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As industries relating to science, technology, engineering, and mathematics in America continue to grow, employers will need more mathematicians and mathematically able workers than are currently graduating. Women are an underrepresented portion of these graduates, and researches say that this could be due to the difference between women's and men's mathematical confidence. Calculus I is a required course for all STEM majors, and this course has proven to be a leaky point in the pipeline, a point at which women leave STEM degree programs at significantly higher rates than men. The purpose of this study is to explore what factors in Calculus I most affect the mathematical confidence of women in STEM-related majors. I share how I analyzed data that I collected during focus group interviews, and what patterns emerged in

my analysis. I also offer an insight into the experiences of a few of my participants; these act as case studies. I explore how identity plays a key role in the experiences of these women enrolled in calculus I. Finally, I offer suggestions as to what universities and professors can do in their classrooms in order to improve the retention rates and experiences of women in their courses.

The Experiences of Women in First-Term Calculus: Factors Affecting Mathematical Confidence

by

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Amanda Petty Blaisdell, Author

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Chapter 1: Introduction

America needs more mathematicians. It is estimated that we need one million more science, technology, engineering and mathematics (hereafter referred to as "STEM") graduates than are currently predicted in order to meet the demands of our workforce, and a retention rate just 10% higher than the current one would meet that demand (United States, 2012). Currently, half of all students who begin college as a STEM major will eventually switch to a non-STEM major, which is the highest switching rate of any major (Lowery, 2010). Persistence in the STEM-related classes is key in producing more graduates, but males persist in these courses 14% more often than females do (Price, 2010). If the persistence rate were the same for males and females currently in STEM-related majors, our country might have a fighting chance at employing the number of mathematicians, scientists, and engineers necessary for the U.S. economy to remain globally competitive.

Calculus, specifically differential calculus, is a pre-requisite for nearly all STEM-related majors and careers. If a student wants to succeed in a STEM-related field, they must first succeed in calculus. Historically, calculus has acted as a challenging gateway for students, with high failure rates and causing students to leave the sciences. This gateway proves to be particularly problematic for the persistence of females; women drop out of STEM after calculus nearly 1.5 times more than men do (Ellis, Fosdick, & Rasmussen, 2016b). Lack of mathematical confidence may be a major reason why women leave STEM fields far more often than men do; males tend do better in calculus and this may be due to higher levels of mathematical confidence, as researchers have found a correlation between mathematical confidence and performance (Pajares, 2005).

Mathematical confidence, which I will define to be the quality of being certain performing mathematical tasks correctly (Dowling, 1978), generally comes easier to men than it does to women, though actual mathematical ability is the same (Pajares, 2005). When I combine the fact that women are dropping out of STEM fields at a higher rate after completing Calculus I and the fact that we need more people completing STEM-related degrees, I come to the conclusion that we must seek to understand the factors that are leading to this lack of retention of women in STEM majors. I aim to explore this area in order to expand on the study done by Ellis, Fosdick, & Rasmussen (2016b) which measured the change in student-reported mathematical confidence grouped by gender and persistence in calculus. In particular, I hope to add to the field of knowledge in this area by using individual and focus group interviews with women to understand how various factors affect mathematical confidence while enrolled in differential calculus. I keep this question very broad to remain open to any factors that may affect the mathematical confidence of the students, including teaching style, professor or instructor, peer interactions, and mathematical background, among other factors.

In addition to classroom and course factors that may affect the mathematical confidence of these women, I also seek to understand how their identities affect their confidence. It has been shown that aspects of your identity such as race (Larnell, 2016), family structure (Zeldin & Pajares, 2000), and femininity or masculinity (Pajares & Valiante, 2002) can affect the way someone feels about and performs in mathematics. By using a qualitative approach and collecting data through interviews and focus groups, I am able to employ identity theory (Nickerson, Bjorkman, Ko, & Marx, 2017) to understand how the intersectional identities of these women may play a role in their mathematical confidence levels.

In Chapter 2 of this thesis, I provide a rationale for aiming to understand mathematical confidence by means of a literature review that is organized by time periods. Chapter 3 describes the methods used to recruit participants for this study, collect data, and analyze the data using thematic analysis (Braun & Clarke, 2006). These methods were determined by my research questions, which are given at the end of Chapter 2. The results from the analysis of my data are presented in Chapter 4, and these themes will be discussed in greater detail in Chapter 5. Additionally, I offer suggestions to universities and professors to aid in the retention of women in STEM-related majors at the end of chapter 5. All materials used for the data collection and analysis can be found in the appendices at the end of this thesis.

Chapter 2: Literature Review

In order to understand the dynamic nature of what mathematical confidence means, how women in STEM-related majors were studied and what the researchers wanted to find, and how gender roles in the classroom have shifted over time, I offer a literature review broken into time periods. After I survey the literature from these periods, I explore common themes and discuss how the research has changed throughout time.

2.1 Literature from 1960-1979

By this time in our history, the term “mathematical confidence,” defined to be the quality of being certain performing mathematical tasks correctly (Dowling, 1978), had been coined and the lack of such confidence was being explored as a reason that women did not go into STEM fields as often as men. Researchers saw this fact as a problem that needed investigation (Fennema & Sherman, 1977) and they looked into many reasons that women could have a lower mathematical confidence, including parental involvement, seeing mathematics as a male domain, and viewing mathematics as a useful subject (Dowling, 1978; Fennema & Sherman, 1977). Several questionnaires and survey scales were developed in order to measure mathematical confidence, some specifically for women who were in college (Dowling, 1978; Fennema & Sherman, 1977). These questionnaires, however, were not designed specifically for women who intended to go into STEM-related fields, but rather for any woman in college. As we can see, in this time period, it was already known that lack of mathematical confidence in women was a reason why women were less likely to complete STEM degrees than men.

Researchers in this time period wanted to de-bunk the then-common misconception that men are naturally better at mathematics than women are (Fennema & Sherman, 1977; Lambert, 1960; Levine, 1975). Additionally, the literature seems to suggest that the problem with lower mathematical confidence in women is that they then do not enter mathematical careers as often as men do, which is a problem for our country and the world, as we have a deficit of people going into mathematical careers; more women entering these fields would help alleviate this deficit (Goldman & Hewitt, 1976; Levine, 1975). Researchers wanted to determine the factors that led to women not majoring in, and thereafter not going into careers in, mathematics, which led to the aforementioned development of confidence scales (Goldman & Hewitt, 1976; Levine, 1975). For example, the scale developed by Goldman & Hewitt (1976) used statistical analysis between data such as SAT scores and college major choice to conclude that mathematical ability is a determining factor in choosing a science-related or non-science-related major. Levine (1975) used questionnaires given to school counselors, teachers, and students to determine a particular student's mathematical confidence, and then analyzed this scores against their mathematical performance.

It is worth noting that, although the literature seems to have a goal of proving that women are not inferior to men in mathematical ability, researchers still want to know why the gaps exist (Fennema, 1979). They acknowledge that, although there should not be a gap based on innate ability, there is an achievement gap. The various questionnaires developed throughout this time, as well as multiple studies, were designed to understand which factors affect this gap, including mathematical confidence and bias against women in teaching mathematics, although they do little to suggest how to aid in fixing those factors (Fennema, 1979; Fennema & Sherman, 1977; Goldman & Hewitt 1976).

During this time period, the only issue related to identity that was explored in the literature pertaining to my research question was that of femininity and masculinity (Lambert, 1960). This is worth noting, as we will later see that different intersectional identities made their way into the literature as time progresses.

2.2 Literature from 1980-1997

During this time period, we see new vocabulary arise in additional to 'mathematical confidence'; the terms 'mathematical self-concept' and 'mathematical self-efficacy' start being used by researchers (Pajares & Miller, 1994; Sax, 1994). Each are carefully defined and differentiated throughout the corresponding literature. Although the differences between these three terms are subtle, the development of new vocabulary shows a broadening of the field, as well as the dive into psychology in order to understand these differences. We see a de-bunking of the myth that girls and women have innately less mathematical ability than men, which shows that this belief is still prevalent during this time (Sax, 1994). In this same research, Sax defines mathematical self-concept as how a student perceives their mathematical ability. Pajares and Miller (1994) make the distinction that "self-concept differs from self-efficacy in that self-efficacy is a context-specific assessment of competence to perform a specific task, a judgment of one's capabilities to execute specific behaviors in specific situations" (p. 194).

The literature from this period states that there is a mathematical gap between men and women during college, and that college widens this gap (Sax, 1994). Although this is an important finding, there seems to be an emphasis during this time of mathematical problem-solving; the new terms such as 'mathematical self-efficacy' and 'math anxiety' are employed in order to understand how women solve problems (Pajares & Kranzler, 1995). There is literature both on how problem solving affects mathematical self-efficacy and how self-efficacy affects mathematical problem-solving (Lundeberg, Fox, & Punćcohaŕ, 1994; Pajares & Kranzler, 1995).

Researchers during this time were still exploring how mathematical self-efficacy plays into the selection of a college major, which often turns into a career (Betz & Hackett, 1983). Some research suggests that this development of mathematical self-efficacy begins with different mathematics experience between boys and girls starting at a young age (Kimball, 1989). We can see that the research from this time spans from early childhood experiences to the selection of a career, with no particular emphasis on how college, or specifically calculus, plays a role in mathematical confidence.

We do, however, see the first mention of how mathematical confidence can affect women in college mathematics classes (Boli, Allen, & Payne, 1985). Similar to other research being done during this time, Kimball's (1989) study focused on the mathematical experiences of men and women who were majoring in mathematics and chemistry, finding that men had stronger mathematical experiences at a younger age than women. This article mentioned that this difference in confidence led to men performing better in the course than women, but the researchers did not investigate to explain other factors that may have been at play there (Boli et al., 1985).

Notably, there was research done during this decade regarding why women switch out of STEM-related majors more often than men do (Seymour & Hewitt, 1997). In this study, the researchers chose seven higher education institutions and examined factors that led men and women to switch in and out of STEM-related majors. They found that those who switched did not do so due to academic challenges, but because of lack of personal support for the individual students. (Note: My study that I describe in this thesis is based on the study by Ellis, Fosdick, and Rasmussen (2016b) that is quite similar to this one, showing that this research may have been ahead of its time.)

2.3 Literature from 1998-2008

From 1960 to 1998, the emergence of literature that is relevant to my research questions was relatively slow. In 1998, more and more research was being conducted that relates to my literature, which is why this time period only spans ten years rather than the twenty and eighteen years that the previous time periods spanned.

In this decade, we see an emergence of theory come into play behind the research. Stereotype threat, defined by Good, Aronson, and Harder (2008) is the phenomenon of "when negative stereotypes *are* activated and left unchecked, they trigger a number of disruptive psychological processes that undermine test performance" (p. 18). Stereotype threat is mentioned in several articles as a key reason why some women do not perform as well in mathematics as men do during college (Good, Aronson, & Harder, 2008; Oswald & Harvey, 2000; Spencer, Steele, & Quinn, 1998). This research suggests that women have internalized the belief that women are naturally inferior to men when it comes to mathematics, and this factor negatively impacts their mathematical performance. This development shows that research is looking beyond the classroom environments for other factors that could be affecting how women perceive mathematics.

This decade also brings the first studies research specific to college-level calculus. Research was conducted to measure the difference between self-efficacy in calculus students and in students enrolled in developmental mathematics (Hall & Ponton, 2005), and we also see research that shows how courses such as calculus dissuade women from studying computer science, which is another field in which women are hugely underrepresented (De Palma, 2001). Researchers may now be aware the calculus classes that students take in college can act as a gateway into careers in STEM, as well as affect the mathematical self-confidence of the students.

Additionally, we see research being done on the intersectionality of women who are in STEM-related majors. Studies were conducted with women of color who were enrolled in doctorate mathematics program and how their self-efficacy came into play in their success (Herzig, 2004), and other studies investigating the persistence of women of color in college in general, not necessarily in mathematics (Landry, 2002). One article was specifically about women of color in mathematics programs and how the climate on college campuses affected their persistence; this study found that the language that professors used in class and when speaking with women of color often discourage them from pursuing the sciences (Johnson, 2007). Herzig (2004) found that factors such as family responsibilities, feelings of isolation, perceived competition, and financial support affected the way that women of color persist in doctorate mathematics programs. Similarly, Landry (2002) found that women of color need support systems such as women's centers on campus and summer transition and orientation programs tailored to them. This new area of research in studying different aspects of woman's identity shows that researchers were aware that different women experience the same universities and mathematics classes in different ways due to their identities.

There continues to be an emphasis on how college course selection and success later affects the careers choices of women. One research study aimed to figure out which factors led women to choose careers in STEM (Zeldin & Pajares, 2000), and another looked specifically at gender differences in engineering programs (Vogt, Hocevar, & Hagedorn, 2007). Zeldin and Pajares (2000) concluded that most women in STEM-related careers had some person in their life that encouraged and supported their learning of mathematics, and that this person was often a family member or teacher. Vogt et al. (2007) found that there were major differences between men and women in engineering programs in terms of learning with peers, academic integration, and seeking help with concepts they didn't understand. This pattern of looking ahead to the career choices of women has been consistent throughout the decades, which shows that researchers want to understand the lasting impacts of courses that women take, and how those impacts echo throughout the country's workforce.

2.4 Literature from 2009 to the present

We saw in the previous decade that calculus finally made an appearance as a gateway course that may influence women's decisions to stay in or leave STEM. The most current literature points to differential calculus as a course that can dramatically alter a woman's mathematical confidence, and with that, her major and career aspirations (Ellis et al., 2016b). In fact, I found this study to be particular inspiring because the first time I took calculus, I left with a very low sense of mathematical confidence, but still entered and graduated college with a mathematics degree. Ellis and colleagues confirmed that women both enter and leave the first term of calculus with lower levels of mathematical confidence than men. Based on this result, my research question focuses on the factors that cause that to occur.

As my study is based on the research conducted by Ellis and colleagues, I reached out to Dr. Ellis regarding my study. We were able to discuss the best direction for my research over an internet video chat service. She encouraged me to take a qualitative approach to my study, and as we will see in the following chapter, I took this advice to heart.

Notably, in the current literature comes more research on sense of identity. Women need to feel like they belong in a mathematics classroom and in a mathematics department in order for them to stay and succeed (Good, Rattan, & Dweck, 2012). Additionally, women succeed best in mathematics when they have someone like them in the department to look up to (Nickerson, Bjorkman, Ko, & Marx, 2017). The literature suggests that if woman have a sense of belonging and kinship in the classroom and department where they study, their confidence will increase, and they are much more likely to persist with mathematics. One study pointed to race in particular as a factor that may affect a student's sense of belonging in a course or at a university (Davies & Garrett, 2012). Finally, a comprehensive literature review that examined research conducted on mathematics identity and student outcomes concluded that a student's mathematical identity is tied to their learning of, perception of, and persistence in mathematics; this study also examined two table partners in a mathematics class to find that their interactions had a profound impact on their identity (Bishop, 2012).

How students perceive a course and its material also seems to have an effect on their mathematical confidence and persistence. One group of researchers from this time period sought to understand how the differing perceptions of a course affected the students' achievements in the course and courses thereafter (Ellis, Fosdick, & Rasmussen, 2016a). As we saw in the previous decade, researchers are still concerned that stereotype threat makes a difference in the mathematics performance and achievement of women (Shapiro & Williams, 2012). We see a turning point in this decade when it comes it the intersectionality of a woman's identities playing a role in their mathematics interest and achievement. There are researchers looking at how women of color enter STEM and stay there, as well as factors that could contribute to their success (Litzler, Samuelson, & Lorah, 2014; Ong, Wright, Espinosa, & Orfield, 2011). Additionally, the sexuality of students comes into question as another factor that could influence their inclination towards or away from mathematics (Charles, Harr, Cech, & Hendley, 2014).

We see something in this decade that we have not seen before: research on which style of teaching closes the achievement gap the most. It was shown that inquiry-based learning (IBL) was the most effective teaching strategy in terms of closing the achievement gap in mathematics between men and women (Kogan & Laursen, 2014). Women who participated in these kinds of classrooms with active learning, instead of the traditional lecture-style classroom, experienced a major boost to their mathematical confidence that was still affecting them years later. Additionally, it was found that the more actively engaged students were in their mathematics class (which often is a positive side effect of IBL), the less mathematics anxiety they had (Everingham, Guyris, & Connolly, 2016).

