Relationship Among Class Perceptions, Math Identification, and STEM Choice: Examining Gender and Racial Differences

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Academic Abstract

The first purpose of this research was to understand the factors that contribute to the underrepresentation of women of color in science, technology, engineering, and math (STEM) career fields, with a specific focus on understanding the issues faced by Black women. The second purpose was to analyze the gender and racial differences in the interrelationship of high school students' class perceptions, math identification, and their decisions to select a STEM major in college. These relationships are important because the growth outlook for careers in STEM is higher than other career fields and providing underrepresented women in STEM equal access to these careers is vital. Additionally, it is important to increase the gender and racial diversity of the STEM workforce. The first manuscript (Chapter 2) was based on a literature review that provided an overview of the social factors that affect the underrepresentation of women of color in STEM by highlighting the experiences of girls of color in their youth. The literature review explored the stereotypes and discrimination girls of color experienced in the K-12 school system that affect their participation in math and science, and how the intersection of race and gender contributed to the experiences of Black females when it comes to their experiences with STEM. Using the MUSIC model of motivation theory and domain identification theory, the study in Chapter 3 explored the relationship between students' math class perceptions, math identification, and decision to major in a math-intensive (i.e., math and statistics, engineering, computer science, and physical sciences) STEM major. The study in Chapter 3 used multigroup structural equation modeling (SEM) to analyze gender and racial differences among four groups Black females, Black males, White females, and White males.

The results indicate that students' math class perceptions of success and interest were positively related to their math identification. Furthermore, students' math identification was positively related to their decisions to select a STEM major as they entered college. The interrelationship between math class perceptions, math identification, and the decision to select a STEM major was not statistically different for Black females as compared to Black males, White females, or White males. Implications for schools and educators for increasing the participation of Black female students in STEM are discussed.

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General Audience Abstract

The purposes of this research were to understand the factors that contribute to the underrepresentation of women of color in science, technology, engineering, and math (STEM) and to analyze the gender and racial differences in the interrelationship of students' class perceptions, math identification, and decisions to select a STEM major. Because Black women are one of the least represented groups in careers associated with STEM, one of the aims of this research was to investigate some of the factors contributing to Black women's underrepresentation in STEM careers. The research was conducted in two parts. The first manuscript (Chapter 2) was based on a literature review that provided an overview of the social factors that affect the underrepresentation of women of color in STEM careers by highlighting their experiences in their youth. The literature review explored discrimination against girls of color in the K-12 school system, especially as it relates to math and science participation, and how the intersection of race and gender contributed to the experiences of Black females in STEM. The second manuscript (Chapter 3) used the MUSIC model of motivation theory and domain identification theory to analyze the relationship between students' math class perceptions, how well students see math as part of their identity (math identification), and decision to major in a math-intensive (math and statistics, engineering, computer science, and physical sciences) STEM major. I used a statistical method, structural equation modeling (SEM), to analyze gender and racial differences among four groups; Black females, Black males, White females, and White males. The math class perceptions of success and interest were found to be positively related to math identification. Students' math identification was found to be positively related to their decisions to select a STEM major. Black females did not show a difference from the other groups in the relationship between their math class perceptions, math identification, and decision to select a STEM major. Implications for schools and educators for increasing the participation of Black female students in STEM are discussed.

Dedication

To my mother, Remanne H. Saint-Fleur, and my father, Jean S. Mondesir without your prayers, love, inspiration, encouragement, and life lessons I would not be the person I am today.

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There are many people I would like to thank for their support and encouragement throughout this journey. Too many to list here. But I would like to highlight a few people who have made tremendous contributions to this PhD degree.

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Attributions

Dr. Brett D. Jones is named as second author and Dr. Jesse L. Wilkins is named as third author on manuscript 2.

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CHAPTER 1

Introduction

Overview/Rationale

Due to major developments in science and technology in the U.S and across the world, industries that require knowledge in science, technology, engineering, and mathematics (STEM) have seen a lot of growth in the last few decades (Noonan, 2017). However, the U.S. and the rest of the world are experiencing a shortage of people pursuing careers in the STEM fields (Lauermann et al., 2017). The lack of minority women in STEM fields is a contributing factor to the shortage of people in the STEM fields. Minority women are more likely to leave STEM than other groups (Gayles & Smith, 2019). To meet the challenge of the shortage of people pursuing careers in STEM, it is important to increase the diversity of people studying STEM, especially in the U.S. Furthermore, because those with degrees in STEM tend to earn more than those with non-STEM degrees (Fayer et al., 2017), having a low representation of minority women in STEM could lead to more economic inequality. In this study, I investigate some of the factors that could contribute to an increase of minority women in STEM fields, especially in fields with the lowest representation of minority women, such as engineering, math, computer science, and the physical sciences.

The main focus of this study was investigating the role that identification with mathematics in high school has on STEM choice, with Black female students as a primary focus. Math identification is the extent to which a student values math as an important part of their self (Osborne & Jones, 2011). Students' identification with a domain, such as math, has been shown to be an important predictor of their intent to pursue a career in the domain (Jones et al., 2017; Jones et al., 2016; Lauermann et al., 2017). Thus, understanding the role of math identification and its antecedents and consequences could provide important insights into students' math and STEM choices.

