree in mathematics with your members of your family.

Since the study is about interpersonal relationships and persistence in mathematics, it can be a sensitive topic to discuss for some participants. In order to make the participants feel more comfortable answering the interview questions, I sent the participants the interview protocols a few days before each interview took place (Herzig, 2004b). This allowed the participants to prepare answers to the questions and filter out anything they did not want to say before the interviews. This also helped with the accuracy of the participants' responses to the interview questions because they had time to reflect on the questions before the interview took place.

The interviews took place over the course of a year and each interview took place at a different time of the year. The interviews were conducted at the convenience of each participant, so the time intervals between one participant's interview and another's were often sporadic. Most interviews took about one hour to complete. The interviews were audio recorded using a digital audio recording device and were stored using an electronic transcribing software program called Express Scribe Pro (NCH Software). The interviews were transcribed using Microsoft (MS) Word after each interview took place. After I transcribed each interview, I listened to each interview for a second time to confirm the accuracy of the transcripts. The MS Word documents were then converted to MS Excel worksheets in preparation for coding.

3.4 Data Analysis

3.4.1 Organizing the Data

In order to organize the data in the most efficient manner, I created a *case study database* (Merriam, 2009) using an MS Excel workbook for each case. Each workbook contained the transcripts and other worksheets that were used during the data analyzing process. Since the interviews were converted to Excel worksheets, each response to an interview question was placed into its own cell (see Figure 2). Therefore, instead of labeling the line numbers as one would do using a word processor, I labeled sheet rows. I also labeled each row according to the point in time of their lives that the participant was discussing. For example, if the participant was talking about being in high school, I labeled that row "high school." This made the data analysis much more convenient later on. At every step of the analyzing process I also kept hardcopies of each document and used a manual filing system to store my data.

3.4.2 Coding the Data

After each interview, I began analyzing the data using codes that I created from the analytical framework (Appendix B). Within each cell, it was possible to have different phrases coded differently, but because I could not keep track of the line numbers, I could not code each line separately. For that reason, I used a color coordinating system to distinguish between different coded passages within a cell. For instance, if I wanted to code one passage within the cell one way, I would color the text of that passage red and color the corresponding code red as well. If there was a different passage within that same cell that I wanted to code differently, I would color the text of that passage a different color and use a matching color for the corresponding code. Figures 2, 3, 4, and 5 are examples of an interview that was coded. The example is a sample from the third interview of Case 4. Figure 2 is an example of the organization of the coded interviews as well as the color scheme that was used to in the coding process.

TIME FRAME	ROW	INTERVIEW	GENERAL IDEAS	CODES
College	580	P4: um, I'm assuming they knew, um, I never really, uh, like, explicitly told them. I mean, at the beginning of class one of my professors, which is my Linear Algebra professor, asked us a little bit about ourselves and asked us to turn in a page with a picture and, um, and, kind of, not a bio but, like, but kind of, speaking about ourselves so that he knew who we were. So that's about as close as it got to them knowing who I was.	She never explicitly told her professors that she was Mexican. Her linear algebra professor did ask her class to provide him with a short biography and a picture of themselves at the beginning of the semester so that he could know who they were.	S1(PC)-, S1(DB)+, S2(DB)+

Figure 2: Sample of Coded Transcripts Organized

3.4.3 Filtering the Data

After all of the interviews were coded, I created another worksheet within each workbook (Figure 3). I called this worksheet "All Interviews Reorganized." On this worksheet, I organized the full set of transcripts of all three interviews by, first, the relationship that the participant was discussing (i.e. professors, peers, or family), second, the time frame that the participant was talking about, third, the specific mathematics course, instructor, or family member that the participant was referring to, and finally by row number.

TIME FRAME	INTVW.	RLTNSHP.	CLASS	ROW	TRANSCRIPT	GENERAL IDEAS	CODES
College	**INTER-VIEW 3**	**PROF.**	**LINEAR ALGEBRA**	580	P4: um, I'm assuming they knew, um, I never really, uh, like, explicitly told them. I mean, at the beginning of class one of my professors, which is my Linear Algebra professor, asked us a little bit about ourselves and asked us to turn in a page with a picture and, um, and, kind of, not a bio but, like, but kind of, speaking about ourselves so that he knew who we were. So that's about as close as it got to them knowing who I was.	She never explicitly told her professors that she was Mexican. Her linear algebra professor did ask her class to provide him with a short biography and a picture of themselves at the beginning of the semester so that he could know who they were.	S1(PC)-, S1(DB)+, S2(DB)+

Figure 3: Sample of "All Interviews Reorganized"

After the worksheet "All Interviews Reorganized" was organized I created three more worksheets called "Professors," "Peers," and "Family." For each of these worksheets I extracted the corresponding sections from "All Interviews Reorganized" to create each of the three worksheets. For example, to create "Professors" I copied the section of transcripts that was labeled "professors" and pasted it in on the worksheet called "Professors." This was a way to filter the data based on the relationship with each group. For an example, see Figure 4 below.

TIME	INTERVIEW	PROF.	ROW	TRANSCRIPT	SUMMARY	CODES
College	**INTERVIEW 3**	**LINEAR ALGEBRA**	580	P4: um, I'm assuming they knew, um, I never really, uh, like, explicitly told them. I mean, at the beginning of class one of my professors, which is my Linear Algebra professor, asked us a little bit about ourselves and asked us to turn in a page with a picture and, um, and, kind of, not a bio but, like, but kind of, speaking about ourselves so that he knew who we were. So that's about as close as it got to them knowing who I was.	She never explicitly told her professors that she was Mexican. Her linear algebra professor did ask her class to provide him with a short biography and a picture of themselves at the beginning of the semester so that he could know who they were.	S1(PC)-, S1(DB)+, S2(DB)+

Figure 4: Sample of "Professors"

Next, I filtered each of the three worksheets based on the analytical framework categories and subcategories that were determined by the codes. I extracted that data to create new worksheets called "Professors Framework," "Peers Framework," and "Family Framework." Figure 5 is an example of the worksheet titled "Professor Framework" for

Case 4. The interview passages are grouped by the *sociocultural being* component of MRIME and, more specifically, the *social being* sub-component.

TIME	INTERVIEW	PROF.	ROW	TRANSCRIPT	SUMMARY	CODES	FRAMEWORK	DETAILS
College	**INTER-VIEW 3**	**LINEAR ALG.**	580	P4: um, I'm assuming they knew, um, I never really, uh, like, explicitly told them. I mean, at the beginning of class one of my professors, which is my Linear Algebra professor, asked us a little bit about ourselves and asked us to turn in a page with a picture and, um, and, kind of, not a bio but, like, but kind of, speaking about ourselves so that he knew who we were. So that's about as close as it got to them knowing who I was.	She never explicitly told her professors that she was Mexican. Her linear algebra professor did ask her class to provide him with a short biography and a picture of themselves at the beginning of the semester so that he could know who they were.	S1(PC)-, S1(DB)+, S2(DB)+	S.C. Being	CULTURAL BEING

Figure 5: Sample of "Professors Framework"

After I used the codes to filter all of the data by the categories and subcategories of the analytical framework, I created a table based on the framework in the relationship groups (i.e. professors, peers, and families) that allowed me to organize an analysis of each case. I used the case analysis to write up each case and Chapter 4. Figure 6 is an sample taken from the Case Analysis of Case 4.

	RELATIONSHIPS THROUGH CARE	SOCIOCULTURAL BEING	MATHEMATICS IDENTITY	RESULTS OF MRIME
PROFESSORS	**General Care:** She felt that she had a relationship with her Calculus 1 professor because her professor knew her by name and was friendly with her on campus. She did not feel that she had a relationship with her Calculus 2 professor at all. She did not feel that she had a personal relationship with any of her professors. She feels that the ideal relationship that she could have with her professors is one in which the professor tries to understand the students, cares for the students, and is approachable. **Mathematical Care:** Her ideal relationship with a mathematics professor is one where she can freely ask for help and it would be given to her, and enjoys what they are doing, like her Linear Algebra professor.	**Social Being:** Sonya felt that her Calculus 1 and her Linear Algebra professors were very approachable. Her Linear Algebra professor asked the class at the beginning of the semester to turn in a page that gives a brief biography about them with a picture. She did not remember her professors knowing anything about her life outside of mathematics. **Cultural Being:** She never explicitly told her professors that she was Mexican nor did they ask. She was able to mention in the biography that her Linear Algebra professor asked her class to write.	**Ability**: Her statistics professor made her feel like she was bad at mathematics. **Mathematical Knowledge:** The reason she changed her major from mathematics to foreign language and culture was because none of her professors told her the importance of having mathematical knowledge and how it pertains to the real world. She really struggled because she did not know how the classes she was taking were useful in the real world and her professors did not give her sufficient reasons for studying mathematics. **Opportunities:** Her mathematics professors never spoke to her about graduate school. She wanted professors that she could go to for guidance on opportunities available to her. **Strategies**: She felt that her Calculus 1 professor was good at explaining mathematics to her and guiding her as she was solving problems. She remembered this professor suggesting that she and her classmates work in groups. This professor would try to make herself available to the students and would offer extra help if they needed it. Her Calculus 2 professor did not encourage her class to study in groups. When she went to his office hours she had a poor experience. **Reasons:** Sonya did not understand the usefulness of mathematics due to her interactions with her professors.	**Grows:** She felt that she did not learn mathematics while working with her Calculus 2 professor and his office hours. She stated that she ended up having to teach herself mathematics. Her Calculus 3 and Linear Algebra professors, on the other hand, seemed to care that their students understood course material. **Enjoys:** She did not enjoy mathematics when working with her Calculus 2 and Statistics professors because neither made the class interesting. She did enjoy doing mathematics with her calculus three professor because she could tell that he enjoyed mathematics.

Figure 6: Sample of “Case Analysis”

3.4.4 Creating the Cross-Case Analysis

To develop a cross-case analysis, I created a fifth Excel workbook for the cross-case analysis. I reviewed each of the participants' "Case Analysis" worksheets and determined which aspects of their relationships were meaningful or not meaningful according to MRIME. I would give those aspects a score of "1" for meaningful or "0" for not meaningful. For example if the participant stated that his or her professors did not recognize her as Latina/o, then their professor did not recognize them as a cultural being, making that part of the relationship not meaningful and I would score that particular part of the relationship as "0". I recorded all of the scores for each participant in a worksheet called "Relationship Scores" (see Figure 7). If there were certain topics that a participant did not discuss, for example if a participant did not mention whether or not his or her family made them feel like they belonged in mathematics, then I would mark the cell "N/A." After the table was filled out, I calculated the percentages of "1s" out of the total topics discussed for each participant's relationships. If the relationship scored 70% or above, then I considered that a generally meaningful relationship, and indicated that using a plus sign. If the relationship scored 69% or below, then I considered that a generally not meaningful relationship and indicated that using a negative sign. I also gave percentages to each component of MRIME for the group as a whole. I chose 70% as the threshold because it takes into account the natural imperfections that occur in interpersonal relationships without exaggerating. The scoring system was the same as the one I used for the professors. Last, I organized the data to determine how the professors, peers, and family scored in each component of MRIME.

PARTICIPANT	RELATIONSHIP	SOCIOCULTURAL BEING		MATHEMATICS IDENTITY						RESULTS OF MRIME			RL.TNSHP. TOTAL	% OF PERSP. GIVEN	PTCPT. TOTAL	% OF PERSP. GIVEN	+/-
		S. B	C. B.	ABILITY	M. K.	CONST.	OPP.	REASONS	STRAT.	GROWS	ENJOYS	BELONGS					
MARTINA	PROFESSORS	0	0	1	N/A	1	1	N/A	1	1	1	N/A	6	75%	12	57%	-
	PEERS	1	0	0	N/A	1	N/A	N/A	1	N/A	N/A	1	4	67%			
	FAMILY	0	N/A	1	0	1	0	0	0	N/A	N/A	N/A	2	29%			
SANDY	PROFESSORS	1	0	1	1	N/A	1	1	1	1	1	1	9	90%	25	93%	+
	PEERS	1	1	N/A	N/A	N/A	N/A	1	1	1	1	1	7	100%			
	FAMILY	1	1	1	1	1	1	1	1	0	1	N/A	9	90%			
JOSE	PROFESSORS	1	1	1	N/A	N/A	1	0	1	1	1	N/A	7	88%	20	83%	+
	PEERS	1	N/A	1	N/A	1	N/A	N/A	1	1	1	1	7	100%			
	FAMILY	1	0	1	1	1	1	1	0	0	N/A	N/A	6	67%			
SONYA	PROFESSORS	0	0	0	0	N/A	0	0	1	1	1	N/A	3	33%	15	60%	-
	PEERS	1	1	1	N/A	N/A	N/A	N/A	1	1	1	1	7	100%			
	FAMILY	1	1	1	0	0	0	0	1	N/A	1	N/A	5	56%			
SUB-FRAMEWORK TOTAL		9	5	9	3	6	5	4	10	7	9	5					
% OF PERSPECTIVES GIVEN		75%	50%	82%	50%	86%	63%	50%	83%	78%	100%	100%					
FRAMEWORK TOTAL		14		37						21							
% OF PERSPECTIVES GIVEN		64%		71%						91%							
+/-		-		+						+							

													RL.TNSHP. FINAL SCORE			
SUB-FRAMEWORK FINAL SCORE	PROF.	1/2	1/4	3/4	1/2	1	3/4	1/3	1	1	1	1		PROF.	71%	+	
	PEERS	1	2/3	2/3	N/A	1	N/A	1	1	1	1	1		PEERS	93%	+	
	FAMILY	3/4	2/3	1	1/2	3/4	1/2	1/2	1/2	0	1	N/A		FAMILY	63%	-	

Figure 7: Sample of "Relationship Scores"

Giving numerical scores to the relationships and components of MRIME was not an attempt to quantify the interpretation of relationships. The purpose was to have a visual representation of how the relationships were perceived. The numerical score acted like check marks or tally marks. I wanted to know and confirm, in general, how any one participant viewed his or her relationships, and also how the group as a whole viewed their relationships. So, in a sense, I tallied up the number positive codes to get a general idea of which participants had mostly positive views of their interpersonal relationships. The worksheet that I created gave me a clear overview of how the participants perceived their interpersonal relationships because it was a summary of each participant's relationships. Therefore, the scores that were given enabled me to make better

generalizations for the cross-case analysis and were not meant to reflect any statistical data.

Last, I used the “Relationships Scores” worksheet and the participants’ “Case Analysis” worksheets to create the worksheet called “Cross-Case Analysis.” This worksheet was identical to the “Case Analysis” worksheets. In this worksheet, I summarized the similarities and differences between the relationships of each individual. I used this worksheet and the “Relationship Scores” worksheet to present the data overall. Figure 8 is a sample taken from the “Peers” row of the “Cross-Case Analysis” worksheet.

	RELATIONSHIPS THROUGH CARE	SOCIOCULTURAL BEING	MATHEMATICS IDENTITY	RESULTS OF MRIME
PEERS	Martina was the only participant who felt that she did not have any relationships with her peers. Sandy and José referred their peers as their "friends". Sonya felt that she developed relationships with her peers in one of her classes and they studied together and they met outside of mathematics. The definition of "relationship" had a general care component and a mathematical care component. José only emphasized the mathematical care component, however.	**Social being:** Every participant had at least one classmate that they had a social relationship with. These classmates knew about their lives outside of mathematics. Sandy and Sonya each had one classmate that knew much about them, while Jose and Martina did not say that any particular classmate knew a great deal about their lives outside of mathematics. **Cultural Being:** Sonya and Sandy stated that they had at least one classmate that knew about their Latina background. They also stated that they compared and contrasted their cultures with those of that classmate. Sonya was the only participant that studied mathematics with other Latinas/os. Martina specifically stated that none of her peers knew that she was Latina. Jose never mentioned if his peers knew that he was Latino.	**Ability:** Martina, Jose, and Sonya all mentioned having interactions with their peers that made them feel confident in their mathematics ability. Martina was the only participant to also describe a time when working with her peers made her feel unsure about her abilities. Sandy never mentioned it. **Mathematical Knowledge:** Not one participant mentioned having interactions with their peers that helped them to develop positive beliefs about the importance of mathematical knowledge. **Constraints:** Martina and Jose said that they talked to at least one of their peers about their struggles in mathematics. Sonya and Sandy never mentioned discussing their struggles in with their peers. **Opportunities:** Not one participant mentioned discussing opportunities with their peers. **Reasons:** Not one participant mentioned having interactions with their peers that helped them to develop healthy reasons for studying mathematics. **Strategies:** All of the participants mentioned collaboration as a strategy that they used to study mathematics. Martina was the only participant who described having a negative experience while working with her peers.	**Grows:** All of the participants, except for Martina, indicated that they grow mathematically from working with their peers. They said that they learned from their peers and teaching their peers also helped them to understand mathematics concepts better. Martina did not mention growing or not growing. **Enjoys:** Sonya and José both stated that working with their peers made doing mathematics more enjoyable. Sandy felt that working with her peers did not change the way that she felt about mathematics. Martina never mentioned how working with her peers affected her enjoyment of mathematics. **Belongs:** All of the participants felt a sense of belonging in mathematics at some point while working with her peers.

Figure 8. Sample of “Cross-Case Analysis”

3.5 Ensuring the Validity of the Data

In order to ensure the validity of the study, I used *triangulation, adequate engagement in data collection,* and *member checks*. One of the types of triangulation is the use of multiple sources of data (Merriam, 2009). Merriam (2009) states that conducting multiple interviews with the same participant is one way of triangulating multiple sets of data. Since I interviewed each participant three times over the course of a year, I was able to confirm my interpretations of previous interviews and follow up with questions as I needed to.

The second strategy that I used was adequate engagement in data collection. Adequate engagement in data collection means spending an appropriate amount of time collecting the data (Merriam, 2009). This allows time for patterns to emerge and no new information to surface while collecting the data. During the data collection time, it is beneficial to also look for variations or alternative explanations to the data. Since the collection of the data took approximately one year to complete, I often saw common ideas emerging from individual participants and the group as a whole. I also checked for alternative explanations while interviewing each participant. Since the amount of time between two interviews with one participant was sometimes three or more months, the participant would have had enough time to reflect on an interview and possibly change the perspective that they originally had. Thus, I would often ask questions that would give the participant the opportunity to provide a different perspective on a topic that was discussed in a previous interview. Due to the fact that the participants' comments and their confirmations of my interpretations of their comments were consistent throughout the entire data collection period, I considered the data more credible.

The last strategy I used to ensure the credibility of the data analysis was member checking. Member checking involves having the participants review the findings of the study and allows them to comment or make changes to the researcher's interpretation of the data to best represent the true meaning of the data (Merriam, 2009). Maxwell describes member checking:

> This is the single most important way of ruling out the possibility of misinterpreting the meaning of what participants say and do and the perspective they have on what is going on, as well as being an important way of identifying your own biases and misunderstanding of what you observed (as cited in Merriam, 2009, p. 217).

After I created each "Case Analysis" worksheet for each participant and wrote up each of the four cases, I emailed each participant their respective MS Word document. Each participant agreed to review their case to confirm that I had interpreted all of the interviews and their perspectives on their relationships accurately. They were also allowed to make changes in whatever way they desired. All, but one, of the member checks came back in a timely fashion with little to no changes requested (see Table 1).

Table 1: Participant Comments in Response to Member Checks

Participant	Comments	Action taken
Martina	"Everything seems awesome. It's amazing to read this and reflect and see how much things have changed. I think I owe you a little credit because this past year I really stepped out of my comfort zone and improved the types of relationships I made with peers and professors."	No action needed
Sandy	Did not complete the member check	Not applicable
José	"Well done! I think you really understood what I was trying to relay. It was very accurate. Good luck with the paper."	No action needed
Sonya	"Here you go, thank you for the opportunity. I fixed very little. I read and re-read it and it looks great."	Made the minor changes that she suggested

3.6 Researcher Bias and Assumptions

In order for the reader to get a clear understanding of my perspective of this study, I will use this next section to talk about my biases and assumptions. It is important for the reader to know that I am a Latina and I identify as Mexican-American. I have a bachelor's degree in mathematics and during the time of this study I was completing a master's degree in mathematics education. As an undergraduate, I had the desire to pursue a doctoral degree in mathematics, but after I graduated with my bachelor's degree I decided that I did not want to continue in mathematics any further. I felt that I would be a better mathematics educator than a mathematician. When I entered the master's degree program at Purdue University, I immediately knew that I wanted to complete a thesis. I had many questions about why, as an undergraduate mathematics student, I did not see many Latina/o or African American mathematicians in the four years of my

undergraduate studies. I was curious about why race and ethnicity seemed to be ignored in mathematics departments. The most critical curiosity I had was why *I* decided to discontinue *my* studies in mathematics. This was how my research question came about.

Going into the study, I had assumed that finding participants would be difficult because, from my own experiences, the number of Latina/o mathematics majors, or bachelor's degree holders, is low across the country. Since "Latina/o" is a general term for any Hispanic person, I thought that there might be variances between the perspectives of students coming from different Latina/o subgroups. Third, I presumed that the experiences of any of the participants who attended a research university would be negative, but this was not the case. Last, I thought that all of the participants would have similar experiences as I did studying undergraduate mathematics, but that also was not the case.

Because of my own experiences in mathematics, I had many biases going into the study. First, when I was a mathematics major, I felt isolated because of my culture. I made many friends who were international students to accommodate my sense of not belonging. Second, I had experiences with my peers, in which, I was openly excluded from opportunities for collaboration and socialization. Third, I had experiences with my professors that I interpreted as negative and not meaningful, and in some cases emotionally harmful. Last, it was difficult being the first in my family to go to college and study mathematics, which was a subject that most members of my family were unfamiliar with. I remember my family not being able to understand my struggles, but often trying to. I also remember it being very difficult to discuss what I was learning with

them because sometimes mathematics is not easy to communicate to people who do not have a strong mathematics background.

In qualitative research, the relationship between the researcher and the participants is a sensitive issue to the research community (Merriam, 2009). While I did not know any of the participants going into the study, as an undergraduate, I attended the university that one of the participants attended. Since the participant was also a mathematics major, I was familiar with some of the professors, courses, and the structure of the mathematics department that was discussed during the interviews. When the participant described their experiences I had to set my own perspectives and memories aside to interpret the statements of the participant accurately. The participant completed a member check, which confirms that I was able to do this.

3.7 Conclusion

Since the purpose of this study is to investigate how Latina/o mathematics students view their interpersonal relationships, a qualitative study, using social constructivism as a theoretical framework, was most suitable for conducting this investigation. This study focuses on the perspectives of individual mathematics students' interpersonal relationships and, therefore, a multi-case study best allowed for a thorough exploration of such perspectives. The case studies were conducted using three interviews over the course of one year. This allowed for triangulation of the data and adequate engagement in the data collection. The interviews were stored and organized using Microsoft Excel. Each case was assigned an Excel workbook and the data was analyzed thoroughly in each workbook. The data from each case was then combined and streamlined to create a cross-case analysis. After the case analyses were completed, each

case was written up in Microsoft Word and was member checked by three of the four participants. I concluded the chapter with my biases and assumptions going into the study so that the reader can gain a better understanding of my personal perspective of the study.

CHAPTER 4. RESULTS

Each participant told unique stories about growing up as Latinas/os and enjoying mathematics from a young age. All the participants were recognized as being mathematically competent, dedicated to their education, and enjoyed being challenged by rigorous academics. They all demonstrated having a respect for their mathematics professors, enjoying the company of their peers in mathematics, and loving their families deeply. All of the participants spoke candidly about their family relations. Some had lost close family members and were eager to talk about the memories of their loved ones who had passed. Some had poor family relationships and opened up about those relationships in time. Some talked about their feelings about their relationships with their professors, their peers, or their families in ways that they had not been able to prior to participating in this study.

4.1 Case 1: Martina

At the time of this study, Martina was a typical college student. She was living away from home while she went to school and was in a Latina sorority. She was a second and third-year student at a university in the midwestern part of the United States. The idea of attending college was not foreign to this young Puerto Rican American woman. Her mother had a bachelor's degree in science and her father had an associate's degree in criminal justice. Both of her sisters were also in college at the time of this study.