Up until now, little of the literature that I reviewed discussed the relevance of calculus for particular career paths. However, recent literature gives new insights into how various college programs could implement different kinds of calculus classes into their curriculum for better student learning and achievement. Additionally, researchers have sought to understand the emotions that life sciences majors have towards mathematics. It has been shown that life sciences majors had more emotional dissatisfaction with mathematics than mathematics majors did, and that gender also played a role in life sciences being less emotionally satisfied with mathematics (Wachsmuth, Runyon, Drake, & Dolan, 2017). Finally, the idea of academic emotions has been studied during this decade; men and women were found to have different emotions regarding academics, and this played a role in their success in STEM-related majors (Pelch, 2018).

Another theme throughout this time period is that of having enough time to learn in college calculus classes. Many students and instructors feel that they do not have sufficient time in their calculus classes in order to learn and teach what is expected of them, and researchers gave insights on what instructors can do in order to combat this (Hagman, Johnson, & Fosdick, 2017). These researchers suggested that in order to make more time for learning in these classrooms, we need to better prepare students before they come into calculus so that students feel confident about their abilities, and that instructors should provide ample time for discussion and group work (Hagman et al., 2017).

Recent research in this field has also focused on the impact that peers and friend groups can have on which field someone decides to go into. A study performed in Sweden showed that girls in high school adjust their academic interests to those of their friend groups, which leads to a higher STEM retention in their peers express a desire to like mathematics, and also leads to a higher drop-out from mathematics if their peers express a dislike for STEM (Raabe, Boda, & Stadfeld, 2019).

2.5 Patterns Through the Decades

I now shift the focus to the patterns that have emerged in the literature as I conducted this literature review. I remind the reader of the various components of my research question: college calculus, women in STEM-related fields, and mathematical confidence. Interestingly, literature involving women's mathematical confidence as it pertains to calculus specifically was not addressed until the early 2000s. Literature before this time period focused on college classes in general, not specifically calculus. This may be due to the fact that some of the literature from this time points to calculus as a sort of gateway course into STEM-related majors, and thus, research needed to be done in order to understand how historically marginalized populations, such as women, broke through that gateway. Additionally, more college programs of study require calculus to be passed in order to obtain a degree now than in decades past; researchers may have picked up on this and sought to figure out why this seemed to discourage women from pursuing STEM-related degrees.

Another pattern worth noting is that of intersectional identities. We again see a shifting point in the literature from the early 2000s. Before this decade, we had not seen any research pertaining to how women with diverse identities, such as women of color or women who identify as LGBTQ+, experienced mathematics courses in comparison with the general population. It was in the 2000s that we saw the emergence of studies with goals to understand how women of color succeed in college in general, as well as how women of color go through mathematics doctorate programs. From 2008 to 2018, we see more research investigating the experiences of women of color, but we also see literature being written on the sexuality of women and how that affects their decisions regarding STEM-related majors. As the nation becomes more diverse, in terms of ethnicity, sexuality, socioeconomic status, or citizenship status, our college campuses also become more diverse. Thus, researchers in the past few years have been rightfully focusing on diverse learners' experiences on college campuses.

I next look at what the literature says regarding the career paths of women in STEM-related majors. I see another shift in the 2000s as the literature hones in on how college course selection and college course success plays into the future careers of women. Before the 2000s, research had not investigated the various factors that impact whether or not women go into STEM; I almost wonder if there simply were not enough women professionals in STEM-related careers before the 2000s for a sample size large enough to study this. Literature from both 1998 to 2008 and 2008 to 2018 points to calculus serving as a gateway not only into STEM-related majors, but into STEM-related careers. This shift may have occurred as the researchers in the U.S. realized the deficiencies in the number of STEM-related workers currently employed in our country, as stated in the introduction to this paper.

Another pattern that we have seen is regarding the various jargon that we see in the research. The term "mathematical confidence," the main one for the research I am conducting, had already been coined in the 1960s. In the 1980's, however, we see a dramatic increase in the number of words being used to describe concepts similar to mathematical confidence: mathematical self-efficacy, mathematical self-concept, and mathematical self-identity. This seemingly sudden increase in the jargon suggests that researchers during this time were attempting to study various aspects of a student's mathematical identity, in addition to mathematical self-confidence. This also shows that researchers of this time were aware that many experiences, past and present, can and will affect a student's mathematical performance; it is not simply capabilities or intelligences that affects a student's performance.

During the first four decades that I have examined, there seems to be a commonality in much of the literature: the researchers were aiming to de-bunk the myth that there is something biological about women that makes them inherently inferior at mathematics than men. This prevalence, though, disappears, once we get to the 2000s. It appears that, by this time, researchers believe they have properly proven that there is indeed no purely biological factor that contributes to the underperformance of women in mathematics. Instead, the research shifts its focus to the other factors that may explain why women underperform in mathematics compared to men.

All of the time periods I looked at have one common thread between them: each piece of literature addresses, in some way, the gap of achievement between men and women in mathematics. Thus, there exists some sort of gap in all four of these time periods. Interestingly, even the latest research seems to use deficit-oriented language; in some social sciences, researchers are moving away from the use of words like “gap” to describe an imbalance of performance, but in all of the literature that I have found, words like “gap” were used explicitly. There is research showing that using anti-deficit language in the classroom has positive effects on student learning and attitudes about the material and concepts with which they are engaging (Adiredja, Bélanger-Rioux, & Zandieh, 2019). It will be fascinating to see if there is a change in the language used surrounding this topic in the coming years.

The last pattern I will look at is that of the use of psychology in order to understand the achievement imbalance. The use of psychological terms and practices such as stereotype threat seemed most prevalent in the research from 1998-2008. This also seems to be the time period in which researchers become interested in studying how the various parts of a woman’s identity affect her learning of mathematics, which also has to do with stereotype threat. We also see stereotype threat cited in literature from the latest decade, which suggests that there may be more research coming that looks into psychological ideas as the basis for the achievement imbalance.

2.6 Conclusion

I have completed the brief journey through time in order to see how the literature surrounded the mathematical confidence of women in STEM-related fields has changed from the 1960s to now. I have addressed how vocabulary, areas of interest to the research, and perceptions of mathematical confidence have changed through time. In particular, I have highlighted patterns that have emerged relating to intersectional identities, career paths of women, the use of psychology, and the use of deficit-oriented language.

If the research of the most current decade is any indication, the research of how calculus affects the mathematical confidence of women in STEM-relating majors seems to be only beginning. It is my hope that the research continues to explore how the various parts of a woman's identity helps her go into mathematics, so that the world has an equal number of women and men mathematicians.

Now that I have describe the research literature about women in calculus, I turn to my research questions. My study aims to answer the following questions:

1. What factors, inside and outside the classroom, affect the mathematical confidence of women in STEM-related majors?
2. How are these factors related to each other, and in what ways do they affect the mathematical confidence of these women?

I left this question open as broadly as possible in order to consider factors that I otherwise may not have included in my study. The following chapters will detail my methods and findings that answer these questions.

Chapter 3: Methods

In this section, I will describe in detail the methods that were employed in order to recruit participants for this study, the participants who volunteered to engage in my study, and explain the process in which I collected and analyzed the data.

3.1 Recruitment and Participant Information

For my study, I sought individuals who self-identified as a woman who were currently enrolled in the first term of differential calculus for STEM majors at a large public university in the Pacific Northwest to participate in one-on-one and focus group interviews. I use the term 'differential calculus' to describe the course the participants took due to the course listing at this university; however, some universities call this course 'Calculus I'. All of these interviews occurred during the Winter 2019 term, which is a ten-week term. Before this term began, I contacted the four instructors who were teaching the six sections of differential calculus in order to schedule a day during the first week of classes when either I or my advisor, Dr. Mary Beisiegel, could come to each section to make a short announcement about the study. The announcement that we read can be found in the Appendix.

During this first week of classes, I also obtained a list from each instructor teaching differential calculus containing the email addresses of each student currently enrolled in their sections of the course. After my advisor or I made the announcement about the study in each section, we sent an email to all students enrolled in the corresponding section describing the study and asking for their voluntary participation. The email that I sent can also be found in the Appendix.

During the Winter 2019 term, approximately 500 students were enrolled in differential calculus at this university; approximately 38% of these students identified as female and approximately 62% identified as male. Of these, eight students responded to my email expressing interest in participating in my study. Some of their demographic information is summarized in the table below.

Table 3.1 Participant Information

Pseudonym	Major	Previously taken Differential Calculus?
Marie	Bioengineering	No
Elise	Computer Science	Enrolled and dropped out
Harper	Biology	In high school
Leanne	Biology	No
Stacey	Biochemistry and molecular biology	Yes, earned a D+ so has to re-take
Janine*	Ocean sciences	Yes, in high school and in college right after high school
Sonia	Bio-health sciences	No

* This participant withdrew from the term and therefore did not complete the study.

I assigned a random two-digit identification number and a pseudonym to each of these participants for confidentiality purposes. After they expressed interest, I asked when they would be available the following week (week 2 of the term) to complete an approximately 20-minute individual interview with me. I arranged meeting times with each of these eight participants. One was unable to meet at the time that we had arranged, so we re-scheduled. She was then unable to make the re-scheduled time, and the next time she was available was after the first focus group interview had occurred, so I decided it was too late in the term to collect the intended baseline data on this participant. Thus, she was unable to complete the study, which meant that I conducted one-on-one interviews during week 2 with seven self-indentifying female students. The participants were not paid or otherwise compensated for their involvement in my study; I did provide food at a couple of the focus group sessions. I audio recorded each of the initial individual interviews, each focus group session, and each of the final individual interviews.

I used the Fennema-Sherman Mathematical Confidence Scale (Fennema & Sherman, 1977) as my guide when developing the questions I asked during the initial interview. This scale can be found in the Appendix section, and includes items such as “I don’t understand why some people love doing math so much”, and “If a woman is good at math, then she must be masculine”. I wanted to gauge how mathematically confident the participants were coming into differential calculus, as well as understanding their career goals, priorities, and how their previous mathematics experiences have affected them. The questions asked during this interview and all subsequent interviews can be found in the Appendix.

One participant, Janine, completed the individual one-on-one interview during week 2 and a focus group session during week 3 of the term. She unfortunately withdrew from the university during week 5, and thus dropped out of my study. She gave me permission to use any data that I had collected from her during the initial interview and the focus group in which she had participated. Thus, six participants completed my whole study, which is detailed in the following sections.

During the initial interviews with the participants, I collected some baseline data about their major, their past experiences with mathematics, and other factors that may affect their mathematical confidence coming into differential calculus. The baseline data is summarized in Table 3.2 below. In the “High School Mathematics Experience” column, I rated how good they perceived their mathematics experience was based on what they told me during the initial interview, where a rating of 1 is a very poor experience and a rating of 5 is an excellent experience. For example, Harper's high school mathematics experience was rated as a 4 because she said:

> I had pretty good math teachers I'd say throughout most of my high school career that really drove me to succeed and I felt like they were super thorough. So I feel pretty prepared for college calculus."
> Her teacher "was always there to help after school, and so I always felt supported even though it was extremely stressful and very rigorous.

Thus, because Harper had good mathematics teachers and felt supported through her mathematics classes, which were stressful, I rated her high school mathematics experience as a 4. I considered the following statements made by Stacy to rate her mathematics experience as a 3:

> In high school I didn't have to take a lot of math classes. I took a lot of my math when I was in middle school, so I got a lot of my high school credit for it, I actually went to a high school in middle school to get a lot of my math classes. So, like, and I graduated in Oregon, so the highest math I had to take I pretty much got it done I think my sophomore year in high school. And, I had the options to go further, and I started, I think, like pre-calc, and I was like, no, I don't want to do this. I just, uh-uh. So, I never really had a problem with math. I think I was pretty efficient, and I know like, I always, at least when I was younger, I always excelled. As I got older I was kinda like, if I don't have to do it, I'm not gonna do it.

Similarly, I rated their baseline mathematical confidence on a scale from 1 to 5 using the Fennema-Sherman Mathematical Confidence Scale as my guideline, where a rating of 1 means they have poor mathematical confidence and a rating of 5 means they have excellent mathematical confidence. For example, I rated Janine's beginning confidence as a 2 due to her saying the following:

R:	Did you take a math class here at OSU last term.
Janine:	I took 112 last term.
R:	Can you tell me a little bit about that experience?
Janine:	I find it interesting that that's the lead-up to calc one, actually, because most of what we covered was trigonometry, and I feel like more of a pre-calculus base would have been more helpful. Um, I don't, I feel better

> when I see the sine and cosine and trig functions in calculus class, but [this university's trigonometry class] is so trig-heavy. And its', um, it was recommended and a pre-requisite to tot take before I re-take calc I, and I don't think it's a good course to prepare you. I even spoke to my GTA for my recitation, 'cause part-way through the term I was thinking that, and I asked her, you know, do you, am I preparing myself for calculus? Is that what this is doing? And she said, honestly, no, and all I can think of is why is this a prerequisite? So that, that's an issue with the math that I've taken so far."

She also spoke of being away from schooling for nine years, which could have affected her mathematical confidence or attitudes about academics:

> And then being away from it for close to nine years, and then trying to come back, um, it's a really interesting transition, and it's a really difficult to get back into the mindset. Which is also why I feel like [this university's trigonometry class] is not, was not a good come-back to math thing, because I don't feel like, like I said, it prepared me. Um, and it's one of those things that I feel like, a math class that covered a little bit more, um, would have prepared me better. Especially coming back, because it's one of those things, like, if you did a job for 12 or 13 years, and then you went and did a completely different one for 10 years, and then you go back to the first one, not nearly as easy as you'd expect.

Table 3.2 Summary of Baseline Data

Pseudonym	Career Goal	High School Mathematics Experience (1-5)	Beginning Confidence (1-5)
Marie	Animal Prosthetics	4	3
Elise	Data analyst	3	4
Harper	Something relating to fungus research	4	4
Leanne	Undecided; possible marine biology	3	3
Stacey	Some sort of research	3	3
Janine*	Research scientist	5	2
Sonia	Retail pharmacy	4	3

* This participant withdrew from the term and therefore did not complete the study.

3.2 Focus Group Interviews

After completing the initial interviews, I started scheduling the first round of focus group interviews, which occurred during weeks 2 and 3 of the term. I sent an email to the participants asking which days and times they would be available for the focus group, which I said would last approximately 90 minutes. Once I received all of their schedules, I found two times that would work – one time for 3 of the participants and another for the other 4 participants. I used this same technique for the subsequent second and third round of focus groups. Scheduling these such that all participants could attend proved to be a challenge. Thus, some of the participants did not attend every round of the sessions. A summary of the participants who attended each focus group session is summarized in Table 3.2 below. The same questions were asked during each of the sessions of the same round of focus group interviews. These questions can be found in the Appendix section. Although I scheduled both sessions of the second round of focus group interviews so that all participants could attend, two participants did not attend due unforeseen circumstances. Focus group 3 proved to be challenging to schedule, and due to time constraints of the term, I was only able to conduct one session. All interviews were held on campus, and they lasted between 35 minutes and an hour.

Table 3.3 Which Participants Attended Which Focus Groups

	Focus Group 1, session 1	Focus Group 1, session 2		Focus Group 2, session 1	Focus Group 2, session 2		Focus Group 3
Which participants attended	Elise, Stacy, Leanne	Marie, Harper, Janine*		Harper, Leanne	Stacy, Sonia		Marie, Harper, Elise

*This is the only focus group interview that this participant attended due to withdrawing from the term.

The choice to conduct focus group sessions (Wilson, 1997) rather than individual interviews was an intentional one. I wanted the participants to play off of what the other focus group members were saying rather than simply answering the questions I was asking. I thought that I could collect more data and that it would be more meaningful by allowing the participants to interact with each other and to hear what they were thinking and felt about various aspects of the course. Additionally, researchers have concluded that when you utilize focus groups, you get more balanced data than when you do not (Wilson, 1997). I am pleased with this choice, as I feel that organizing these focus groups helped facilitate a dynamic of sharing and openness that individual interviews would not have allowed.