Researchers have identified several factors that can influence a student's domain identification, including race, gender, school climate, and educational experiences (Osborne & Jones, 2011). For example, middle school students' perceptions of classes within a domain such as science have been shown to be related to their science identification (Jones et al., 2017). In turn, domain identification has been shown to affect outcomes such as effort, persistence, achievement, and career intentions (Appleton et al., 2008; Chittum & Jones, 2017; Jones et al., 2014; Osborne & Jones, 2011;). Thus, domain identification plays an important role in relation to many psychological constructs that have been shown to affect students' career intentions and may provide insight into Black female students' intentions to pursue STEM careers.

Statement of Problem

Jobs in science, technology, engineering, and math (STEM) are some of the fastest growing jobs in the U.S. A report on STEM jobs published in March 2017 by the U.S Department of Commerce stated that STEM jobs grew by 24.4% from 2005 to 2015, while non-STEM jobs only grew by 4.0% (Noonan, 2017). The same report projects that STEM jobs are expected to grow by 8.9% from 2014 to 2024, while non-STEM jobs are expected to grow by 6.9% (Noonan, 2017). On average, people in STEM jobs or with STEM skills earn more than those in other fields (Fayer et al., 2017). Given the growth trajectory of STEM and the salary benefits, STEM careers are some of the most coveted jobs today. Yet, studies have shown great gender discrepancy between the participation of men and women in STEM.

Women are less likely than men to pursue a career in math and science (Steele, 2003), and women studying science at all levels of education tend to outnumber men in dropout rates

(Simon et al., 2015). According to a 2017 report on Women in STEM by the U.S Department of Commerce, while the number of women that hold overall undergraduate degrees are about the same as men, working women holding undergraduate degrees in STEM make-up only 30.0% of working STEM degree holders, the largest discrepancy being in computer, math, and engineering degrees (Noonan, 2017).

Although the statistics on women in STEM show a wide discrepancy in representation, the underrepresentation appears to be far more substantial when considering the representation of minority women in STEM disciplines. For example, women of color, mainly Black, Latina, and Native American women, are still the most underrepresented in the engineering and computing fields in comparison to their representation in the general population (Corbett & Hill, 2015). For all the science and engineering degrees awarded in 2016, underrepresented minority women (Black, Hispanic, American Indian, Native Alaskan) received 12.6% of all the bachelor's degrees, 7.8% of all master's degrees, and 5% of all doctoral degrees (NCSES, ncses.nsf.gov, 2019). Increasing the number of minority women in these fields is not only necessary for economic equity, but it is also one of the ways to address the shortage of people pursuing STEM careers.

Purpose of the Studies

Although researchers have addressed the lack of women in STEM and the lack of minorities in STEM, there is a dearth of research specifically targeting minority women in STEM (Ong et al., 2011). Due to having dual salient identities (i.e., being a woman and being a minority) that have been the target of discriminatory practices for centuries in the U.S (Blanton, 2000; Gayles & Smith, 2019; Nisbett, 2011; Thomas et al., 2018), the intersectionality of race and gender makes focusing research on minority women in the U.S pursuing STEM especially important. This document includes two studies, presented in Chapters 2 and 3, that focus on factors that affect Black females' experiences, attitudes, intentions, and achievement in STEM, especially within mathematics.

Chapter 2 includes an extended literature review covering the sociocultural factors affecting women's opportunities to pursue studies in STEM, with a focus on Black girls' experiences in STEM. The literature review expands on the way American society has treated young women and girls in relation to STEM and covered the relationship that they have with math in the K-12 school system. I explore how that relationship has affected their pursuit of careers in STEM, particularly in engineering, computer science, and the physical sciences.

Much of the research that has been conducted on minority women has focused on external factors (e.g., lack of opportunity to take certain courses in high school; discriminatory practices of college faculty in STEM disciplines) that affect the lack of opportunities that minority women receive in the pursuit of a future career in STEM (Collins et al., 2020; McGee & Bentley, 2017). The purpose of the study presented in Chapter 3 is to focus on Black girls' career aspirations in STEM and its relationship with their experience with high school math classes. Black girls were selected as the focus instead of Black women because when it comes to career decision, many students start to think about what career they want to pursue prior to college, and in many cases, prior to high school (Maltese & Cooper, 2017). This study focuses specifically on internal psychological factors (e.g., mathematics identification) that have been shown to contribute to high school students' intent to pursue studies in STEM majors and obtain STEM careers (Eccles & Wang, 2016; Jones et al., 2017;). For STEM careers, students' perceptions of math can have a lot of influence on their decision to major in a STEM discipline, especially those known to be math intensive, such as engineering, computer science, and physical sciences (Nix et al., 2015; Watt et al., 2017). Therefore, the internal psychological factors I investigate are in relation to students' experience, attitudes, and achievement in math classes. My research analyzes the role that identification with mathematics has on Black girls with intentions to major in math-intensive STEM majors as compared to other demographic groups. This study addresses this primary research question: *To what extent are students' math class perceptions related to their math identification and choice of STEM major?*