Martina grew up living with her mother following her parents' divorce. While she was growing up, her mother worked for the department of human services in their county, then in social security administration. Her father was a police officer. On their free time, Martina's mother played soccer and her father enjoyed cooking and gardening and taught Martina how to cook. At the time of this study she felt that she had a much closer relationship with her mother than she did her father. Martina's mother was highly involved in her education, even going on college visits with her.

While Martina was growing up, she felt as though she was above average compared to her peers in mathematics. At home, she usually studied by herself, something she did throughout her school years. In middle school she was tracked into advanced mathematics classes. Because Martina's school had a high percentage of Latina/o students, she saw many of her Latina/o peers in these advanced mathematics classes. She remained in advanced mathematics classes through high school and earned college credit for Pre-Calculus. In high school, she was able to teach herself mathematics and would help her peers if they did not understand course material. She felt that she had good relationships with her mathematics teachers. They helped her get a summer internship, wrote letters of recommendation for her, talked to her about college and courses she should take. Since Martina always liked mathematics, she decided to study engineering in college, but later changed her major to mathematics.

4.1.1 Interactions with Mathematics Professors

Martina was very matter of fact when she described how she viewed her interactions with her professors, peers, and family members. She made it clear when she felt that her professors did not support her in the way that she needed. She also made it

known when they did, and she recognized and appreciated those professors. Martina often talked about her Calculus 3, Linear Algebra, Differential Equations and Abstract Algebra professors. Those four professors seemed to have had the most impact on her mathematical studies.

4.1.1.1 Getting to know Martina as a person

Martina enjoyed socializing with other people. This was especially true when others would respond to her by showing their desire to socialize also. For that reason, she seemed to appreciate having professors who were approachable and easy to talk to. Of the four professors that she mentioned, it was her Calculus 3 professor that she felt was not approachable. While most of Martina's professors were approachable, they were "all business" with her. She did not remember any of her professors asking her about her life outside of mathematics:

> V: Now did [your Differential Equations professor] ever know anything about you besides being a math student?
>
> Martina: Not too much. We would chat a little bit in her office hours, but it wasn't anything about family….We talked about little things that were still pertaining to math. I talked to her a couple times this year about what classes I should take. So, I don't want to say anything too personal….(rows 583 – 584).

> But they don't really ask. You know what I mean? The only reason I really talk to [my Abstract Algebra professor] a lot is because I go to her office hours so much, like, maybe two times a week. Sometimes we'll chat. I've talked to her a

> little bit, but nothing ever gets really personal or on a different level of communication besides math (row 606).

4.1.1.2 What about being Latina?

Martina asserted that cultural differences were at the heart of her discomfort with her professors. She stated that she was unsure if they knew that she was Puerto Rican American because she never discussed it with them. Martina seemed to pick up on the fact that her professors had little desire to get to know about her Puerto Rican American culture. Unfortunately, this may have shaped how she viewed her interactions with her professors. She remembered how her Calculus 3 professor exhibited his ignorance toward her as a Puerto Rican American individual:

> I don't know if I told you [that] I went into his office hours one time and he stopped me in the middle of the question, and was like “if you need me to speak to you in Spanish, I can do that” and I just looked at him, and I was like "Ok, [chuckles], um.” I kind of took offence to it because I'm not fluent in Spanish, so I feel like he was judging me a little bit because I wasn't really doing that well in the class and I feel like he thought that because I wasn't getting the information in Spanish that I wasn't doing well. So, I don't think his intentions were bad, but at the same time, I think he didn't know he came off that way (row 572).

4.1.1.3 “He would correct me and then work out the rest of the problem by himself.”

Feeling comfortable doing mathematics with her professors seemed to be very important to Martina. Therefore, she may have needed professors that made her feel confident with her mathematics ability. Martina stated that she felt good whenever she

got a positive reaction from her professors while doing mathematics. She said that she was content when she knew that her professors noticed her hard work and acknowledged when she had performed well in mathematics. She said that her Differential Equations professor wanted her to grow in her mathematics abilities and tried to make her feel confident:

> She is just really approachable all the way around, but when I go into her office hours, it doesn't feel like— I mean, sometimes it feels like someone is judging you because you don't know what you are doing, but it never feels like that with her….So, she just goes that extra step to make sure that you're comfortable and you know what you're doing (row 438).

Martina seemed to get conflicting messages about strategies for studying mathematics. On one hand, her Linear Algebra professor would take time to discuss how Martina understood mathematics problems and tried to teach her how to look at problems differently. On the other hand, her Calculus 3 professor did not seem to want to discuss her point of view on a problem:

> He would explain things and I thought that I would understand. I was like "oh, ok. I get it, I get it." And then I would ask if we could do an example problem, but if I were to try to work it out, he would correct me and then work out the rest of the problem by himself. So it really wasn't helpful at all. (row 261)

4.1.1.4 What Martina could do with a degree in mathematics

Martina seemed to feel the most comfortable with her Linear Algebra and Differential Equations professors. Because of that, she was able to learn more about what she could do with a degree in mathematics and develop healthy reasons for studying mathematics. Martina stated that she had an opportunity to discuss her future goals with her Differential Equations professor and this professor was eager to write a letter of recommendation for her. During their discussion, they talked about studying abroad and which mathematics classes she should take. Martina also discussed opportunities available to her through studying mathematics with her Linear Algebra professor. When Martina was still an engineering student, she spoke to him about majoring in mathematics:

> He was actually the person that I went to last year about a math degree. I asked him what was the procedure of changing the major. [I also] asked him what profession I could get into and what kind of classes I would have to take….I also contacted him about a letter of recommendation for a summer program (row 217).

4.1.1.5 Martina enjoyed mathematics and grew

Martina's professors seemed to have had a significant impact on her sentiments toward mathematics and her mathematical growth. While working with her Differential Equations professor, Martina stated that she felt excited and encouraged about doing mathematics. In fact, she stated "I feel like if I did not have a good professor, it would probably suck" (row 322). She seemed to believe that her professors had a strong influence on how she felt about mathematics.

Not only did her professors seem to influence how she felt about mathematics, it seemed that when Martina worked with her Linear Algebra and Differential Equations professors, she was able to grow. The manner in which her Linear Algebra professor guided her while doing mathematics suggests that he provided opportunities for Martina to grow mathematically. Also, Martina stated that when she visited her Differential Equations professor's office hours, she encouraged questions and would often go over topics Martina had not suggested. Unfortunately, however, her Calculus 3 professor did not display an attempt to help her grow mathematically, as demonstrated by Martina's description of how he solved mathematics problems in his office hours. Nevertheless, Martina explained how she was still able to learn Calculus 3:

> I went to [my Linear Algebra professor's] office hours about Calc 3 because I needed help with Calc 3 and my professor, he wasn't helping me much. So, I ended up talking to him. He was able to clarify some things for me….(row 217).

4.1.1.6 What we can conclude from Martina's interactions with her professors

Martina felt that she had relationships with some of her professors. Unfortunately, according to the definition of a Meaningful Relationship in Mathematics Education, Martina's professors did not recognize her as a sociocultural being because they did not seek to learn about her as a social being or as a cultural being. Her professors did attempt to foster her mathematics identity by making her feel mathematically capable, teaching her positive strategies for studying mathematics, and by helping her develop healthy reasons for studying mathematics. Nonetheless, they still fell short because they did not help her prepare for the constraints and struggles of being a mathematics student. Martina

seemed to recognize the deficiencies in the relationships that she had with her professors, but since she still had positive interactions with them, she did not let it discourage her from studying mathematics. It is possible that she noticed that even though her professors neglected to recognize her as a sociocultural being, most of her professor seemed open to having a relationship centered on mathematics with her.

4.1.2 Interactions with Her Peers in Mathematics

Being in a sorority, Martina was probably used to interacting socially with her peers, which was quite a contrast from the experiences she described having in mathematics. When she discussed her interactions with her peers in mathematics, she mentioned the difficulty of communicating with other mathematics students.

4.1.2.1 Her perspective on "relationships."

Throughout the course of the three interviews, Martina consistently stated that she did not have any "relationships" in her mathematics classes. She was probably sure that she did not have "relationships" with her peers in mathematics because she had developed her own personal definition of a relationship with her peers in mathematics. Her definition of "relationship" was based on what seemed to be her need to be recognized as a social being and her need for the development of her mathematics identity:

> V: You don't know. Ok. So if you could have any kind of relationship that you wanted with your peers in math, what would that look like?
>
> Martina: I feel like it would be a relationship where you could walk in class — I always picture it like high school. You walk in class and you could say "hi" to

> everyone because you know who they are and before the class starts you can't stop talking and the teacher has to "shush" you for you to be quiet. After class you'd walk out and be like "yeah, ok I'll see you later." You know, like that kind of relationship (rows 467-468).
>
> V: Ok, so, if you had a relationship based on mathematics with your peers, what would a strong relationship look like to you, in that respect, based on mathematics?
> Martina: I'd probably say forming our own kind of study group together. [I would want to be] able to call or text someone knowing that they'll be able to help you with your homework or if you have a question that they'll understand (rows 471-472).

4.1.2.2 They hardly knew anything about Martina

Unfortunately, Martina's description of the ideal relationship she would like to have with her peers seemed far from her reality**.** She mentioned that when she was in her Calculus 3 course, she did not talk to anyone. One young lady was an acquaintance of hers and they acknowledged each other in passing. In her Differential Equations course, she had conversations with a woman while working on a class project with her. Martina described the discussions she had with this student:

> One of the girls, she lives off campus, and she's a lot older than all of us and she has a child. We talked about that. I have a niece, so we were talking about their ages. We [also] talked about her job because she sells cars and about things other than math and our class (row 416).

4.1.2.3 "They knew that I could contribute."

Even though Martina seemed confident in her mathematics abilities, she said, "I'm really confident in my mathematics abilities when I'm not around peers that are in my class" (row 736). When she discussed working with her peers, she never indicated that she actually felt mathematically incompetent. She only mentioned the potential for her to feel that way. Martina provided two examples of working with her peers on mathematics. In her Differential Equations class, she had two assignments that she was to do with her peers. The first group consisted of all males except for her. She stated that when she was working with this group they did not encourage her to have positive beliefs about her mathematics abilities:

> I don't think the math was a problem. I wasn't intimidated by the math or anything. I thought I did that perfectly fine. I'm really comfortable doing that. But when it came to working with them *and* the math, I felt like I didn't know what I was talking about because they knew so much more. But, I was able to solve problems and do everything just like they could (row 372).

> If I didn't understand my portion, I felt awful and uneducated because I didn't really know what I was supposed to be doing as opposed to what they did. They knew what they were supposed to be doing and I didn't.…(row 374)

The second group of peers was made up of all females. Her description of her experience working with this group was quite different than her experience with the all male group:

> It was a way better experience….I felt like I contributed a lot with the project and I knew what I was talking about….I feel like if they gave me a responsibility, I felt like they trusted me a lot more and they knew that I could contribute, as opposed to the other group (rows 386, 396).

4.1.2.4 Tools for successfully studying mathematics

Martina did not seem to be used to working with her peers on mathematics, but she demonstrated knowing that collaboration was a productive study strategy. In Abstract Algebra she shared her struggles with another student. After that, Martina and her classmate worked together on course material. It seemed as though Martina thought of collaboration as a tool for studying mathematics. This may be why she was bothered that her first Differential Equations group did not seem to care about working with her, but she appreciated the inclusive team working environment of the second group. Martina was able to work on mathematics and discuss strategies for successfully completing her degree in mathematics:

> I asked them for advice because I know that next semester I'll probably have to take Real Analysis and Abstract Algebra. Well, in the future I will. I don't know if I'll take both of them next semester. But, I asked them their take on it and what professors they had and what they thought of the class (row 418).

4.1.2.5 What we can conclude about Martina's interactions with her peers

Martina's interactions with her peers seemed to be very limited. She mentioned not socializing much with them. They also did not get know her as a Puerto Rican American woman. When Martina described working on mathematics with her peers, she

remembered two different situations. In those situations, she described experiencing feelings of being mathematically capable and incapable. Martina said that she learned to be more aggressive in her pursuit of meaningful relationships from those experiences. It is possible that to Martina, the relationships that she had with her peers, whether they were negative or positive, were results of her own actions.

4.1.3 Her Interactions with Her Family

When Martina began to discuss her family, it sounded as though her strongest relationships were with her mother and her sisters. She seemed to feel that her immediate family tried to understand her as a mathematics student more than her extended family. Martina often compared and contrasted the interactions she had with both groups of family members.

4.1.3.1 Even if Martina tried to explain it, they still would not understand

Martina made it apparent that she felt that no one in her family understood what it was like to be a mathematics student. She said that she had tried to tell her sisters about her experiences in mathematics, but they did not seem to really understand. Martina also felt that members of her extended family were not interested in what her life was like as a mathematics student. The only member of Martina's family that seemed to show some interest in her as a mathematics student was her mother. Martina expressed her response to her family's general lack of concern for her as a mathematics student:

> V: Okay. Can you tell me about a time that members of your family actually tried to understand what you are going through?

> Martina: No not really. When I go home, the furthest that I talk to my family about it is like, “oh, how are you doing in school?” “Oh I’m doing good.” And that’s really it. That’s like the furthest the conversation will ever go.
>
> V: And what do you think about that?
>
> Martina: I don’t really mind it just because when I go home I don’t want to think about school, especially on my break, but at the same time I feel like even if they did ask, and I tried explaining it to them, they still wouldn’t understand. So, I just don’t really care (rows 681-684).

4.1.3.2 Martina was a “nerd” A.K.A. “smart.”

Martina seemed confident in her own mathematics ability. She stated several times that she felt that her mathematics ability exceeded that of other members of her family. She could tell that her immediate family also thought highly of her mathematical competence. Her interactions with her sisters were an indication to her that they felt that she was skilled in mathematics:

> I mean they call me a nerd and stuff because I like math, but I have a feeling that they know that I'm intelligent. They know I'm smart, but they don't really say anything besides calling me a nerd to justify what they think (row 646).

Martina, unfortunately, did not seem to feel that members of her extended family felt that she was mathematically competent. She told a story about how her aunt’s disbelief that she could become valedictorian of her class:

> I think they're kind of amazed…. [Being the valedictorian] was my dream in high school. I remember telling my aunt, one time, "I want to be number one. I want to be the valedictorian" and she laughed at me. She was like, "[chuckles] ok, yeah, you can do that!" I don't think my family really knew that I was smart. They didn't know I was good at school. When I ended up being the valedictorian, she was like, "I can't believe you did it." I was like "did you think I was stupid?" So, now, when I tell people I'm majoring in mathematics, they still get amazed, like they don't believe it. They don't understand (row 644).

4.1.3.3 "You're the one that pays for your college, so it's your decision."

Martina gave the impression that she was most disappointed in the fact that her family did not understand the importance of mathematical knowledge. She could tell that her family did not understand the importance of mathematics because they suggested that being a teacher was the only career that they could think of that a person with a degree in mathematics could have. She had to tell them there were more opportunities for her. Martina did not know how her parents, in particular, felt about the importance of mathematical knowledge. It is possible that her parents did not have memorable conversations with her about the importance of mathematics or the opportunities available for her through studying mathematics. Martina's testimony about her mother's reaction to her decision to change her major to mathematics was a manifestation of what her family understood about the importance of mathematical knowledge:

> My first semester in college, I was originally a mechanical engineering major because I really liked math. When I decided that I wanted to switch my major, I

> did it myself. I didn't ask my parents approval. I called my mom and I said, "Mom, I changed my major" and she said, [in a suspicious sounding tone] "to what?" She was nervous to see what I changed it to. I was like, "um, math" and she was like, "why? What are you going to do?" I was like, "I don't know. I just don't like engineering and I enjoy my math classes, so I'm going to switch to a math major." She was just, like, "okay. Well, I mean, it's your decision. You're the one —" I mean I pay for my school, so she said "you're the one that pays for your college, so it's your decision" (row 686).

4.1.3.4 Her mother was her "woosah."

Martina implied that she felt that members of her family did not realize how difficult it was for her to study mathematics. While her mother never studied mathematics to the extent that she did, Martina felt that her mother was the only person who actually tried to understand aspects of her life as a mathematics student. She called her mother her "woosah," which is a term in popular culture that is used to refer to something as a relaxation mechanism:

> She's my supporter….she was in college, she graduated, she has her bachelor's degree, and she knows studying for ten hours straight probably isn't a really good idea. If you're frustrated with something at some point, it's not going to get better in the next twenty minutes. So, she definitely encourages me to take some time for myself. She's kind of like my "woosah" basically. She's the person that, ironically, relaxes me while I'm away at school (row 672).

On the other hand, her sisters did not seem to try to understand her as a mathematics student. She felt that they did not take her struggles seriously and that they expressed that they did not believe that she actually had struggles. She felt that because they did not study subjects that are mathematics based, they did not understand nor attempt to understand the mathematics culture that she was a part of:

> Martina: My sisters would be the only other example that I have. I'll call one of them and talk to them and say, "oh I just took this exam. I probably failed it." But they just joke with me about it because they don't really think that I failed the exam because they all know that I'm not that type of person. I wouldn't go into an exam oblivious as to what's going to happen or what's going to be on it. But, they are just like, "oh, you got it dude! Like, you're okay, whatever!"
>
> V: So you feel like maybe they don't completely understand your struggles?
>
> Martina: Yeah. I don't think they understand it for one, where they are studying, it's a community college back home, so it's not as tough as a four-year university. On top of that, what they are studying is probably— whatever classes they are taking may not— I don't want to say they are not more difficult than the classes that I'm taking, but to me they seem that way (rows 673-675).

4.1.3.5 What we can conclude from Martina's interactions with her family

Martina's interactions with her family involving mathematics seemed to be less meaningful than her interactions with her peers or her professors. She felt that her family did not understand her life as a mathematics student nor did they attempt to understand the mathematics culture. Thus, they did not recognize her as a sociocultural being.

Likewise, she felt that her family did not understand the importance of mathematical knowledge or what opportunities were available to her through studying mathematics. Members of her family, with the exception of her mother, did not understand the struggles that she had as a mathematics student, nor did they seem to care. Only her immediate family seemed to give her the impression that they felt that she was good at mathematics. Her extended family suggested the opposite to her. It is possible that because of how she perceived the interactions that she had with her family, she did not really care to involve her family in her life as a mathematics student.

4.1.4 Conclusion to Martina's Case

In examining Martina's interactions with the three groups of people in her life — her mathematics professors, her peers in mathematics, and her family, we can conclude that Martina's relationships with each group was deficient according to MRIME. Her professors did not get to know about her life outside of mathematics nor did they acknowledge that she was Puerto Rican American. Therefore, they did not recognize her as a sociocultural being. Her professors, with the exception of her Calculus 3 professor, attempted to foster her mathematics identity. They made her feel like she was mathematically capable, they taught her about the importance of mathematical knowledge and what opportunities were available to her, and they taught her sound strategies for studying mathematics.

A few of her peers attempted to get to know about her life outside of mathematics, however, Martina never mentioned that they tried to understand about her Puerto Rican American background. Martina seemed to learn the importance of collaboration in mathematics by studying with her peers. When she had negative experiences working

with her peers on mathematics, she did not let them discourage her about her skills. Instead, when she had positive experiences, she allowed her peers to build her up. Martina was very realistic about her sense of belonging in mathematics which she described studying with her peers. For Martina, her peers seemed to be the weakest in recognizing her as a sociocultural being. But unbeknownst to them, they helped her develop certain aspects of her mathematics identity.

Martina's interactions with her family seemed to be the most negative. She struggled because her family could not understand her life as a mathematics student and, to her, they did not try to. Most of her family felt that she was skilled in mathematics and she felt that they were, essentially, helping her develop positive beliefs about her mathematics abilities. Martina felt that her family did not understand the importance of mathematical knowledge and, therefore, could not understand why she chose to major in mathematics. Martina felt that her family did not understand the struggles that she had as a mathematics major. She seemed appreciative of the fact that her mother attempted to support her by calming her down when she felt stressed.

Even though Martina seemed to know that her relationships were lacking, she persisted in mathematics. She never mentioned changing her major or not liking mathematics. In fact, it seemed that she wanted to continue in her degree with intentions of developing more meaningful relationships. Because Martina had not yet completed her degree in mathematics during the time of this study, without pursuing that information, it is impossible to know if she would have actually continued in mathematics.

4.2 Case 2: Sandy

Sandy was a woman in her thirties at the time of this study. She was a non-traditional student because she had gone back to school in her early thirties. During the time of this study she was living in the southwestern part of the country and was in the process of graduating with her master's degree in mathematics from a research university that was a forty-five minute drive from her home. She identified as racially mixed because her father was of German descent and her mother was of Cuban descent. She grew up being closer to her mother's family and, therefore, spent most of her life around the Cuban-American culture and was bilingual. She grew up in a neighborhood that had a small population of Latinas/os.

While Sandy was growing up, her mother was an insurance claims adjuster and her father worked for the cargo unit at the airlines. During those years, she remembered taking family trips and being very active outdoors. Her mother enjoyed crocheting and even attempted to teach her how to crochet a few times. Often Sandy and her family would play dominoes or canasta. When she was young she played softball and her father taught her how to pitch. She remembered him talking to her about angle, velocity, arc on the pitch and some geometry in ways that she could understand.

Both of her parents enjoyed and appreciated mathematics, which rubbed off on her as a student. Growing up, Sandy felt that she was a very capable mathematics student. In middle school she was placed in advanced mathematics courses, even though she really was not excited about mathematics. In high school, one of her teachers recognized her mathematics abilities and suggested that she join a school wide mathematics competition, which she did not for personal reasons. However, his suggestion built her

confidence in her mathematics ability. Sandy did not study mathematics with any of her classmates in school or even as undergraduate student.

Immediately after high school, she chose to attend a small private school that was close to her home. Due to financial circumstances, however, she was unable to continue at that school and did not return to her degree for several years. When she did go back to school she wanted to be a pilot, so she studied aeronautics. That is when she found that she really enjoyed mathematics and with the encouragement of her late husband, she decided to study that instead. She completed a bachelor's degree in mathematics and went on to complete a master's degree. When Sandy's parents were younger they had attended college, but were never able to finish. This made Sandy the first person in her family to graduate from college. After getting a bachelors degree, she started working for the U.S. Geological Survey.

4.2.1 Interactions with Mathematics Professors

Because Sandy was in graduate school, completing her master's degree during the time of this study, she often talked about her experiences as an undergraduate and as a graduate student. After she finished her bachelor's degree, she attended the same school to finish a master's degree. She had two professors that she talked about the most. Sandy often talked about her Calculus professor when she was an undergraduate and her Linear Algebra professor, who later became her thesis advisor when she was in graduate school.

4.2.1.1 Getting to know about Sandy as a person

As an undergraduate student, her Linear Algebra professor encouraged her to participate in a summer Research Experience for Undergraduates (REU). It was during

that time that he was able to get to know about her life outside of mathematics. One element of the REU included hikes that the participants and professors would go on together. It was then that she and her Linear Algebra professor learned about each other's hobbies, interests, and life outside of mathematics. He met her husband and she met his wife and children. She talked about this experience:

> They would take us on weekly hikes around the area, either him, or one of the other professors. Sometimes you're on a hike and you start to get to know each other a little bit better. I met his kids and his wife and we'd talk more about interests outside of school. On one of the hikes, me and my husband took care of his kids for him while he wanted to go hike up a little farther. The kids were getting tired, so we were happy to hang back with the kids because we had already gone up and come back. We watched his and another professor's kids for about a half hour while they hiked up a little bit further and the kids were playing in the creek there (row 250).