After the initial one-on-one interviews, I transcribed the data and searched for patterns that emerged that could inform the questions I should ask during the first round of focus group interviews. Based on the article by Ellis, Fosdick & Rasmussen (2016b), as well as other literature that is discussed in the previous chapter, I knew I wanted to focus on some factors that may affect the participants' mathematical confidence throughout their taking differential calculus. These factors included instructor's teaching style, classroom environment, family support and background, and previous mathematical experiences. However, I wanted to be open to any other factors or patterns that emerged through the focus group sessions. Thus, I waited until after the initial interviews to develop the questions for the first round of focus group interviews, and I waited until after each round of focus group sessions to develop the questions for the following round of interviews. I felt that this allowed me to focus on the themes that were most prevalent in the dialogue occurring in the focus groups, rather than adhering to a set of pre-determined questions that may or may not have been relevant to the participants' experiences.

At the beginning of each focus group session, I read a statement regarding their voluntary participation in my study, outlined that they could withdraw from the study at any time without penalty, and asked for their verbal confirmation that I could record and use the recording in my research. Additionally, I asked the participants to keep anything said in the group confidential, as some of the topics discussed may be considered private. I gave each participant a chance to answer each question and left room and time for them to discuss their responses; if they didn't wish to answer a particular question, they were welcome to not respond. I used my discretion to ask follow-up questions to gain clarification on their responses or to gain additional information regarding their answers. All questions are listed in the Appendix, but here are a few examples of questions I asked during the focus group sessions:

What pressures are you feeling in regards to differential calculus?
How has differential calculus compared to your expectations of what it would be like?
Do you feel like your voice is heard, literally or metaphorically, in your calculus class?
Have you noticed anything about the way you learn calculus?
How do you feel you fit into your calculus class?

3.3 Thematic Analysis

After transcribing all of the individual and focus group interviews, I analyzed the data using thematic analysis (Braun & Clarke, 2006). This method of analysis is a tool used for qualitative data that results in a rich and complex set of data. In their paper, Braun and Clarke outline the six stages of thematic analysis, which are summarized in Table 3.4 below. Also included in this table is a short description of how I completed each step, which I will describe in more detail later in this section.

Table 3.4 Descriptions of stages of Thematic Analysis

Phase	Description of Phase	What I did to complete this phase
1	Familiarizing yourself with your data set	Transcribed the data myself; read through the data multiple times
2	Generate initial codes	Read through the data and noted any themes and

		created a code for that theme; developed a list of 20 codes and coded each data set with these codes
3	Searching for themes	Kept a journal and noted themes that were prominent during phase 2; collected any data relevant to a theme
4	Reviewing Themes	Read through collected data for each theme and searched for a coherent pattern; if no pattern emerged, I combined or separated themes.
5	Defining and naming themes	Analyzed data in each theme and discussed how the theme relates to my overarching findings
6	Producing the report	Summarized my findings and drew conclusions based on the results

Because I transcribed each of the individual and focus group interviews myself, I became quite familiar with the data. As I was transcribing, I made notes of possible codes that I might want to use in Phase 2 of thematic analysis. After I completed the transcriptions, I read through each of the data sets twice, looking for and noting any patterns that emerged right away.

When it came to generating initial codes, I first had to decide whether to take an inductive or deductive approach to my data. My first thought was to use a deductive approach; as I am using Dowling's (1978) definition for mathematical confidence, as well as the Fennema-Sherman (1976) scale for mathematical confidence, I thought I may try to code using a combination of the frameworks that these researchers used. I generated a set of codes from both of these papers, and summarized them in order to make them easier to see in my data. I tried to code the data from the first round of focus group interviews using these codes, which I have listed in the Appendix section. However, I found that much of the data was not captured by using these codes, since my data was focused on calculus and the papers whose frameworks I was using were not. Additionally, my data is all at the college level, and the Dowling and Fennema-Sherman papers were focused on students in high school. I briefly considered using the framework from the Ellis, Fosdick, and Rasmussen article (2016b) on which my research is based, but theirs was a quantitative study, and thus did not have the framework I was looking for. I decided to move forward with an inductive approach, creating codes that I saw relevant to my particular data set.

Since I was familiar with the data at this point, I had already made notes of some possible codes. I read through much of the data again and generated a list of twenty codes, a list of which can be found in the Appendix section. These codes included items such as “The participant is saying something regarding active learning”, “How family and friend relationships are affecting them”, and “Time management”. I coded each of the focus group sessions and the final one-on-one using the list that I developed, making comments in the margins about anything that I thought was interesting or was coming together into a common theme.

I attempted to code the initial individual interviews using these twenty codes, but found that much of the data was being glossed over, since the codes I developed were aimed at understanding their experience in differential calculus and the initial interviews were aimed at understanding their previous mathematics experiences. Thus, I developed another set of codes to use for the initial individual interviews, which can be found in the Appendix.

After completing the coding using the list that I developed, I conducted another round of coding for identity. I use the following definition of identity: identity is “an individual’s sense of self defined by (a) a set of physical, psychological, and interpersonal characteristics that is not wholly shared with any other person and (b) a range of affiliations (e.g., ethnicity) and social roles” (American Psychological Association, 2007). Identity involves a sense of continuity, or the feeling that one is the same person today that one was yesterday or last year (despite physical or other changes). As is apparent in my Chapter 2 Literature Review, one's identity can have a huge impact on the way that they understand and learn mathematics. I returned to the original transcriptions for the data that did not contain any prior coding, as I did not want the other codes to interfere with my reading for identity. I coded 4 items: how past experiences have affected their identity, their identity in regards mathematics or their major, identity in regards to friends and family, and general identity. For example, the below statements were coded as general identity.

> Marie: Yeah, I think like, everyone, in my case, everyone's like close to my age it looks like, or seems like at least. Um, with you, within like 10 years, so you know, like 20, like maybe 18 to like 25ish ages. And so that's nice. Um, and then like you know, ethnicity-wise and everything like that, like everyone looks the same. So yeah, I feel like I fit in generally.

> Harper: I have trouble being bad at things. I just don't like it, so yeah, and definitely, I think I have to take a couple more calc classes, but also just not being good at something, that I know, I think to myself that I could be good at, is like, one of the worst things in my life, so I kinda have to be good at things.

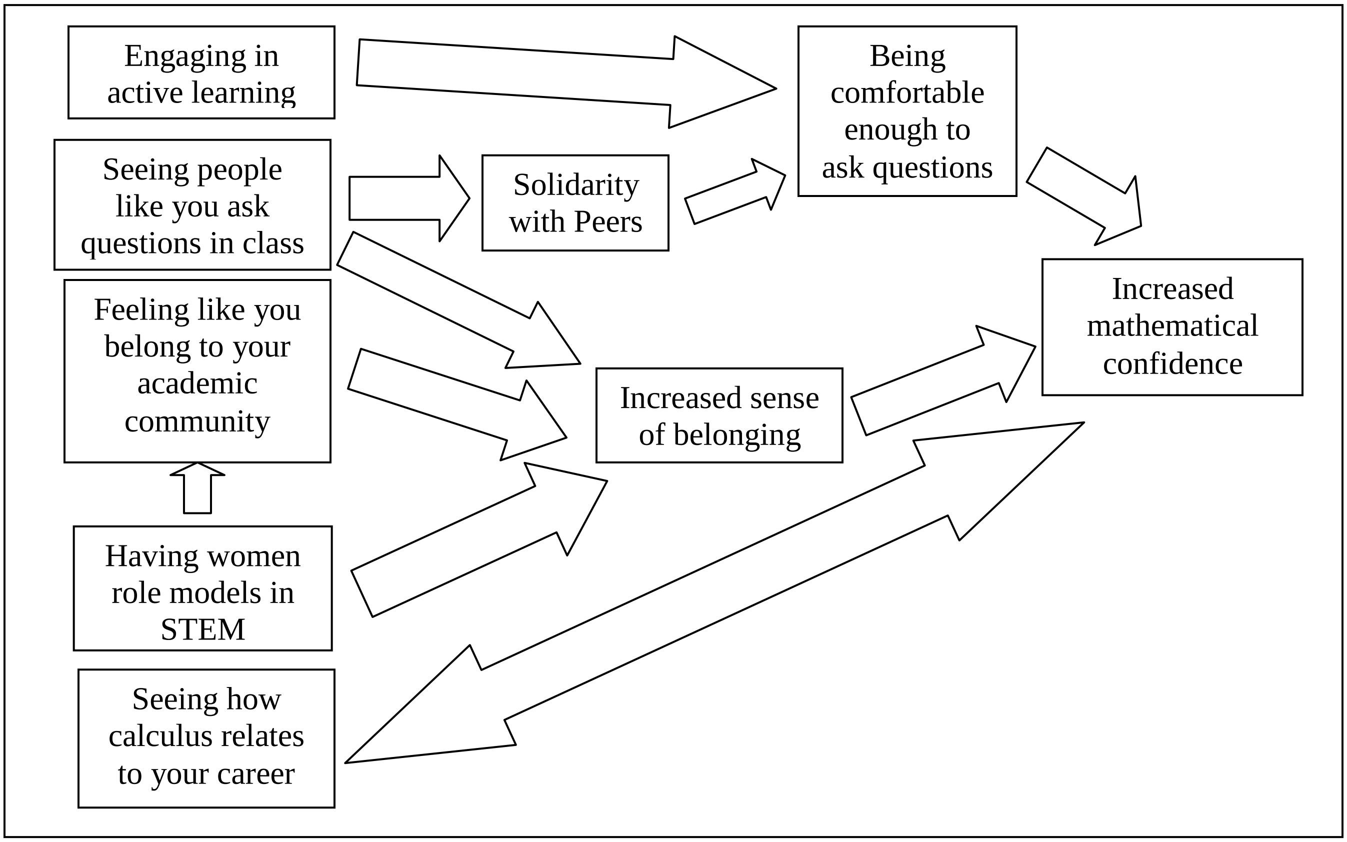
I coded all data sets using these identity-related codes, and made comments in the margins to identify potential themes.

After the initial round of coding and coding for identity, it was time to group the data into themes that became prevalent during the first rounds of analysis (step 3 of Table 3.4). Using the codes as a guide, I read through each interview carefully and copied and pasted the relevant data into another document that contained data for a specific theme. I defined seven of these groupings: solidarity with peers, how calculus relates to the participants' future careers, identity, asking questions related to calculus, active learning, belonging to their academic community, and gender and men.

The next step in my analysis was to review the themes into which I had grouped the data. In order to accomplish this, I combed through each grouping of data, highlighted the parts that I thought were relevant to the theme, and wrote comments about what each piece of data contributed to the theme. The purpose of this process was to search for and validate a coherent theme to which the groups of data point. Through this process, I found that some data pieces that I had originally thought fit into a particular theme did not contribute in a meaningful way; I left this data with these themes throughout this phase, in case I wanted to go back to them later. I also found that I needed to combine or separate certain themes. For example, I found that I had originally collected a group of data into a theme about belonging to academic communities, but as I was reviewing this theme, I found that the data strongly overlapped with what I had found in the theme of identity. Thus, I decided to make belonging to academic communities a sub-theme of identity.

During phase four, I created a thematic map of how my themes relate to each other, and which data fits as a sub-theme to a larger pattern. Creating this thematic map also fed into the next phase of my analysis, which was defining and naming themes. This thematic map can be seen in Figure 3.1 below.

Figure 3.1 Thematic Map



In the following chapter, I will discuss the implications of the above figure. Additionally, I will explore the relationships between the factors in Figure 3.1 in order to better understand the experiences that the participants went through while taking differential calculus.

Chapter 4: Results

In this chapter, I will discuss each of the themes that I presented at the end of Chapter 3, as well as how they relate to each other and how they are woven through various participants' narratives. I will then present a section on how identity relates to a number of these themes. Additionally, I will examine the data collected from two participants as case studies; I will discuss how the themes are present in their stories, as well as how various factors interacted with their individual identities to create their unique differential calculus experience. In each of the sections, I will examine pieces of data from the participants and describe how that data relates to other participants and the theme as a whole.

4.1 Calculus Relating to their Future Careers

During each of the initial individual interviews, I asked the participants how they saw themselves in the future in terms of a career path. Some of them had very concrete answers, such as animal prosthetics or retail pharmacy, and others were undecided. Each of them, however, were majoring in something related to STEM and had career aspirations related to STEM. It is only natural, then, to examine how they felt differential calculus relates to their future career. I use the term 'differential calculus' here due to the fact that many of the participants will go on to take other courses in calculus, such as integral calculus and multi-variable calculus; my study focuses only on differential calculus.

Throughout their experience in their differential calculus courses, many of the participants struggled to make meaning as to why differential calculus was included as part of their program of study for their particular major. As they grappled with this, I noticed that they did not seem to understand why taking differential calculus was required often led to a decreased sense of belonging in the class. Below are some excerpts from different participants that show this idea.

> Stacy: Umm, I feel like it's really not gonna help me much in my major and like what I want to do, like it's not really gonna be anything I'm gonna do anything with… But I just feel like there's other things, like math-wise that they could, we could have a class like that that would tailor to what I'm doing more than calculus. I feel like that doesn't really help. Like in the real world, if we were to do anything, it would be more based on statistics, like we you know, is this significant, is it not significant? So I feel like the calculus is like, it doesn't really help me with my future. So I feel like, meh about it. Like if I was taking biophysics, I feel like, if that was my major, that would be more applicable, it would make more sense. But I'm biochemistry and molecular biology, there's not a lot of calculus when you're talking about biology, so it's just doesn't feel like it fits at all.

In this excerpt, Stacy expresses that she feels like calculus will not relate to her future career, and suggests instead that there are other mathematics subjects that could be taught to her major that would help them more in their careers. She mentions that "in the real world", she feels that she would need more knowledge of statistics than calculus, and thus, she feels "meh" about calculus. Her statement of "there's not a lot of calculus when you're talking about biology" is an interesting one, as she separates these two subjects as nearly disjoint ideas in her mind. Thus, she comes to the conclusion that "it just doesn't feel like it fits at all", which distances her from feeling like she belongs in this calculus class.

Stacy is not the only participant who feels this way. The excerpt below follows directly from Stacy's above comment.

> Elise: I feel the same way. Like, we had a term of discrete math, and that class was so helpful. Like I feel like it helped me with my major and like the classes that I was in and the classes I will be in, and I think that it would make more sense for us to continue taking more classes like that rather than take calculus classes. And like maybe in the future, I'll be like, oh that's how calculus helped me you know? But I, it doesn't really feel super relevant right now. Which makes it kinda hard to like, feel like… like

discrete math, I like worked really hard on it ‘cause it was related, and it was pretty fun, too. But with calculus, it’s kinda like, where does this fit in? Like, why am I spending my time on this?

R: Mmhmm.

Leanne: I guess I just viewed it like, I need to check this box, better get it done…Yeah, um, so I feel like math is a lot of like learn this so you can learn that thing, which also might not apply. Uh, but as far as like, um, belonging, like fitting in, like I feel like everyone in the class is kind of like that. Like there’s definitely like, the people who do math and like math sit in a clump. And then they’re with their tippity-types writing. Like, okay guys. And everyone else is just like, what’s going on?

Elise describes the usefulness of discrete mathematics and how she felt it relates to her major, and expresses that she thinks it would be more useful to continue taking courses like that instead of calculus classes. By saying this, she is forming two groups of mathematics classes – mathematics classes that are helpful to her major, and mathematics classes that are not, and calculus falls into the latter category. She then goes onto say that she worked really hard in this discrete mathematics course that she took since she felt it would help her with future courses, but, as she has separated this course into a different group than calculus, we can see that it is harder for her to work hard in calculus since she does not find it “relevant.” Finally she says, “Where does this fit in? Like, why am I spending my time on this?”which signifies that she views calculus as not fitting into what she needs to be spending her time on in order to be successful in her future career. This feeling of not understanding why she is taking this course could lead to a decreased sense of belonging in the course.

After Elise talks about this, Leanne chimes in and agrees with Stacy and Elise. Leanne expresses that she is taking calculus simply because her degree requires it, and that she feels that learning calculus is only helpful to learn mathematics, which may not be helpful to her either.