Significance of Research

The study presented in Chapter 3 clarifies the role of Black girls' identification with mathematics in high school. Although researchers have documented the importance of domain identification in other fields (e.g., science, engineering) at different levels of schooling (e.g., middle school, undergraduate), researchers have not investigated whether the role of mathematics identification is similar for Black girls as it is for other Black and White students in high school. Ultimately, this research has the potential to inform the pedagogical approaches that mathematics teachers could implement to improve the performance of Black girls in math and increase the likelihood that they will pursue careers in STEM. It could also help schools design academic experiences that can target young Black girls' relationship with math that could lead to math identification. Although there has been a history of discrimination and stereotyping of Black girls in relation to STEM, focusing on the internal psychological factors could help them overcome these social barriers and develop the confidence and interest to pursue studies in STEM.

Outline of Dissertation

The dissertation is divided into four chapters for which Chapters 2 and 3 are written as separate, stand-alone manuscripts that can be submitted for publication in journals. This chapter,

Chapter 1, provides an introduction of the problem I intend to investigate. This chapter also includes an overview of the role that STEM careers play in the U.S. economy and the lack of representation of minority women in STEM, and the economic impact of that discrepancy. This chapter also sets the stage for the question I investigated in this dissertation. In Chapter 2, I present a literature review examining the sociocultural factors affecting women's opportunities to pursue studies in STEM, with a focus on Black girls' experiences in STEM. In Chapter 3, I present an empirical study investigating the antecedents and consequences of Black girls' math identification, including their career intentions in math related disciplines. I present the theories guiding my research, including domain identification (Jones et al., 2016; Osborne & Jones, 2011;) and the MUSIC Model of Motivation (Jones, 2009, 2018). I also detailed the research methodology and the analyses that I employed to address the question in my investigation. At the completion of the study, I provide detailed results of my analysis of the variables, conclusions drawn from the findings, and the implications of these findings. In Chapter 4, I summarize the main findings from my studies presented in Chapters 2 and 3, discuss the broader implications of these studies, and draw conclusions from these studies.

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CHAPTER 2

Factors affecting the persistence of young women of color in STEM disciplines

Introduction

Research related to people's choices of careers in science, technology, engineering, and mathematics (STEM) has gained in popularity over the years. Some of that research targets minorities and women in STEM, but there is a dearth of research targeting minority women specifically (Ong et al., 2011). The American Association for the Advancement of Science (AAAS) published a report in April 1976, *The Double-Bind: The Price of Being a Minority Woman in Science* (Malcolm et al., 1976), which highlighted the plight of underrepresented minority women in STEM. Since the publication of this report, research has shown that minority women continue to be disproportionately underrepresented in the STEM fields in the United States. To understand the slow progress that women of color have made in STEM, it is important to investigate the factors affecting women getting on or staying on the path to a STEM career.

In this chapter I explore the phenomenon of minority women's underrepresentation in STEM by addressing the sociocultural factors that have contributed to their underrepresentation in STEM fields. I focus on minority women because they are more likely to leave STEM than other groups (Gayles & Smith, 2019). I address the issue by reviewing the literature highlighting studies that focused on the factors that have affected Black girls' relationship with STEM, primarily in engineering, computing, and the physical sciences, prior to college. My reason for highlighting young Black girls prior to college is that in order to understand the lack of women of color, especially Black women in STEM, it is important to analyze the problem at its roots by investigating their experience in their youth.

Defining STEM and Its Importance

I want to begin by establishing what I will refer to as "STEM" in this chapter. The STEM Education Act of 2015 (Public Law 114-59-October 7, 2015) formally defines STEM education as education in science, technology, engineering, and mathematics, including computer science. However, depending on the source, the STEM fields sometimes include the health sciences, agriculture, and psychology. The Standard Occupational Classification (SOC) manual (2018) provides standard categories to be used by federal agencies when collecting data on different occupations in the United States. The SOC manual has three major groups which encompasses virtually all the occupations that could be considered part of the STEM family: computer and mathematical occupations; architecture and engineering occupations; and life, physical, and social science occupations. Many studies about STEM focus on a major or career that includes one of these broad categories. My primary focus is on engineering, mathematical, computer, and physical science occupations because females are less represented in these occupations (Noonan 2017; NSB, NSF, Science and Engineering Indicators, 2020).

The lack of female representation in STEM is important mainly due to the increase in job opportunities in STEM. Recent reports show that STEM jobs grew by 24.4% from 2005 to 2015, while non-STEM jobs only grew by 4.0% (U.S. Department of Commerce, 2017). Additionally, jobs are expected to grow by 8.9% from 2014 to 2024 in STEM, while non-STEM jobs are expected to grow by 6.9% (Noonan, 2017). These statistics indicate that, overall, STEM jobs are growing faster than non-STEM jobs. Therefore, it is imperative that these jobs get filled. Furthermore, the careers in the STEM fields have higher wages than non-STEM fields on average, and people with STEM degrees had higher wages than those with non-STEM degrees on average, regardless of their occupation (Fayer et al., 2017). In a 2018 Congressional Research

Service (CRS) report on STEM education in the U.S., it was reported that the federal agencies usually spend between 2.8 to 3.4 billion dollars on STEM education (Granovskiy, 2018).