4.2.1.2 Her professors being "color-blind"

When it came to being Cuban-American, Sandy expressed that she had a great deal of pride in her culture. For that reason, she said she wished more people knew that she was Cuban-American. It seemed as though her professors took a more "color-blind" approach to teaching her mathematics in that they did not incorporate race, ethnicity or culture in the way that they presented mathematics. Even though none of them knew that she was Latina, except for her Linear Algebra professor, they did not tell her about any Latina/o mathematicians or about anything in mathematics that was related to her culture.

She stated that her Linear Algebra professor was one of the only professors who knew that she was Cuban-American. He did not, however, acknowledge that she was Latina to develop her sense of belonging in mathematics when she was a graduate student:

> V: Now do you recall your undergraduate professors, any mathematics professor, talking to you about any Latino mathematicians that they may have known about or anything that is mathematically related to the Latino culture?
>
> Sandy: No.
>
> V: What do you think about that?
>
> Sandy: I'm not really sure what I think about it. I guess it's a shame. Especially [this state in the southwestern part of the U.S.] does have a huge Latino population. But not a single one of my professors at the school are Hispanic or have any Hispanic background. So, you find that a shame but I guess not surprising.
>
> V: Now, what about in graduate school?
>
> Sandy: In graduate school I actually met a few visiting mathematicians. There was a couple from Argentina who had come to work with one of my professors to collaborate on a project together…
>
> V: Do you remember that your professor — that maybe he took a special interest in you because you are Hispanic and he wanted you to meet these other professors or did you know about these professors on your own?
>
> Sandy: No, it was more they had a reception and he just was introducing them around. So, no it wasn't in particular me that he went out of his way to introduce them to me or anything (rows 528-535).

4.2.1.3 Why mathematics is important and why she should study it

As an undergraduate, Sandy attributed her attraction to mathematics to her Calculus professor. He taught her the importance of mathematical knowledge by providing application examples that she found very interesting. She would read the text book before class because she found it interesting. It was because of his class that Sandy decided to major in mathematics. This Calculus professor taught her the importance of mathematics, but also seemed to provide her with a healthy reason for studying mathematics, which was because she simply enjoyed it:

> The professor was very good. You know, he's older, I think getting ready to retire, but he just presented it in such a way that it all made perfect sense. The examples that he would give us— the applications that he would give us for using the Calculus— it was just a very interesting course for me. And I would find myself reading the text book ahead before a lecture. I just really enjoyed it (row 186).

4.2.1.4 Planting the seed

When Sandy got a little further along in mathematics, her Linear Algebra professor approached her about doing research as an undergraduate. He explained the benefit of doing research to her. She was a little reluctant at first, because research in mathematics seemed intimidating to her, but he planted the seed in her mind. She later decided to do research by participating in the REU. This professor encouraged her to go to graduate school. He also helped her to get an internship that later became a permanent

job. She explains how this professor attempted to inform her about opportunities for success in mathematics:

> That first semester he had come up to me and said that I should do some research as an undergrad and that he'd be happy to do some with me. He told me that there were other opportunities that I could do: independent study, that there are summer internships out there, that I had all kinds of opportunities, and that definitely I should do some sort of research as an undergraduate. [He told me] that these days that was really highly sought after by employers and grad schools and that sort of thing. And so he kind of put the thought in my mind, but, I figured I had time and didn't do anything right away. Then I wound up taking a couple other classes with him and, as I said, he was my advisor, so we kept in contact. I would still see him around all the time and he would ask me—he asked me a couple of times after that if I had thought of it. I didn't know where to go from there and he said I should do research but I wasn't really sure at the time what it meant, or where to start, or anything like that. When he approached me again about it, I asked him, "well, how does it work? What should I do?" So, he explained the options, that I could do research as a three credit course…instead of one of my regular classes, or he also told me that there was going to be that REU opportunity…(row 220).

4.2.1.5 Feeling confident about her mathematics ability

Sandy seemed to have plenty of confidence in her mathematics ability. Part of this may be due to her interactions with her professors. When talking about her Calculus professor, she stated that he never made her feel bad about not knowing something

whenever they were doing mathematics. Her Linear Algebra professor made her feel like she was mathematically competent because he approached her a few times to suggest that she do research as an undergraduate student. The fact that he felt that she was capable of doing research gave her the confidence to go to graduate school. He also recommended that she go to graduate school because he thought she would be a strong candidate. Later, he assured Sandy she would be successful at getting a PhD in mathematics as well. It seemed as though her Linear Algebra professor attempted to foster her beliefs about her own mathematics ability:

> V: You said that he approached you and he kept approaching you about doing research?
>
> Sandy: Uh huh.
>
> V: How did that make you feel?
>
> Sandy: Oh! Again, it made me feel really good. It definitely made me feel—I recognized that he thought I would be good at something like that because the idea of research sounds very intimidating (rows 223 - 226).

The fact that he felt that she was capable of doing research gave her confidence to go to graduate school: “He explained that whole thing a little bit better to me, which really affected a lot of things. It affected my confidence in going to grad school because the idea of research wasn’t so scary anymore” (row 234). Not only did he give her confidence to go to graduate school, but he also suggested that she go to graduate school: “He had recommended I go. He thought that I was a strong candidate and that it would be a shame if I just stopped with my bachelor’s degree” (row 258). Later, he suggested

that she get a PhD in mathematics as well: “A lot of students find it hard going on to do PhD work, but he thought that with my style of learning he said that he thought that I could be very successful at it” (row 286).

4.2.1.6 Sandy grew mathematically and felt like she belonged in mathematics

As a result of her interactions with her professors, Sandy grew mathematically. She learned Calculus because she felt that her professor presented it in a way that made perfect sense to her:

> V: Ok, can you explain, like can you describe what it was like going to his office hours?
>
> Sandy: I guess it was intimidating the first few times because it’s always scary to admit you don’t know something, especially in a class where you want to get a good grade and convince them that you understand everything entirely….He was really laid back and welcoming. [He] never made me feel like I should have known something that I didn’t. He was really good at guiding me without giving me any answers and without confusing me even more with his explanations (rows 185 – 186).

Also, she felt like a mathematician because she was able to do research as an undergraduate. This is a result of her Linear Algebra professor suggesting that she participate in the REU:

> Up until then I had always taken a class [in which I was supposed to] attend a lecture, take notes, do [my] homework, take a test, and it didn't really feel that much different than other experiences in high school, it’s just more difficult

> material. But with this experience, I had no idea what it meant to do research in math…. The idea of being able to do that seems crazy [chuckles]! You know, since so many people have been doing math for thousands of years, how could there be things that people haven't discovered that I could do [chuckles]? And so, to do this I think definitely made me realize what it was to do research in math…. It gave me an idea of what it meant to actually do research and what it meant to solve problems that people haven't solved before.… So, it definitely—being in the computer lab and getting results and having to think about the results and compile them into paper with diagrams explaining everything. And then we had to also present our findings at a couple of conferences we did talks presenting our findings. I definitely felt like a mathematician (row 430).

4.2.1.7 What we can conclude from Sandy's interactions with her professors

Sandy's interactions with her professors indicate that they recognized her as a sociocultural being and attempted to help her develop a positive mathematics identity according to MRIME. Her professors seemed to have made an effort to acknowledge her need for social interaction and learn about her life outside of mathematics. They seemed to disregard, however, her Cuban-American background. When mathematics professors from Argentina visited the school, her mathematics professors did not attempt to embrace her Latina culture by making it a point to introduce her to Latina/o mathematicians.

Her professors helped her develop a positive mathematics identity. They taught her the importance of mathematical knowledge, they gave her healthy reasons for studying mathematics, they presented her with multiple opportunities for her to be

successful in mathematics, and they made her feel that she was mathematically capable. Because of that, she grew mathematically and she felt a part of the mathematics culture. Sandy perceived the relationship as meaningful and it did not seem to bother her that her professors disregarded her Latina background.

4.2.2 Interactions with Her Peers in Mathematics

Sandy mentioned that she usually kept to herself when it came to studying mathematics. When talking about her mathematical background she stated that she often studied alone. As an undergraduate, she did not spend much time on campus and, therefore, did not get to know many other undergraduate students. Her experience in the REU changed that and prepared her for her experiences in graduate school.

4.2.2.1 Her “friendships” in mathematics

When talking about her interactions with her peers, she used the word "friends" to describe those interactions. When she became a graduate student she made good friends with several students. She felt that the relationships that she had with her peers had a great influence on her. Unfortunately, since she lived far away from campus it was more difficult for her to have a social relationship with her peers. Like Martina, she seemed to have had her own personal definition of what the ideal relationship with her peers would look like:

> It would be nice to have the sort of relationship where you did work together and help each other out with research problems and that sort of thing, but also would have the ability to have a social life together too [chuckles].… Other than what

> kind of relationship I already did have with them, I think it would be more of a social relationship as well (row 470).

4.2.2.2 Having a social life

As an undergraduate, when she was in the REU, she said that she often went to lunch with a group of students. They got to know about her boyfriend, her dogs, or what she did over the weekend. One of her friends even met her grandmother. Other than that, her peers did not seem to know a great deal about her life outside of mathematics and she did not spend much time socially with her peers. As a graduate student things began to change. Sandy made friends with three of the students in her classes. They would get together outside of class to have lunch and get to know each other. Sometimes she and her friends would meet to have coffee and talk about classes, things they saw in the news, or classes that they were teaching. She made one really good friend:

> It was really great to get to know her and to have that connection. I would say of both my undergraduate and graduate experiences, she's the person that I connected with more than anyone. We still get together at least a couple times a week to hang out. It definitely was a nice experience, especially in the last couple of years she's been a great support for me (row 553).

4.2.2.3 Proud of being Cuban-American

As previously noted, Sandy was proud to be Cuban-American. Her experiences with her peers regarding her heritage were different than her experiences with her professors. For example, when she was in the REU, one of her friends met her grandmother who had a very heavy Spanish accent. Because of that, she felt that he knew

that she was Cuban-American. She alluded to the fact that she talked very briefly to him about her Cuban-American culture, but they did not go in depth about it. When Sandy was in graduate school, she and another friend would often discuss their cultural backgrounds:

> V: Now, did they know anything about your culture?
>
> Sandy: Yeah, especially one friend of mine in particular. She's from Indonesia and so we've talked a lot about our respective cultures and how things are a bit different than what we experienced growing up sometimes (rows 548-549).

4.2.2.4 Learning to collaborate

Sandy stated that she liked doing the REU because it taught her a fundamental strategy for studying mathematics — how to do mathematics with others. While participating in the REU , she had to collaborate on projects with her peers. As a result, she was able to grow mathematically because she learned how to communicate with other students and collaborate better. For her particular project that summer, she had to work with a partner. She said that she learned from working with that student:

> V: Okay, so do you think that studying with her helped you to think mathematically?
>
> Sandy: I'm not sure if I'd say that it helped me to think mathematically. No, I don't think so. But, it definitely helped me learn to communicate with other students better and to collaborate better--
>
> V: Okay--

> Sandy: As an undergrad I rarely worked with other students. I pretty much did everything on my own, but I think because of this experience, as a grad student, it definitely helped me. I found as a grad student it's just impossible to do it on your own. Having that experience helped me be more comfortable with people as a grad student.
>
> V: Okay, so you don't think that working with her helped you to grow mathematically?
>
> Sandy: I mean the whole experience absolutely. Working with her in particular, yes. [It] helped me to grow mathematically, yes. I just wouldn't say that it changed my way of thinking mathematically, necessarily (rows 419 – 424).

As a graduate student she continued to grow mathematically as a result of working with her peers in mathematics. In graduate school, she formed a study group with students in her classes. They would work on mathematics at school or each other's homes. She stated that she had close relationships with some of her peers, who she would contact if she needed help with mathematics. She explained how she grew mathematically because of her interactions with her peers in graduate school:

> I would say that I learned more about mathematics sometimes working in a group because somebody else could explain something to me that I either wasn't aware of or didn't have as deep of an understanding as they did. And vice versa, I would have a proof done a different way and explain it to them. I'd say it helped deepen my understanding of math… (row 452).

4.2.2.5 What we can conclude from Sandy's interactions with her peers

Unlike Martina, Sandy described the interactions that she had with her peers as friendships. These friendships developed more in her graduate years than in undergraduate years. She talked about having lunch with her friends and getting to know them better. One friend of hers, in particular, got to know Sandy as a cultural being through discussions about their respective cultures. According to MRIME, especially as a graduate student, her peers recognized her as a sociocultural being.

Since Sandy was an older student who was married and lived off-campus, she was unable to study mathematics with her peers as an undergraduate student. It was not until the REU that she had such an experience. Studying with her peers at that time seemed to help her to prepare for graduate school. In graduate school, she learned that she needed to collaborate with her peers in order to be successful and that seemed to benefit her. To Sandy, it is possible that the social aspect of getting to know her peers and learning to work on mathematics with her peers was influential. Even though, according to the definition of a Meaningful Relationship in Mathematics Education, her relationship with her peers was deficient, Sandy perceived it as meaningful. She saw her relationship with peers as as supportive in and out of mathematics.

4.2.3 Her Interactions with Her Family

Sandy spoke very highly of her family and their appreciation for mathematics. Her parents may have played a role in her enthusiasm for mathematics when she was younger. As an adult, her husband and her sisters seemed to be influences on her in mathematics.

4.2.3.1 Her husband's interest in her life as a mathematics student

She often talked about how her husband was supportive of her studies in mathematics. Sandy said that she and her husband often discussed her life as a mathematics student. When she would come home from school they would talk about things that she was learning in class or problems that she was working on. Her husband was very interested in discussing mathematics because he appreciated it as well. In fact, he wanted to go back to school to get a second degree in physics because he really enjoyed mathematics. In discussing her experiences in mathematics with her husband, she also discussed her struggles:

> V: Do you remember him trying to understand your experiences?
>
> Sandy: Oh, absolutely. Sometimes I was able to explain it in such a way that he got it and sometimes I was not. It was just one of those things where he just didn't have enough of a background for me to entirely explain things. But, he was always interested in trying to understand problems that I was having and giving his perspective. And he often did understand them.

4.2.3.2 Her family knows the importance of mathematical knowledge

Sandy stated that her sisters felt that mathematics is important. She said that they told their children about the importance of mathematics and the career opportunities that were available for people studying mathematics. In fact, they used Sandy's career as an example. Sandy believed that her family as a whole had always put a lot of importance on mathematics:

V: Okay. So now can you tell me what you think that members of your family believe about the importance of mathematics?

Sandy: I had conversations with my sisters and my dad. I'd say that my whole family has always put a lot of importance in it. I'd say my dad was definitely a big influence there. My mom was always naturally gifted at mathematics, but my dad was one of those who didn't necessarily get it at first, but he would try and try and try and try until he understood it finally. My sisters both have kids now and we've often talked about —they'll say that their kids will come home and complain about well, like "why do I even need to know this stuff?" I know they find it very important and will explain to the kids that "sometimes even if you don't think that you're specifically using this, it's still problem-solving and critical thinking aspects that you get out of it" (rows 606- 607).

4.2.3.3 Getting encouragement from her husband

Sandy's husband wanted her to pursue a field that interested her and made her happy. She felt that he was very supportive of her studying mathematics. Her husband had suggested that she see how much she liked mathematics and encouraged her to study if she liked it. Sandy said that it was because of his support that she decided to major in mathematics and to get a master's degree in mathematics:

V: Yeah, do you remember discussing your reasons for studying mathematics with him?

Sandy: Yeah absolutely. When I decided to change my major to math, at the time I was studying aeronautics and of course that's interesting. I came home and I

> would have my homework that I had to do every day and every day it was my Calculus homework that I looked forward to doing. That's the first thing I'd do because I would look forward to it and then I would do the rest of the homework because I had to. After doing that for a month and realizing that that was the one class that I really looked forward to going to everyday and the one class that I really looked forward to actually doing my homework, he actually suggested that I take more math classes and see how I liked it. He was a big part of me deciding to change my major to math. Because he was definitely one who was big into studying what interests you more than anything else, not necessarily something that you thought was going to get you a job. I mean, that's good if that's a side effect of it. He thought that I should just study what fascinates me and I agreed so I changed my major (row 643).

4.2.3.4 Knowing that her family is proud of her

Sandy seemed to be very confident in her mathematics ability. Along with her professors expressing that they felt that she was mathematically capable, her family did as well. Sandy knew that her husband was proud of her mathematics ability because he bragged about her to his family and friends. Her sisters used her as an example for their children and she helped their children with their mathematics homework. Her father told her that he was very proud of her:

> V: Okay, so can you discuss how members of your family feel about your mathematics ability?

> Sandy: Well, I know my dad is very proud, he's told me. He likes to tell me how proud he is about it and every now and again he'll find one of his old textbooks. He just found an old textbook about a couple weeks ago and some of his old papers that he has written and he was very excited to talk to me about some work he had done back when he was in college. I know that that's how my parents feel, definitely proud. They definitely respect what I do…(rows 612-613).

4.2.3.5 What we can conclude from Sandy's interactions with her family

Sandy's family seemed to make great efforts to try to understand her as a mathematics student. Her discussions with her husband and her sisters are evidence of that. Her husband even went as far as discussing mathematics problems with her. This shows that they recognized her as a sociocultural being. Her family seemed to understand the importance of having mathematical knowledge and the opportunities that one could have by studying mathematics. Since she grew up having this understanding, she was able to appreciate mathematic. Sandy's family made her feel like she was mathematically competent because they verbally expressed how proud they were of her. Sandy's husband wanted her to study mathematics for the right reasons, which is for enjoyment.

While she had a strong relationship with her family centered on mathematics, it was lacking in that she felt that she was not able to fully grow mathematically with them because her family did not have the same mathematics background that she did. Even though this relationship was not perfect, according to the definition of MRIME, it seemed that to Sandy it was meaningful and fulfilling.

4.2.4 Conclusion to Sandy's Case

Sandy seemed to have had meaningful relationships in her mathematics experience. Her relationships with her professors, her peers, and her family helped her develop her mathematics identity and provided support for her as a sociocultural being. All of her relationships seemed to have had positive effects on her attitude toward mathematics. In fact, she stated that if her life situation was different, she would have continued in mathematics. Nevertheless, it seemed that her relationship with each individual party (i.e. peers, professors, family) lacked in some way. For example, her professors did not recognize her as a cultural being, her peers did not fully foster her mathematics identity, and she could not grow to her full potential mathematically with her family. Despite their imperfections individually, the relationships that she had worked in harmony so that Sandy perceived that she had positive meaningful relationships in her mathematics educational experience. Where one relationship was deficient another relationship picked up the slack, in a sense. With these relationships working together, Sandy was able to have a positive relationship with mathematics.

4.3 Case 3: José

Growing up in a big city in the midwestern part of the United States, José had somewhat of a unique experience in school. At the time of this study he was attending a highly diverse, research intensive university in the heart of that big city. His university served the large urban community that surrounded it. Because of his university's dedication to the local community, when he was in middle school, José was given the opportunity to study mathematics more intensely than most children his age. Due to this experience, he developed a desire to major in mathematics in college.

José was raised by his mother, whose ethnic background came from a mixture of Irish, Black, and Native American. His father, who had passed away when he was a young child, was born in Puerto Rico. José most identified with his father's ethnicity and was very proud to be Puerto Rican American. While both of his parents graduated from high school, his father did not go to college. José, however, grew up knowing that his father was very intelligent and was known for his mathematical skills. His mother attended college later in life and completed a bachelor's degree and master's degree in social work. José remembered his mother being in school for many years of his childhood. His mother's dedication to her education influenced José to go to graduate school.

José attended an elementary school that had a high population of African-American students. He remembered being good at mathematics in elementary school and he felt that he was the highest performing student in his classes. José remembered helping many of his classmates in mathematics, which would continue throughout college. He attended the same school for middle school and continued to excel in mathematics. In the sixth grade, José remembered many of his peers not caring about mathematics, until he joined a special mathematics summer program led by the university that he later attended. In this summer program he met many children his age and older from around the city who also enjoyed mathematics. Being in the summer program encouraged him to enjoy mathematics and to think more deeply about mathematics. Every summer José participated in this program until he graduated from high school. It was during this time that mathematics became his favorite subject in school.

José was accepted into one of the most respected college preparatory high schools in his city. There he took Advanced Placement Calculus and continue to participate in the

mathematics summer program. José's mother passed away when he was a senior. Because of his mother's influence on his life, José decided to major in mathematics. José felt comfortable attending the university that the summer program took place at because the program instructors were university professors. The university was also his mother's Alma Mater. During the course of our interviews, José was a second and third-year student.

4.3.1 Interactions with Mathematics Professors

José often talked about his Calculus 2 professor, who was an instructor in the summer program that José was a part of for many years, and his Calculus 3 professor. He seemed to have had different experiences with each of these professors, but his Calculus 2 professor seemed to be the most influential to his study of mathematics.

4.3.1.1 José's perspective on "relationships."

When discussing his professors**,** José confidently stated that he had relationships with them. José felt that he was very close to his Calculus 2 professor. He often went to his office hours, but not to discuss mathematics. His Calculus 2 professor would check on José after class to make sure that his home life did not affect his schoolwork. While other professors had known things about his life outside of mathematics, José seemed to feel the most comfortable with him:

> So he would sometimes pull me aside after class and everything and ask "is everything ok?" First he would ask me if outside life is affecting the class life. If something was going on, I would talk about it (row 212).

> He's always been like a father figure to me. He was my first teacher through [the mathematics summer program] and I've known him since seventh grade. He's always able to tell if something's troubling me. I've always been comfortable talking with him (row 224).

4.3.1.2 Embracing his Puerto Rican American heritage and life outside of mathematics

José seemed to be proud of his Puerto Rican American culture. He stated that there were professors who knew about his Latino heritage. In fact, he said that his peers and professors lightheartedly teased him about not being able to speak Spanish. Unlike what happened with Sandy when Latina/o mathematics professors visited her department, José was encouraged by his professors to meet a group of professors who were visiting from Puerto Rico:

> V: Okay, so did you ever talk to them about being Puerto Rican?
>
> José: A few times. It was kind of cool. There in [the mathematics summer program], they're opening up, or trying to open up, [the mathematics summer program] at the University of Puerto Rico, so that topic came up a lot when we had visitors from Puerto Rico. They had them all with me for the day [and] I got to hang with them.
>
> V: Oh, I see. So how did that make you feel when you stood out because you are Puerto Rican?
>
> José: Actually it was pretty cool that they recognized and then they also thought that maybe the visitors will feel a little bit more comfortable being around me

> knowing that I'm Puerto Rican. So, it was kind of cool that I could help out with that (rows 540 – 543).

His Calculus 3 professor did not know anything about José's life outside of mathematics or that he was Puerto Rican American. This did not seem to bother José because he felt that his relationships with his other professors were more important to him.

4.3.1.3 Conflicting messages about his mathematics ability and strategies for studying mathematics

José was highly confident in his mathematics ability. He seemed sure that his professors felt the same way about his mathematical competence. He stated that his Calculus 2 professor demonstrated having confidence in José's mathematics ability. On the other hand, he felt that his Calculus 3 professor did not encourage him to have positive beliefs about his mathematics abilities. Even though José had studied mathematics intensely for approximately ten years before entering his Calculus 3 class and had been taught how to study mathematics, when José had trouble passing his exams, this professor told him that he needed to study more for tests and quizzes and to ask more questions in class. To José, this professor did not recognize that his troubles were not due to a lack of understanding the course material, it was because the assessments that the professor used were not providing accurate information about what José actually knew. Not only that, but José also described feeling that this professor was slightly arrogant:

> He was not able to see that what he finds easy others would probably find difficult. He puts everybody at [the same] level as him. He goes under the assumption that

> he's smarter than pretty much everyone in Calc 3. Of course! He's the professor! So he actually is [more knowledgeable in Calculus 3] because he knows what we don't. But, he doesn't know how to put things in lower terms or say "maybe they wouldn't understand this" (row 342).