She then says something that distances herself from those who may find calculus useful: "but as far as like, um, belonging, like fitting in, like I feel like everyone in the class is kind of like that. Like there's definitely like, the people who do math and like math sit in a clump. And then they're with their tippity-types writing. Like, okay guys. And everyone else is just like, what's going on?" By saying this, she is describing two separate groups: the people who do mathematics, like mathematics, and seem to understand the content in the course, versus the people who do not appear to understand the mathematics that is being discussed in class and its relevance to their future careers. She places herself, as do Stacy and Elise, in the latter group. She does mention, interestingly, that "everyone in the class is kind of like that," which shows some sense of belonging to a group in the class that does not like calculus, but as she is distancing herself from those who like mathematics, she is essentially stating that she does not belong with the "math people."

Another participant, Sonia, mentions throughout the term that she was talking to a pharmacist with whom she worked about the importance of calculus in this career. Several times through the term, she mentions interactions such as the following:

Sonia: And especially talking to people like, people in my profession, I texted my boss from like the pharmacy, and I was like, 'hey, do you ever use differential calculus?' He's like, no, I haven't since, and then he mentioned how old he was, and I was like wow, okay. So, yeah.

R: So since you're not gonna be using it, you don't feel as bad for not totally getting it?

Sonia: Yeah, not really. Well it's more like, he's like, well, you know, I could use it, but it's really more important things are, and then he listed a bunch of things that I am good at, so like memorizing medical terminology, or knowing conditions, memorization techniques, um, that stuff, I'm like oh, well I kill it in those areas. I'm not really good at calculus, and he's like, well you never really use it, so.

In this piece of data, Sonia describes how someone in her field whom she admires is telling her that her chosen career path does not require calculus. She mentions that there are other things this person says she needs to be good at in order to be a successful pharmacist, but calculus is not one of them; since she does well in these other areas, she does not feel as bad for not understanding calculus as well as the other subjects. Because her former boss is telling her that she will not need this kind of mathematics, it sounds like she is giving herself permission to not do as well in calculus as the other subjects required for this career. Thus, because calculus is not required for her career, according to a previous boss, she may not feel as if she belongs in the class.

In the above excerpts from individual and focus group interviews, we can see that some of the participants struggle to see where calculus fits into their future careers, and thus, it is hard to want to try hard or do well in this course. One participate makes a distinction between herself and “math people,” which gives us insight into how she sees herself belonging in the class.

4.2 Engaging in Active Learning

As is discussed in Chapter 2, inquiry-based learning (IBL) is the most effective teaching strategy in terms of closing the achievement gap in mathematics between men and women (Kogan & Laursen, 2014). IBL is a large umbrella of various teaching methods; active learning falls under this umbrella and is a form of IBL. I will use the terms “IBL” and “active learning” interchangeably to refer to the kind of learning that the participants expressed desire in which to participate. In the literature, it was shown that women who participate in these kinds of classrooms with active learning, instead of the traditional lecture-style classroom, experience a major boost to their mathematical confidence that will affect them for a long time (Kogan &

Laursen, 2014). Additionally, it was found that the more actively engaged students were in their mathematics class (which often is a positive side effect of IBL), the less mathematics anxiety they had (Everingham, et al., 2016). The differential calculus courses at the university at which this study was conducted consists of two portions: a traditional lecture-style class with classes of about 150 students that occurs for three hours a week, and a recitation that often involves worksheets and quizzes that occurs one hour a week in classes of about 30 students. Thus, active learning, if it happened at all, would most likely occur in these recitation sections. Throughout this study, I found that without specifically naming IBL, the participants expressed a desire to be more engaged in the mathematics and to participate in what is active learning. As is evident in the literature, this kind of learning would in fact help their mathematical confidence and their mathematical performance.

Many of the comments regarding this desire for IBL were directed at these recitation periods which the participants attend once a week. These classes are led by Graduate Teaching Assistants, and usually consist of a worksheet that the students work on with each other that covers the material they are currently learning in lecture. Additionally, there is usually a quiz given to the students towards the end of this class.

A number of the participants express a dislike of the traditionally lecture-style classes that they went to for three hours a week. Here is a piece of data from one of the focus group sessions that makes this clear:

R : Do you think it helps that you have more, like since your TA classes are smaller, do you think that helps with your interactions with your TA?

Stacy : Probably. Definitely, 'cause it's like a recitation, so instead of just standing there lecturing at us, it's kind of him walking around, checking on everyone. So I definitely think that that makes it a lot better. And I

> think if the lectures were more aimed at that too, then it would be the same thing. But I feel like with all the lectures, someone just stands in front of you, and they just do problems. They do one problem, and they do the next, and oh we're out of time, see you next time… So I think the TA, it is a little bit better in the sense where like, he'll do a lot of problems on the board, and he won't do it. He'll be like, as a class, we have to help him do it. But he knows how to do it. You know what I mean? So I think if like the lecture was more based like that, where everyone kinda threw some input in on what to do, what they were thinking, I think that would be a better way to work through the lecture. There is a lot of students, so it could be hard.

By describing class as the instructor "just standing there lecturing at us," she gives the impression that the instructor is teaching *at* her instead of *with* her. This also makes it sound like she is not truly engaged in the mathematics she is learning during this lecture. Additionally, she explains that the instructor does "one problem, and they do the next"; her saying this makes it sound like the professor is presenting problems and their solutions from a list, going through some examples without engaging students in their learning of the material. Stacy contrasts this style with what her TA does, saying "I think the TA, it is a little bit better in the sense where like, he'll do a lot of problems on the board, and he won't do it. He'll be like, as a class, we have to help him do it." The TA is still at the board doing the problems, but he is actively including the students by having them give input as to what he should do next. She then goes on to express that lecture would be more beneficial to her learning if the students were more involved in solving the problems, which is the essence of active learning.

Although Stacy seems to prefer the way her TA led recitations over the way her instructor led class, Elise has some criticism on the way her TA led recitation. She says:

> I wish that the recitation was more like, you guys work on this together, and then like we'll work on it like, work through the problems together. 'Cause right now it's just kinda like, everybody hang out and work on the worksheet , which I don't feel like is very helpful, or necessarily the best use of that time. 'Cause like we could do that on our

> own. So I kinda wish, even like the last 15, 20 minutes were kinda going over what we were attempting to do on our own or with our tablemates.

Elise would like the recitations to be structured in such a way as to go over the problems together instead of simply working on worksheets with her tablemates the whole time. Working on problems with your peers can facilitate meaningful mathematical discussions, but it can also allow students to get off-track and start discussing other things; Elise makes it sound like this is what is happening due to her calling it "hang out and work on the worksheet together." She thinks it would be helpful, then, to bring the class all back together at the end of the period in order to review the problems, which would allow for less time for the students to get off-track.

A large part of active learning is collaborating with your peers in order to understand mathematical concepts more deeply. Janine had taken differential calculus back in 2009, and speaks of her experience:

> The teacher that I had previously, um, and this is in the fall term of 09, um, she was very rude if anyone asked a question in class. I don't believe she teaches here anymore. I think if anyone asked a question, she would like, humiliate them in class by acting like they were stupid, and we all had the same questions, and it got to the point where two weeks in, everybody was afraid to ask questions, and none of us knew what was going on. And it just happened that a veteran student was like, this is BS basically, and so after every class, he would get up and say, 'Hey, I'm studying in the library, and I'll get a big table for anyone who wants to join.' So we had study sessions and we basically taught ourselves math. Um, so I didn't have a good experience then, but it was the professor, and not the content.

It is unfortunate that Janine had this experience, but this "veteran student" she describes helped other students learn the materials through collaborative learning. Since she did not learn the material as well as she would have liked during class, Janine went to the library with other students, and they "basically taught ourselves math." This kind of learning shows that Janine values collaborative learning and that she learns material by studying with her peers.

The university at which this study occurred is making large strides in order to shift its college algebra and trigonometry courses to a more inquiry-based learning style, and it will be interesting to see if this university develops plans to do the same for its calculus courses. From what these participants express, the traditional lecture-styles mathematics classes aren’t working for them anymore.

4.3 Being Comfortable Enough to Ask Questions

In the previous section, I discussed the theme of active learning and how the participants expressed a desire to learn calculus in an engaging way. An essential part of this classroom practice is students feeling comfortable enough to ask questions. In every single focus-group session, at least a couple of the participants had something to say about being able to ask questions, and I felt this was interesting, especially as it relates to active learning. When asked how the interactions with her professor have affected the way she feels about calculus, Elise responds:

> They’ve been pretty good, I think. I went to uh office hours one time, ‘cause it’s been a long time since I’ve taken math 111 and like done any algebra, so that tends to be where I get my mistakes at. So I just went and I was like, ‘alright, this is, I’m gonna ask you like a million algebra questions.’ And he was really helpful and like walked me through a bunch of problems, and gave me some starting points for one of the written homework questions I was stuck on, so it was helpful.

Elise seems like she was a little self-conscious about being stuck on these kinds of algebra problems, and therefore felt the need to tell her professor ahead of time that these were going to be the questions she was asking. Her professor taking the time to walk her through some algebra problems showed that they cared about her learning, not only of calculus but of mathematics in general, and that made an impression on Elise. Additionally, her professor gave Elise “some starting points” for a homework question; by not walking her through the entire question but only giving her a place to start, the professor is showing that they have confidence that Elise can complete the problem herself, which probably increased her confidence in this particular problem.

When also asked about how their interactions with their professors affected they feel about calculus, two more participants respond as follows:

> Janine: My professor is really nice and really helpful. Like, if somebody raises a hand in class, he will stop the entire class to go through another problem like insanely slow, and he did that today for a student, and I thought it was really cool. Like it might have pushed us a little back in time that we might have to make up next class, but it was really awesome that he did that.
>
> Harper: Um yeah, my professor is similar. He's pretty good about going slow, and he never pokes fun at people for asking questions. He's super light-hearted, which is really interesting, 'cause I didn't think that would happen with a college professor just coming into it, but he's really funny. So that's helpful.

In this quote, Janine is equating being helpful with the professor pausing to answer a question. Her use of the phrase "stop the entire class to go through another problem" gives the impression that the professor does not simply rush through the problem as an aside, but takes the time to go through the problem "insanely slow," so that they are going through each step. Janine likes this about her professor, and prioritizes this ability to freely ask questions and receive a thoughtful and complete response over staying on schedule. Similarly, Harper makes a point to say that her professor "never pokes fun at people for asking questions." This gives me the impression that there have been opportunities that the professor could have poked fun at someone for asking a question that was perceived as off-topic, but chose to simply answer the question at face-value. She also equates this attribute of her professor as being "helpful"; it is worth noting that both of these participants use this word to describe their professor when speaking about how patient they are when it comes to students asking questions in class, which shows that professors answering questions well is a priority for them. Finally, it appears the students are able to feel comfortable enough to ask questions in these classes, as the professors do not make fun of the questions and take the time to go through them.

One of the recurring comments that the participants gave regarding the recitation sections was that they were not allowed to ask any questions until after their group had completed their worksheet. A number of participants express that this was not how they would have preferred this class to be run, as shown in Marie's comment below:

> I guess, I think it's generally helpful, but it would be more helpful if instead of like, 'cause we always get like a worksheet, if instead of getting a worksheet, we had like, we could just ask questions, like we could be like, 'hey, this is like, hard, can you go through it?' Or like, we go through like, maybe we could do like a midterm review or like, something like that. It would be a lot, a lot, not easier, but like efficient, a lot more efficient to do that.

Marie is expressing that recitations are "generally helpful," but is suggesting a way to make them more helpful. She is creating a dichotomy between working on the worksheets and asking questions; other participants mentioned that they were not allowed to ask questions about the worksheet. Thus, Marie is saying that having the opportunity to ask questions about the material that she and her peers are struggling with would be more beneficial to her learning the material than working on a worksheet. This goes hand-in-hand with active learning; instead of simply solving problems with your group, asking relevant questions shows a deeper engagement and room for understanding the material.

Beyond the classroom environment and the restrictions about when they can ask questions, there is another factor that impacts how the participants felt about asking questions: how they felt they fit into the class. Janine mentions that she feels she does not fit into her class due to her age and past experiences. We had the following dialogue about how this affects her learning:

> R: Um, when you go to your class and you kind of have that in the back of your mind, do you think that affects how you're learning at all?
>
> Janine: Definitely. Because it makes me uh, less likely to ask somebody else for help, I guess. It makes me more worried that I'm gonna look stupid. Because this, I mean especially because it's a class that I've taken here before. I took it in high school. I have passed this class twice, and I am struggling so hard, and I struggled not as much, but pretty pretty hard with [trigonometry]. So it's just like, I don't feel confident enough to ask somebody else for help. 'Cause also in my head, I'm like, am I asking an 18-year old for help? God, I feel like stupid. Which, in the military, you have people who are younger than you tell you what to do all the time, but in this school culture, it's more difficult for me.

Janine says her age and the fact that she feels she does not fit into the class is preventing her from asking questions in class. In particular, the fact that she has already taken differential calculus twice and passed it both times makes her feel as if she should know the material well enough as to not necessitate asking questions during class. She is worried about what her peers will think if she, an older non-traditional student, asks questions in class, and this stops her from fully participating. She also has trouble asking her peers for help due to the age difference. The fact that she feels she does not fit into the class is preventing her from both asking questions due to the fact that she is worried what other might think, and due to the fact that she does not want to ask her younger peers for help.

Similar to Janine's above comment, Sonia mentions that men seem to dominate the questions and conversations that occur in class, which makes her feel she cannot ask questions. She feels like she does not belong to the group of people who are "allowed" to ask questions due to her being female. She summarizes her experience below:

> On top of that, I can't like, I don't know why, but it's only three guys, or just guys in general, that ask questions in class, and they're usually super sophisticated questions that have to do with not even what we're talking about, but how it could be applied in the next topic that we're talking about. So if I want to ask a small question, like why is that a nine and not a three, I don't know. I just, I can't do it, I have to wait until after class, which really sucks…

The fact that only men in her class are asking questions makes her feel like she, a woman, should not ask questions. On top of already feeling like she cannot participate in the class to the same extent as the men, she also feels like if she did ask questions, they would less "sophisticated" as the ones being asked, which further prevents her from asking them. It is worth noting that she refers to what she would ask as "small" questions; she is differentiating between what she perceives as higher-level questions that these men are asking, and the questions that she would like to ask. She is putting her questions in a different category, which distances her from this group of men. She does, however, say that she asks the question after class. This shows that it is not the professor that she is worried about in terms of her asking these, but her peers. These men who are dominating the conversation, and possibly other people in the class, are creating an atmosphere that she perceives as not welcoming to her questions. She feels as if her inquiries are not worth asking in front of her peers, even though it is likely that other people are wondering the same things that she is.

I have highlighted some of the key pieces of data as they relate to the theme of feeling comfortable enough to ask questions in class. We have seen that it is vital that professors are patient with students as they ask questions, even if they questions are not completely relevant to the course material, and that they do not make fun of the students' questions. By examining Marie's comment, we see that being given ample opportunity for students to ask questions is essential for their learning, especially inquiry-based learning. Finally, we have seen that feeling like you fit into a class can impact whether or not you choose to ask a question in front of your peers. This is a broad theme, but it shows that instructors must make a point to create an atmosphere in their classrooms that encourages all kinds of questions from all kinds of learners.

4.4 Belonging to Academic Communities

Given as this study was conducted at a large public university, there are ample opportunities for students to participate in their respective academic communities in any number of ways. There are clubs for every major, career path, and interest; dormitories can be sectored by major or courses that are being taken. A large variety of STEM majors is offered, and there are ways to connect with professionals in those areas through seminars, research projects, and club meetings. Thus, I thought it was important to look at how the participants were involved in their academic communities impacted their mathematical confidence.

A large part of belonging to a community is being able to find someone to whom you look up as a role model. The following exchange between participants occurred during the first focus group session:

R: Okay. Do you have any role models in STEM, and what stands out about them?