Underrepresentation of Women in STEM

Underrepresentation of women in STEM may not seem like a major national concern, unless it is highlighted with concrete data. In this section, I establish the findings on women's representation in STEM in the U.S. With higher pay and more potential job growth than other disciplines, as documented in the aforementioned reports, the STEM disciplines are important parts of the U.S economy, and the U.S government shows a strong interest in promoting education in STEM. Despite the importance of STEM to the U.S. economy and government support, there has been a lot of research showing that the STEM fields have been grappling with a gender and racial/ethnic gap for a long time (e.g., Malcolm et al. 1976; Main & Schimpf, 2017). This gap, if not addressed effectively, could lead to further income inequality across racial lines and between men and women, which could lead to more social issues. Increasing diversity, equity, and inclusion in STEM is one of the goals of the U.S government according to a report by the Committee on STEM education. Despite efforts to close the gender gap, women continue to be underrepresented in many STEM fields. Studies show that of all the academic disciplines, science is the only one in which women outnumber men in the dropout rate at every level of education (Simon et al., 2015), and women are less likely than men to pursue a career in math and science (Steele, 2003).

For years, researchers have been attempting to explain the reasons why there are so many more men than women in STEM, especially in mathematics, engineering, and computer science (Steele, 2003). While the number of women that hold undergraduate degrees are about the same as men, working women holding undergraduate degrees in STEM make up only 30% of working

STEM degree holders (U.S. Department of Commerce, 2017), the largest discrepancy is in computer, mathematics, and engineering degrees (Noonan, 2017). In the U.S. women make up about 52% of the total workforce, but in 2017 it was found that women made up only 27% of computer and mathematical scientists, 16% of engineers, and 29% of physical scientists. Many studies have linked the gender gap to gender discrimination. Women have long been dealing with a lot of discrimination and bias when it comes to studying and working in the STEM fields (Di Bella & Crisp, 2016; Hughes, 2014). Over the years, women have made some headway in STEM, with the largest progress seen in the biological/life sciences, medical sciences, and agricultural studies (Eccles, 2007; Granovskiy, 2018). Women are actually overrepresented more than 50%, in the life sciences and social sciences (NSB, NSF, Science and Engineering Indicators, 2020). As mentioned earlier, the life sciences and the health fields usually fall under the STEM umbrella. Therefore, depending on the discipline, it may not appear that women are underrepresented in STEM because women are overrepresented in the health fields. However, women are still very much underrepresented in math, engineering, and computer science.

Overall, the statistics on women show a wide discrepancy in representation. But the underrepresentation appears to be far more substantial when considering the representation of minority women in STEM disciplines. For all the science and engineering degrees awarded in 2016, underrepresented minority (Black, Hispanic, American Indian, Native Alaskan) women received 12.6% of all the bachelor's degrees, 7.8% of all master's degrees, and 5.0% of all doctoral degrees (NCSES, 2019). In Silicon Valley for example, as of 2016, women were 30.2% of all employees at the largest 177 tech firms. However, Black women were only 1.8% of all employees in those firms and Latina women were 2.4% of all employees (Tomaskovic-Devey and Han, 2018). The root of the discrimination focuses on the proliferation of stereotypes about women's cognitive abilities and interest, and how they lead to social barriers. Stereotypes about women's capabilities have had a negative impact on women's access to STEM (Corbett and Hill, 2015). These stereotypes include women not being interested in science and engineering, not being good in math, or not being as logical as men. Others claim that women are much more interested in careers that deal more with emotions or that are human-centered than with objects such as computers or machines (Spelke & Grace, 2007). One could expect that these stereotypes have been very influential on the education of young girls.

Even when individuals have shown to be successful in a particular domain and defy these stereotypes, they could still be impacted by them and be affected by what is known as stereotype threat (Blackburn, 2017). Steele (1997) describes stereotype threat as the fear that some members of a group, especially minorities and women, have of confirming the negative stereotypes associated with their group. Robinson et al. (2019) suggest that stereotype threat could have a negative impact on women and minorities when it comes to developing a science identity. Although stereotype threat is considered a real barrier to success in some circles, some studies show that it does not seem to be one of the salient factors in STEM persistence. Cromley et al. (2013) found among a diverse group of undergraduates in STEM, that sex and ethnic stereotype threat did not have a significant impact on grades or retention in STEM.

Underrepresentation of Women of Color in STEM

Women of color's lack of access to quality education has been exacerbated by their color in addition to their gender. In 2016, only 3% of the bachelor's degrees in computer science were awarded to Black women (Thomas et al., 2018). There could be a multitude of factors that lead to such a low percentage of the computer science bachelor's degrees being awarded to Black women, but research has shown that Black women experience many challenges in their pursuit of computer science and other STEM degrees. Some of these challenges include the low expectation others have of them and the outright racism and sexism that they face (Thomas et al., 2018). Women of color have had far more discriminatory experiences than White women, going as far back as slavery for African American women to legalized segregation in the U.S, and other forms of discrimination that impacted their access to quality education.