4.3.1.4 What his plans were for studying mathematics

José's described his professors as being encouraging in his study of mathematics, however, they did not seem to teach him about the benefits of having a degree in mathematics. José mentioned how he discussed his future plans in mathematics with his Calculus 2 professor, but no one else. José said that no professor ever talked to him about going to graduate school for mathematics, yet he still felt that he had their support if he were to do so. Because of the lack of discussions with his professors about continuing in the mathematics pipeline, José did not know much about getting a doctoral degree in mathematics and was unsure if that was what he wanted to do:

> I would only get the PhD—because I know with the master's I should be able to teach at the lower level. If I need the PhD to teach the lower levels then I'll definitely get the PhD, but really, staying for the PhD program really just depends on if I still just feel like being in school after my master's (row 454).

4.3.1.5 Growing mathematically

Because of his interactions with his professors, José seemed to have opportunities to grow mathematically. With both of his professors, he described how doing mathematics with them helped him learn mathematics better. He felt that his Calculus 2 professor knew instinctually when he did not understand:

> If I didn't understand something, I could go to him….And if I wasn't understanding the material, he was always spot on. He understood or he noted that there was something that I was confused about…. they would say "ok, so what's not clear to you?" So I would explain it to them and they would either say something…(row 212).

Like his interactions with his Calculus 2 professor, his Calculus 3 professor also helped him to grow mathematically:

> It actually went pretty well. Like, I was able to understand him, but that's the thing, even though he does speak with [a sophisticated vocabulary], I was able to understand him. So we would go over the problem, I was answering it, doing it, he would stop me if I was doing something wrong. So, I was able to do the problems and I seemed to understand it, but it was just like, it was mainly just the tests and quizzes that are just really impossible.

4.3.1.6 What we can conclude from José's interactions with his professors

There seemed to be distinct difference between the interactions that José had with his Calculus 2 professor and the interactions that he had with his Calculus 3 professor. José's Calculus 2 professor knew about his life outside of mathematics, embraced his Puerto Rican American culture, made him feel that he was mathematically competent, and helped him grow mathematically. His Calculus 3 professor, however, did not know about his life outside of mathematics, did not recognize that he was Puerto Rican American, did not make him feel mathematically competent, and while he helped him

grow mathematically, it was not enough to prepare him for the course assessments. Neither professor, however, prepared him well for opportunities for success that would be available to him through studying mathematics.

Notwithstanding, José perceived that his Calculus 2 professor recognized him as a sociocultural being and attempted to help him develop his mathematics identity, while his Calculus 3 professor did not. By the tone of the interviews with José, it did not seem to matter that his relationship with his Calculus 3 professor was not meaningful because it was more important to José that his relationship with his Calculus 2 professor was.

4.3.2 Interactions with His Peers in Mathematics

José seemed to think highly of his peers in mathematics. Since he had these peers in his classes from the start of college, he did not refer to them based on what class they were in or where he met them. Rather, he talked about them in a manner which seemed as though they were always around and had always been around.

4.3.2.1 His “friends” in mathematics

When José spoke about his peers in mathematics, he referred to them as his "friends." José talked about how he and his peers would socialize before class. He said that they would often discuss their feelings toward the professor, what they were learning in class, and the tests and quizzes. José said that he often discussed his experiences in mathematics with his peers in the mathematics department. José’s personal definition of a meaningful relationship in mathematics was different from Martina’s and Sandy’s definitions. Martina and Sandy seemed to place an emphasis on both social care and mathematical care whereas José only placed the emphasis on mathematical care:

> I think the perfect relationship is just about what I have now. No matter at what time of the day or what day of the week, no matter what, if I don't understand something in math, I could just easily call one of them and they'll either help me out with it or we'll both work together to either figure it out or find someone else who can teach us both that, or I'm always there for them. It's just like a support system (row 466).

4.3.2.2 They collaborated for success

Since José had been studying mathematics more deeply than most of his peers for many years, he was trained to know good strategies for studying mathematics. Thus, to study for Calculus 3, he joined a study group with some of his peers in mathematics that was lead by a friend who was a physics major and had already taken Calculus 3. He said that they would meet three times a week. José knew these students because he had taken classes with them before. He described how their study sessions were held:

> What would happen is we would bring up some of the stuff we were going over in class. We would start from the beginning with the book and the chapter and the tutor would [re-teach us the lesson]. Then, us as a group, we would go over different problems that we had, the extra-credit problems, like the harder ones, or we'll just pick random problems out of the book and we would do them together, or we'll do them separately and come together and see what our result is (row 406).

José felt confident in his mathematics ability when he worked with those students, which was opposite of Martina's perspective of working with her peers. He felt that he contributed mathematically just as much as he learned from the group. In fact he stated that he knew that he understood course material because he was able to help many of his peers with their tests and quizzes:

> I got the Calc 3. I know I understand the Calc 3 material, because, like I said, some of my other friends are in other Calc 3 courses with different teachers and they'll show me their different tests and quizzes that they got and I'm looking over it and I'm teaching them how to do it. I know how to do the stuff and I'm showing them how they could have gotten a hundred percent on the different tests, but when it came to our own tests and quizzes, it just was not working out (row 410).

4.3.2.3 Only his peers understood him

José made it very clear that the interactions that he had with his peers had an influence on him. He felt that the people who were mathematics majors were the people that he could talk to the most about his struggles. He mentioned this five times during the course of the interviews. This is quite different from both Martina's and Sandy's perspectives on their relationships with their peers. Martina did not discuss her struggles with her peers in mathematics and Sandy only began to do so as a graduate student. José, however, would talk about what it was like to be a mathematics major with his peers in the mathematics department. He felt that he could have better discussions with his peers in the mathematics department than he could with anyone else:

V: And so when you talk to these people who do you feel understands your struggles the most?

José: I would say people who are math majors or, in one case, my friend who is an applied physics major, who are slightly [more advanced] than me and they just got done doing it….(rows 690 – 691).

4.3.2.4 José learned *with* his peers

Because José was so close to his peers when it came to mathematics, it was almost as if he was growing in mathematics *with* them. When he was in the above-mentioned study group, he felt that he learned from being in this group because it helped him understand the material in class. José seemed to have had a sense of belonging in mathematics because of his interactions with his peers. He stated that he felt like a mathematician because of his mathematical competence and his ability to work with others on mathematics. José inferred that he was a part of a community in the mathematics department due to the relations that he had with his peers. He described the sense of community that he felt:

> Well most of the people that I hang with and everything are all either math majors, engineering majors or either applied physics majors. Most of the time when we're speaking, it's in like math terms a lot. [For example], telling somebody to look a certain way, we'll say the angle that they are supposed to look. It helps us keep up on our math stuff. A lot of our conversations revolve around math or figuring out different, random problems. We use math and different logic or different proofs, proving things. So, constantly just math stuff (row 426).

4.3.2.5 What we can conclude from José's interactions with his peers

José's interactions with his peers seemed to be highly influential to him. José did not mention having a strong need for a social relationship with his friends, but it seemed as though he had one. José never mentioned that his peers knew that he was Puerto Rican American and neither did he mention that he had dealings with them outside of mathematics. Most of what José talked about regarding his peers had to do with their relationships around mathematics. He felt that his peers were the only ones that understood what it was like to be a mathematics major and that he could discuss his struggles with them. When José was doing mathematics with his peers he grew mathematically and he felt mathematically competent. He never mentioned discussing with his peers the importance of mathematical knowledge or the opportunities available to him because of mathematics.

For José, his peers did not recognize him as a cultural being and they did not help him to fully develop his mathematics identity, and therefore his relationship with his peers was deficient according to the definition of a Meaningful Relationship in Mathematics Education. Nonetheless, José perceived the relationship as meaningful. Every comment that he made about his peers was positive and he called their relationship with him "support system."

4.3.3 His Interactions with His Family

José seemed to enjoy talking about his family. It was evident that he thought highly of his parents. His mother seemed to be the biggest influence on his life, but he also talked about his sister and his uncle. The way José described his communications with his family indicates that his family was a great support to him.

4.3.3.1 His family did not understand

Like Martina, José seemed to struggle with his family's inability to understand his life as a mathematics student. He said that he felt like he was alone sometimes because he studied mathematics. He did not have anyone in his family who really attempted to understand his experiences in college mathematics. He did discuss his experiences with his sister who tried to understand his experiences in mathematics, but she was never able to. On rare occasions he talked about his experiences in mathematics with his uncle. He did not seem to feel that his family would ever understand what it was like to be a mathematics major or the culture of mathematics. He described how his family responded to him discussing his experiences in mathematics:

> V: Okay. So can you tell me about a time that you've talked about your experiences in college mathematics with members of your family?
>
> José: Mainly, it was my sister. At times it was just things I didn't really thoroughly understand in the math, it was just a lot of work and I was getting annoyed. I would complain about the math to her and I could see that she was getting lost in the things that I was talking about. But she would pretend like she understood everything so she can just listen and try and give me some type of advice in easing it up (row 654 – 655).
>
> V: So, you talked to your uncle about this?
>
> José: Uh, yeah like once or twice when he was just asking me how was the math going (rows 678 – 679).
>
> V: Oh. So you don't feel like you could tell him what it's like to be a math major?

> José: Not really, no. I mean, I think in some way, maybe my family would be able to relate to the hard work part and the studying and practice and everything. But none of the specifics — probably not. I feel like I can have better discussions with actual people in the math department (rows 682 – 683).

4.3.3.2 Mathematics can open a lot of doors

Even though José's family could not fully understand what his life was like as a mathematics student, they instilled in him at a young age the importance of mathematical knowledge and the opportunities available to him because he studied mathematics. José' stated that his mother fully supported his decision to study mathematics compared to other subjects. Other members of his family told him that it made sense to pursue mathematics because of how strong he was in mathematics. His family told him that mathematics can provide him with opportunities for success:

> V: What does your family think about how you can benefit from mathematics?
>
> José: Okay, well, I know my mom always pushed me to know more math. She was always telling me how important math is and how having a good foundation in mathematics can open a lot of doors. So, she was behind me studying math. My uncles felt the same way about me studying math. A lot of my family was, in a way, supporting and pushing me because they all saw that it was really important that I keep a strong foundation in math (rows 636 – 637).

> V: So, they just encouraged you to go on and do that?

> José: Yep. Yeah, they were really just encouraging me and telling me they see that because of how strong I was in math and how much I did enjoy doing it, they did see that as a fit for me. It was just really encouragement (rows 702 – 703).

4.3.3.3 José was the “math genius” of the family

José’s family taught him about the importance of mathematics, but they also seemed to support him in another way. Members of his family made him feel that they thought that he was mathematically skilled. José said that they called him "the math genius." He stated that his family often requested tutoring from him, which was an indication to him that they thought highly of his mathematics abilities. There was, however, a downfall to being “the math genius” of the family. José talked about his feelings toward the pressure that was put on him because of his skills in mathematics:

> V: Okay. So how did that make you feel that they thought you were a math genius?
>
> José: I mean, it was cool, but it also put a lot of pressure on me. I always had a habit, especially in math, that I would tend to get a little upset if I didn’t understand it right away. If I had a small grasp on it then I was okay, but if I was completely lost then I was upset easily. So, when they’re calling me a “math genius” repeatedly, it feels like an added pressure that I had to understand it (rows 610 – 611).

4.3.3.4 What we can conclude from José’s interactions with his family

José’s family placed a strong importance on having a mathematical foundation, they emphasized that there were opportunities for success available to him through studying mathematics, and they supported his reasons for studying mathematics. José

perceived that members of his family also felt that he had high mathematics ability yet, it is possible that José would have liked to have had more from his communications with his family. He felt that his family did not understand his life as a mathematics student, nor did they understand his experiences in the mathematics culture. He felt that he really did not have any family members that he could talk to about his experiences and struggles in mathematics. José said that he felt somewhat lonely because he studied mathematics and his family had no real way of connecting with him in that area of his life. José's family was able to help him cultivate many aspects of his mathematics identity, and although they tried, they were fruitless in their attempts to understand him as a sociocultural being.

4.3.4 Conclusion to José's Case

José's relations with his professors, peers, and family in mathematics proved to be influential to him in certain areas of his life in mathematics. José felt that he had a strong positive relationship with his Calculus 2 professor, but his relationship with his Calculus 3 professor seemed to be weak and ineffectual. He saw his Calculus 2 professor as a father figure, which seemed to trump how he felt about his Calculus 3 professor. The interactions that José had with his peers were significant to him as a mathematics student. While the interactions that he had with his peers did not fully constitute a meaningful relationship as it is defined, for José, it seemed to create an outlet by which he could grow mathematically and belong in mathematics. José felt that his peers understood him because they were in a similar situation by being mathematics majors.

José's family played a big role in his decision to major in mathematics because they felt that it was a good fit for him. José thought that his family taught him the

importance of mathematical knowledge and felt that he was strong in mathematics. He seemed to value the opinions of members of his family greatly, but he felt that there was something missing in the relationship. Since his family had trouble understanding his life as a mathematics student, it was difficult for him to fully relate to his family.

While the three different relationships had their flaws, according to the definition of MRIME, José seemed to look at the good in all of the relationships. He was not naïve to the reality of the deficiency of the relationships, however, he did not let those deficiencies take away from his experience in mathematics.

4.4 Case 4: Sonya

Sonya was a very energetic and passionate woman who, at the beginning of this study, was preparing to graduate with a bachelor's degree in mathematics from a research university in the northwestern part of the United States. By the end of the study, she had graduated with a degree in foreign language and culture and was getting ready to go to law school that coming fall.

Sonya was born in Mexico, one of four children, to laborers. Her family moved to the United States when she was just three years old. Although neither of her parents finished high school, Sonya grew up in a household that emphasized the importance of education. In fact, Sonya's older sister and brother had also graduated from college. While he never was able to complete high school, she remembered her father being good at mathematics. When Sonya was a young child, her mother encouraged her to learn mathematics by giving her advanced mathematics problems to do for fun. While she was growing up, her father had multiple labor jobs, including being a truck driver. Her mother was a caregiver. She remembered members of her family having a variety of hobbies. Her

mother liked to write, her father was an artist, she and one of her brothers liked to dance, and she had another brother who was in mixed martial arts.

When Sonya was in elementary school, she spent a lot of time learning how to speak English. She remembered, however, being more advanced in mathematics than the rest of her peers. Growing up, mathematics was her strongest subject and she remembered receiving all As. In middle school, after taking a state standardized test, she was placed into two mathematics classes—a remedial mathematics course and a regular mathematics course. In the seventh grade, she took the state standardized test again and tested at a 10^{th} grade mathematics level. She was then placed into a regular mathematics course. Because she was at the top of her mathematics class, she was chosen to visit a university, which boosted her confidence in her mathematics ability.

In high school, Sonya placed into Honors Algebra and did well in that class. She continued to take Honors mathematics classes throughout high school. She participated in a dual-enrollment program, in which she was able to attend community college full time while being a full-time high school student. She took a Pre-Calculus course at the community college during this time. By the time Sonya graduated from high school, she had an associate's degree in arts and science.

While still in high school, her mathematics teachers encouraged her to continue in mathematics and told her that teaching was one way that she could stay in mathematics. She attended an out-of-state university for her first year of college. There she majored in mathematics and after she finished her first year, she transferred to the university that she was attending during the time of this study. At this university, she majored in

mathematics until her last year when she changed her major. At the age of 20, she graduated with a bachelor's degree in foreign language and culture.

4.4.1 Interactions with Mathematics Professors

When Sonya spoke about her mathematics professors, she was very clear about how she felt about each professor. Sonya spoke very passionately about the interactions that she had with her professors. During the interviews, she talked about her Calculus 1 professor, her Calculus 2 professor, her Linear Algebra professor, and sometimes she would mention professors of other courses.

4.4.1.1 Sonya knew what she wanted in her relationships with her professors

Sonya's experiences with her mathematics professors seemed to shape the way that she viewed her interactions with them. Like the other participants, she had her own definition of what the ideal relationship with her professors was. Based on her reflections, she was able to determine what kind of interactions she would have liked to have had with a mathematics professor, which included elements of general care and mathematical care:

> I think my ideal relationship with my math professors [would be with] someone, like my Linear Algebra professor, that's very open to helping the students. But not only that, open for questions and ready to answer questions….[Also], the ideal relationship would be [with] a professor that can relate what we're learning to — turn it into the real world and [with] professors that would understand you and care for you as a student and as a person. That would be the ideal relationship [I

could have] with a professor…. Also, my ideal relationship would be with a professor that enjoys what he's doing….(rows 606, 608).

4.4.1.2 Her professors really did not care to know about her as a person

Sonya made it very clear that she would like to have had better social interactions with her professors. When she did have positive social interactions, they seemed to have stood out in her mind. For example, her Linear Algebra professor asked her class at the beginning of the semester to turn in a brief biography about themselves with a picture of themselves attached. Sonya explained how she felt about this:

V: So, what did you think about that, when you're professor did that?

Sonya: I thought it was really cool that he actually wanted to know who we were and where we were coming from and I thought it was a good tactic to also know our faces and relate it to a story and start off the class like that. I thought that was pretty cool (rows 581 – 582)!

Other than that, she did not remember her professors knowing anything about her life outside of mathematics. She stated that she did not have a relationship with her professors that would allow her to discuss her life outside of mathematics. Because of that, she was unsure if they even knew that she was Mexican. She never told her professors that she was Mexican, nor did they ask.

Sonya described herself as being a sociable person and enjoying social relations with other people. For that reason she frequently mentioned how the approachability of her professors was important to her. Sonya felt that her Calculus 1 and her Linear

Algebra professors were very approachable and influenced her in mathematics. Sonya described how she perceived the interactions that she had with her Linear Algebra professor:

> He was very approachable and that's what I liked about him. He was a very nice teacher and he actually seemed to care more about the students than the rest [of the professors I have had]. I talked to him more than the rest just because if I needed help I knew I could go to him. So, it was really easy to approach this professor (row 584).

4.4.1.3 "Do it because it's going to take you to the next class!"

Sonya expressed on several occasions that the reason she changed her major from mathematics to foreign language and culture was because she did not know the importance of mathematical knowledge and how it pertained to the real world. To Sonya, this was detrimental because she wanted to be able to use her education to help people and, other than teaching, she did not know how to use mathematics to do that. She talked about what drove her to change her major:

> So, what happened is that I had talked to a couple of people and let them know that I wasn't really liking the whole math thing anymore. I think it was mainly because it didn't really allow me to question too many things. It was just given to you [like] "these are the formulas, follow it." But I had very little teachers tell me what it was actually used for. Another problem is that I always like to question things and I always wanted to know why and I almost never got that answer from teachers. Most of my teachers just give you that grade and [say] "do it because it

> is going to take you to the next class." I'm like, "okay, I guess [chuckles]." So, that was one of the biggest things why I did that and ultimately I wanted to be a lawyer, so [I said] "well, I'm just going to switch my major and get out of here real quick — out of undergrad and just pursue a law degree." So that's what I did. I switched my major to foreign language and culture, focusing on Spanish, and I didn't minor in math, but it was a focus that I also did (row 548).

4.4.1.4 Sonya learned good and bad strategies

Sonya had conflicting experiences when she did mathematics with her professors. This was made evident in the way she described how her different professors worked with her on mathematics. For example, she elaborated on her views of the way that her Calculus 1 professor taught her mathematics and the strategies that she suggested to help her learn mathematics better:

> V: Ok, so when you went to see your professor, in this particular math class, at his office hours, or her office hours, how did that go?
>
> Sonya: It actually went really good….She was very helpful, the way she approached the problem. Helping me, personally, she really took her time to either explain it if I didn't understand or lead me to the right direction if I was doing something wrong but still had some knowledge of the problem. (rows 214 – 215)

> V: Okay. So going back to this Calc teacher, did she ever encourage you to work in groups?

> Sonya: Yeah, sometimes. There were times where she said “if you don’t understand a problem, try to form study groups or look outside of the classroom if you need to and just try to engage yourself with other students that are thinking the same way, that are in the same field” and maybe we could have helped each other that way. So, she did encourage us to form our own groups to study and not necessarily just studying, but to build a relationship with students that are in the same field as we are (rows 258 – 259).

> She was a very approachable [professor]. She made herself available at whatever time you really needed her. She gave us her personal phone number and if you needed something outside of her office hours she would extend them for that, if you really needed it. If you really, really felt like you needed extra, extra help, like she would go out of her way to try to find you help or help you herself (row 223).

Her Calculus 2 and Statistics professors seemed to be different from her Calculus professor. Her Calculus 2 professor did not teach her sound strategies for studying mathematics and Sonya felt that she did not learn mathematics while working with him. She stated that she had to teach herself mathematics. She described the experience she had in his office hours:

> He didn’t seem to care too much about students because he was too focused on his research. He didn’t go out of his way whatsoever. I mean he doesn’t have to, but it didn’t seem like he made any effort to really, really make sure that you

> understand something. Because I did visit him at his office hours before and it seemed like he would get frustrated if I asked him questions. [He said] "yeah I already told you that in the classroom" I'm like, "I understand you said it in the classroom, but I don't understand what you said in the classroom, can you elaborate?" "No, no, I said it in class." So it was something that kind of made me feel like he didn't care for his students too much (row 235).

Sonya's statistics professor seemed to be no better than her Calculus 2 professor. When I asked her if there was a professor that made her feel as though she was mathematically incompetent, she stated that her statistics professor did:

> I think he made me feel like I was pretty bad at math….I would do some things different than he would and I would find the same answer and it was kind of a similar method, but I would incorporate my own ways of doing things because it was easier for me to follow my own methods. He would dock me off for not following his correct method. It made me feel like mine wasn't good enough for him even though I was getting the same answers. He really didn't care for how I knew how to do things. It was his way or no way at all. So I didn't really like that at all (row 618).

4.4.1.5 Keeping Sonya's interest

Sonya really had a desire to know why mathematics was useful, but not only that, she wanted to enjoy mathematics. When Sonya was still in the process of considering changing her major, she said that she was losing interest in mathematics. The evidence

suggests that the interactions that she had with her professors seemed to be the main cause of this. She stated that she did not enjoy mathematics when working with her Calculus 2 and Statistics professors because neither made the class interesting. She commented on the monotony of rote drill and practice and the lack of enthusiasm that those professors exhibited. Although she rarely mentioned her Calculus 3 professor, she said that she enjoyed doing mathematics with him:

> He seemed to have really enjoyed what he was doing in the process. You knew he was actually having a good time doing this thing and he [had] a great way of explaining it to me and to the whole class. [He] constantly asked questions about whether students understood or not and wouldn't go on until the whole class would get it.… He would just really have a good time teaching math and I guess that vibe rubbed off on us. If the teacher's having a good time, then more than likely students would have a good time as well (row 610).

4.4.1.6 What we can conclude from Sonya's interactions with her professors

Sonya viewed her interactions with her professors realistically and that seemed to have had a strong impact on her. Sonya noticed everything, good and bad, that her professors did. She perceived that her relationships with her Calculus 1 and Linear Algebra professors were more meaningful than those she had with other professors. She appreciated that they tried to recognize her as a social being by being approachable and attempting to get to know a little bit about her life outside of mathematics. She also recognized that they tried to help her develop her mathematics identity by teaching her sound strategies for studying mathematics. This, however, was not enough for her. Her

professors did not recognize her as a cultural being in that they never attempted to learn about her Mexican culture. More importantly, to Sonya, most of Sonya's mathematics professors did not: (1) attempt to make her have positive beliefs about her mathematics ability, (2) teach her the importance of mathematical knowledge, (3) help her develop healthy reasons for studying mathematics, and (4) make mathematics enjoyable to her. Sonya noticed this and, unfortunately, it encouraged her to discontinue her studies in mathematics in her senior year of her undergraduate studies.

4.4.2 Interactions with Her Peers in Mathematics

Sonya described herself as being a sociable person and she enjoyed having interactions with her peers. She often talked about a group of peers that she studied with in her Linear Algebra class. These peers seemed to have had the most impact on the way she studied mathematics. She also mentioned a group of peers that she studied with in her Calculus 2 class, but these students did not seem to have the same influence on her as those in her Linear Algebra class.