Stacy: I definitely feel like I have a lot of role models, like at least in my major. Like they're just really up there in their field and they write these amazing papers that people all over their world cite, and it's just, it's amazing to be a part of that. And, just to have them as my mentors and they've been my instructors in the past, and if I have questions about life or career or whatever, I can go to them and it's really nice. And I just feel like I have a really good community within my major. So, yeah.

R: That's wonderful. What stands out about those role models to you?

Stacy: Um, their determination. How a lot of them have kind of a similar story as me, like no one in their family ever got any degrees, they started from nothing, they were very poor growing up. And now they're very advanced in their field. And they love what they do. And it’s just, so I admire them for that. So.

Elise: That’s cool. I have, I think I’m still, like I was a transfer student, so I’m still pretty new here and I haven’t like, met a lot of professors or anything. So I, my one role model I have is probably my uncle, ‘cause he’s been working in the field that I’m hoping to go into since like the mid-80s, so I can text him and just be like, ‘help’, and he can encourage me and basically be like, ‘no, you’re where you should be.’ … it’s really nice to talk to people who were already there, who say like, no, you’re doing okay. Everything’s gonna be fine. Yeah.

Leanne: … My best friend, she’s roughly year older than me but we’re on the same level, and she’s a mathematical and computational science major at Stanford. And therefore, she’s a lot of help. ‘Cause she likes to send me a lot of links. And she’s like, ‘I found this one guy online and he explains calculus and it’s really funny.’ And it’s like, your sense of humor is weird, but yeah.

R: Oh, the internet. Well it sounds like you all have some pretty cool role models. That’s really good.

Stacy: … I feel really lucky ‘cause part of the reason why I feel so connected ‘cause I’m also a transfer student, is my major does uh, they’re called faculty socials. And we go to, every term we go to a faculty member’s house and they throw a party at their house, and they’re very accommodating and really nice, so that’s like the biggest reason, ‘cause I don’t think without that I would have reached out to get to know them. But it kinda was like, here’s an event, here’s some food, let’s hang out. We’re gonna play games and stuff. Go! And so that’s why I got that opportunity, I think. And I think without that I would be in a similar situation, where I wouldn’t really have that.

Stacy feels like she is “a part of” the people in her academic community who are well-published and well-known in their fields, which makes her feel like she can ask these people for help or advice. One reason she probably feels this way is due to the faculty socials, where she and her peers are able to have meaningful interactions with these professors outside an academic setting. She feels that the opportunities she has to “hang out” with these people has really given her the chance to get to know her mentors on a personal level; this also gives her the chance for her to identify with some of her professors. For example, she says she looks up to them because "lot of them have kind of a similar story as me," and they are now advanced in their fields. It sounds like knowing this about them gives her hope that one day, she can be in their shoes. Without these faculty socials, it is possible that she would not know the background of her mentors.

Elise responds that she is a transfer student and has not had a lot of opportunities to get to know her professors, but she does have academic community with her uncle. Her uncle has been in the field that Elise wants to go into for many years now, and she feels that she can ask him for advice. It also appears that her uncle can assure her that she is where she needs to be in terms of classes, what she is learning, and how she is feeling. Her having a personal relationship with someone in the field, as Stacy does with her professors, allows her to receive meaningful advice and encouragement from someone who has been in her position before

Finally, Leanne's best friend is a mathematics major who likes to send her helpful videos that explain calculus in a funny way. This kind of camaraderie in regards to mathematics certainly helps Leanne feel like she belongs in the mathematics community; her best friend being a mathematics major surely humanizes mathematics for Leanne and allows her to see that she can also be a part of this community.

In this exchange, there were a couple phrases that really stood out to me. Stacy says that it is amazing to "be a part of" her mentors publishing papers, which signifies that she feels like she belongs to this community. Similarly, Elise says that her uncle assures her that she is "where you should be," which evokes a sense of belonging. By creating and being part of these academic communities, these participants are increasing their sense of belonging in their respective majors and career paths.

On large college campuses, most of the majors or programs have their own buildings, and thus, part of belonging to an academic community means feeling comfortable in this building. Harper describes her experience with this:

> Um, I just switched my major, and there's a, there's like a biochemistry club I guess that I'm automatically in now, but I haven't been to a meeting yet, so I'm not sure if I fit in there. But um, the lady that I, the advisor I met with, she walked me around the entire bio-chem floor and introduced me to everybody, and then, yeah, she's really nice, and they seem really down to earth, which I feel like I fit in there.

The academic advisor with whom Harper met took the time to walk her around the floor and introduce her to the people in the building, who were all presumably part of the biochemistry community at this university. By doing this, this advisor helped Harper feel like she "fit in there," and sparked a sense of community. Since this woman was an advisor, she was probably also a professor in this major, and thus, her being so "down to earth" probably made Harper feel as if she could ask this woman for advice or help if she needed to, helping her to feel like she belongs.

Sonia is the only participant who says she feels like she does not necessarily belong to her academic community. She makes the following comment about the program of which she is a part:

> Yeah, I don't know, I mean like we have these meetings and I'm trying to get on the little like newsletter or whatever, but [name] never like emails me, so I never know when the meetings are and I've been missing a lot of them. But it's fine, you only have to go to one. And I made one, so I made the minimum requirement for like, yeah. I guess so. There's like cliques within it, and I just kinda wanna be there, so yeah.

Sonia mentions that she has been missing a lot of meetings due to a friend not emailing her about them, which gives the impression that attending these meeting is not one of her top priorities.

Since she made the minimum requirements and attended one of these meetings, she says that it is okay; however, attending these meetings with peers from her program would certainly increase her sense of belonging. She also makes a comments about how there are “cliques” within the group, creating distance between her and other members of the group. She just wants to be there, even though there are cliques, which signifies that she feel she does not have a solid sense of belonging there.

As the above data shows, professors, family, and friends can all have an impact on whether or not someone feels they belong in their respective academic community. We will now examine how this plays into the participants’ sense of solidarity.

4.5 Solidarity

Throughout the focus group sessions, the participants repeatedly made comments that evoked the sense of being in solidarity with each other and their peers. For example, if their peers were struggling with a concept, it made the participants feel relieved when they were also struggling. Similarly, the participants seemed to want to build each other up throughout the term, and encouraged each other during the group interviews. This theme gives the sense that they find some relief and solidarity in seeing their peers have similar experiences with difficult concepts or the class in general, and that they will help each other encourage each other to feel better about themselves in these experiences.

Almost all of the participants say, at one point during this study, a comment along the following lines: “It’s nice when I hear one of my peers talking about how hard a concept is, because it makes me relieved that I’m not the only one.” These kinds of comments were made in every single focus group session. We will now examine a couple of these comments to see how they fit into the theme.

When asked about how she feels she compares to her peers in class, Elise makes the following comment:

> It kinda feels like we're all on the same page. And it's always nice when you, well it's not nice but like when you overhear someone else talking about like how hard it is or something, you're like you know, 'thank god!' [laughs] So I kinda feel like we've all been on the same page. And like in recitations, I've kinda been talking to the people I sit by and we've been helping each other with problems, and so.

It sounds like at some points during the term, Elise was nervous that she was the only one who was struggling with a particular concept. By her saying that she overheard someone else talking about "how hard it is," this means that she does not necessarily want to bring this kind of anxiety up directly with her peers, possibly out of fear that she was the only one who felt this way. When she overhears her peers discussing this, however, she feels a sense of relief; she is not alone in her struggles with this concept. At first she says that this kind of interaction "is nice," but then she backtracks and says, "well, it's not nice, but…" which signifies that she knows it is not a good thing that they are all having a difficult time with something, but it is still a relief that she is not the only one. After describing this, she says that it makes her feel like they are "on the same page." This evokes a sense of community, like their common struggles are bringing them together since they are all sharing similar feelings towards something. Finally, she describes that in recitation, she works with her peers to complete the activity, which also gives the impression that she is in community with her peers, even if they only thing they have in common is that they are having difficulties with the problems.

Harper formed a study group with some of her peers, and she makes the following comment about it:

> Um, everyone in my little study group, it's just kind of interesting, they all kind of seem to struggle with different things, I guess we all seem to struggle with different things, so we complement each other well, 'cause usually we can figure things out 'cause what I'm good at, someone else isn't, and what I'm bad at, they're good at. And then also they kinda like, what you said, they have really weird things to remember things that actually work really well. They helped a lot on the last midterm actually. But yeah, that's nice to have other people.

At first, Harper excludes herself from the group by saying "they all kind of seem to struggle with different things," and then she backtracks and changes this to "*we* all seem to struggle with different things." This subtle shift in language shows that she sees herself as part of the group, and that she is allowing herself to be vulnerable and admit that she struggles with certain concepts. She then goes on to say that they "complement each other well." This gives a sense that, although they are having a hard time with different problems, they all come together to support and help each other. She reinforces this idea by saying "we can figure things out 'cause what I'm good at, someone else isn't, and what I'm bad at, they're good at." Her use of "we" makes it seem like she is talking about a team working together to solve problems; even though she does not necessarily struggle with the same concepts that her study-mates are, she feels a sense of camaraderie because they are all sharing their struggles and their strengths with each other. She ends by saying "it's nice to have other people." Given the context, she is effectively saying "it's nice to have other people who struggle with this class as I am, and that we can work together to get through it." She has formed solidarity and community with her study group, which has helped her in the class.

Interestingly, the participants made encouraging comments to each other during the focus groups, which lent themselves to forming a sense of community between them. Elise and Stacy make the following exchange after I asked them how they felt coming into calculus:

Elise: Kind of nervous, 'cause I withdrew from it last winter, 'cause I, it ended up being a lot more work than I thought it would, especially with all of my other classes, so this is like the big leagues now. So yeah, so hopefully I pass [laughs]

Stacy: Yeah, you got this! For me, it feels terrible. Um, and I think part of it is because it's my last year, I have to pass 251 and then next term I have to take 252, so like I can't not pass them so I can graduate on time. So like, it's a lot of pressure. But, I'm gonna do my best.

Elise: We'll be good.

Elise starts out by expressing reasons why she is nervous coming into class, and by her saying that "this is like the big leagues now," gives the impression that she is feeling a lot of pressure to pass. After hearing this, Stacy encourages her by saying, "You got this!" These two participants did not know each other beforehand, nor were they in the same section of calculus, so an encouraging comment like this is worth noting. Stacy goes on to explain that she is also nervous about coming into calculus, for different reasons that what Elise said. They both, however, feel pressure to pass. In response, Elise says, "we'll be good." What Stacy said did not necessitate a response, so it is interesting that Elise said this. It is also fascinating that she said "*we'll* be good" instead of "*you'll* be good." Her use of the word "we" elicits a sense of community and puts them both in the same situation. In this short exchange, these two participants seem to encourage and build solidarity with each other simply from the fact that both of them are nervous coming into differential calculus.

During the second round of focus group interviews, I asked the participants how they think the recitation periods affect their learning and confidence in the material. Sonia makes a comment that I felt summarized the theme of solidarity quite well:

> At the very beginning of the term, I was like gosh, everybody knows everything, I'm behind. And now it's like we're kind of all mixed even, maybe 'cause I kicked myself into working harder, maybe 'cause they're slacking, I don't know which, maybe it's both, but yeah. It's a little bit better now. I'm starting to pick out the people who are where I'm at, and it's really nice to be able to surround yourself with people who are like able to teach you and people who don't know what anything is either, because then we can both like, okay, well I figured out this part, what do you think,…

In this quote, we see Sonia shifting from feeling isolated in the class to feeling like she can help others around her. Her saying that at the beginning of the term, "everybody knows everything" puts a distance between herself and her peers, as well as what she perceives she knows and what she perceives her peers know. She then explains that it is different now; they are "mixed even." Given the context, I conclude that what she is saying is that she feels that there is an even mix of people with whom she interacts that are more confident in the material and less confidence in the material than she is, rather than placing herself separate from the rest of her peers. She then states that "it's really nice to be able to surround yourself with people who are like able to teach you and people who don't know what anything is either." This creates sense of solidarity between her and her peers. By surrounding herself with people who have similar skills and confidence with this material, she no longer feels that she is alone in her struggles. Her use of the phrase "people who don't know what anything is either" gives the impression that she has solidarity with those peers in her class who are having difficulty with the material. Finally, she ends with saying that these peers help her in that "we can both like, okay, well I figured out this part, what do you think?" They are sharing their knowledge with each other and helping solve problems together. This is a huge shift from how she felt at the beginning of the term, as if she did not know nearly as much as her peers. Now, she feels like she has knowledge to share, and her peers reciprocate.

The first term of differential calculus is a challenging course for many students, and the participants seemed to find it vital to their success in the class that they create community and solidarity with their peers, no matter what they had in common.

4.6 Identity as it Relates to the Themes

I now shift attention to how the participants' individual identities play into some of the themes discussed in the previous section. Identities are multi-faceted and ever-changing, so the analysis here cannot encompass all part of how the participants identify. It is, however, essential that we look at how various parts of themselves play into the ideas that we have discussed thus far.

4.6.1 Identity as it relates to future careers.

For a number of the participants, their future careers comprise a large part of their identity. In the individual initial interviews, for example, when asked what was important to her future, Harper states, "I would say that, where I am now, I would say my career is probably going to be the most important thing, as far as like, having a family, maybe that, later," implying that her career is more of a priority to her than having a family. She is not the only participant who mentioned their career being a top priority. I will now take a deeper look at how identity and mathematical confidence are related to how calculus relates to one's career aspirations.

If a student has a different career path than their parents, the parents may not be able to fully understand what it is the student is doing or what classes the student is taking. Elise describes her experience with this below:

> My mom is a teacher, and she's like an elementary school teacher, so she's really supportive and gun-ho, even though she obviously hasn't taken a lot of STEM classes. Like my computer programming classes, whenever I show her anything I do, she's like, 'Wow, that's really cool!' [laughs] And then my dad is a STEM major, and he's more in like, biology and like, chemistry, that kind of side of things. So he's supportive, but I think he also doesn't really understand, too. Like, he's just like, 'good job with that code you're writing, I guess.' But he liked calculus, so he's all excited for me to take it, which is interesting.

She describes her dad as supportive, but as he does not have experience with coding, she cannot fully explain or share this part of her identity, a future computer scientist, with him. He does have experience with calculus, and his excitement for her taking a calculus course could be an encouragement for her when she struggles with it. Somewhat similarly, Elise's mom does not have experience with mathematics classes or computer science classes; when Elise shows her mother a computer program, her mom has a positive reaction, but does not fully understand what it means or how hard Elise worked in order to make the code happen. Even though her parents are encouraging in regards to her becoming a data analyst, they do not quite comprehend what it is she is doing, which is a big part of her identity. Thus, she might feel as if she cannot fully share this part of herself with her parents, even though it is important to who she is as a person.

Harper's parents are both in STEM-related careers, and her mom is in fact a calculus teacher. Thus, her parents are probably more understanding of what she is doing in her classes and can thus share this part of her identity with them, but this does not come without difficulties. The other participants in this focus group session were surprised to learn that Harper's mom was a calculus teacher. She responds as follows:

> I guess not professor, but calculus teacher at uh [a] community college, and so she was pretty adamant that I went into a STEM field, and so was my dad, which was fine, 'cause that's what I wanted, but definitely supportive.

In this case, Harper has similar career aspirations to her parents, and in fact, she is taking a course for which her mom is a teacher. Her parents both understand the STEM part of her identity very well. However, she describes both her parents as being "pretty adamant" that she go into a field related to STEM. Harper may have felt pressure from one or both of her parents to go into a certain career; even if she did want to go into STEM, this pressure from her parents may have affected this part of her identity in a negative way. She ends by saying that her parents are supportive of her going into a STEM-related career. Although she probably feels she can share this part of her identity with her parents, I wonder if their pressuring her to go into STEM also prevents her from asking them for help or career advice when she needs it.

It is not only parents or family that can have an impact on what career a student chooses or how a student feels about their classes. Sonia worked in a pharmacy in high school and wants to be a pharmacist herself. She has friends in this field, and she has the following to say about their reactions to her taking calculus:

> …In my line of work, and I have very close friends who are pharmacists, and they're like, 'yeah, we never really use derivatives. It's dumb, you're just doing it to learn how to work hard.'