Having to deal with discrimination on the basis of more than one identity is something scholars refer to as intersectionality: one's experiences are affected by the interweaving of more than one salient identity (Thomas et al., 2018). Intersectionality takes into consideration the "historical, social, political, and cultural dynamics" that affect the construction of identity in a society (Gayles & Smith, 2019, p.28). Not only has there been bias against women in STEM, but there is also the long history of people of color, especially Blacks, having to deal with studies that claim they were not as intelligent as Whites (Blanton, 2000; Nisbett, 2011). The misinformation about intelligence and race have had a strong influence on policies that limit Black and Hispanic people's access to education or access to disciplines that are considered intellectually challenging (Blanton, 2000). Some studies like the Double-Bind (Malcolm et al. 1976) have shown that the experience of being a woman and a person of color created an added burden than if one only belongs to one of those identities. The lack of access that U.S women overall, and women of color in particular, had to deal with could be partially responsible for the low representation of minority women in STEM. Intersectionality plays a major role in affecting minority women in STEM (Charleston et al., 2014).

Similar to the experiences of women, Black students in general experience bias such as a belief that they are not interested or are not good in math and science. Even high achieving Black students in STEM experience low expectation of being perceived as competent and experienced negative bias in regard to their aptitude (McGee & Bentley, 2017). Some studies have found that Black undergraduate women in STEM majors reported being in an unwelcoming environment and feeling isolated and excluded in their majors (McGee & Bentley, 2017). These experiences send a message that they do not belong in those majors (Herrmann et al., 2016). Belonging is an important component that can lead to more academic and social engagement, improve academic performance, leading to persistence in STEM for all students (Wilson et al., 2015). Black women can feel that they do not belong in certain academic disciplines like math for being a woman (Good et al., 2012) and also for being Black (Martin, 2012). In a qualitative study conducted on college seniors, Rainey et al. (2018) found that women reported feeling less belonging in their STEM majors and students of color were less likely to report feelings of belonging in their STEM majors. Being Black and female presents a dual challenge for Black females that should be considered in understanding Black females' underrepresentation in STEM.

The Youth Experience

To really explore the lack of women of color in STEM, one must take a look at the early experiences that women have in their youth. In this section, I examine how the literature has addressed the experiences of girls of color with STEM in the K-12 school system in the U.S. and in the larger social context.

One of the key factors to pursuing a career in STEM is developing an interest in one or more of the STEM disciplines at an early age (Green & Sanderson, 2017). In their study on STEM interest, Maltese and Cooper (2017) found that for a majority of the respondents, initial interest in STEM started prior to middle school. More females than males reported that their initial interest in STEM started in school related activities. Also, more females than males reported that having the support of someone such as teachers or parents during their youth helped them maintain an interest in STEM. These findings demonstrate that early exposure, opportunities in school, and support from others have stronger impact on females developing and maintaining an interest in STEM. Meanwhile adults' behaviors, such as teachers' treatment of female students and students of color, could also negatively affect girls' motivational beliefs about their abilities in subjects like math (Diemer et al., 2016; Mckellar et al., 2018). Adults have the capacity to reinforce stereotypes, and researchers found that stereotypes can negatively affect girls' aspirations to pursue a career in STEM (Correll, 2001; Dweck, 2006; Good et al., 2008; Nosek et al., 2009)

In addition, Black girls do not receive the same opportunities to pursue STEM tracks in the P-12 school system; they are often tracked out of STEM preparatory courses (Collins et al., 2020). King and Pringle (2018) found that Black girls' loss of interest in science starts in the middle school years, which affects their choices in taking advanced science courses once they get to high school and college. Many times, they are steered toward disciplines in the social sciences instead of math and science (McGee & Bentley, 2017). When they get to high school, instead of being encouraged to pursue courses in math and science, Black girls tend to be directed away from advanced math and science courses, such as Advanced Placement (AP) courses which later limits their opportunities to pursue studies that require rigorous math and science (Farinde & Lewis, 2012; McGee & Bentley, 2017). Black girls usually do not perform as well as their peers on achievement tests in part due to low socioeconomic status and poor academic preparation (Moses et al., 1999). Their poor performance is then used to label many of them as low achievers. These labels are then used to limit their options for higher level courses in math and science (Farinde & Lewis, 2012). Researchers attribute the persistence of Black women in STEM at higher academic levels to the preparation they received as young Black girls at the early and secondary school levels (Charleston et al., 2014). Positive experience with math achievement has been shown to have a positive effect on math self-efficacy, a person's beliefs about their capabilities of achieving the desired results when performing a particular task (Bandura, 1994), which could contribute to an interest in STEM (Charleston et al. 2014).