4.4.2.1 <u>She enjoyed being sociable</u>

Sonya often studied mathematics with her peers. While she was studying, like in her Calculus 2 class, she would chat with the students that she studied with. Those students knew about her life outside of mathematics. Sonya mentioned that there was one student in particular who knew more about her. This student was from Japan and she talked about her experience with this student:

> He knew where my family was from and where I was from. He knew when I came here to the U.S. and he knew my hobbies. He did know my hobbies because

> we had similar hobbies and, again, he knew my educational journey and stuff like that. And I knew the same about him (row 600).

In her Linear Algebra course she had a study group that she said she had fun being in. She often ate with these students and they chatted a bit, but they were not very close. In fact, she did not do anything outside of mathematics with these students. She enjoyed the fact that those students were sociable.

4.4.2.2 They spoke Spanish when they were not talking about mathematics

Sonya spoke about being Mexican very casually, as though she was speaking about the color of her hair or eyes. To her, it seemed that being Mexican was a part of who she was, but it did not fully define her. Still, she appreciated when she was able to share experiences in mathematics with other Mexican students like herself. The students that she studied with for her Linear Algebra class were Mexican as well and she felt that that was what drew them together. They were able to speak Spanish together and she felt that they had a connection because they were Latinas/os. Sonya expounded on this unique experience:

> Actually, in that same Linear Algebra class, the first day of class I sat next to this girl. She was Hispanic as well, Latina, she was also Mexican actually. She noticed that about me, I'm thinking, because I sat there and she [introduced herself] and from then on, we just always studied with each other and we built a little study group with other students (row 590).

V: Ok, so why do you think she felt comfortable with you?

Sonya: That's an interesting question. I mean, I think it goes back to the whole being Latina thing because I was the only brown girl, especially up here in the northwest, you don't see too many brown people. I was the only Latina in that classroom. Especially in the STEM, it's kinda hard to find someone Latino in there, so maybe she felt comfortable because we have some sort of familiarity there, I guess. Or maybe because I was a girl as well and there [were] not a lot of females (rows 428 – 429).

It was really cool because the students that I did get to talk to, they were Latinos as well. So we were drawn together because of that almost. So we decided to make our own little study group. It was fun…(row 355).

V: Did these other students speak Spanish?

Sonya: Yeah! Yeah they did.

V: Did you speak Spanish with them when you were studying?

Sonya: Yes, but not when we were talking about math.

V: Okay. Why is that?

Sonya: [Chuckles] Math is a whole new language and for me it would be really difficult to interpret math in Spanish terms (rows 390 – 395)!

4.4.2.3 Sonya collaborated with her peers for success

Sonya was able to form study groups and she mentioned that she learned strategies for studying mathematics. In her Calculus 2 class, she and her peers would study for tests together. She met those students in her Calculus 1 class and they went on to take Calculus 3 together. Sonya said that she felt that studying with the other students in her Linear Algebra class boosted her confidence in her mathematics ability. She also felt that since she was more advanced than the peers in that study group, because she had already taken the class once before, she was an asset to the study group. The students that she studied with in her Linear Algebra class learned from each other and bounced ideas off of each other. Sonya also stated that when she studied with these students, she was forced to address issues that she otherwise may have skipped and was able to work in a team to solve a problem rather than work alone. Sonya explained the benefits of collaborating with her peers in mathematics:

> I feel a lot more comfortable or a lot more confident going into a test when I study with people than when I study alone because studying alone, sometimes the frustration would get to me that I wouldn't get a question and sometimes I would question myself. It was just hard to cover a lot of material by myself with all that questioning of whether I was right or wrong. Studying in a group, you are a lot more confident about what you're doing because you know the other people are almost checking your work as we go on, as we study together and cover more material. So I feel more confident going into tests when I study with people (row 413).

4.4.2.4 She grew, she enjoyed mathematics, and she felt like she belonged

By studying with the students that she did in Linear Algebra, she felt that she grew mathematically. When she studied with those students, she was forced to understand the course material by investigate the mathematics further in order to explain it to them. Due to studying with her peers, Sonya was encouraged to enjoy mathematics. She remembered one of the young ladies in her study group in the Linear Algebra course being enthusiastic about learning mathematics and Sonya felt comfortable with her because of that. Not only was she encouraged to enjoy mathematics, but because she studied with her peers, she had a sense of belonging in mathematics:

> V: Alright. So do you think that studying with these students made you feel like a mathematician?
>
> Sonya: Made me feel like a mathematician?
>
> V: Yeah
>
> Sonya: In a sense, yeah, because the way that we were talking. If there were other students around or something, they wouldn't even understand what we were talking about. It was good to have a conversation with a student about math and have them understanding what you're trying to tell them (rows 370 - 373).

4.4.2.5 What we can conclude from Sonya's interactions with her peers

Sonya seemed to view her interactions with her peers positively. She enjoyed the fact that she was able to socialize with them and she seemed to appreciate being able to do mathematics with them as well. The group of students that she studied with for her Linear Algebra class recognized her as a cultural being. To Sonya, this was a good thing.

She stated that the fact that they were all Latinas/os is what drew them together. While Sonya said that they did not socialize outside of mathematics, it did not seem to bother her. It is possible that it did not bother her because these peers also helped her to develop her mathematics identity. They did this by making her feel good about her mathematics ability and by, probably unconsciously, showing her sound strategies for studying mathematics. Even though, according to the definition of a Meaningful Relationship in Mathematics Education, her relationship with her peers was deficient, she perceived it positively.

4.4.3 Her Interactions with Her Family

Sonya had a great deal of respect for her parents and her siblings. It seemed that her family made her feel special and loved her very much. She seemed to relate differently to different members of her family. She was probably close to her mother because she said that she spoke to her on the phone every day. She seemed proud of her father because she bragged about his mathematical abilities. She felt that her family supported and trusted any decision that she made with regards to her education.

4.4.3.1 Sonya's family did not understand

Sonya's experience with her family not understanding her life as a mathematics student was very similar the experiences of Martina and José. Just like those other two participants, her family could not understand what she went through. She felt that her family tried to understand her lifestyle in college when she was studying mathematics but because they had never been through it, they had trouble understanding her life as a mathematics student and the mathematics culture:

V: Okay, so, have you ever talked about what it's like to be a math major?

Sonya: Yeah. Most of my time in college, while I was in math, I was focusing on classes and I would tell them that…. They would know that math is very time consuming and as a math major it was very difficult to be as involved as I usually am….So they kind of knew the busyness of it, but other than that I didn't talk to them too much about it (rows 677 – 678).

V: Okay. Can you tell me about a time that members of your family tried to understand your experiences in math?

Sonya: I think that, like I said before, my parents a lot of times they tried to learn why I was doing what I was doing. But other than that, [that was] as far as it got. They tried to understand why I was doing what I was doing and they tried to understand my lifestyle of [being] in college when I was studying math because it was little sleep, a lot of work and tests every week. So, other than that they didn't — even if they tried to do more they couldn't — they couldn't really try to understand more than what they already understood (rows 683 – 684).

4.4.3.2 <u>They felt that she had taken more than enough mathematics</u>

Sonya thought that her parents tried to understand the importance of mathematics but they really did not. They could not understand why she needed to know so much mathematics. She said that her siblings knew a bit more about the importance of mathematics, but she thought that they did not care about learning it in depth. It seemed that, to her, they only cared about the courses they had to take in order to graduate. Sonya

felt that it was important for her family to know how mathematics could benefit her personally. Even though she felt that they would never fully understand it, she said it did not bother her. Sonya seemed understanding of how members of her family felt about her being a mathematics major because she knew that the idea of studying mathematics in depth was new to them. Since her family did not understand the importance of mathematical knowledge to the extent that she did, they felt that she had already taken more than enough mathematics:

> V: Now did your family ever try to encourage you to continue in math at all?
>
> Sonya: No, I think that when it came to my studies, I think that a lot of my family they just kind of let me do my own thing. They trusted me and they trusted what I was doing, so they never told me "oh, well, why are you stopping there? Continue math." No, they knew it was a tough subject, so if that's what I wanted to do as far as a bachelor's, then that's all that they were going to —they weren't going to encourage me to do more if that's all I wanted. That's more than enough math they thought…(rows 693 - 694).

4.4.3.3 Sonya did not want to worry her parents

Sonya seemed to cared about her parents. For example, Sonya did not talk about her struggles in mathematics with her parents because she did not want to worry them. In this respect, Sonya's situation was different than those of the other participants. The other participants never mentioned the fact that they were concerned about worrying their family by discussing their struggles in mathematics. But to Sonya, protecting her family

seemed to be very important. She was willing to suffer in silence to avoid worrying members of her family:

> I think for my parents, especially my mom, I tried to avoid talking about struggling in math. I let them know it wasn't an easy thing to pursue, but I never really told them "I'm struggling really bad in class" or "I don't get it" or anything like that because I think that my mom would start thinking, "oh man, she's having a hard time." And I didn't want to worry her in anyway. So, I think that that's what kept me from letting her know like, "oh I'm struggling in a class or I don't know if I'm gonna pass this class" or whatever. So I just kept that to myself and just let her know, "it's tough but I can do it." She never really knew the specific details of why it was tough or what I was having troubles with because she would feel like she would want to help me. But, at that point not a lot of people could help me, even in college. So, my mom would feel not useful in that way and I never wanted to make my mom feel like that. So I didn't really tell her the specifics of where I was struggling or why, I just told her "I got this. It's hard but I got this" (row 674).

4.4.3.4 What could she do with a degree in mathematics?

Because Sonya's family did not understand the importance of mathematical knowledge, it was difficult for them to understand the opportunities available to Sonya through studying mathematics. She felt that her siblings knew about the opportunities that she could have because they all went to college and they knew what mathematics could do for her. Sonya stated, however, that she had to explain to her parents that having a

strong foundation in mathematics would help her become a better teacher. She would tell her mother that she wanted to study mathematics to help students:

> Yeah that's what I would tell my mom….So I would try to explain that to my mom and just let her know how I wanted to encourage Latinos and females to pursue mathematics because I think it's very important. I also wanted to make it more understandable….(row 670).

4.4.3.5 "¡No te quiebras la cabeza!"

Sonya felt that her family did not understand why she decided to major in mathematics, so they were unable to help her develop healthy reasons for studying mathematics. Still, she said that her family felt that it was wonderful that she was studying something that was not commonly studied. They thought that she was brave for studying mathematics. Her mother, however, asked her why she chose a field that was so difficult and encouraged her to choose something easier:

> Although, my mom kept on telling me "oh, *mi hija*, do something easier! *¡No te quiebras la cabeza!"* So she felt like a protective mom would. She wanted me to do something that wasn't going to give me headaches and that wasn't going to take so much time out of me. She wanted me to be okay. So, that was how my mom felt about it. But other than that they thought it was really cool that I was doing something like that. (row 690)

4.4.3.6 What we can conclude from Sonya's interactions with her family

Sonya felt that her relationship with her parents concerning mathematics was weak. Since, however, she understood her family's perspective on the situation,

especially her mother's, she tried to not let it bother her. Sonya knew that her family did not understand the importance of mathematical knowledge or the opportunities that would be available to her because she studied mathematics. She also knew they would not be able to help her develop healthy reasons for studying mathematics. It seemed as though Sonya perceived that her family was so far removed from her life as a mathematics student that she did not even want to talk to them about it for fear of worrying them. It seems that she cared for her family so much, because she was willing to deny her own needs as a mathematics student to care for the needs of her family. While Sonya never said it, it could be possible one of the reasons that she decided to change her major was so that she could be closer to her family.

4.4.4 Conclusion to Sonya's Case

Sonya was a very intelligent and ambitious woman who was dedicated to her education and to her family. Sonya seemed to be a very realistic person. She saw the relationships that she had with her professors, peers, and family centered on mathematics for what they were. While it was not true of all of her professors, she recognized that her professors in general did not support her in the way that she needed it. She knew that she needed them to recognize her as a sociocultural being and to *want* to help her develop her mathematics identity. Sonya seemed to have more positive feelings toward her relationships with her peers. Even though those relationships were lacking, according to the definition of MRIME, she seemed to feel that they were enough for her. Sonya's relationship with her family regarding mathematics was not meaningful nor did she perceive it as so. Her family could not understand her as a mathematics student and they could not help her develop her mathematics identity. She felt that her father really

enjoyed mathematics, but because of his limited ability to relate to her as a college mathematics student, his enthusiasm did not have a great enough effect on persistence in mathematics. As a whole, Sonya perceived her interpersonal relationships in mathematics negatively and, unfortunately, she is no longer in mathematics.

4.5 Cross-Case Analysis

The participants in this study had unique personalities and unique perspectives on life and mathematics. With all of their differences, however, they shared the same love for their Latino culture and for mathematics.

All of the participants were high achieving and highly motivated students upon entering college. One student was the valedictorian of her class, one earned a college degree before she graduated from high school, one participated in summer mathematics programs, and one was recognized in high school as highly competent in mathematics and encouraged to participate in mathematics competitions at school. The participants felt that they were more advanced than their peers in mathematics all throughout school.

All of the participants attended public research universities in different parts of the country and their universities were surrounded by and served different types of communities. Upon entering college, Sonya and José knew that they wanted to study mathematics immediately. Martina and Sandy initially chose majors that were mathematics intensive, but later chose to study mathematics. At the time of this study, Sandy had graduated with her master's degree in mathematics, Sonya had graduated with a bachelor's degree in foreign language and culture, and Martina and José were still completing their bachelor's degree in mathematics.

4.5.1 Interactions with Mathematics Professors

In general, the participants seemed to have had positive experiences with their professors. Three of the four participants were able to describe one professor that had a positive influence on the mathematics experience and one professor that did not. Sandy was the only participant who never mentioned having negative interactions with a professor.

4.5.1.1 What are “relationships?”

The participants seemed to be careful when they talked about having “relationships” with their professors. Each participant felt that they had a relationship with at least one professor. For Martina and Sandy, it was their Linear Algebra professors, for José, it was his Calculus 2 professor, and for Sonya, it was her Calculus 1 professor. Some of the participants described what their ideal relationships with their professors would look like. I took this description to be the participants’ personal definitions of “relationship” with their professors. When describing what their ideal relationship with their professors would be, José and Sonya defined "relationship" as involving ideas of general care and mathematical care. They both wanted to have a social and mathematical component to their relationships. This theme was woven through all of the participants’ personal definitions of “relationships” at some point.

4.5.1.2 Approachability and knowing something about the participants

The approachability of the professors was important to some of the participants. Martina appreciated the fact that her Differential Equations professor was approachable. Sonya thought that her Calculus 1 and her Linear Algebra professors were both

approachable. In fact, to Sonya, the approachability of her professors was imperative. She stated “I think that if I had a lot more approachable teachers, teachers that I can come to for questions… Maybe I could think about [continuing in mathematics]” (row 291). Both Martina and Sonya indicated that they needed to have a social relationship with their professors. Neither of these women had professors that knew about their lives outside of mathematics.

José and Sandy on the other hand, had mathematics professors that knew about their lives outside of mathematics. Sandy’s Linear Algebra professor got to know about her through the Research Experience for Undergraduates (REU) on the hiking trips. José remembered his Calculus 2 professor being like a father figure to him. Both of these participants seemed to appreciate the fact that their professors attempted to get to know them in ways not pertaining to mathematics. It is interesting to note that these participants never mentioned the approachability of their professors as being something important to them. Maybe, it was because the professors who got to know them were inherently approachable and thus, it was a miniscule characteristic that was overshadowed by their care for the participants’ lives outside of mathematics.

4.5.1.3 The “color-blind” professors

When it came to knowing about their culture, it was common to hear that participants’ professors did not recognize that they were Latina. Martina, Sandy, and Sonya all said that they had no professor that acknowledged their Latina heritage. All three women said that they were not sure if any of the professors even knew that they were Latina. Sandy and Sonya were never asked about, nor did they ever volunteer

information about being Latina. Sandy's Linear Algebra professor knew that she was Cuban-American because he knew so much about her life outside of mathematics, yet when other Latina/o mathematicians were visiting their department, he did not introduce Sandy to them. Because he did not care to get to know Martina as a person outside of mathematics, Martina's Calculus 3 professor made the mistake of assuming that she was fluent in Spanish. José was the only participant who had a professor that recognized his Puerto Rican American background and took advantage of it. José remembered his Calculus 2 professor and other professors knowing that he was Puerto Rican American.

4.5.1.4 They all can do mathematics, but why should they?

Feeling mathematically competent or incompetent around their professors was something that stood out in the minds of the participants. Sandy was the only participant whose experiences with professors were positive. The other three participants had interactions with at least one professor that did not recognize them as mathematically capable. Sonya did not have a professor that made her feel mathematically competent. Martina and Sandy specifically commented about professors did not embarrass them whenever they did not understand mathematical topics.

All the participants seemed to feel that they were skilled in mathematics, but only some had professors who taught them why learning mathematics was important. Martina and José did not mention if their professors taught them the importance of mathematical knowledge. Sandy remembered that her Calculus 1 professor gave her application problems that she found to be very interesting. This taught her the importance of mathematical knowledge in the real world. On the other hand, Sonya stated that not one

of her professors taught her the importance of mathematical knowledge. In fact, this bothered Sonya so much that it was one of the reasons she dropped out of mathematics.

4.5.1.5 Some were prepared for good or bad times

Most of the participants commented on how professors attempted to prepare them for either the constraints or opportunities for success through studying mathematics. Martina was the only participant that talked with a mathematics professor about her struggles in mathematics. When she talked to her Abstract Algebra professor, she encouraged her, noting that the course was difficult but she would get it. No other participant mentioned discussing their struggles with their professors. With the exception of Sonya, however, all of the participants had professors that talked to them about opportunities available to them through studying mathematics. The professors discussed professions that mathematics students could pursue, future goals, study abroad, summer research, internships, and the like. While Sonya did not have professors she could consult regarding opportunities available to her, Sandy had at least one professor suggest that she go to graduate school. Sandy was the only participant who had a professor suggest graduate school to her.

4.5.1.6 Good strategies for studying mathematics

All of the participants had at least one professor who taught them sound strategies for studying mathematics. The professors taught strategies by guiding the students as they did mathematics problems, encouraging them to work in groups, presenting material clearly, suggesting courses to take, and making themselves available when the participants needed help. Martina, José, and Sonya each had at least one professor that

did not attempt to teach them sound strategies. Martina's Calculus 3 professor would cut her off when she was trying to do mathematics problems in his office, which did not teach her how to think about mathematics herself. José's Calculus 3 professor suggested that he pick up better study habits for preparing for exams, even though José had been studying mathematics intensely for a number of years already. Sonya's Calculus 2 professor refused to even help her in his office hours, which made it impossible for her to learn how to study mathematics from him.

4.5.1.7 Growing, enjoying, and belonging in mathematics

Because of their interactions with their professors, some of the participants grew in mathematics, some felt a sense of belonging in mathematics, and some enjoyed doing mathematics. All of the participants said that they had at least one professor that helped them to grow in mathematics, either by the way that they taught the mathematics or the way that they were able to help the individual participant learn mathematics. Unfortunately, Martina, José, and Sonya each had a professor that they felt that they did not learn much from. For Martina, it was her Calculus 3 professor who would cut her off while doing problems, for José it was also his Calculus 3 professor who did not feel that the advice he received from him helped him grow mathematically, and for Sonya it was her Calculus 2 professor who refused to help her, so she was forced to teach herself the course material.

All of the participants had a professor that engendered enjoyment in mathematics. Two of the participants stated that their professors' enthusiasm for mathematics rubbed off on them. Sonya thought that it was especially important that students know that their

mathematics professors enjoy mathematics and enjoyed teaching mathematics. Sandy was the only participant who seemed to develop a sense of belonging due to her interactions with her professor. Her professor encouraged her to participate in the REU, where she learned what doing research in mathematics was like.

4.5.1.8 What we can conclude from the participants' interactions with their professors

For the most part, the participants had positive interactions with their professors. Their mathematics professors, as a group, had strengths and weaknesses. The most apparent shortcoming of mathematics professors was that they did not recognize their students as sociocultural beings. Only two of the four participants reported having a professor that knew about their lives outside of mathematics and only one had a professor that openly expressed appreciation for his Latina heritage.

Even though their mathematics professors overall did not acknowledge them as sociocultural beings, the participants felt that the professors helped them to develop their mathematics identities. Most had at least one professor that made them feel mathematically capable, informed them about opportunities for success, and taught them sound strategies for studying mathematics. Unfortunately, their professors were not perfect in this area. Sandy was the only participant that said that she had a professor who meaningfully taught her the importance of mathematical knowledge and Martina was the only participant that said that she discussed her struggles with her mathematics professor. Nevertheless, all of the participants felt that they either grew mathematically, enjoyed mathematics, or felt a sense of belonging in mathematics due to interactions with at least one professor.

4.5.2 Interactions with Their Peers in Mathematics

All of the participants seemed to have had at least one positive experience with their peers in mathematics. Some of the participants had to learn how to communicate mathematics with their peers while others had already developed that skill earlier in life. Whichever the case was, the participants saw the importance of interacting with their peers around mathematics.

4.5.2.1 They had "friends" in mathematics

When the participants talked about working with their peers in mathematics, it was clear that they had a different relationship with their peers then they did with their professors. The way that each participant felt about their interactions with their peers differed from one another. For example, Martina was the only participant who felt that she did not have any relationships with her peers. On the other hand, Sonya felt that she developed relationships with her peers in one of her classes and they studied together and they met outside of mathematics. It seemed as though José and Sandy found their interactions with their peers more meaningful than the other two participants because they called their peers their "friends." Each of the participants provided a personal definition of "relationship" with their peers. The three women indicated that a "relationship" with their peers should have a social component and a mathematical component. José only emphasized the mathematical component.

4.5.2.2 The other facets of the participants' lives besides mathematics

All the participants seemed to enjoy socializing with their peers. Every participant had at least one classmate that they had a social relationship with. These classmates

knew about their lives outside of mathematics. Sandy and Sonya each had one classmate that knew much about them, while José and Martina did not say that any particular classmate knew a great deal about their lives outside of mathematics.

Sonya and Sandy stated that they had at least one classmate that knew about their Latina background. They also stated that they compared and contrasted their cultures with those of that classmate. They felt that discussing their cultures helped them to bond with their peers more. Sonya was the only participant that studied mathematics with other Latinas/os. She felt that she and her peers were drawn to each other because of their ethnic background. Martina specifically stated that none of her peers in mathematics knew that she was Latina and José never mentioned if his peers knew that he was Latino.

4.5.2.3 They felt confident

Most of the participants felt that working with their peers helped them to feel more mathematically competent in some way. Martina, José, and Sonya all mentioned having interactions with their peers that made them feel confident in their mathematics ability. Martina felt that her peers in her Differential Equations class expected her to do well in mathematics. For that reason, she knew that they thought that she was skilled in mathematics. José and Sonya both thought that helping their peers do mathematics made them realize that they were good at mathematics. Martina talked about a time when working with her peers made her feel unsure about her abilities. This was when she was working with the first group of students in her Differential Equations class. She stated that she felt “uneducated” when working with them. She was the only participant to mention having a negative experience like this.

4.5.2.4 Collaboration was the best strategy

It appeared as though the main strategy all of the participants learned from the interactions that they had with their peers was collaboration. For some of the participants, like Martina and Sandy, collaboration was a new technique that they were learning at the time of this study. Martina concluded that she needed to practice working with her peers more and Sandy stated that she learned the importance of group work in mathematics. Sonya did not seem to have a problem with working with her peers. Early in her time as an undergraduate, she learned to study with her classmates in most of her mathematics courses. José had learned from his years of participating in the summer program that he could learn mathematics more productively with a team rather than alone.

4.5.2.5 More on their mathematics identities

Other than the participants getting a boost in their confidence and being more productive in studying mathematics, their peers did not do much to support their mathematics identities. Martina and José said that they talked to at least one of their peers about their struggles in mathematics. Not one participant mentioned having interactions with their peers that helped them to develop positive beliefs about the importance of mathematical knowledge or healthy reasons for studying mathematics. Neither did any participant say that they discussed the opportunities that studying mathematics can provide for them.