For Sonia, wanting to be a pharmacist has been and continues to be a prominent aspect of her identity. She has apparently asked her friends who are in this field about their experience with calculus in this line of work. Since they know what a derivative is, and say that they do not use them, they appear to have taken calculus before. Thus, by them telling her that she will "never use" differential calculus in her career and by using the word "dumb" to describe her having to take it, they are giving her the impression that calculus should not be important to her. Thus, as she identifies as someone who wants to be a pharmacist, this is allowing her to distance her identity from that of a mathematician. Her career aspirations, and the experiences of her friends in this career, have affected the way she feels about calculus as it relates to her future career.

Finally, Janine, who would like to be a research scientist in oceanography, does not describe her identity as it relates to her career by anecdotes from friends or family, but by an experience in a seminar course she has taken:

> So there was one that was geology, um, and it was uh, actual PhD people who flew in to talk to us, and then the other one was oceanography, it was graduate students, and all of them talking about their research, and showing videos of them like flying over Greenland. I just want to be all of them, and do all of that cool stuff. So I feel like anyone that I see that's like going out and like doing that, that's just who I want to be and who I'd like to be.

Janine sounds inspired by the PhD professors and graduate students who were presenting their research. She mentions that she wants to "be all of them"; she would like to identify as someone who is doing this "cool stuff." She says that this kind of person is "who I want to be and who I'd like to be." Janine is a Coast Guard veteran, and much of what she said during the focus group session she attended was related to her service. Thus, her comment about how she would like to identify signified to me that this is what drives her to do her best in difficult classes. She can see herself in these people to whom she looks up and admires, and knowing that they have taken and passed calculus is probably motivation for her to make it through this course.

The above analysis shows that participants had varying experiences relating their identity and their future career to calculus. However, in the three pieces of data that I analyzed, I can see that their future careers had an impact not only on their identity, but on how they perceived calculus as relating to them on a personal level.

4.6.2 Identity as it relates to asking questions.

For many students, asking questions during class can be intimidating and takes a lot of courage. This sentiment was brought up by several participants during the study, and I noticed that in most instances, this intimidation can be traced back to their identity. Thus, their identity is either preventing them or helping them to ask questions.

I'd like to re-visit a piece of data from Janine in order to analyze it with identity in mind:

> …It makes me more worried that I'm gonna look stupid. Because this, I mean especially because it's a class that I've taken here before. I took it in high school. I have passed this class twice, and I am struggling so hard, and I struggled not as much, but pretty, pretty hard with [trigonometry]. So it's just like, I don't feel confident enough to ask somebody else for help. 'Cause also in my head, I'm like, am I asking an 18-year old for help? God, I feel like stupid. Which, in the military, you have people who are younger than you tell you what to do all the time, but in this school culture, it's more difficult for me.

Janine first expresses the potential for embarrassment when she asks questions – she is afraid she is going to look "stupid" in front of her peers if she asks a question during class. She goes on to explain why this might be the case: her age and her previous experiences with this course. Janine is almost 30, and she expressed in this focus group session that this makes it so that she has a hard time feeling connected to her peers in classes. She also cites the fact that she has taken and passed this class twice before – this is part of her identity, and although people will not know this previous experience of hers unless she tells them, she is afraid her age might reveal that she is different from her classmates. Finally, she expresses that, in the military, it is normal to ask someone who is younger than you for help, but she feels differently about doing this in an academic setting. Her military experience, age, and previous experiences taking this class are causing her to feel the potential for embarrassment in asking questions. She also does not seem to see anyone like herself in the class – it is possible that if she knew someone in the class that was her age and had similar experiences, she would feel more of a part of the class and feel more comfortable asking questions.

Sonia mentions in a focus group that she felt that only men in her class asked questions. She repeats this sentiment during her final individual interview when asked what stood out to her about her peers:

> Uh, the main thing that stands out with my peers is um, I feel like there was maybe two or three men that really led the class, or asked questions or knew anything about it. Um, every time I was in recitation, it just felt like, the same thing, usually one or 2 guys, literally, um, yeah. I don't know, so it was very male-dominated, maybe it's just the vibe I'm getting and maybe that's not fair… It's the same feeling I get from math, there were just a lot more dudes, and it felt a little bit more catered to them.

She describes how she felt that these same couple of men "led" the class, and that she perceived that they were the only ones who were asking questions during class. She has the same thing to say about recitation; it is worth noting that there are generally about 120 students in the class, and about 30 students in each recitation. Thus, it is likely that there were different men in the class and in the recitation who were asking the questions. Her identity as a female made her feel as if she does not quite fit into the class since "there were just a lot more dudes." She ends by saying that she feels as if this course were more "catered" to the men. This led to the following exchange:

> R: How did it feel catered to them?
>
> Sonia: Um, so it's like if a girl went onto the football team, right? It's just, it, they use a little bit more like, language or there's just a vibe you get when you don't feel like it's a classroom, it just, it feels a little bit more like, this is, yeah… Um, better analogy, like uh, if I went into a video game store, it's mostly male-dominated, right? There's just, yeah, there's a different communication style is the only way I can think about.

Sonia perceives a different communication style in her calculus classes that allows men to feel more comfortable asking questions and excludes her from doing so, since she identifies as a female.

Most large universities have some form of an honors college, and often, the students who are placed in the honors college have a part of their identity that relates to them being a part of a prestigious group of students. Harper is in this university's honors college and lives in its dorm. She describes how this makes it easier for her to ask questions:

> Harper: …And then also the um, the math tutor in my dorm is also really helpful.
>
> R: Is that like an SI table or just a math tutor?
>
> Harper: It's the honors college math tutor weekly thing.
>
> R: Okay. Is it individual or is it with a group?
>
> Harper: It's individual. You just go an ask questions.
>
> R: Cool. I didn't know that they had that.
>
> Harper : I didn't either, 'til I walked down there one time and there's, and he had a little sign that said 'honors college math', and I went, 'can I ask for help?' And he goes, 'yeah, that's what I'm here for.' Now I go every week.

I observe here that the honors college is providing additional resources to their students to help them succeed in their courses that other students do not get the opportunity of using. Thus, Harper being in the honors college dorm allows her to have easier access to asking questions. This identity as an honors college student also allows her to feel more comfortable asking questions; in another focus group session, she mentioned that she sometimes has a hard time asking her professor questions. In this interaction, it appears that Harper has a relatively easy time asking this tutor in her dorm. We see that identifying as an honors student and using this identity to her advantage allows her more comfortable opportunities to get her questions answered.

I have examined how certain aspects of participants' identities have affected how comfortable they feel asking questions during class and outside of class. There are many other facets of their identities, such as socioeconomic status or race, which I did not address in this analysis. However, the above data shows that various aspects of a student's identity can have an impact on whether or not they ask questions in class.

4.6.3 Identity as it relates to academic communities.

I have looked at how belonging to an academic community can change a participant's perspective on their future career or how calculus relates to their career. I now want to delve into how identity plays a part of this by looking at some of the data I have already examined, but with identity in mind.

I have previously looked at this piece of data from Stacy and analyzed it in terms of what it means that she belongs to this community. I will now look at this from the perspective of identity. When asked what she admires about her role models in her academic community, she says:

> Um, their determination. How a lot of them have kind of a similar story as me, like no one in their family ever got any degrees, they started from nothing, they were very poor growing up. And now they're very advanced in their field. And they love what they do. And it's just, so I admire them for that…

In this quote, I see several aspects of Stacy's identity, and how these aspects affect how she identifies with her role models. She says that these people to whom she looks up "have kind of a similar story as me," which gives the impression that she can see her past experiences and history in these people. She then expands on this. She explains that she is a first-generation college student; being this kind of student can often have a profound effect on one's college experiences. She mentions that, like herself, "they started from nothing, they were very poor growing up." This gives a hint of her socioeconomic status, as well as what her experience growing up was like. In this relatively short piece of data, she identifies herself as a first-generation college student with a low socioeconomic status, both of which appear to be aspects of her identity that are at the forefront of her college experience. The fact that she has people in her department who share these parts of their identity with her is a big deal, as the vast majority of professors are not first-generation college graduates who came from a poor background. Thus, her identifying with these professors must give her a real sense of belonging and helps her see that she can succeed in her future career, too.

As we have seen in the Chapter 2 literature review, women have been and continue to be underrepresented in STEM-related majors and careers. A number of the participants make comments about this throughout the term, as well as how much they appreciated the women who were in these careers. Marie gives us insight into how she feels about seeing women in her academic community:

> …It's like empowering also to see women in STEM because like it used to be so taboo. I feel like now it's not anymore 'cause it's like 2019, so like, it's pretty normalized, but like it's still a little bit. So that little bit kind of is like, what makes it like even more cool to see like women in STEM generally. Or even minorities, like in general, people that didn't have the opportunity before can actually pursue these kinds of careers.

Marie describes it as "empowering" to see women in careers related to STEM. She is aware that women were not always welcome in these spaces, and seems appreciative that it is less "taboo" for people like her, who identify as a woman, to work in whatever career they wish. She makes the point that although we have made large strides in terms of women being represented in these fields, it is still “a little bit” stigmatized. This stigma is what makes it powerful for her to see women, and other minorities, in the kind of careers of which she would like to be a part. Thus, seeing her identity as a woman represented in this kind of academic community makes her feel like she is a part of it, and gives her the empowerment necessary to believe that she can succeed in this field.

The above pieces of data illustrate to me that identifying with people who are in your academic community can have a real impact on whether you feel you belong to this community. As we have seen in the literature review, having a sense of belonging is essential for succeeding in your career path, especially when that career has historically excluded people like you.

4.6.4 Identity as it relates to solidarity.

One’s identity and with whom you choose to be in solidarity go hand in hand. In fact, when I coded the data for solidarity, much of it overlapped with data that I had coded for other aspects of identity. I want to take a closer look at how these two ideas are related to each other, and how the participants’ identities helped created solidarity with certain groups of people.

A number of the participants categorize themselves as people who do not like mathematics. This was a common narrative throughout the term – they do not like mathematics because it does not relate to them, or because they do not see the point in taking it, or they have had previous bad experiences with it. This not liking mathematics becomes a part of their identity – they identify as people who do not like mathematics. This is summarized below after I asked Leanne if she feels like she fit in with her peers:

> Uh, but as far as like, um, belonging, like fitting in, like I feel like everyone in the class is kind of like that. Like there’s definitely like, the people who do math and like math sit in

> a clump. And then they're with their tippity-types writing. Like, okay guys. And everyone else is just like, what's going on?

In this excerpt, Leanne is creating two mutually exclusive groups of people in her calculus class – "the people who do math and like math" and the people who do not. She refers to the people who like mathematics as grouped into "their tippity-types," which means that she perceives there is a certain type of person who likes mathematics. Since she refers to these people as "they" and not "us," she is excluding herself from this group and placing herself into the group who does not like mathematics. She says that the non-mathematics people, which she perceives as the majority of the students since she refers to them as "everybody else" do not seem to understand what is going on in class. As I discussed in the section exploring the theme of solidarity, the participants feel relieved when they are not the only one who do not seem to understand a certain concept in class. Thus, her identity as not being a mathematics person helps her to create solidarity with her peers around her.

Some of the participants spoke about incidents where they were in the minority in some regard, and this leaves them feeling isolated from their peers. An example of this is Sonia, who speaks of her experience with state-issued standardized testing in high school:

> Um, but throughout, even in elementary school, it was all, I was with the boys, I was in the boys club, you know. When we had out math reading things, I was in the top one, and I was only in the guy's group. When I was in the [state] testing, not really a contest, but it gets made into a contest, I was the single girl in a group of like ten guys that were all at the top. Even when we were, you know, I was salutatorian of my class, again, mostly guys, you know, and it's, I don't know, and it's not necessarily that the guys are smarter, that's definitely not true, 'cause we have brilliant young ladies, but why are they being shown more? I don't know, my experience I guess is being in the top half, the top, ten percent of the academics of my school and it's always been the boy's club. You're the only girl. And you can either take a lot of pride in that, or you can be like, why is that the case? Feel kind of alone, and you know, singled out.

Sonia excelled at these exams that were given by the state, but she was the only girl from her school who earned high scores on the exams, and all the other high-scorers were boys. She describes this feeling as being a part of "the boy's club," which signifies that she felt left out because of her identity as a woman. Indeed, she goes on to say that this experience made her feel "kind of alone" and "singled out." She did not feel like she belonged to this group of high-achievers, even if her test scores said otherwise, simply because she was a girl. She recognizes that there are "brilliant young ladies," but they are often excluded from this "boy's club." Instead of feeling a sense of solidarity with the other smart women in her school, she felt a sense of being singled out by the men who were being recognized. In other focus group sessions, she describes how she felt that her calculus class was taught with men in mind, and that men often led the class. This shows that her identity as a woman has excluded her from the sense of solidarity that comes with being a man in a STEM-related discipline.

The participants also describe how their personalities and different character traits affected how they felt during various parts of the class. For example, Elise does not like asking questions in front of large groups of people – she is shy. Below, she gives an example of how this creates a sense of solidarity with her peers:

> I'm not really good at, I'm not really a raise my hand and ask a question kind of person like I wish I was more, but I'm not. Um, and most of the time, like other people end up asking the question, so like kinda wait and listen, I'm like, someone else gonna ask it? That would be really awesome.

Elise does not identify as the kind of person who raises her hand to ask a question in class. This is part of her personality, and we see that this can impact her question-asking during class. Instead, she hopes that other people will ask the questions that she has. By assuming that her peers will ask questions similar to the ones that she has, she is acknowledging that she struggles with or has questions about concepts that her peers might struggle with as well; she is creating solidarity by grouping herself with her peers and hoping they ask questions.

As I have shown above, different parts of the participants' identities play into whether or not they have solidarity with a certain group of people. Identities such as being a "math person," a woman, or shy all contribute to the kinds of people these participants choose to relate to. In this section, I have discussed how identity influenced some of the major themes of my research. I will now examine if taking differential calculus affected the rating of each participants' mathematical confidence.

4.7 Baseline Data Re-visited

In Table 3.2, I presented the baseline data for each of the participants and rated their high school math experience and beginning level of mathematical confidence from 1 to 5, where a score of 1 represented low confidence or a poor experience, and a score of 5 represented high confidence or a great experience. I now re-visit this baseline data and add a column for the participants' mathematical confidence after taking differential calculus. As in Table 3.2, I am using the Fennema-Sherman Mathematical Attitudes Inventory in order to rate the participants' confidence. This table can be seen below.

Table 4.1 Baseline and Post-Calculus Confidence

Pseudonym	Career Goal	High School Mathematics Experience (1-5)	Beginning Confidence (1-5)	Confidence after Calculus (1-5)
Marie	Animal Prosthetics	4	3	3
Elise	Data analyst	3	3	4
Harper	Something relating to fungus research	4	4	4
Leanne	Undecided; possible marine biology	3	3	3
Stacey	Some sort of research	3	3	3

Janine*	Research scientist	5	2	*
Sonia	Retail pharmacy	4	3	2

* This participant did not complete calculus.

As this table suggests, I found that most of the participants had the same level of mathematical confidence as before they took calculus. Elise’s confidence increased, and Sonia’s confidence decreased. These two cases are studied more in-depth in the following section.

4.8 Case studies of two participants

Given their prior mathematical experiences, as well as their identities and life experiences, taking differential calculus affected each of the participants in this study differently. In this section, we will take a look at key points throughout the journey of taking this course of three of the participants in this study: Elise and Sonia.

4.8.1 Case study of Elise.

Elise is a transfer student to the university at which this study took place, and a computer science major whose ultimate career goal is to become a data analyst. She had a rough experience in mathematics classes the first two years of high school, but had a teacher the second half of her high school career who really shifted how Elise felt about mathematics. When Elise was taking courses at community college, she failed college algebra three times before she passed it, and she credits her passing the course in part to a friend who tutored her through it the fourth time. Elise was enrolled in differential calculus at this university once before, but dropped the course after realizing her other courses had to take priority. At the beginning of the term, she says that she has to work hard in order to think mathematically, and that having a mathematical mind does not come naturally to her.