Girls tend to show lower self-efficacy in STEM than boys of similar academic ability, and girls tend to also show lower self-efficacy for more male-dominated career fields such as math and science (Nnachi & Okpube, 2015; Patterson & Johnson, 2017). From 1999 to 2011, in the K-12, girls' representation was at the lowest in computer science (about 19%), and about 30% in physics, engineering, and math; however, girls' representation in biochemistry and environmental science was above 50% (Ashcraft et al., 2012). This report shows a similar pattern with women in STEM careers, for which biological and health sciences have an overrepresentation of women, while the other fields in STEM show an underrepresentation of women.

Stereotypes about women's capabilities have had a negative impact on women's access to STEM (Corbett & Hill, 2015). Aside from general intelligence, some of the stereotypes on women's intellectual ability centered around mathematics. Negative gender stereotypes about math abilities are often reinforced, sometimes unconsciously by parents and teachers (Reinking & Martin, 2018). Parents of girls would have lower expectations of their daughters' math abilities after reading news articles that discuss women's disadvantage in math (Hines, 2007). The low expectations of girl's abilities in math (and science for that matter) may lead to fewer girls believing they can have high achievement in math. That can then lead to girls showing less interest in pursuing a subject that requires mastery of math. As seen in the results of some international tests in math and science, like the Programme for International Student Assessment

(PISA), young women in several countries perform practically as well as young men, or if there is a gap, the gap is sometimes really small. The biggest discrepancies seem to come from the U.S (Reilly, 2012). Women are not innately different in intelligence, but the culture or social environment could be playing a significant role in the gender gap in some disciplines.

Cultural expectations of girls and Blacks have also had an effect on Black girls' development of a STEM identity (Collins et al., 2020). The preponderance of images of scientists, whether in fiction or real life, depict scientists as old White men. This, in combination with a lack of images of Black women, sends a message that young Black females do not belong in science (Farinde & Lewis, 2012). Girls and women are constantly being reminded by explicit and subliminal messages in their environment that they are not as good in math and science as men are (Stout et al. 2011). The lack of images can have an effect on Black girls' self-concept when it comes to math and science. Self-concept can be affected by how someone perceives others view of them (Bong and Skaalvik, 2003). Despite the low representation in and the discrimination women and girls have experienced in disciplines like math and engineering, women are more likely to identify with these disciplines when exposed to female professors and other female professionals in these disciplines. They also show positive attitudes toward their STEM self-concept when they are exposed to female role models in math (Blackburn, 2017; Stout et al. 2011).

Conclusions and Implications

In this chapter I have highlighted that the STEM disciplines are some of the more relevant disciplines right now, and for the foreseeable future many career fields will require some skills that one would gain by pursuing a degree in a STEM major. As important as STEM is for the future, a discrepancy exists in the type of people who pursue a STEM major or obtain a career in a STEM field. Although there has been some progress made over the years, there are still few women pursuing their studies in a STEM discipline, especially minority women. Depending on how wide a net one casts when evaluating these fields, women's participation in STEM may not appear low when one includes biological or health sciences. However, in math-intensive fields such as engineering and computer science, which are also the fastest growing fields, women are underrepresented, with minority women having the lowest percentage of the share of the degrees and career opportunities.

The findings cited in this chapter show that widespread discrimination based on negative stereotypes of women's math abilities have played a major role in the lack of women in STEM fields. Girls, especially Black girls' path to STEM are not encouraged, and at times their paths are directed away from STEM and into the social sciences or other non-STEM fields. As a result, Black girls usually miss out on opportunities to develop their math skills, and they demonstrate less self-confidence, reflect lower self-efficacy for math because they receive subliminal and explicit messages that they are not good enough in math or math related disciplines. In addition, Black girls' math or science identity are also affected by popular images of scientists as old White men, which project a social message that math and science are not associated with women, let alone women of color.

Research indicates that there is not an innate deficiency that women or minorities carry around with them that impacts their opportunities in STEM, instead there are a multitude of sociocultural factors in play when it comes to the representation of young women in STEM, especially for young women of color (Koch et al., 2019). These sociocultural factors such as lack of encouragement from parents and teachers, access to advanced courses in high school, instructor support, and institutional characteristics have strong effects on student interest in and pursuit of STEM overall. It is apparent that the low percentage of women in the U.S. who study STEM or pursue a career in STEM is due in large part to sociocultural factors and cannot be attributed to a lack of innate cognitive ability. Negative views that women are not that good at math, gender discrimination, and a misconception that women are not interested in STEM fields also contribute to young women having less exposure to math and science related programs in middle school and high school. These factors usually affect young women's preparation for STEM, therefore affect their confidence in STEM (especially in math), affect their self-efficacy, and affect their interest and motivation to pursue a degree in STEM. However, when girls have role models in disciplines like math and engineering that share similar identities such as gender and ethnicity it tends to have a positive effect on their attitudes towards those disciplines which help them identify with these disciplines.

Given these findings, it is imperative that schools, teachers, and parents make a concerted effort to improve the participation of young girls in STEM, which could lead to more young women pursuing a STEM major in college and eventually pursuing a STEM career. Mathematics is one of the cornerstones of many of the STEM fields. Developing strong math ability through college preparatory courses has a strong correlation with success in STEM (Green & Sanderson, 2017; Griffith, 2010). Therefore, schools should increase the exposure that girls get to preparatory math courses. This should be done by encouraging girls early on in high school or earlier to participate in advanced math courses.