4.5.2.6 They grew, enjoyed, and felt like they belonged in mathematics

Most of the participants indicated that they grew mathematically from working with their peers. They said that they learned from their peers and that teaching their peers

also helped them to understand mathematics concepts better. Sonya and José both stated that working with their peers made doing mathematics more enjoyable. Sandy felt that working with her peers did not change the way that she felt about mathematics. All of the participants felt a sense of belonging in mathematics at some point while working with their peers.

4.5.2.7 What we can conclude from the participants' interactions with their peers in mathematics

In general, the participants' viewed their interactions with their peers as meaningful. They also spoke very highly of their peers, even when they had difficult experiences with them, like Martina. Most of the participants had social interactions with at least one of their peers, which they all appreciated. Two of the four participants said that they had interactions with their classmates who wanted to learn about them as Latinas.

Even though, for the most part, their peers recognized the participants as sociocultural beings, they fell short when it came to helping the participants develop their mathematics identities. Working with their peers helped them to feel mathematically capable and taught them how to collaborate, but they were not able to learn the importance of mathematical knowledge, opportunities that were available to them through studying mathematics, or develop healthy reasons for studying mathematics. Regardless, all of the participants felt that the relationships that they had with their peers were meaningful. This may be due to the fact that they thought that working with their peers helped them to grow mathematically, gave them a sense of enjoyment while

studying mathematics, and gave them a sense of belonging in mathematics. Therefore, when the relationships were deficient, according to the definition of MRIME, the participants seemed to be willing to settle for what their peers offered them in terms of having a relationship.

4.5.3 Interactions Centered on Mathematics with Family

All the participants expressed a deep love and appreciation for their families. They all felt that they received support in some way from their families when it came to mathematics. Most of the participants, however, felt that their families were not capable of supporting them in ways that they would like to have been supported. It seemed that Martina and Sonya had very similar experiences when it came to interacting with their families and Sandy and José also had similar experiences.

4.5.3.1 What is it like to be a mathematics major?

Being understood as a mathematics student by their families was very important to the participants. All of the participants, with the exception of Martina, were able to give an example of a time when a family member tried to understand their experiences in mathematics. Sandy remembered her husband and her sister listening to stories of what it was like to be a mathematics major or to have a job in mathematics. José remembered his sister pretending to understand what he was talking about when they would discuss his experiences. Sonya said that she would explain to her mother why she was staying up so late studying. Martina, however, said that she did not remember a time in which her family tried to understand her as a mathematics student. All of the participants, except for

Sandy, said that their families could not understand what they went through as mathematics majors.

4.5.3.2 They were respected because they studied mathematics

All four of the participants felt that their families helped them to believe that they were mathematically competent. In fact, this seemed to be the biggest contribution that their families made with respect to their relationships centered on mathematics. Martina was teased by her sisters for having high mathematics abilities and José was called “the math genius” by his family. Sandy was used as an example to her nieces and nephews and Sonya was often asked by her siblings to help them with mathematics. All of those experiences caused the participants to infer that their families thought highly of them because they studied mathematics.

4.5.3.3 The importance of mathematical knowledge

Some of the participants realized that their families did not understand or attempt to teach them the importance of mathematical knowledge. Martina and Sonya are examples of that. Martina wanted her family to understand how important mathematics was and wished that they would choose to have more mathematics in their lives. Sonya said that her family could not understand why a person would need mathematics beyond arithmetic or algebra. Martina was bothered by how her family felt about mathematics, but Sonya was more understanding of her family’s perspective. Unlike Martina and Sonya, Sandy and José grew up understanding why mathematics was important. Sandy was taught by her family the importance of mathematical knowledge at a young age and she knew that her family respected and appreciated mathematics. José said that his family

would tell him that mathematics was in everything. He knew that his family encouraged him to study mathematics because they thought that mathematics was important.

4.5.3.4 The difficulties of being a mathematics major

Discussing their struggles with members of their family was something that most participants did. Martina discussed her struggles with her mother, whom she called her "woosah" because she helped Martina relax when she was stressed out. Sandy talked about her struggles with her husband who would often give his perspective and advice about her situation. José remembered telling his sister his struggles and she would try to relate his struggles in mathematics to her struggles in her place of work and try to give him advice. Sonya was the only participant who did not discuss her struggles with members of her family. She knew that her family would not be able to help her and they would find it difficult if she was in distress and they could not help her. She said that she did not want to worry them. All of the participants wished that their family members would have been able to understand the troubles they had because they studied mathematics, but they all knew that their families had never gone through what they had been through and could not fully understand.

4.5.3.5 Why should they study mathematics?

Martina and Sonya thought that their families did not fully understand the importance of mathematical knowledge. They also stated that their families did not understand the opportunities that would be available to them through studying mathematics. Martina's family thought that all she could do with a degree in mathematics was be a teacher, so she had to explain to her family that there were so many more

opportunities for her. Sonya's family did not understand why she needed to take so many mathematics courses and she had to explain that if she wanted to be a good mathematics teacher she needed to have a deep understanding of mathematics.

Opposite of how Martina's and Sonya's families understood the opportunities available to those who study mathematics, were the perspectives of Sandy's and José's families. Sandy said that her family knew that studying mathematics would allow her to have better opportunities for success. Her sisters often told their children how Sandy was able to get a good job because of her degree in mathematics. José stated that his mother and uncles often told him that mathematics could open doors for him.

As a result of their families not understanding the importance of mathematical knowledge or what opportunities would be available to them, it was difficult for Martina's and Sonya's families to grasp why they chose to major in mathematics. Martina remembered her mother being nervous about her changing her major to mathematics. Sonya remembered her mother asking why she chose such a difficult major and suggesting that she change it to something easier. Sandy and José, on the other hand, were applauded and encouraged to major in mathematics because their families saw how much they enjoyed mathematics. Both of their families thought that mathematics was a good fit for them and showed support immediately.

4.5.3.6 How to study mathematics

While their families were limited in the ways that they helped them develop their mathematics identities, most of the participants gave an example of how their families taught them strategies for studying mathematics. Sandy and Sonya learned about studying

mathematics from at least one member of their family. Sandy grew up knowing that both of her parents were very mathematically competent, but she specifically remembered her father being persistent when trying to learn a new concept in mathematics. Sandy learned this strategy from her father which she used while she studied mathematics. Sonya remembered her older sister teaching her college mathematics when she was only in middle school. José experiences were different. José's family called him "the math genius" of the family and that put pressure on him to perform in mathematics when added to José's self-imposed pressure. Trying to live up to an expectation is not a sound strategy for studying mathematics. Martina never mentioned how interactions with her family encouraged sound strategies for studying mathematics.

4.5.3.7 Not growing, not belonging, but enjoying mathematics

No participant felt that they grew in mathematics as a result of interactions with their families. José and Sandy specifically noted that they were too advanced mathematically to benefit from talking with members of their families about mathematics. Not one participant mentioned how interactions with their families gave them a sense of belonging in mathematics. Sandy and Sonya said that at least one family member's enthusiasm for mathematics was passed on to them. Sandy felt that talking with her husband made mathematics more enjoyable. Sonya felt that her father's love of mathematics encouraged her to love mathematics as well. These experiences, however, did not contribute to a sense of belonging.

4.5.3.8 What we can conclude from the participants interactions with their families

The relationships that the participants had with their families was the least meaningful according to the definition of MRIME. This was due to the fact that most participants felt that their families had trouble understanding the mathematics culture and what it was like to be a mathematics major. Three out of the four participants reported that their families attempted, at some point, to learn about their experiences in mathematics, but only two reported any attempt from members of their family to understand the mathematics culture.

The participants' family members were limited in their abilities to help them develop their mathematics identity. Martina and Sandy viewed their interactions with their families very similarly in that respect. Neither of their families understood the importance of mathematical knowledge, the opportunities that would be available to them because they studied mathematics, and healthy reasons for studying mathematics. Sandy and José perceived their interactions positively. In fact, the only shortcoming between the two families was that José was not taught a sound strategy for studying mathematics. Because the participants, in general, felt that their relationships with their families had many deficiencies, their relationships were viewed as not meaningful.

4.5.4 Conclusion to the Cross-Case Analysis

While each of the participants had different types of interactions with their professors, peers, and families, there seemed to be some commonalities amongst their perceptions of these interactions. Table 2 summarizes the strengths and weaknesses of the relationships based the participants' perceptions. Table 3 summarizes how the participants viewed their interpersonal relationships and if the participants continued in

mathematics. Martina and Sonya viewed the collection of their relationships as not meaningful, whereas Sandy and José perceived their relationships to be meaningful. The least meaningful relationships for Martina and José were the ones they had with their families involving mathematics. The least meaningful relationship for Sonya was a relationship she had with her professors. Sandy felt that all of her relationships were meaningful. As an entire group, the participants perceived that their relationships with their families centered on mathematics were the least meaningful of all of the relationships. The most meaningful relationships for the group were the relationships they had with their peers.

Table 2: Summary of Strengths and Weaknesses of Interpersonal Relationships Based on Participants' Perceptions

Relationship	Sociocultural Being	Mathematics Identity	Results of MRIME
Professors	Lives outside of mathematics—okay Latino culture—weak	Strategies—strong Ability--strong Opportunities—strong Math. knowledge—weak Constraints—weak Reasons—weak	Grow—strong Enjoy—strong Belong—weak
Peers	Lives outside mathematics—strong Latino culture—okay	Strategies—strong Ability--okay Constraints—okay Opportunities—none Math. knowledge—none Reasons—none	Belong—strong Grow—strong Enjoy—okay
Families	Lives as a mathematics student—okay	Ability--strong Constraints—strong Opportunities—okay Math. knowledge—okay Reasons—okay Strategies—weak	Enjoy—okay Belong—none Grow—none

Table 3: Participants' Perceptions of their Interpersonal Relationships

Participant	Relationship	Perspective	Outcome
Martina	Professors	Meaningful	Had plans to complete bachelor's degree in mathematics and pursue meaningful relationships
	Peers	Not Meaningful	
	Family	Not Meaningful	
Sandy	Professors	Meaningful	Completed master's degree in mathematics
	Peers	Meaningful	
	Family	Meaningful	
Jose	Professors	Meaningful	Had plans to complete bachelor's degree in mathematics
	Peers	Meaningful	
	Family	Not Meaningful	
Sonya	Professors	Not Meaningful	Dropped out of mathematics by changing her major
	Peers	Meaningful	
	Family	Not Meaningful	

4.6 Conclusion

The purpose of this study was to answer the question: How do Latina/o mathematics students perceive their relationships with their mathematics professors, peers in mathematics, and their families centered on mathematics? Based on the four cases, it was possible to determine how the participants viewed their relationships.

The ways in which the participants perceived the relationships with their mathematics professors, peers in mathematics, and families centered on mathematics seemed to be one factor that influenced their persistence and continued study. Sonya felt

that her relationships with her professors and her family were not meaningful and, therefore, dropped out of mathematics before completing her bachelor's degree. Martina felt that her relationships with her peers in her family were not meaningful, but she had plans to continue in mathematics while attempting to develop more meaningful relationships. José perceived that his relationship with his family was not meaningful, but he also had plans to continue in mathematics in the hopes of maintaining the meaningful relationships that he did have. Sandy perceived all of her relationships as meaningful and completed a bachelor's degree and a master's degree in mathematics. Therefore, we can conclude that the perceptions of the relationships that the participants had with their professors, peers, and families may have been a factor that influenced their persistence in the mathematics pipeline.

These participants were dedicated students, loved mathematics, and were highly motivated, yet for these four Latina/o mathematics students, interpersonal relationships were everything. Some relationships were more important than others, nevertheless, all of the participants attributed their continuation or discontinuation in mathematics to interpersonal relationships. Therefore, it is imperative that mathematics educators and the mathematics community recognize interpersonal relationships as fundamental for students coming to know mathematics and persisting in mathematics.

CHAPTER 5. DISCUSSION AND CONCLUSION

The underrepresentation of Latinas/os in mathematics is a problem in the United States. Mathematics educators (Civil, 2007; Gonzalez et al., 2001; Gutierrez, 1999; Gutstein, 2006; Treisman, 1992) have been investigating this problem. Some mathematics educators have recognized that interpersonal relationships are significant to the success of Latina/mathematics learners (Gutierrez, 1999). Unfortunately, interpersonal relationships in mathematics are understudied (Hackenberg, 2010). For this reason, this study sought to answer the following question: How do Latina mathematics students perceive their interpersonal relationships with their mathematics professors, peers in mathematics, and families with respect to mathematics?

Through interviewing four participants and analyzing their interviews using MRIME, I found that, in general, the participants felt that their relationships with their peers and their professors were meaningful, but their relationships with their families were not. Each individual had a different perspective on their own interpersonal relationships involving mathematics. Martina found that only her relationships with her professors were meaningful, but she decided that she wanted to complete her bachelor's degree in mathematics while pursuing meaningful relationships. Sandy felt that all of her relationships were meaningful and she ended up completing a master's degree in mathematics and stated that she would continue to get a doctoral degree if her

circumstances in life were different. José felt that his relationships with his professors and peers were meaningful and he decided that he would complete his bachelor's degree in mathematics. Sonya felt that her relationships with her peers were meaningful, but she discontinued her studies in mathematics and changed her major to foreign-language and culture. Last, in general, the relationships were the weakest in the area of recognizing the participants as sociocultural beings and were the strongest at helping the participants develop their mathematics identities.

5.1 Conclusions Drawn from the Results

These findings clearly show how some Latina/o mathematics students viewed their interpersonal relationships involving mathematics with their mathematics professors, peers in mathematics, and families. The findings also show there are factors that are possibly connected to their perceptions of interpersonal relationships which may contribute to the participants' decisions to persist in mathematics. Also, the findings show that the element of support of the future mathematician as a sociocultural being was the weakest aspect of the relationships, yet three of the four participants had persisted in mathematics. Therefore, the results suggest that the sociocultural element of MRIME may need to be reconsidered. The next questions to ask are: What are some possible causes for the results? What do the findings mean? What do the findings not mean? and How do these findings fit into the bigger picture? This section will attempt answer these questions.

5.1.1 Possible Causes for the Results

The participants viewed their relationships with their professors and peers as the most meaningful. This may be because those relationships can be the most influential to a

student while studying mathematics. When discussing how he designed the Emerging Scholars Program, Treisman (1992) placed a heavy emphasis on mathematics professors developing relationships with mathematics students, as well as the importance of undergraduate students collaborating with one another while working with mathematics. He designed the Emerging Scholars Program to follow that model.

Unfortunately, Treisman's model did not include involving the families of mathematics students. The least meaningful relationships to the participants were relationships they had involving mathematics with their families. It is likely that the reason that this relationship was the weakest was because none of the participants' family members studied mathematics in depth and were, therefore, limited in how meaningful they could make the relationships. Even though members of Sandy's family did not study mathematics as much a she did, she felt that her relationship with them was meaningful. This was because she felt that they all appreciated mathematics and wanted to hear about mathematics. No other participant had this experience. So, these data suggest that the participants who did not find their relationships with their families as meaningful did not have family members who expressed a sincere desire to learn about mathematics and the mathematics culture.

5.1.1.1 How each participant viewed their relationships

Another part of the results show that some of the participants viewed their relationships, in general, as meaningful or not meaningful. Martina viewed her relationships as generally not meaningful, but she wanted to continue mathematics anyway. Martina may have thought that she was the reason that the relationships were not

meaningful. The fact that she decided to pursue meaningful relationships indicates that she felt she had control over her relationship status with her professors, peers, and family.

Sandy decided to pursue a master's degree in mathematics and she stated that her decision was directly influenced by her professors and her husband. It is plausible that Sandy felt that mathematics was a good fit for her and all of her relationships confirmed that interpretation, so she felt they were meaningful. Like Sandy, José found most of his relationships meaningful and decided to continue in mathematics. It is possible that José felt that his relationships would always be meaningful, and therefore continuing in mathematics was justified for him.

Sonya found that the only relationship that she had that was meaningful was a relationship she had with her peers and she ended up abandoning mathematics study. One of Sonya's main concerns was that her professors did not care to tell her about the importance of mathematical knowledge. Sonya mentioned that she liked helping people and that being a mathematics teacher would be one way that she could help people. It seemed as though she already knew why she wanted to study mathematics. Why then did she quit? Maybe she chose to quit for the same reasons that the other participants chose to remain in mathematics. The relationships that she had sent the message to her that no one really seemed to care if *she* learned mathematics and if she learned in ways that were meaningful to *her*. On the contrary, the other participants may have felt that their relationships sent them the message that *they* could learn mathematics in ways that were meaningful to *them*, as individuals.

When students recognize that the education they are receiving is not meaningful to *them* as individuals, they will sometimes choose to not learn (Kohl, 1992). Therefore,

it would make sense that the other participants chose to continue in mathematics, but Sonya did not. Sonya felt that her professors did not care to teach *her*, specifically, the importance of mathematical knowledge. She also felt that some of them did not express an interest in helping *her* develop her mathematics identity. Sonya was very gentle when she spoke about her family, but she implied very boldly that they were not involved in her life at all when it came to mathematics. This could be another reason why she deliberately chose to quit mathematics. She made it very clear that she was very close to her family, as a consequence, it may have been too emotionally difficult for her to feel that separated from her family. It is likely that the mathematics department that Sonya was a part of did not encourage her family, who was very important to her, to be involved in her mathematics education. It is possible that, as a result, Sonya chose not to learn from them.

5.1.1.2 Not being recognized as sociocultural beings

Another finding of this study was that out of all of the components of MRIME, the participants' relationships were the weakest at recognizing them as sociocultural beings. One reason for this could be the context in which the relationships took place. Universities often implement policies to protect professors and students from harmful conduct, but these policies may also cause professors to avoid such relationships altogether. It is possible that some professors want to maintain a sense of professionalism that does not include getting to know their students in personal ways. They may also be reluctant to bring up the issue of race and culture for fear of offending their students. It may be that the students, themselves, created the boundaries or allowed the boundaries to

exist. Kuther (2003) found that students expect a certain level of professionalism from their college professors. The participants may have believed that it would be unprofessional for their mathematics professors to discuss race or ethnicity or ask about their personal lives. Another reason could be that mathematics presents itself as a non-social discipline. That has proven to be a fallacy. Burton (2009) claims that mathematics is, in fact, a very social discipline:

> Mathematicians themselves, in their research practices, were engaged in personal and socio-cultural activities that acknowledged the interplay of emotion and cognition, depending upon a discourse community, valued heterogeneity, and reflected upon the complex ways in which mathematics interconnects, both internally and externally…. Far from the stereotypic image that portrays the mathematician as a loner, working in isolation, the mathematicians I interviewed were working collaboratively...(p. 170).

Burton (2009) goes on to say that these same mathematicians exemplify exactly the opposite in their pedagogical styles. Therefore, not recognizing that the participants are social beings is actually contrary to how the professors themselves engage in mathematics.

Another false belief about mathematics is that it is not multicultural. The dominant mathematics that is usually taught to students today is Eurocentric. Gutierrez and Irving (2012) argue that African American and Latina/o mathematics students should be taught that mathematics is done differently in different cultures around the world.

They suggest that students should also learn the history of mathematics different from how they are currently taught:

> For the most part, mathematics curricula rarely teach the history of mathematics — how it was developed by different peoples in different parts of the world or how it is still developing….Few students realize that the Pythagorean theorem was known by the Babylonians and Chinese more than a millennium before Pythagoras lived or that the system we use today is Hindu-Arabic. Omitting this dynamic history from the classroom can give students the impression that excellence in mathematics is the exclusive domain of Europeans (p. 8).

It is, therefore, possible that because their mathematics professors, and hence, their peers in mathematics did not recognize that dominant mathematics is Eurocentric, they did not think to consider the participants' Latina/o heritage as a significant medium by which they could be integrated into mathematics.

Not only did their heritage have the potential to be an asset to the participants persistence in mathematics, but their family backgrounds did as well. Some of the participants' families had hobbies and jobs that required them to do some mathematics, even if they do not realize that that was what they were doing. The participants reported that their families sewed, cooked, danced, were artist, and played games. All of these activities produced funds of mathematical knowledge within each family that would have had the potential to be utilized by their mathematics professors (Gonzalez et al., 2001).

Sonya stated that her family could not understand why anyone would need to learn mathematics beyond arithmetic or algebra. If Sonya's family would have been

encouraged by her mathematics department to be more involved in her mathematics education, they may have been able to share their funds of knowledge and may have been able to learn the importance of mathematical knowledge beyond algebra. Therefore, it is possible that Sonya may have decided to continue in mathematics. Since her family, and the families of other participants, did not have the opportunities to be involved in mathematics, it may have been more difficult for them to understand the participants' lives as mathematics students. Maybe because of their own feelings toward mathematics or their own mathematics abilities, they did not fully attempt to engage in discussions with the participants about their lives as mathematics students.

5.1.2 What the findings mean and do not mean

The results of this study show that interpersonal relationships may be a factor that could positively or negatively impact a mathematics student's decision to persist in mathematics. Mathematics professors should get to know about their students' lives outside of mathematics. That includes getting to know about their cultural backgrounds. For Latina/o students, this is especially important because Latina/o students can have a wealth of funds of knowledge and also benefit from the acknowledgment of their culture in mathematics (Gonzalez et al., 2001; Gutierrez & Irving, 2012).

It is also imperative that students learn why mathematical knowledge is important. Mathematical topics must be placed in a context. We saw that not having this knowledge drove Sonya out of mathematics. It is also helpful that students feel mathematically capable when working with their professors and their peers. The institutionalization of competition in mathematics can sometimes make students feel "stupid" and often pushes them out of mathematics (Burton, 2009). Instead, students should learn that professional

mathematicians collaborate and think freely among their peers. These findings, in particular, put the onus on mathematics professors to integrate younger mathematicians (i.e. mathematics majors) into mathematics as a community of practice (Wenger, 2000).

These results also have implications for the families of mathematics students. The participants appreciated when their family members tried to understand their experiences in mathematics. As stated previously, families should be involved in the mathematics education of mathematics students. This is especially true for Latina/o students. Since many Latina/o students are first-generation college students and, more than likely, first-generation mathematics students, many of their families do not understand their lives as mathematics students. Involving the families would be very beneficial to the students and their relationships with their families centered on mathematics, in that they may view their families as a part of their lives in mathematics. José stated that he felt alone sometimes because his family could not understand his life as a mathematics student. Martina and Sonya assumed that their families would never understand their lives in mathematics and so they did not even discuss it. Both of their relationships could have been more meaningful if this was not the case.

It is important to recognize what these findings do not mean. These results do not mean that all students who have meaningful relationships will persist in mathematics. Neither do they mean that all students who do not have meaningful relationships will not persist in mathematics. Martina was a counterexample of the latter statement. These results also do not mean that all Latina/o mathematics students feel the need to be recognized as sociocultural beings. Sandy was not always recognized as a sociocultural being and yet she still persisted in mathematics. Thus, these results do not mean that this

framework is a useful tool in exploring every student of color, but, they do imply that future research should be done to explore the impact of the sociocultural component of MRIME.

5.2 How Do the Findings Fit Into the Bigger Picture?

The analytical framework, MRIME, focuses on the mathematics student as a whole person—a person who is a social being, a cultural being (Gutierrez, 1999), and has a need to develop their mathematics identity (Martin, 2000). In keeping with the theme of focusing on the whole student, this study recognized that students' interpersonal relationships in mathematics do not exist in a vacuum on their college campuses. Instead, they are all around them. That is why this study focused on mathematics students' relationships with their mathematics professors, peers in mathematics, and families. Interpersonal relationships with faculty and peers influence mathematics achievement and persistence (Herzig, 2004b; Treisman, 1992) and families can be mathematical assets to students (Gonzales et al., 2001).