Elise describes her dad and brother as "math geniuses." She says that both of her parents are supportive of her going into a STEM-related career, although her mom doesn't always understand the difficulty of the classes Elise is taking. She has many friends who are not in STEM-related majors as well, and she explains that, similar to her mom, they have an attitude of "'you do your thing, and don't talk to me about it, 'cause it's very confusing," which implies that she cannot share this part of her identity with some of the people she is closest to. However, she describes her uncle, who has been in the field that Elise wants to work in since the 1980's, as very supportive and encouraging. Thus, we can see that Elise has supportive family and friends, but, except for her uncle, they do not necessarily understand what she does in her major-related courses.

Throughout the term, Elise participated in two of the three sessions of focus groups. During these sessions, a number of the themes discussed previously in this chapter seem relevant to her. She explains the importance of being able to ask her professor questions, even mathematics questions that were not directly related to calculus, one-on-one in their office hours rather than asking questions during class. She also notes that it was important that her professor did not make her feel "dumb" for asking algebra questions. Elise appears to have a preference for group learning, as well as active learning, in which she was allowed the opportunity to ask plenty of questions. She discusses that timely and thorough feedback was important to her success in the course. Finally, she explains that although calculus does not feel "super relevant" to her future career at this point, she could see how maybe someday she will be thankful that she knows calculus.

Now that I have provided a general sense of Elise's experience in calculus, I turn to how taking this course has affected her identity, both mathematically and otherwise. When asked about how calculus has affected the way she solves problems, she replies:

> I feel like it's made me more determined, 'cause I get like, when I'm trying to solve something and it's just not working, it's just ridiculous, I'm like, well I can't give up now, 'cause I've already put in all this effort it, like if I give up now, it was all for nothing, and like I learned to put things down and come back to them too, sometimes, like if I get stuck on something, 'cause like my brain would just reach that point where there were no wheels turning at all, so I'd be like, we're gonna come back to this in the morning, and I think that helped a lot."

She describes how the difficulty of some of the calculus problems she has been given to solve have increased her sense of determination. She feels that, once she puts a certain amount of time and effort into solving a problem, she cannot give up; instead, she has learned that it is okay to come back to the problem later. This shows that taking this course has impacted the way that she approaches difficult problems, as well as increased her determination when faced with challenges.

She also expresses that calculus has the power to make her feel "very smart." She explains:

> I feel like everybody I know that's really really smart is really good at math, so there's this part of me that's like, if I can be good at math, then I too will be very smart, so yeah. And it is like, math is one of those things where when I don't understand it, I hate it so much, it ruins my life, but when I do understand it, it's really really cool and I have a good time doing it, so it's kind of a double-edged sword.

She refers to her dad and brother as "math geniuses," so I wonder if this impacts her view of "really really smart" people. Here, she is linking her being good at mathematics to being smart – she feels she cannot be smart if she is not good at mathematics. Thus, she is giving calculus a lot of power here – if she is good at calculus, then she will perceive herself as a smart person. This implies that this course can really affect her identity as a smart person.

It is worth noting that taking and succeeding in calculus seemed to have an impact on her enjoyment of mathematics. During her individual initial interview, as well as the focus groups in which she participated, she does not express an enjoyment of mathematics. However, during the final individual interview, she explains:

> Yeah, it's fun now. Like I do really, I like doing math now which I didn't used to. Like it still drives me crazy sometimes, but it's really rewarding so, I like that."

It sounds like she genuinely enjoys doing mathematics, and although it can be challenging at times, she finds it "really rewarding." Her success in calculus contributed to this shift in her mathematical identity.

Finally, we have the following exchange:

> R: Um, did math 251 affect the way that you feel about yourself as a person at all?
>
> Elise: It did I think in a positive way. Like I, I feel like it's, I feel like it's nice to be successful at things that are difficult. And so, even if, even if I didn't end up passing this first time, like I'd still feel like I was successful at it, 'cause I learned a lot and I feel like I grasped a lot of the concepts, so it made me feel more capable mathematically, which is nice."

I observe here that Elise's perceived success in calculus has boosted her sense of mathematical capability, and thus, her mathematical confidence. It seems that, given her history of struggling with mathematics, her success in this difficult course really means a lot to her and affected the way she sees herself both as a person and a mathematician.

As we saw in Chapter 2, the literature has much to say about the various factors that can affect mathematical confidence. In Elise's case, she has several positive and several negative factors going for her. She has a mathematical role model, her uncle, and this increases her sense of belonging in this field, which has been shown to increase confidence. She has supportive parents and friends. While she was taking calculus, she feels she had and took advantage of the opportunity to ask her professor questions, and her professor is supportive and does not belittle her questions. All of these could have had a positive impact on her success in the course. However, she has historically struggled with mathematics classes in the past, and it appears that she does not always feel she can share her STEM-related identity with her parents or friends. She would have preferred that her calculus class was more centered on active learning, and that she got more timely feedback. Ultimately, she succeeded in this course, and that her success leads to an increase in her personal and mathematical confidence.

4.8.2 Case study of Sonia.

Sonia is a freshman bio-health sciences major who would like to go into retail pharmacy. Her dad was one of her mathematics teachers in high school, and this seems to have a profound impact on her. She explains, "he's the kind of guy that wants women to feel successful" and that his confidence in her made her feel smart. Even though mathematics has always come easily to her and she has excelled in it, it is not her favorite subject. She was enrolled in differential calculus the term before this study took place, but dropped out of it after a week when she realized she needed to take the prerequisite course. She mentions that although she does not like mathematics, she believes she has a mathematical mind.

Sonia states in the initial individual interview that she felt like she had always been a part of the "boy's club" when she succeeded in mathematics. Additionally, coming into to college and seeing the gender disparity in her mathematics classes is confusing to her. She explains that "there are three or four other girls in my class, which is strange to me because I don't see math as being a typically male or female dominated field."

Sonia participated in one of the three rounds of the focus group sessions throughout the term; even so, since I have data from her at the beginning, middle, and end of the term, I believe I have enough information to do a case study on Sonia. Like Elise, a number of the themes discussed previously in this chapter seemed to resonate with her. She feels like she cannot ask questions during class because several men in her class ask questions that she does not understand. She does not see the relevance of calculus in terms of her future career, and speaks several times of talking with her friends who are pharmacists; these friends tell her she will not ever need calculus in order to be a pharmacist. She seems disconnected from her academic community, and does not participate in the meetings or clubs that are available to her and her major. It is important to Sonia that when she asks questions, she does not feel like the person who is helping her is condescending or shames her for not knowing a particular concept. She finds it helpful when the people around her have a similar understanding of the material, and expresses that she enjoys the solidarity that comes with constructive group work. She also expresses a desire to learn in groups and to learn through active learning.

Taking differential calculus seems to have a negative impact on Sonia's personal and mathematical confidence. At the beginning of the term, she expressed that mathematics is not her "favorite thing," but recognized that she was good at it and that she had natural mathematics skills. However, several times during the focus group session in which she participated, she says that she "hates math." This shift in language suggests that taking this course has negatively affected the way she feels about mathematics. This class also seems to impact the way she feels about herself as a person. She says the following:

> Yeah, you feel, you're like, wow, just because I can't take this one stupid math class that I will never need to use, I'm dumb, and you base all of you value off that, and not like, oh you took chemistry and like you really understand it, you get it and you love the periodic table! That makes you smart. No, actually, it doesn't because you just took this math class and you're doing horrible. So, yeah.

In this piece of data, Sonia is expressing that she is basing some of her value off of not understanding calculus. She explains that she could base her value off of classes that she excels in, such as chemistry; she loves chemistry and seems to have a deep understanding of it. Instead of finding her worth in classes that she loves, she is finding her worth in this class that she does not enjoy. This seems to be a large part of her identity at this point; instead of identifying as someone who loves chemistry, she seems to be identifying herself as someone who "hates math." Thus, we can see that calculus has affected her identity by shaping her worth in this way.

It is also worth noting that she understands that her motivation to pass calculus is negative. When asked what motivates her to keep going in this course when it gets difficult, Sonia responds:

> It's negative motivation, 100 percent. There is no positive, I never feel like, I'm gonna study really hard 'cause I wanna do really well. It's, I'm gonna study really hard 'cause I don't want to fail. So, yeah.

Understanding where one's motivations comes from can be important in exploring one's motives for doing well in a particular class, and here, Sonia recognizes that her motivation is that she does not want to fail. Before she says this, she mentioned that she loves studying chemistry because she wants to succeed in it; her motivation for chemistry is positive. But with calculus, she studies hard because she is afraid of failing.

I now shift the focus to how taking calculus seems to affect Sonia's identity. When asked at the beginning of the term if she felt she had a mathematical mind, Sonia said that she did. However, at the end of the term, she responds, "I feel like I have a chemistry mind, which has a little bit of math in it, but math in terms of chemistry." This shows that her mathematical identity has changed – instead of identifying as having a mathematical mind, she now says that she has a chemistry-oriented mind, which requires some signicant mathematics. Thus, throughout the term, something about this part of her identity changed. During her initial individual interview, Sonia expresses that she had never really struggled with mathematics before, and that she had always been at the top of her class when it came to standardized mathematics tests. After taking calculus, though, she feels like she was below her peers mathematically. This feeling makes her very self-conscious, and of this, she says:

> I felt super self-conscious the whole like, I dreaded going to that class. Monday, Wednesday, Fridays, I felt physically sick walking up the stairs. It was awful.

She feels physically sick on her way to calculus class because of how self-conscious she was that she was no longer at the top of her class. This part of her identity, being a high mathematical achiever, has changed, and it appears that she is having a hard time with that.

Sonia had a number of positive and negative factors going for her coming into and during calculus. Her dad is a mathematics teacher who supported Sonia in everything she did; she views him as a mathematical role model. Throughout high school, she excelled in mathematics, and even though it wasn't her favorite subject, she knew she was good at it. Additionally, throughout her taking this course, she was able to find peers who were on the same level as her and with whom she could work without feeling shamed for not knowing a particular concept. However, she feels like she cannot ask questions during class due to her gender and because she does not feel like she knew the material as well as her peers. She seemed to be disconnected from her academic community. Finally, she has difficulty understanding the relevance of taking calculus in terms of her career goal of being a pharmacist; she has friends in pharmacy who often tell her that she will not need calculus in this career. Sonia did end up passing this course, but she also left differential calculus with a decreased sense of mathematical confidence.

In this chapter, I explored data that contributed in a meaningful way to the thematic map that I created, and discussed how these themes relate to the participants' identities. I also dove into case studies of two participants in order to understand the factors that may have impacted their experience in this course. In the following chapter, I will take another look at these themes, as well as discuss future directions to which this study could extend.

Chapter 5: Conclusion

In Chapter 4, I examined individual pieces of data that contributed to several major themes that emerged when I analyzed the data using thematic analysis. In this chapter, I will discuss these findings, as well as the limitations of the study, implications for future studies, and implications for current calculus instructors. Before that, I will re-visit my research questions.

As stated at the end of Chapter 2, I had two research questions: What factors, inside and outside the classroom, affect the mathematical confidence of women in STEM-related majors? And, how are these factors related to each other, and in what ways do they affect the mathematical confidence of these women? Through the data that I collected and the way that I analyzed them in Chapter 4, I believe I have answered both of these questions. I have found that several factors affect the mathematical confidence of women in STEM-related majors: how the participated perceived differential calculus as it related to their future careers, being comfortable enough to ask questions, feeling a sense of solidarity with their peers, learning through active learning, and belonging to their academic communities. Figure 3.1 gives an idea of how these factors relate to each other, and this chapter will discuss how these factors can affect a woman's mathematical confidence.

5.1 Discussion of Findings

As explored in Chapter 4, I developed several themes when I analyzed the data. These themes were calculus relating to the participants' future careers, active learning, being comfortable enough to ask questions, belonging to their academic communities, and solidarity with their peers. I also discussed how identity can play a part in each of these themes. I would now like to explore how each of these themes relates to mathematical confidence. As I have used the definition of mathematical confidence from Dowling (1978), I will use the scale that he used in order to measure mathematical confidence, which was the Fennema-Sherman Mathematical Confidence Scale, as well as some more modern literature, in order to understand how each of these factors relates to mathematical confidence.

5.1.1 Calculus relating to future careers and mathematical confidence.

In the inventory scale which Dowling used (1978), the belief that mathematics will be relevant to a person's life and future career appears often. Fennema and Sherman (1979), the researchers who developed this scale, believed that the more a student understood the relevance of mathematics as it pertained to their future, the more confident they would be in learning it. Thus, in my study, participants such as Sonia and Stacy, who often express confusion as to how calculus relates to their future careers, would be expected to have lower mathematical confidence due to this factor.

Other literature from Chapter 2 also makes the connection between mathematical confidence and how mathematics relates to one's career. De Palma (2001), Zeldin and Pajares (2000), and Betz and Hackett (1983) state that women with higher mathematical confidence and mathematical self-efficacy often choose careers that they know are more mathematically-oriented, and that women who have lower mathematical confidence or a dislike for mathematics choose careers that they perceive as not mathematically-oriented. The research from which my study was based (Ellis et al., 2016b) states that more women than men leave STEM-oriented careers due to lack of mathematical confidence, even if they earned the same grades in the course. It is possible that Sonia and Stacy, for example, chose careers that they perceived as not requiring a lot of mathematics due to their low mathematical self-efficacy or dislike for mathematics. In my study, it appears that this is some sort of feedback loop: as Stacy and Sonia have a dislike for mathematics or lower mathematical confidence, they chose careers that they believed will not employ a lot of mathematics, and the knowledge that they will need to use mathematics in their futures perhaps led back again to a lower level of mathematical confidence.

5.1.2 Active learning and mathematical confidence.

In the Fennema-Sherman Mathematical Confidence Scale, many of the items relate to feeling engaged in learning mathematics, and these researchers believed that the more engaged the students were during their math classes and while they were solving math problems, the more likely they were to be mathematically confident (Fennema & Sherman, 1976). Active learning is, by nature, designed to be more engaging for all students in the classroom. Thus, the participants in my study expressing a propensity for active learning makes sense, as the more engaged they would be their desire to learn and use mathematics would increase.

There are a number of studies that I used in my literature review that explore active learning as it relates to how women learn math. In particular, Kogan and Laursen, (2014), Everingham, Guyris, and Connolly (2016), and Hagman, Johnson, and Fosdick (2017) all state in their respective research that learning through active learning as long-term positive effects on women's mathematical confidence. In addition, this research explores the fact that in general, students who are enrolled in classes that use active learning are indeed engaged in the mathematics for a higher ratio of the class time than those students in traditional classes. All of the students in my study were in classes that did not have an emphasis on active learning, but were the traditional lecture-style classroom. According to this research, this factor may have led to a decrease in their mathematical confidence, and their desire to participate in more inquiry-based classes shows that they might recognize that being more engaged in the math would lead to higher mathematical confidence.

5.1.3 Asking questions and mathematical confidence.

Active learning and asking questions go hand-in-hand. In fact, active learning is sometimes called inquiry-based learning, which draws attention to the fact that students should be encouraged to inquire, or ask questions, about the material that they are learning. In this study, there seemed to be two factors at play that affected whether or not the participants felt they could ask questions in class. The first is that they had to feel that the professors are not going to belittle their questions or make them feel like they are not being taken seriously. The second is that the women have to feel like they fit into their class enough in order to ask questions without feeling embarrassed. In the inventory that Fennema and Sherman created, there are several items about feeling like your teacher takes you seriously. Additionally, there are many items regarding mathematics as a male domain; Sonia, for example, expresses that she felt she cannot ask questions in class due to the men asking all of the questions. Thus, this inventory suggests that if professors take the students seriously enough to answer their questions, and if the students feel like men and women are asking questions during class, then they can make inquiries about the material. This higher level of engagement, as I illustrated in the previous section, leads to higher mathematical confidence. This does not address other aspects of the participants' identities that they felt inhibited them from asking questions; Janine expresses that she felt embarrassed to ask questions due to her age. We see, therefore, an underlying sense of identity and how this contributes to the participants feeling comfortable enough to inquire during class.

5.1.4 Belonging to academic communities and mathematical confidence.

As I described in the previous section, much of the Fennema-Sherman Mathematical Confidence Scale considers the dichotomy of math as a male or female domain. If women feel, on some level, that mathematics is a male domain, they might feel as if they do not belong in their math classrooms or in their STEM-related academic communities. Thus, as the scale suggests, an understanding of math as a neutral domain could increase the sense of mathematical confidence of women.