In addition, mentoring, early exposure, social persuasion, and vicarious experiences all could lead to developing a positive STEM self-concept, promote confidence, and promote positive self-efficacy for young women in science (Blackburn, 2017). Developing self-concept in math is a great way to increase motivation in STEM which will help Black girls develop math or science identity. Another way to help with the development of identity is highlighting successful women and women of color in STEM. The lack of images that reflect the salient identity of race and gender for Black girls cannot be underestimated. Furthermore, it is important for researchers studying women's underrepresentation in STEM to consider how much the environment impacts women and minorities, and when the environment is not supporting women and minorities to persist in STEM, what other internal characteristics do they rely on in order to overcome the environmental impact.

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CHAPTER 3

The relationship between mathematics identification and choice of STEM major: Racial and gender differences

Introduction

Despite all of the major advances that many countries have made in science and technology, there is a national and a global concern that there are not enough talented young people in the pipeline for science, technology, engineering, and mathematics (STEM) careers (Lauermann et al., 2017). Even though the U.S. is regarded as one of the most technologically advanced countries in the world, as of 2016, the European Union and China have conferred slightly more college and graduate degrees in STEM than the U.S. (National Science Board (NSB), National Science Foundation (NSF), Science and Engineering Indicators, 2020). In the 2018 report *Charting a Course for Success: America's Strategy for STEM Education*, the Committee on STEM Education of the National Science and Technology Council (NSTC) wrote: "Today, the economic prosperity and national security of the United States rests increasingly on its capacity for continued scientific and technological innovation" (p. 1). Given all the technological advances that have been made, it is not far-fetched to say that science and technology will continue to be seen in the U.S. and across the world as crucial to society for the foreseeable future.

According to the aforementioned 2018 report by the Committee on STEM Education, increasing diversity, equity, and inclusion in STEM is one of the goals of the U.S government (NSTC: Committee on STEM Education, December 2018). Despite efforts to close the gender gap, women continue to be underrepresented in many STEM fields. In the U.S. women make up about 52% of the total workforce, but in 2017 women comprised only 27% of computer and mathematical scientists, 16% of engineers, and 29% of physical scientists. At the same time, women were overrepresented, more than 50%, in the life sciences and social sciences (NSB, NSF, Science and Engineering Indicators, 2020). The life sciences and the health fields usually fall under the STEM umbrella. Therefore, depending on how it is reported, it may not appear that women are underrepresented in STEM because women are overrepresented in the health fields. Women of color, mainly African American, Latina, and Native American, are still the most underrepresented in the science, engineering, and computer science fields in comparison to their representation in the general population (Corbett & Hill, 2015; NSF, National Center for Science and Engineering Statistics [NCSES], 2019). These statistics serve as the impetus for this study.

Purpose

In this study, I investigated how high school students' perceptions of their mathematics classes relate to their identification with math, their achievement, and their intentions to pursue math-intensive STEM majors in college. I focused on the difference between Black female students and three other demographics (Black males, White females, and White males) because Black females are the most underrepresented in engineering, computer science, and other math-related STEM fields compared to other groups (NCSES, 2019; NSF, 2019) and because studies on women in STEM tend to group women collectively, instead of considering the intersection of race and gender. This study also focuses on high school female students because more research has been conducted on the experiences of women in STEM at the college level and beyond (Kim et al., 2018). I used students' responses from a national survey to analyze the relationship among students' math class perceptions and their identification with math, and subsequently, their decision to select a college major in a math-intensive STEM discipline. It is important to consider students' motivational beliefs in math because math is considered a gatekeeper for students who intend to have a career in a STEM field (Cribbs et al., 2015).

The aim of the research was to investigate the relationships between students' math class perceptions, math identification, math achievement, and choice of STEM major. To answer the questions, I applied two theories that explain academic persistence and career intentions. I used domain identification theory (Osborne & Jones, 2011) and the MUSIC Model of Motivation theory (Jones, 2009, 2018). These theories suggest that students' math course perceptions will affect their math identification and intention to pursue a STEM career (see Figure 1).

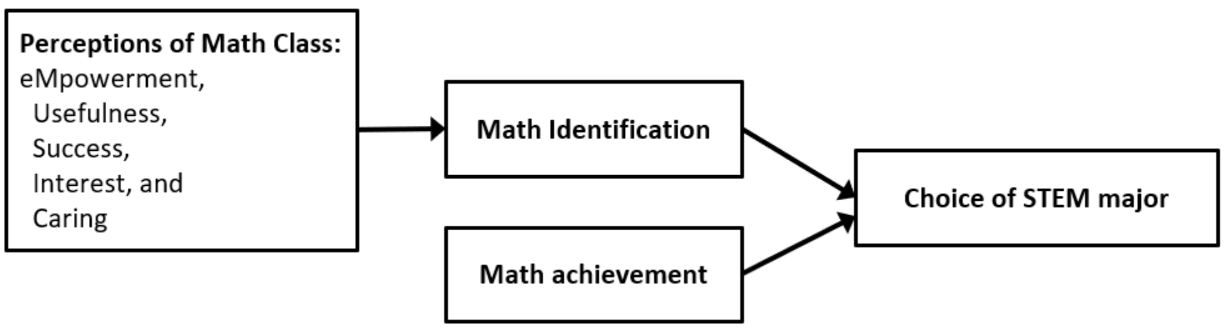

Figure 1. Relationships between students' perceptions of their math class, their math identification, grades, and intention to pursue a STEM major