The recognition of students as social beings is helpful in providing mathematics students with positive experiences while studying mathematics, as was the case for Sandy and Martina. Mathematics is a social activity (Burton, 2009; Gutierrez & Irving, 2012) and the acknowledgment of the social aspect of mathematics can benefit students greatly. Sandy and Martina deliberately expressed the influence that socializing, especially with their peers, had on their enjoyment in doing mathematics. Sandy and José had the opportunity to socialize with their professors and they both felt a part of the community in their departments. Mathematics students need to feel that they are a part of a community (Gutierrez, 1999; Herzig, 2004b; Ladson-Billings, 2009). Being a part of the

mathematics community is consistent with how professional mathematicians work (Burton, 2009) and should be encouraged by mathematics educators.

Being recognized as cultural beings had a different effect on the participants' experiences than being recognized as social beings did. The explicit acknowledgment, good or bad, of their Latina culture impacted how they felt about individuals, but not necessarily mathematics. José's mathematics professors recognized and utilized his Puerto Rican heritage, which José appreciated, but it did not seem to greatly influence his persistence in mathematics. Martina had a negative experience with a professor recognizing her Latina culture, yet it did not have a negative impact on her continuation in mathematics. Gutierrez and Irving (2012) and Ladson-Billings (2009) specifically address the importance of recognizing students' cultures in the classroom. While it is true that the participants who had a relationship with someone that acknowledged their Latina culture described having more positive experiences in mathematics, not one participant stated that being recognized as a cultural being encouraged (or discouraged) persistence in mathematics. These findings suggest that the "sociocultural" component of MRIME may need to be reconsidered, which will be discussed later in this chapter.

The fostering of mathematics students' mathematics identities (Martin, 2000) was a fundamental aspect of students' continuation in mathematics. The participants who had relationships with people who: (1) encouraged them to have confidence in their own mathematics abilities, (2) taught them the importance of mathematical knowledge, (3) taught them about opportunities available to them through studying mathematics, (4) acknowledged the struggles of being a mathematics student, (5) provided them with sound strategies for studying mathematics, and (6) encourage healthy reasons for

studying mathematics, were more likely to continue mathematics study. Martin (2000) found that the students who characterized having a positive mathematics identity tended to be successful in mathematics. The results of this study show that interpersonal relationships that help develop a student's mathematics identity can not only encourage success in mathematics, but also, persistence. Sandy had relationships with her professors, peers, and family members that touched all six aspects of the mathematics identity, and Sandy studied mathematics beyond a bachelor's degree. Sonya, on the other hand, did not have interpersonal relationships with people who taught her the importance of mathematical knowledge, the opportunities available to her through studying mathematics, and healthy reasons for studying mathematics. Thus, Sonya chose to discontinue her studies in mathematics. These findings show the potential power that interpersonal relationships can have on students' attrition and persistence in mathematics.

The results of this study indicate that how mathematics students view their interpersonal relationships may possibly be connected to their persistence and attrition in mathematics (see Table 3). This implies that mathematics education researchers should focus their attention on interpersonal relationships. Future research should be conducted to investigate relationships and the potential impact they may have on mathematics students' decisions to persist in mathematics. Suggestions for future research are discussed in the next section.

5.3 Limitations and Possibilities for Future Research

In this study there were certain limitations that hindered my ability to draw significant conclusions from the data. First, the results revealed that not being recognized

as a sociocultural being was the weakest element of the interpersonal relationships that the participants had with their professors, peers, and families. This, however, did not seem to affect the participants' relationship with mathematics or their persistence in mathematics. It is likely that the interview protocol did not adequately measure how the participants perceived being recognized as a sociocultural being. The interview protocol should be reconstructed so that the questions better match the research literature. This may provide more details about how students perceive their relationships and what effect the sociocultural element of MRIME has on students' perceptions of their interpersonal relationships in mathematics. In addition, more studies should be conducted that focus on mathematics students being recognized specifically as social beings or as cultural beings to determine the impact of having interpersonal relationships that address these issues.

Second, this study did not take into account the context that the interpersonal relationships existed in. For example, no data was collected on the university policies regarding interpersonal relationships, the class sizes, and the sizes of the mathematics departments of the schools that the participants attended. This information could have revealed the contexts of the relationships and may have provided more information on the cause of the results. Third, it is possible that by sending the interview protocol to the participants before the interviews were conducted, the participants may have prepared answers that were exaggerated or modified to answer in the way that they thought I might want them to answer. It is possible that the results could have been affected

As previously mentioned, further research should be conducted that investigates the perceived MRIME as a potential factor in students decisions to persist in mathematics. In order to gain a better understanding of the importance of relationships in mathematics

as they pertain to Latina/o students, another study could be done using a sample of Latina/o graduate students in mathematics. This would provide information on the importance of meaningful relationships in continuing in the mathematics pipeline after the bachelor's degree. Another suggestion for future research is to determine if the need for meaningful relationships is unique to mathematics educational settings. To do this, similar studies could be conducted in other fields (e.g. English, political science, or other STEM fields).

5.4 Recommendations

The results of this study lead to some recommendations for mathematics departments and mathematics educators. First, since the culture of mathematics is represented as less social and collaborative when, in fact, professional mathematicians are social and collaborative (Burton, 2009), the cycle must be broken for undergraduates students. Herzig (2002) asserted that graduate students model the pedagogical styles of their professors and, therefore, mathematics professors must recognize the influence they have on mathematics education:

> Etzkowitz et al. (1992) describe graduate research as a tradition in which "master scientists create successors in their own image as a form of asexual reproduction" (p. 159). Indeed, since teachers' own classroom experiences shape their beliefs and knowledge about mathematics teaching and learning (Fennema and Franke, 1992; Thompson, 1992), these graduate students' educational experiences are likely to pass on to other students in a type of 'domino effect.' That is, if the survivors of this educational environment teach the way *they* were taught, and the pre-service teachers they teach later teach the way *they* were taught, then it is

> critical, and alarming, to consider the effect of this model of graduate education on children learning mathematics in schools (p.205).

Mathematics professors should train graduate students that mathematics is a very social discipline and does not have to be competitive or seclusive. If future mathematics professors are trained to think this way and express this view, then maybe they will integrate this idea into their pedagogical philosophies. More Latinas/os would perceive their relationships with their professors and their peers as meaningful and might be more likely to persist in mathematics. Treisman (1992) called for faculty to lead the change in the culture of mathematics and mathematics education because the future of mathematics depends on it:

> In conclusion, the time has come to re-examine undergraduate instruction and to make it more responsive to the needs of today's students….The challenge is to reconfigure undergraduate science and mathematics education in ways that will inspire students to make the choices we have made. This can happen only if we change the boundaries of faculty responsibility. It is the faculty that must take the lead (p. 372).

Faculty of mathematics departments should strive to make undergraduate students feel more comfortable doing mathematics with their professors. Mathematics students should feel that their professors think that they are mathematically capable and want them to grow mathematically (Burton, 2009; Herzig, 2004b). Faculty should also encourage

group work and healthy collaboration by attempting to eliminate competition (Burton, 2009; Treisman, 1992).

Mathematics professors must learn about their students so that they can better attend to their needs. Likewise, mathematics students need to get to know their colleagues and professors so that they can develop more meaningful relationships. A practical way that mathematics departments can encourage undergraduate students to have meaningful relationships with their peers and professors in mathematics is to have monthly "meet and greets" designed especially for mathematics majors and mathematics professors. This would be a time set aside for the students and the professors to get to know one another socially.

Herzig (2002) found that graduate students who had family members that were involved in mathematics were more likely to persist in mathematics. Thus, involving the families of mathematics students in mathematics may be one way to encourage persistence. In order to involve the families of the students, families could be invited to the "meet and greets." Mathematics professors could take turns giving brief talks about their research and the importance of their research so that the undergraduate students and their families can learn about mathematics in the real world. Mathematics students need to know how to use mathematics in the real world and how they can use mathematics to help others (Gutstein, 2006; Wager & Stinson, 2012).

Last, mathematics departments could have faculty mentors for mathematics majors. Graduate students are always assigned a faculty advisor. The job of the faculty advisor is to assist the students with research, help them get acclimated to the department, teach them the culture of the discipline, and are sometimes emotional support systems

(Herzig, 2002). Herzig (2002) found that graduate students "suffered in important ways from the lack of advising, which might have helped them make better decisions about courses to take and could have given them a more clear idea of what to expect" (p. 195). It would make sense that undergraduate students would have a similar experience from a lack of advising and mentorship. Thus, if every mathematics major was assigned a faculty mentor then they would have someone to talk to about being a mathematics major, the mathematics culture, and course material. Undergraduate mathematics students should also be given opportunities to do research. Herzig (2002) found that graduate students who had research experiences as undergraduates were more likely to persist in mathematics, which is consistent with Sandy's case. Again, faculty must take the lead in providing such opportunities for undergraduate students.

5.5 Conclusion

The underrepresentation of Latinas/os in mathematics is an unfortunate problem. This study showed that when Latina/o mathematics students in college have meaningful relationships with their mathematics professors, peers in mathematics, and families, they are more likely to persist in the mathematics pipeline. It is imperative that meaningful relationships in mathematics educational settings be taken seriously. The participants in this study made it very clear that they either remained in mathematics or discontinued their studies in mathematics partly due to the relationships that they had. Therefore, I propose that meaningful relationships are the key to the Latina/o mathematics students' persistence in the mathematics pipeline.

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APPENDICES

Appendix A Facebook Pages

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About Research Study on Latinas/os in Mathematics

Description Dear student:

If you are at least 18 years old, a mathematics major or have a bachelor's or master's degree in mathematics, and are Hispanic or Latina/o, you are invited to participate in a research study to discuss your experiences in mathematics. Participants will be interviewed eitl by telephone or in person and all information given by the participan will be confidential. If you or someone you know is interested, pleas contact Victoria R. Pardo at vpardo@purdue.edu

The purpose of this study is to gain an understanding of Hispanic or Latina/o mathematics students' relationships with their mathematics professors and how these relationships have influenced their decisio to (or not to) pursue doctoral degrees in mathematics. The results o this study may provide some insight into the broader problem of the underrepresentation of Hispanics or Latinas/os in the field of mathematics. Your participation in this survey is voluntary. It should take the average person about an hour to complete the interview. Y responses will be kept strictly confidential and all data will be identifi using pseudonyms, thus any reported responses will be unidentifiabl

We appreciate your participation in this important study that has bee reviewed and approved by the Purdue University Human Subjects Research Committee. If you are aware of other Hispanic or Latina/o students I should contact, please forward this link to them.

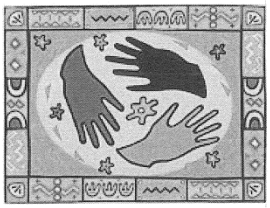
All participants must be at least 18 years old to participate.

Thank you for your participation,

Victoria R. Pardo
Graduate Student
Mathematics Education
Curriculum and Instruction
College of Education
Purdue University
West Lafayette, IN
vpardo@purdue.edu

Chat (Offline)

Search



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¿Donde se fueron los Latinos? (Where did the Latinas/os go?) Research Study

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Basic Information

About Research Study on Latinas/os in Mathematics

Description Dear student:

If you are at least 18 years old, a mathematics major or have a bachelor's or master's degree in mathematics, and are Hispanic or Latina/o, you are invited to participate in a research study to discuss your experiences in mathematics. Participants will be interviewed either by telephone and all information given by the participant will be confidential. If you or someone you know is interested, please contact Victoria R. Pardo at vpardo@purdue.edu

The purpose of this study is to gain an understanding of Hispanic or Latina/o mathematics students' relationships with their peers in mathematics and how these relationships have influenced their decisions to (or not to) pursue doctoral degrees in mathematics. The results of this study may provide some insight into the broader problem of the underrepresentation of Hispanics or Latinas/os in the field of mathematics. Your participation in this survey is voluntary. It should take the average person about an hour to complete the interview. Your responses will be kept strictly confidential and all data will be identified using pseudonyms, thus any reported responses will be unidentifiable.

We appreciate your participation in this important study that has been reviewed and approved by the Purdue University Human Subjects Research Committee. If you are aware of other Hispanic or Latina/o students I should contact, please forward this link to them.

Thank you for your participation,

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About

Research Study on Latinas/os in Mathematics

Description

Dear student:

If you are at least 18 years old, a mathematics major or have a bachelor's or master's degree in mathematics, and are Hispanic or Latina/o, you are invited to participate in a research study to discuss your experiences in mathematics. Participants will be interviewed either by telephone and all information given by the participant will be confidential. If you or someone you know is interested, please contact Victoria R. Larabell at vpardo@purdue.edu

The purpose of this study is to gain an understanding of Hispanic or Latina/o mathematics students' relationships with their family around mathematics and how these relationships have influenced their decisions to (or not to) pursue doctoral degrees in mathematics. The results of this study may provide some insight into the broader problem of the underrepresentation of Hispanics or Latinas/os in the field of mathematics. Your participation in this survey is voluntary. It should take the average person about an hour to complete the interview. You will also be asked to review a summary of your interview and write a 1-2 page personal reflection about your interpersonal relationships in mathematics and your experiences in mathematics. Your responses will be kept strictly confidential and all data will be identified using pseudonyms, thus any reported responses will be unidentifiable.

We appreciate your participation in this important study that has been reviewed and approved by the Purdue University Human Subjects Research Committee. If you are aware of other Hispanic or Latina/o students I should contact, please forward this link to them.

Thank you for your participation,

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Basic Info

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Chat (4)

Appendix B Code Book

CODES	DESCRIPTION	EXAMPLE	NOTES
Evidence of Relationships Through Care			
General Care			
GC + = YES	I would code a statement as GC+ if the participant uses the word "relationship" in a way that indicates that the participant concludes that the other party **is** attempting to acknowledge the uniqueness of the participant OR the participant's need for social interaction, based on the actions of the other party.	**V: Ok. So can you describe to me what the ideal relationship would be with your peers in mathematics?** P2: …but also, um would have, you know, the ability to, um, have, you know, kind of a social life together too… (P2, Rows 469-470)	I coded this quote based on the fact that the participant agreed with my word "relationship" and that she is indicating that the other party is attempting to acknowledge her need for social interaction.
GC- = NO	I would code a statement as GC- if the participant uses the word "relationship" in a way that indicates that the participant concludes that the other party **is not** attempting to acknowledge the uniqueness of the participant OR the participant's need for social interaction, based on the actions of the other party.	**V: How about any relationships with the professor?** P2: Nope. I don't remember. (P2, Rows 157-158)	In this example, the participant is agreeing with the word "relationship" to state that she concludes that her professor was not attempting to acknowledge her uniqueness or her need for social interaction.
GC-(LRM)	I would code a statement as GC-(LRM) if the participant uses the	**V: Ok, now in your classes do you have any friends? In your math classes.**	I coded this quote based on the fact that the participant concludes that

CODES	DESCRIPTION	EXAMPLE	NOTES
	word “relationship” or words like “friendship” in a way that indicates that the participant concludes that NO PARTICULAR PARTY is attempting to acknowledge the uniqueness of the participant or the participant’s need for social interaction, based on the actions of the other party.	P1: Um, not really. (P1, Rows 182-183)	NO PARTICULAR PARTY is attempting to acknowledge her uniqueness or her need for social interaction.
Mathematical Care			
MC+ = YES	I would code a statement as MC+ if the participant uses the word "relationship" in a way that indicates that the participant concludes that the other party **is** attempting to acknowledge the needs of the participant as a mathematics student, based on the actions of the other party.	"Um, I’d probably say that this is, that he’s-- I’ve had the strongest relationship with him." (P1, row 237)	Earlier in the interview she stated that this professor helped her do mathematics. I inferred that she saw an attempt by the professor to acknowledge some of her needs as a mathematics student. However, *I would not have called this interaction a "relationship"*, but SHE used the word herself.
MC- = NO	I would code a statement as MC- if the participant uses the word "relationship" in a way that indicates that the participant concludes that the other party **is not** attempting to acknowledge the needs of the participant as a mathematics student, based on the actions of the other party.	**V: That made it hard. I see. So with this professor, did you feel that you had any kind of relationship with him?** P1: Not at all. (P1, rows 254-255)	Here the participant is agreeing with the word “relationship” and she is concluding that her professor did not attempt to acknowledge her needs as a mathematics student.
MC-(LRM)	I would code a statement as MC-	**V: Ok. Do you remember having any**	The participant is agreeing with the

CODES	DESCRIPTION	EXAMPLE	NOTES
	(LRM) if the participant uses the word "relationship" or words like "friendship" in a way that indicates that the participant concludes that NO PARTICULAR PARTY is attempting to acknowledge the needs of the participant as a mathematics student, based on the actions of the other party.	**relationships with your, uh, your peers in that course?** P2: No. none. (P2, rows 155 – 156)	word "relationship" and is concluding that her peers in mathematics (as a general group and not one particular party) were not attempting to acknowledge her needs as a mathematics student.
Sociocultural Being			
Social Being			
S1(PC)+ = YES	I would code a statement as S1(PC)+ if the participant indicates that he or she concludes that the other party is attempting to acknowledge aspects of participant's life outside of mathematics *(or in mathematics if other party is a family member)* OR the participant's need for social interaction, based on the actions of the other party.	"First he would ask me about, like, if outside life, uh, is affecting the class life and everything like that. If something was going on, I would talk about it." (P3, Row 212)	Here the participant is concluding based on his perception that his professor was acknowledging his life outside of mathematics.
S1(PC)- = NO	I would code a statement as S1(PC)- if the participant indicates that he or she concludes that the other party is not attempting to acknowledge aspects of participant's life outside of	"…I'll call one of them and talk to them about like, "oh I just took this exam. I probably failed it." But they, I mean we—they, they just joke with me about it because they don't really think-- they don't really think that I failed the exam…" (P1, Row	To the participant, her sisters do not attempt to acknowledge her life in mathematics. Because she states that they really don't think she failed the exam, she is perceiving that they are not really attempting to understand

CODES	DESCRIPTION	EXAMPLE	NOTES
	mathematics *(or in mathematics if other party is a family member)* OR the participant's need for social interaction, based on the actions of the other party.	674)	her life in mathematics.
S1(DB)+ = YES	I would code a statement as S1(DB)+ if the participant's description of the behavior of the other party indicates that the other party is acknowledging aspects of participant's life outside of mathematics *(or in mathematics if other party is a family member)* OR the participant's need for social interaction.	"Um, yeah, um we when we would be together, a lot of times people would be just complaining about the professor, but, uh, just chatting, it would be over like the different math stuff. Whatever the topic was at the moment, usually our conversation ends up, uh, guiding towards that, or we would discuss the quizzes and tests, especially before class" (P3, Row 478)	Here the participant is describing the behavior of his peers in a way that indicates that his peers are acknowledging the participants need for social interaction by conversing with the participant.
S1(DB)- = NO	I would code a statement as S1(DB)- if the participant's description of the behavior of the other party indicates that the other party is not acknowledging aspects of participant's life outside of mathematics *(or in mathematics if other party is a family member)* OR the participant's need for social interaction.	"I wouldn't say, he wasn't, like, unwelcoming, but he just wasn't the easiest person to, um-- he wasn't the easiest person to approach." (P1, Row 265)	The participant is describing her professor as not being easy to approach. Thus, she is describing her professor's behavior as not acknowledging the participants need for social interaction.
S1-(LRM)	I would code a statement as S1-(LRM) if the participant describes a situation in which NO PARTICULAR PARTY is	"…So sometimes it's harder for me to develop a relationship with the students and with the professor because when the professor looks like the students, and I don't	The participant does not feel comfortable enough to develop relationships with her peers in her professors due to cultural

CODES	DESCRIPTION	EXAMPLE	NOTES
	acknowledging aspects of participant's life outside of mathematics OR the participant's need for social interaction.	look like the students, it's just, um, it's uncomfortable, it's not really something that, you know, I'd like to get used to…" (P1, Row 175)	differences. This indicates that no particular party is acknowledging aspects of her life outside of mathematics or her need for social interaction.
Cultural Being			
S2(PC)+ = YES	I would code a statement as S2(PC)+ if: (1) if the participant indicates that he or she concludes that the other party is attempting to acknowledge aspects of the participant's Latino race/ethnicity/heritage/culture, *(or mathematics culture if the other party is family)* (2) if the participant indicates that he or she concludes that the other party is acknowledging the participants Latino race/ethnicity/heritage/culture (or mathematics culture if the other party is family) in a positive manner	**V: So they try to understand what it's like to be a math major?** P1: Yeah. (P1, Rows 723-724)	The participant believes that her sorority sisters try to understand what it's like to be a mathematics student. Thus, she believes that they are attempting to acknowledge aspects of her mathematics culture.
S2(PC)- = NO	I would code a statement as S2(PC)- if: (1) if the participant indicates that he or she concludes that the other party is not attempting to acknowledge aspects of the participant's Latino	"And, uh, sometimes closed mindedness about things that they don't-- and people make assumptions about things that they really don't really know firsthand as much—" (P2, Row 310)	The participant is concluding, based on her perception, that her peers are not attempting to acknowledge her Cuban-American culture in a positive way.

CODES	DESCRIPTION	EXAMPLE	NOTES
	race/ethnicity/heritage/culture *(or mathematics culture if the other party is family)*, (2) if the participant indicates that he or she concludes that the other party is acknowledging the participants Latino race/ethnicity/heritage/culture *(or mathematics culture if the other party is family)* in a negative manner		
S2(DB)+ = YES	I would code a statement as S2(DB)+ if the participant's description of the behavior of the other party indicates that the other party is attempting to acknowledge aspects of the participant's Latino race/ethnicity/heritage/culture *(or mathematics culture if the other party is family)* OR if the other party is acknowledging the participants Latino race/ethnicity/heritage/culture in a positive manner	**V: Okay, the question was if you could talk about when you talked to members of your family about your experiences in mathematics.** P2: Oh, okay. Yeah and so when I was getting ready for this presentation, um, uh, my sister and I were talking about, you know, um, the different aspects of my job and why it was that, um, you know, my title is actually a computer programmer but, um, we talked about why it was that, um, that they valued at math major — you know, I didn't have to be a computer science major to be hired and we were talking about how, um — how often I actually get to use what I learned in class at work and, um, how it's one of those things where, um, all of the	Here, I coded the participant's response based on the fact that her sister was attempting to understand the mathematics culture by understanding the participants job and why her degree in mathematics was viewed as an asset to her company.

CODES	DESCRIPTION	EXAMPLE	NOTES
		computer scientists and computer programmers there have a really strong math background. Like, they won't just hire somebody with a computer science degree in less they also had, like, a math minor or math degree or something like that because, uh — because it is so heavily involved in what we do there. And, uh — so yeah my sister and I were recently discussing that.(P2, rows 648-649)	
S2(DB)- = NO	I would code a statement as S2(DB)- if the participant's description of the behavior of the other party indicates that the other party is not attempting to acknowledge aspects of the participant's Latino race/ethnicity/heritage/culture *(or mathematics culture if the other party is family)* OR if the other party is acknowledging the participants Latino race/ethnicity/heritage/culture in a negative manner	**V: No. Ok. And did she know that you're a Latina?** P1: Um, I mean, I'm not really sure. Sometimes I just assume people know that because of the way I look, but, um, I don't know if she knew, like, exactly. She never really asked me. (Rows 587-588)	The participant states that her professor never discussed or inquired about her culture. This is a description of the professor's behavior that indicates that she is not attempting to acknowledge the fact that the participant is a Latina.
S2-(LRM)	I would code a statement as S2-(LRM) if the participant describes a situation in which NO PARTICULAR PARTY is attempting to acknowledge aspects	"…So sometimes it's harder for me to develop a relationship with the students and with the professor because when the professor looks like the students, and I don't look like the students, it's just, um, it's	Here the participant finds it difficult to develop relationships in mathematics because of cultural differences. She feels uncomfortable because no particular party is

CODES	DESCRIPTION	EXAMPLE	NOTES
	of the participant's Latino race/ethnicity/heritage/culture OR if no particular party is acknowledging the participants Latino race/ethnicity/heritage/culture at all.	uncomfortable, it's not really something that, you know, I'd like to get used to…" (P1, Row 175)	attempting to acknowledge her Latina/o culture.
Mathematics Identity			
Fostering Student's Beliefs about Mathematics Ability			
M1(PC)+ = YES	I would code a statement as M1(PC)+ if the participant indicates that he or she concludes that the other party is attempting to encourage positive beliefs about the participants mathematics ability.	"If I didn't understand something, I could go to him, or he knew I would figure it out and everything." (P3, Row 212)	The participant is concluding based on his perception that his professor had confidence in his mathematics abilities and would try to encourage him to believe that too.
M1(PC)- = NO	I would code a statement as M1(PC)- if the participant indicates that he or she concludes that the other party is not attempting to encourage positive beliefs about the participants mathematics ability.	"I felt like I was not--like, not helping at all because they knew exactly what they were doing and I had, like, no idea what they were talking about…. I didn't feel like I contributed at all." (P1, Row 360)	The participant is describing working on the mathematics project with her peers. She concludes based on her perception that they were not attempting to encourage her to have positive beliefs about her mathematics abilities.
M1(DB)+ = YES	I would code a statement as M1(DB)+ if the participant's description of the behavior of the other party indicates that the other party is encouraging positive beliefs about the participants mathematics ability.	"He thought that I was a strong candidate, and, um, that it would be a shame if I just stopped with my bachelor's degree" (P2, Row 258)	The participant is describing what her math professor told her about going to graduate school. His comments indicate that he was attempting to encourage positive beliefs about her mathematics ability.