There has also been some research done in this area. Research conducted by Good, Rattan, and Dweck (2012) as well as Nickerson et al. (2017) suggests that a sense of belonging increases a woman's mathematical confidence. Furthermore, having a female role model in their department to look up to vastly increases the chance that they perceive that they belong (Good et al., 2012). Thus, Harper, whose mother is a calculus teacher at a nearby community college, probably has an increased sense of belonging, as she has someone close to her to loop up to in this field. Elise, whose uncle is in the field in which she would like to go, probably has some sense of belonging, as she can be encouraged by someone she knows who has been in her position. This research suggests, though that her sense of belonging might be increased if this person she knows were a woman instead.

5.1.5 Solidarity with peers and mathematical confidence.

There are no items in the inventory scale using by Dowling that address feeling a sense of solidarity with peers. There has also been little research conducted in this area. Raabe, Boda, and Stadfeld (2019) found that women whose friends expressed that they liked mathematics were more likely to go into a STEM-related field, and those whose friends expressed that they did not like mathematics were less likely to go into a STEM-related field. This research does not, however, address the feeling of solidarity with peers, not necessarily friends, in the class. However, we can imagine that a feeling of solidarity with one's peers increasing one's sense of belonging in the class, which, as we have seen in the previous section, has the potential to increase mathematical confidence.

5.2 Limitations

This study was designed in order to gain an understanding of the factors that affect the mathematical confidence of women in STEM-related majors. There are limitations to this study, and I will discuss a few of them in this section.

Although about 500 students were enrolled in differential calculus at this university the term in which this study took place, only eight of them self-selected to participate in this study. The number of participants in this study is definitely a limitation, as I only had a handful of narratives and perspectives to work with. One way to change or improve this would be to conduct the study over several terms, in order to get more participants. Planning the study over the course of several terms would also increase the number of instructors teaching the course, as well as eliminate mitigating factors such as certain peers in class or the use of technology in the class.

Another limitation of this study was the lack of diversity in the participants. Three of the participants were non-traditional students who had work experience before coming to college, and two of them identified as low socio-economic status. All of the participants, however, were white, and none of them openly identified as LGBTQ+. As there has been much research completed on how race and sexuality affect women in mathematics, it would have been great to have had diverse voices from these minority groups present.

Finally, I recognize that, given the relatively small number of participants in this study, more or different themes from the data could have emerged with more participants included. Thus, the themes that I found and analyzed cannot be generalized to other differential calculus courses. Additionally, I recognize that it is impossible to completely eliminate bias when analyzing data. However, I believe the themes that I found contribute valuable information to this field of knowledge. I would also like to note that the themes and findings were my own interpretation of the data that was collected; another researcher could have found that different themes emerged from the data.

5.3 Future Directions

Much research has been conducted in order to understand why there is still a gap in the persistence of women in STEM-related fields, and as my research shows, we still have a long way to go, and there are still many questions to be answered.

It would be interesting to conduct this study with more participants over a longer period of time to see what themes emerge from the data. Similarly, it would be interesting to follow up with the women who participated in my study to see how their experience in calculus has affected them in the other mathematics classes they have taken since they completed differential calculus.

My study focused primarily on how the experiences that the participants had both before and during differential calculus affected their mathematical confidence, but it would also be fascinating to understand where their mathematical beliefs come from, as well as how particular mathematical experiences have shaped their personal and mathematical confidence. One research question that may address these issues would be: how do women's past mathematical experiences shape their learning in differential calculus? Another relevant research question in order to understand the implications of this course on their future learning would be: how do women's experiences in differential calculus affect their experiences in later mathematics courses?

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APPENDICES

Appendix A: Announcement in Class

My advisor, Dr. Mary Beiseigel, and I made the following announcement to each section of the differential calculus courses at the university where the study took place:

My name is Amanda Petty, and this is my advisor Mary Beisiegel. I am conducting a research study The Experiences of Women in First-Term Calculus investigating how [differential calculus] affects the mathematical confidence of women in STEM-related majors. I am seeking students in [differential calculus] who identify as a woman to participate. Your participation will include a 20-minute interview with me next week, three 90-minute-long focus group sessions throughout the term, and an individual 20-minute wrap-up interview at the end of term. Your participation is completely voluntary and would not affect your standing in the course or with the university. You would be offering valuable information to the field of math education if you choose to participate. You will you receiving an email from me later in the week asking if you're interested in participating. My email address is pettya@math.oregonstate.edu. Thank you for your time, and I hope to hear back from you.

Appendix B: Recruitment Email

After Dr. Mary Beisiegel and I made the announcement in Appendix A to each section of differential calculus, I sent the following email to all students who were currently enrolled in the course. I obtained the email addresses of the students from their respective instructors.

Dear [differential calculus] student,

My name is Amanda Petty, and I am a graduate student in the math department at [university name]. I am conducting the study The Experiences of Women in First-Term Calculus for my thesis to investigate how [differential calculus] affects the mathematical confidence of women in STEM-related majors. I am seeking students in [differential calculus] who identify as female to participate in my study. Your participation is completely voluntary and will not affect your academic standing in the course or with the university.

If you choose to participate, you will be completing a short interview with me, approximately 20 minutes, during week 2 of this term. Then, you will participate in three 90-min-long focus group sessions throughout the term, as well as a final individual interview at the end of the term. You may withdraw from the study at any time for any reason without penalty. Any information collected will remain completely confidential.

Although you will not be monetarily compensated for your participation, you will offer extremely valuable information to the field of mathematics education. Additionally, your participation in the focus groups may allow you to meet other women in the class who you otherwise may not have met.

If you are interested in participating, please contact me at pettya@oregonstate.edu along with the times you are available during week 2 to complete a 20-minute interview. For more information about this study, please contact the principal investigator, Dr. Mary Beisiegel, by phone at 541-737-8397 or email at mary.beisiegel@oregonstate.edu. You can contact the Human Research Protection Program with any concerns that you have about your rights or welfare as a study participant. This office can be reached at (541) 737-8008 or by email IRB@oregonstate.edu.

Thank you,

Amanda Petty

Appendix C: Fennema-Sherman Mathematical Confidence Scale

I used the Fennema-Sherman Mathematical Confidence Scale in order to understand the baseline data for my participants. The scale is below.

A strongly agree E strongly disagree

1.	I am sure that I can learn math.	A B C D E
2.	My teachers have been interested in my progress in math.	A B C D E
3.	Knowing mathematics will help me earn a living.	A B C D E
4.	I don't think I could do advanced math.	A B C D E
5.	Math will not be important to me in my life's work.	A B C D E
6.	Males are not naturally better than females in math.	A B C D E
7.	Getting a teacher to take me seriously in math is a problem.	A B C D E
8.	Math is hard for me.	A B C D E
9.	It's hard to believe a female could be a genius in mathematics.	A B C D E
10.	I'll need mathematics for my future work.	A B C D E
11.	When a woman has to solve a math problem, she should ask a man for help.	A B C D E
12.	I am sure of myself when I do math.	A B C D E
13.	I don't expect to use much math when I get out of school.	A B C D E
14.	I would talk to my math teachers about a career that uses math.	A B C D E
15.	Women can do just as well as men in math.	A B C D E
16.	It's hard to get math teachers to respect me.	A B C D E
17.	Math is a worthwhile, necessary subject.	A B C D E
18.	I would have more faith in the answer for a math problem solved by a man than a woman.	A B C D E
19.	I'm not the type to do well in math.	A B C D E
20.	My teachers have encouraged me to study more math.	A B C D E
21.	Taking math is a waste of time.	A B C D E
22.	I have a hard time getting teachers to talk seriously with me about math.	A B C D E
23.	Math has been my worst subject.	A B C D E
24.	Women who enjoy studying math are a little strange.	A B C D E
25.	I think I could handle more difficult math.	A B C D E

26.	My teachers think advanced math will be a waste of time for me.	A B C D E
27.	I will use mathematics in many ways as an adult.	A B C D E
28.	Females are as good as males in geometry.	A B C D E
29.	I see mathematics as something I won't use very often when I get out of high school.	A B C D E
30.	I feel that math teachers ignore me when I try to talk about something serious.	A B C D E
31.	Women certainly are smart enough to do well in math.	A B C D E
32.	Most subjects I can handle OK, but I just can't do a good job with math.	A B C D E
33.	I can get good grades in math.	A B C D E
34.	I'll need a good understanding of math for my future work.	A B C D E
35.	My teachers want me to take all the math I can.	A B C D E
36.	I would expect a woman mathematician to be a forceful type of person.	A B C D E
37.	I know I can do well in math.	A B C D E
38.	Studying math is just as good for women as for men.	A B C D E
39.	Doing well in math is not important for my future.	A B C D E
40.	My teachers would not take me seriously if I told them I was interested in a career in science and mathematics.	A B C D E
41.	I am sure I could do advanced work in math.	A B C D E
42.	Math is not important for my life.	A B C D E
43.	I'm no good in math.	A B C D E
44.	I study math because I know how useful it is.	A B C D E
45.	Math teachers have made me feel I have the ability to go on in mathematics.	A B C D E
46.	I would trust a female just as much as I would trust a male to solve important math problems.	A B C D E
47.	My teachers think I'm the kind of person who could do well in math.	A B C D E

Appendix D: Interview Questions

I asked the following questions to the focus group participants during their respective sessions, along with relevant follow-up questions if I felt they were necessary.

Initial Individual Interviews

1. What's your major? What do you want to do with your degree?
2. How do you see yourself in the future – what is important to you, to your career, to who you are as a person?
3. Can you tell me a little bit about your experience with math in high school?
4. Did you take a math class here at [university name] last term? If so, can you tell me a little bit about that?
5. Can you tell me about a time you felt you succeeded in a math class?
6. When you're confronted with a difficult math problem, what thoughts run through your head?
7. Do you feel like you have a mathematical mind?
8. What things or people seem to have the biggest impact on whether you feel you can be successful in mathematics? Can you explain why these things or people have an impact on you?
9. Do you have any other thoughts or comments you would like to share that the interview questions did not address?

First Round of Focus Groups

1. Did you take a math class here at [university name] last term? If so, how does this calculus class compare to last term's class so far?
2. How do you feel coming into calculus?
3. How do your parents or other family members feel about you going into STEM (science, technology, engineering or mathematics)?
4. Do you feel like you have any role models in STEM? If so, what stands out about them? What about them inspires you?

5. How have the interactions with your professor so far affected the way you feel about calculus?
6. How have the interactions with your peers in class so far affected the way you feel about calculus?
7. What have you noticed about the environment about your calculus classroom so far?
8. How have the interactions with your TA so far affected the way you feel about calculus?
9. Do you feel like there are any obstacles to your success in calculus? If so, what are those obstacles?
10. Can you tell me about a time in the past you succeeded in a math class?
11. Do you have a mathematical mind?
12. How do you feel you fit into your calculus class?
13. Are you planning on taking [integral calculus] next term?
14. Writing component – If there is something you wanted to talk about but didn't feel comfortable bringing up in the group setting, could you please take a couple of minutes to write that down for me?

Second Round of Focus Groups

1. What do you like or dislike about your instructor's teaching style and what occurs in the classroom?

2. What pressures are you feeling in regards to [differential calculus]?

3. Do you feel that you belong to your academic community? Could you describe what makes you feel that way?

4. When you study [differential calculus]with someone else, what is most helpful?

5. How does calculus relate to your future career?

6. What kinds of mistakes do you make when working on a [differential calculus] problem?

7. How has [differential calculus]compared to your expectations of what it would be like? What did you expect in the class? With the subject material? And what has it been like?

8. What motivates you to keep going when [differential calculus]gets difficult?

9. What resources are most helpful to you or would be most helpful to your success in [differential calculus]?

10. How does the recitation period affect your learning and confidence in the material?

Third Round of Focus Groups

1. How does discipline play a role in your success in [differential calculus]?
2. What has surprised you about [differential calculus]?
3. Have you noticed anything about how you learn calculus?
4. What people, inside or outside of school, have been helpful to you during [differential calculus]?
5. Do you feel like your voice is heard, literally or metaphorically, in your calculus class?
6. How has calculus affected the way you solve problems?
7. What frustrates you the most about [differential calculus]?
8. How do you feel when you ask for help or don't understand a concept? Do you ever feel put-down or shamed?
9. Do you want to be good at calculus?
10. How do you think your calculus experience would change if you took this course online and didn't have a set of classmates?
11. What is harder or easier in [differential calculus] than what you expected?

Final Individual Interviews

1. Can you tell me about your overall experience in [differential calculus]? Do you expect to pass?
2. Can you tell me about a time you felt you succeeded in [differential calculus]?
3. Do you have a mathematical mind?
4. When you're confronted with a difficult math problem, what thoughts run through your head?

5. Do you plan on taking [integral calculus] next term?

6. What stands out to you about your experience in calculus – about the professor, your peers, the material, or something else?

7. Did you feel like you were on the same level as your peers throughout the term?

8. Did [differential calculus] affect the way you feel about yourself as a person?

9. What did you struggle with the most in [differential calculus]?

Appendix E: First set of Possible Codes

1 - There will be differences in confidence expressed with respect to three cognitive levels of demand of the mathematics problems. Students will express more confidence with respect to problems involving computation than comprehension, comprehension than application.

2 - Students will express more confidence when faced with problems in a real context than in an abstract context.

3 - There is a significant positive correlation between women college students' confidence in mathematics and other background and attitude variables associated with the learning of mathematics. Specifically, there is a significant positive correlation between: number of years of study of high school mathematics, number of college mathematics courses, the students' beliefs about the usefulness of mathematics, effectance motivation in mathematics, influence of teachers, anxiety when faced with mathematics problems, views about mathematics as a male domain, and confidence in mathematics among women students.

4 - There are significant differences in background, attitude, and sex-role identity between women students who are overconfident and under-confident in mathematics. Specifically, women students who are under-confident will have studied mathematics for fewer years in high school will have taken less mathematics in college, will be more anxious when faced with mathematics problems, will not be as challenged by mathematics, will view mathematics as being less useful, will be less influenced by their teachers, will view mathematics more as a male domain, than those students who are overconfident or neither.

5 - Attitude toward success in mathematics

6 - Mathematics as a male domain,

7 - The attitude of mother, father, teachers, confidence in learning mathematics,

8 - Mathematics anxiety,

9 - Effectance motivation, and attitudes about the usefulness of mathematics.

Appendix F: List of Codes Used to Analyze Data

I used the following sets of codes to code the first, second, and third rounds of focus group interviews, as well as the final individual interviews.

1 – Instructors affect the way they feel about the material.
2 – Instructors affect the way they feel about math or the course in general.
3 – Family and friend support means something to them.
4 – Motivation/discipline
5 – There is some anxiety or nervousness regarding doing well in the course.
6 – They show confidence in themselves on a personal level.
7 – They downplay their accomplishments or abilities.
8 – They see someone like them in their field who they admire.
9 – They feel dis/connected with their academic community.
10 – Math not related to the concepts they're learning.
11 – Something related to active learning.
12 - They feel dis/connected to their peers.
13 – Something about the way they learn best.
14 – Classroom environment
15 – Feedback for the course
16 – Course learning aids (homework, exams, etc)
17 – Time management
18 – Mathematical language
19 – Calculus relating to their future
20 – Feelings towards calculus

I used the following codes for the initial and final individual interviews, as well as all of the focus group interviews, to code for identity.

1 – Past experiences shaping identity
2 – Mathematical identity or identity relating to major
3 – Identity with friends and family
4 – General identity

Appendix G: Codes used to Analyze Initial Individual Interviews

I used the following set of codes to code the initial individual interviews to gain a better understanding of the baseline data.

1 – Career aspirations and professions
2 – Shows a strong mathematical background or good mathematical experiences
3 – Shows weak mathematical background or bad mathematical experiences
4 – Shows interest in getting good grades
5 – Someone has impacted the way that they view math
6 – Something related to motivation or discipline
7 – Something related to how they did well in a math class
8 – Something related to logical/emotional thinking