CODES	DESCRIPTION	EXAMPLE	NOTES
M1(DB)- = NO	I would code a statement as M1(DB)- if the participant's description of the behavior of the other party indicates that the other party is not encouraging positive beliefs about the participants mathematics ability	"Um [pauses] I don't, it wasn't,-- I mean I would go-- he would explain things and I thought that I would understand. I was like "oh, ok. I get it, it get it." And then I would ask if we could do an example problem, but like he-- if I were to try to work it out, he would kinda just like correct me and then like work out the rest of the problem by himself so it really wasn't helpful at all." (P1, row 261)	I coded this quote M1(DB) - because the fact that the professor cut her off while she was doing a problem is an indication to me that he was not attempting to encourage her to have positive beliefs about her own mathematics ability.
Fostering Student's Beliefs about the Importance of Mathematical Knowledge			
M2(PC)+ =Yes	I would code a statement as M2(PC)+ if the participant indicates that he or she concludes that the other party is attempting to encourage positive beliefs about the importance of mathematical knowledge.	P2: Um, well, I know, I mean, I had conversations with, um, my sisters and, uh, um, you know, my dad and stuff and, um, and yeah, I'd say that my whole family has always, um, put, uh — you know, put a lot of importance in it and, uh, um [pause] I'd say my dad was definitely a big influence there. You know, my mom was always naturally gifted at mathematics, but my dad was, kind of, one of those who, um, didn't necessarily get it at first, but he would try and try and try and try until he understood it finally [chuckles], you know, um, and, uh. And I know, you know, my sisters both have kids now and we've often talked about — you know, like, they'll say that their kids will come home and complain about well, like "why do I even need to know this	The participant feels that her family understands the importance of mathematical knowledge based on the interactions that she is had with members of her family.

CODES	DESCRIPTION	EXAMPLE	NOTES
		stuff?" And, uh, you know, I know they, uh, find it very important and will explain to the kids that "you know, sometimes, you know, even if you don't think that there specifically using this, it's still problem-solving and critical thinking aspects that you get out of it." (P2, row 607)	
M2(PC)- = No	I would code a statement as M2(PC)- if the participant indicates that he or she concludes that the other party is not attempting to encourage positive beliefs about the importance of mathematical knowledge.	"…like, when people ask me what I am studying, I say "I'm a math major" and automatically, like, the first thing that everyone asks me, and I hate it, is "Are you going to be a teacher?" And that's--that's how, like-- it kind of distinguishes the difference between, um, someone who really knows what you can do with math and someone who just understands education…" (P1, Row 634)	Based on the perception of the participant, the participant concludes that her family does not understand the importance of mathematical knowledge because they can only think of one career a person can have with a degree in mathematics. So they are not encouraging positive beliefs about the importance of mathematical knowledge.
M2(DB)+ =Yes	I would code a statement as M2(DB)+ if the participant's description of the behavior of the other party indicates that the other party is encouraging positive beliefs about the importance of mathematical knowledge.	"…you know, um the instructor, the professor was very good….he just, presented it in such a way that it, that it all, um, made perfect sense, and um, and the examples that he would give us, you know, the applications, um that he would give us for, um, um, for you know, for using the calculus, it was just a very interesting course for me…." (P2, Row 186)	The participant is describing that her professor would give them application problems that kept her interest in Calculus 1. Through the use of application problems I conclude that her professor was attempting to encourage positive beliefs about the importance of mathematical knowledge.
M2(DB)- = No	I would code a statement as M2(DB)- if the participant's description of the behavior of the	"…like, my dad, I don' think that-- I don' t think he did too much math….I don't think he did any-- a lot of math…. Um, my mom	Since the participant does not know the mathematics that her parents did in their careers, this is an indication

CODES	DESCRIPTION	EXAMPLE	NOTES
	other party indicates that the other party or is not encouraging positive beliefs about the importance of mathematical knowledge.	on the other hand, um, I don't think she does too many, like, calculations." (P1, Row 616)	that her parents did not discuss mathematics as it pertains to their careers with her. Thus, they are not encouraging positive beliefs about the importance of mathematical knowledge.
Fostering Student's Beliefs about the Constraints and Opportunities in Studying Mathematics			
M3C(PC)+ = Yes (CONSTRAINTS)	I would code a statement as M3C(PC)+ if the participant indicates that he or she concludes that the other party is attempting to prepare the participant for the struggles and constraints of studying mathematics.	"…So, she definitely encourages me to, like, take some time for myself. Um, she's kind of like my "woosah" basically. She's the person that, ironically, she relaxes me while I'm away at school." (P1, Row 672)	The participant perceives that her mother is attempting to help her prepare for the struggles that she has while studying mathematics.
M3C(PC)- =No (CONSTRAINTS)	I would code a statement as M3C(PC)- if the participant indicates that he or she concludes that the other party is not attempting to prepare the participant for the struggles and constraints of studying mathematics	"…like, with my sisters, like, I would joke around and I'll be, like, "I just failed that exam" and they'll laugh because they don't really think I failed the exam. But in my— like, in reality, I'm like, "oh shit, I probably really failed that exam!" [chuckles]…" (P1, Row 668)	The participant is concluding that her sisters do not understand the struggles that she has while studying mathematics. They do not try to help her prepare to handle the struggles.
M3C(DB)+ = Yes (CONSTRAINTS)	I would code a statement as M3C(DB)+ if the participant's description of the behavior of the other party indicates that the other party is attempting to prepare the participant for the struggles and constraints of studying	"…I have her in two of my classes this semester, um, it's, like, a Spanish class and in Abstract Algebra. And I've talked to her, like, "you know, I'm really struggling in this class," like, if I don't understand the material, and, you know, she helps me out. We— we talk in class, like, if we need help	She discusses her struggles with her classmate and her classmate discusses her struggles with participant. The description of this behavior indicates that her classmate is attempting to prepare or help her get through the struggles of studying

CODES	DESCRIPTION	EXAMPLE	NOTES
	mathematics.	on the homework then she'll ask me questions and I'll ask her questions…." (P1, Row 726)	mathematics.
M3C(DB)- =No (CONSTRAINTS)	I would code a statement as M3C(DB)- if the participant's description of the behavior of the other party indicates that the other party is not attempting to prepare the participant for the struggles and constraints of studying mathematics.	Um, I think from my mom, especially my parents, I tried to avoid talking about struggling in math. Um, I let them know, I mean it's, I let them know it wasn't like an easy—an easy thing to pursue, but I never really told them "I'm struggling really bad in class" or "I don't get it" or anything like that because I think that, um— like my mom would start thinking, you know, "oh man. She's having a hard time." And I didn't want to worry her in anyway. So, I think that that's what kept me from like letting her know like "oh I'm struggling in a class or I don't know if I'm gonna pass this class" or whatever. So I just, kind of, kept that to myself and just let her know like "it's tough but I can do it." And she never really knew the, um, specific details of why it was tough or what I was having troubles with or anything like that. Because she would feel like she would want to help me. But, I mean, at that point not a lot of people can help me, even in college. So, um, my mom would feel kind of, I guess, not useful in that way and I never wanted to make my mom to feel like that so I didn't really tell	The participant does not discuss her struggles in mathematics with her family because she does not want to worry them and she does not want them to feel bad because they cannot help her. Therefore the participant's family is not helping her prepare for the struggles or handle the struggles of studying mathematics.

CODES	DESCRIPTION	EXAMPLE	NOTES
		her the specifics of where I was struggling or why, I just told her "I got this. It's hard but I got this." (P4, row 674)	
M3O(PC)+ = Yes (OPPORTUNITIES)	I would code a statement as M3O(PC)+ if the participant indicates that he or she concludes that the other party is attempting to prepare the participant for the opportunities for success due to studying mathematics.	"…he was able to reassure me that it wasn't as intimidating as all that…" (P2, Row 232)	The participant's professor made her feel that doing research was not intimidating. The participant concludes from her perspective that he was attempting to prepare the participant for opportunities for success.
M3O(DB)+ = Yes (OPPORTUNITIES)	I would code a statement as M3O(DB)+ if the participant's description of the behavior of the other party indicates that the other party is attempting to prepare the participant for the opportunities for success due to studying mathematics	"Um, he kind of just gave a brief description of like, you know, there's a lot of options that you can get into. He asked me if I was interested in education, uh, that's like the usual question I get when I talk about a math degree is education. But, um, he kind of went over some of the courses that I would have to take and then if I had any questions about the course he would answer them for me, um, but that was, that was really it." (P1, Row 233)	To me this was an indication that her professor was attempting to tell her about some of the opportunities available to her as a result of studying mathematics. I would not code this M3O(PC)+ because she did not directly say that he was telling her about opportunities available. I had to come to that conclusion myself.
M3O(DB)- =No (OPPORTUNITIES)	I would code a statement as M3O(DB)- if the participant's description of the behavior of the other party indicates that the other party is not attempting to prepare the participant for the opportunities for success due to studying mathematics	**V: Ok, did he ever talk to you about graduate school?** P1: Um, not really, no. (P1, Rows 234-235)	The participant's professor did not ever talk to her about going to graduate school. So, her description of his behavior indicates that he did not attempt to prepare her for the opportunities for success due to studying mathematics.

CODES	DESCRIPTION	EXAMPLE	NOTES
Fostering Student's Reasons and Strategies for Studying Mathematics			
M4R(PC)+ = Yes (REASONS)	I would code a statement as M4R(PC)+ if the participant indicates that he or she concludes that the other party is attempting to help the participant develop healthy reasons for studying mathematics.	**V: That her enthusiasm had an effect on-- on you?** P2: Oh yeah, oh yeah! Definitely! I mean it was, uh, it was definitely, uh, um, you know, like with anything else, um, enthusiasm can be contagious, absolutely. Um, so whenever we would, uh, succeed or get the results for some problem and then it would open up new questions so we'd-- you know, it was always fun trying to, uh, sort of explore more questions that we could expand our research to. (P2, Rows 441-442)	A healthy reason for studying mathematics is because you are excited about it. The participant concludes based on her perception that her peer's enthusiasm encouraged her to studying mathematics further.
M4R(DB)+ = Yes (REASONS)	I would code a statement as M4R(DB)+ if the participant's description of the behavior of the other party indicates that the other party is attempting to help the participant develop healthy reasons for studying mathematics.	"…it was just a very interesting course for me. And I would find myself reading the text book ahead before, you know, before a lecture and stuff, and so, uh, so yeah, I just, uh, really enjoyed it." (P2, Row 186)	The participant enjoyed doing mathematics as a result of her professor attempting to make mathematics interesting. Thus the actions of the professor indicate that he was trying to help the participant develop healthy reasons for studying mathematics.
M4R (DB)- =No (REASONS)	I would code a statement as M4R(DB)- if the participant's description of the behavior of the other party indicates that the other party is not attempting to help the participant develop healthy reasons for studying mathematics.	"I know a lot of my friends and everything are just going and getting their, like, doctorates, in, uh, math and things like that so they'll probably like push me to, like, go with them and everything so well continue to like work together and things like that, so more than likely, it would like actually help	Studying mathematics because your friends are studying mathematics is unhealthy. Therefore his description of the behavior of his peers is not attempting to help him develop healthy reasons for studying mathematics.

CODES	DESCRIPTION	EXAMPLE	NOTES
		more than hinder" (P3, Row 444)	
M4S(PC)+ = Yes (STRATEGIES)	I would code a statement as M4S(PC)+ if the participant indicates that he or she concludes that the other party is attempting to help the student develop sound strategies for studying mathematics.	"…he's been very helpful and, uh, throughout my whole college career, and you know, suggested some really great classes for me to take that, uh, that helped me…" (P2, Row 236)	The participant concludes based on her perception that her professor was helpful because he suggested that she take specific mathematics courses, which was a sound strategy for studying mathematics.
M4S(PC)- =No (STRATEGIES)	I would code a statement as M4S(PC)- if the participant indicates that he or she concludes that the other party is not attempting to help the student develop sound strategies for studying mathematics.	"I didn't feel really included, it was really delegated and separated, so, it wasn't really inclusive." (P1, Row 374)	Based on the participant's perception she did not feel included in a study group, which is not a sound strategy for studying mathematics.
M4S(DB)+ = Yes (STRATEGIES)	I would code a statement as M4S(DB)+ if the participant's description of the behavior of the other party indicates that the other party is attempting to help the student develop sound strategies for studying mathematics.	"Yeah, we had our own study group going on actually and one of my friends, he's, um, and applied physics major--… And everything, and he's taken Calc 3, he's like a minor in math or he's double majoring in math, but he an applied physics major, so, he's had it and everything, and since that Calc 3 is pretty much like physics in general, he was like, uh, our tutor and everything, so he was like teaching us, and we had like-- it was a group of us, we would work together, we met up like three times a week" (P3, Rows 390-392)	Here the participant is describing that his peers were attempting to help him develop sound strategies for studying mathematics.
M4S(DB)- =No (STRATEGIES)	I would code a statement as M4S(DB)- if the participant's	**V: Ok, so does he ever encourage the students to work in groups?**	I coded this quote M4S(DB)- because to me, this is an indication

CODES	DESCRIPTION	EXAMPLE	NOTES
	description of the behavior of the other party indicates that the other party is not attempting to help the student develop sound strategies for studying mathematics.	P1: Uh, no. (Row 248 - 249)	that the professor was not attempting to teach the participant strategies for studying mathematics, in particular, studying with others.
Results of MRIME			
Student Grows Mathematically			
R1(PC)+ = Yes	I would code a statement as R1(PC)+ if the participant indicates that he or she concludes that he or she is or learning mathematics as a result of interactions with the other party.	"Um, yeah, yeah and working with her in particular, yes, yes-- yeah, helped me to grow mathematically, yes…" (P2, Row 424)	Here the participant perceives that she grew mathematically by working with one of her peers.
R1(PC)- = No	I would code a statement as R1(PC)- if the participant indicates that he or she concludes that he or she is not learning mathematics as a result of interactions with the other party.	"…it really wasn't helpful at all." (P1, Row 261)	The participant is describing her experience when she went to her professor's office hours for help. To her, he did not help her grow mathematically.
R1(DB)+ = Yes	I would code a statement as R1(DB)+ if the participant's description of the behavior of the other party indicates that the participant is learning mathematics as a result of interactions with the other party	"…I went to his office hours a couple of times about his class then I went to his office hours um, actually, I went to his office hours about Calculus 3, because I needed help with Calculus 3 and my professor, he wasn't helping me much, so I ended up talking to him. He was able to clarify some things for me…" (P1, Row 217)	The participant's professor helped her with material from his course and from other courses. The description of his behavior indicates that he attempted to help her grow mathematically.

CODES	DESCRIPTION	EXAMPLE	NOTES
R1(DB)- = No	I would code a statement as R1(DB)+ or R1(DB)- if the participant's description of the behavior of the other party indicates that the participant is not learning mathematics as a result of interactions with the other party	"…If I were to try to work it out, he would kinda just like correct me and then like work out the rest of the problem by himself so it really wasn't helpful at all."(P1, Row 261)	To me she is not learning mathematics as a result of interactions with her professor.
Student Enjoys Mathematics			
R2(PC)+ = Yes	I would code a statement as R2(PC)+ if the participant indicates that he or she concludes that he or she does enjoy mathematics as a result of interactions with the other party.	**V: Ok. Now in what way do you think that your relationship with your math professors have influence your decision to get a PhD in mathematics?** P3: Um, well seeing them, like, teach and everything, especially in math and things like that, how excited they were and everything and how excited and comfortable the class felt and I know how I felt when they were teaching me and everything, like, I knew I could count on them. Like I could always go to them if I needed help. And just the relationships I had, um, it influenced me and showed me what I want to do. Like, I realized like going to college, I said "I might as well just major in math" and I was gonna do that I guess until I figured out— (P3, Rows 260-261)	The participant is concluding that he enjoys mathematics because of his interactions with his math professors.
R2(PC)- = No	I would code a statement as	"I don't think that studying by myself or	The participant concludes based on

CODES	DESCRIPTION	EXAMPLE	NOTES
	R2(PC)- if the participant indicates that he or she concludes that he or she does not enjoy mathematics as a result of interactions with the other party.	with a group, I don't think that that necessarily changed my feelings about mathematics" (P2, Row 452)	her own perceptions that interactions with her peers did not influence how much she enjoyed mathematics.
R2(DB)+ = Yes	I would code a statement as R2(DB)+ if the participant's description of the behavior of the other party indicates that the participant does enjoy mathematics as a result of interactions with the other party	"I think it was the one that wanted to learn, the girl. She was also wanting to be a teacher so I feel like us, as mathematicians or, like, as one--as aspiring teachers, we need to be enthusiastic about the subject or else our students are not. So, I think I felt more comfortable with her." (P4, row 385)	The participant was studying with a woman who was enthusiastic about mathematics, which encouraged the participant to also be enthusiastic about studying mathematics.
Feels that they belong in Mathematics			
R3(PC)+ = Yes	I would code a statement as R3(PC)+ if the participant indicates that he or she concludes that he or she does belong in mathematics as a result of interactions with the other party.	"And then we had to also present our findings at a couple of, um, conferences we did talks presenting our findings. So yeah, definitely, uh, I felt like a-- yeah, I definitely felt like a mathematician." (P2, Row 430)	The participant stated that she felt like a mathematician while working on a summer research project. This is the result of her interactions with her professor who encouraged her to do this summer research program.
R3(DB)+ = Yes	I would code a statement as R2(DB)+ if the participant's description of the behavior of the other party indicates that the participant does belong in mathematics as a result of interactions with the other party	"Um, yeah, well most of the people that, uh, like, I hang with and everything are all either, like, math majors or engineering majors or either an applied physics major or things like that, and, uh, like usually, like, most of the times when were speaking it's in like math terms a lot, or like, you know, telling somebody to look like a certain way well like say the angle that they are supposed to look and things like that so it	The participant describes that he and his peers would discuss mathematics frequently and use mathematics terminology in their casual conversations. They also try to do mathematics problems together. This is an indication that he belongs in mathematics, at least at the level that he is at in the mathematics pipeline.

CODES	DESCRIPTION	EXAMPLE	NOTES
		helps us keep up on our math stuff so like a lot of our conversations revolve around math or like figuring out different, just random problems and everything, we use math and different logic and stuff like that or different, like, proofs, so like proving things and everything, so, like constantly just math stuff." (P3, Row 426)	
R3(DB)- =No	I would code a statement as R2(DB)- if the participant's description of the behavior of the other party indicates that the participant does not belong in mathematics as a result of interactions with the other party	**V: I see. So you guys don't talk about math or anything?** P1: No, not really… (P1, Rows 353-354)	The participant is describing that she and a former mathematics classmate do not discuss mathematics. Because the classmate does not discuss mathematics with the participant, I would conclude that the participant is not participating in behavior that would indicate that she belongs in mathematics. Therefore, the participant does not belong in mathematics as a result of interactions with this particular classmate.
Other			
Lack of Relationship in Mathematics			
LRM	I would code a statement as LRM if the participant concludes or indicates that he or she had NO relationship of any kind with another party OR if no particular party is mentioned.	**V: That made it hard. I see. So with this professor, did you feel that you had any kind of relationship with him?** P1: Not at all. (P1, 254-255)	I coded this LRM because she stated that she did not feel that she had a relationship with this professor.

VITA

VITA

Education

B.A., Mathematics, 2010, Wayne State University, Detroit, MI
M.S. Ed., Curriculum and Instruction, 2013, Purdue University, West Lafayette

Research

Investigator, *Developing Tools to Evaluate Mathematics Lessons and Curricula*, Purdue University, 2012

Investigator, *A Look at How a Group of Graduate Students View Students Learning Mathematics*, Purdue University, 2012

Investigator, *Fractions, Decimals, and 111111111*
Wayne State University, Mentor: Dr. Daniel Frohardt, 2009

Investigator, *In the Math Department, the Numbers Just Don't Add Up!*, Wayne State University, 2007

Awards

Recipient, Best Poster Award, Annual Graduate Students Educational Research Symposium (AGSERS), Purdue University, 2012

Recipient, Center for Chicano-Boricua Studies Estrella of the Year Award, Wayne State University, 2011

Recipient, The Karl W. and Helen L. Folley Endowed Mathematics Scholarship, 2010

Recipient, Latino En Marcha Scholarship, 2004, 2005, 2006, 2007

Recipient, Michigan Merit Award, 2004

Presentations

Presenter, Indiana Conference of Teachers of Mathematics, Indianapolis, IN, 2012

Presenter, Annual Graduate Students Educational Research Symposium (AGSERS), Purdue University, 2012

Participant, Summer Research Opportunity Program, Purdue University, 2011

Participant, AGEP Summer Bridge Transitional Program, Purdue University, 2011

Presenter, Research and Leadership Conference, Albuquerque, NM, 2009

Presenter, Undergraduate Research Conference, Wayne State University, 2009

Presenter, Michigan Undergraduate Mathematics Research Conference, Wayne State University 2009

Presenter, Student Institute for Latino Public Policy, Washington, DC, 2007

Organizations

Member, McNair Scholars Program, Wayne State University, 2008-2009

Publications

V. Pardo, *Fractions, Decimals, and 111111111.* McNair Scholars Research Journal 2010 (p. 71-93)

Professional Experience

Instructor, Mathematics, Wayne State University, Detroit MI, 2013-Present

Instructor, Mathematics, Wayne State University, Detroit MI, 2010-2011

Instructor, Mathematics, Baker College, Allen Park MI, 2010-2011

Private Math Tutor, Dearborn MI, 2008-2011

Student Assistant to Undergraduate Advisor, Wayne State University's Department of Mathematics, August 2008 – August 2010

Peer Mentor-Specializing in Mathematics, Wayne State University's Center for Chicano-Boricua Studies, June and July 2007, June 2008-May 2009

Grant Writing Committee Member, Wayne State University's Center for Chicano-Boricua Studies, 2008

Contributing Editor, *Onda Latina*, Wayne State University's Center for Chicano-Boricua Studies, Fall 2007 Issue

Student Assistant, Wayne State University's Center for Chicano-Boricua Studies, May 2007-August 2008

Math Tutor, Wayne State University's Center for Chicano-Boricua Studies, September 2006-May 2007

Extra Curricular Activities:

Director and Teacher of Children's Ministry, Calvary Chapel Downriver, Romulus, MI, 2006-2011

Missionary at Capilla Puerta del Manzano, Cd. Cuauhtémoc, Chihuahua, Mexico, October 2007-April 2008:

Teacher of English as a Second Language, Arab-American Friendship Center, Dearborn, MI, 2006-2007

Adult Caregiver, State of Michigan, 2006

President, Via Veritas, Wayne State University, 2006

Participant, Alternative Spring Break Detroit, Wayne State University's Project Volunteer, the Detroit Orientation Institute, and the Dean of Students Office, 2005

References

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