This study contributed to the knowledge base about the role that math identification plays in high school students' decisions to pursue STEM, with Black females as a central focus. In reviewing the existing literature, I did not find a lot of studies that used quantitative methods to analyze a large national sample of students with an emphasis on Black female students' paths toward a STEM career. Additionally, the theoretical frameworks that I am using in this study were developed using predominantly White middle-class students (Osborne, 1997; Osborne & Jones, 2011). Some researchers caution that theories may not apply to minority groups due to an overreliance of using predominantly White samples in their development (Riegle-Crumb et al., 2010; Usher, 2018). An aim of this study was to investigate how well these theories apply to a national sample of Black female students. This study can contribute to the literature by determining how well Black female students' math class perceptions relate to their math identification, achievement, and career choices, and how it compares with other groups.

Literature Review

Domain identification

When young people are exploring a potential career, the career path that they eventually choose to pursue is an important part of their identity development (Lent & Brown, 2013; Porfeli & Lee, 2012). Science identity for example, is positively correlated with STEM persistence and choice of a STEM career (Jones et al., 2017; Puente et al., 2021). Therefore, domain identification is a construct that should be considered when investigating factors that contribute to career decisions. Domain identification is the extent to which individuals view a domain (e.g., math, science) as an important part of who they are; that is, the extent to which they view the domain as part of their self (Jones et al., 2016; Osborne & Jones, 2011;). "An individual's domain identification affects his or her choices, effort, persistence, behaviors, and academic outcomes" (Jones et al., 2013, p. 474). In academics, effort and self-regulation are indicators of identification with a domain which will more likely lead to persistence and higher achievement (Osborne & Jones, 2011). In essence, identification with a domain is important in educational contexts because of the likelihood that the individual will be motivated to perform well in that domain and select college majors related to that domain.

Illeris (2003) explains that during youth development the learning process plays a role in identity formation. Part of that learning process is what to learn and how that applies to one's future. It is not simply learning for learning's sake but learning as part of who one is and whom one wants to be. An adolescent's internal values and their sense of belonging tend to play a major role in academic identification (Matthews et al., 2014). Academic identification has been found to be associated with student success (Jones et al., 2015; Osborne, 1997; Osborne & Jones, 2011). Students who identify with academics are also expected to show fewer problematic behaviors in school (Osborne, 1997). There is a predictive association with certain domains such as mathematics, science, and literacy with career aspirations and academic motivation (Lauermann et al., 2017). Students pursuing careers in STEM have shown that subject-specific identities in domains such as math, engineering, or science play an important part of their academic performance and choice (Carlone and Johnson, 2007; Cass et al., 2011; Chemers et al., 2011; Godwin et al., 2013; Hazari et al., 2009; Stets et al., 2017; Syed et al., 2011).

The MUSIC Model of Motivation

The environment and the students' experience in and out of school can contribute to the development of domain identification (Osborne & Jones, 2011). Classroom factors that can affect identification include students' perceptions of empowerment/autonomy, usefulness, success, interest, and caring (Jones et al., 2014, 2016). These five class perceptions are summarized in the MUSIC Model of Motivation (Jones, 2009, 2018). The MUSIC model identifies motivational teaching strategies that are associated with current theories in academic motivation research, including self-determination theory (Deci & Ryan, 2000), expectancy-value theory (Eccles et al. 1983; Eccles and Wigfield, 2020; Wigfield & Eccles, 2000), self-efficacy theory (Bandura, 1994), interest theories (Hidi & Renninger, 2006; Schiefele, 2009), and attachment theory (Bergin & Bergin, 2009) (see Jones, 2018 for a more complete list of theories used to develop the MUSIC model). The MUSIC model has been used to study academic outcomes and career goals in science and engineering (Chittum & Jones, 2017; Jones et al., 2016; Jones et al., 2014). The premise of the MUSIC model is that if students feel *empowered* in the learning process, believe that the class is *useful* to their future, believe they can *succeed* in the class, find the class *interesting*, and believe that the people in the class (the teacher and peers) *care* about them and their success, then the students will be more motivated to put more effort in the class and achieve highly. Subsequently, students begin to identify with the domain and consider careers related to that domain.

Students' MUSIC perceptions are related to their identification with the subject matter in that class (Jones et al., 2016; Jones et al., 2017), and identifying with a domain tends to motivate students to continue to engage with that subject matter (Jones et al. 2016). For example, when students believe that math is important (*Usefulness*) and they believe that they can succeed (*Success*) in it, they are more likely to be motivated to achieve in math (Mckellar et al., 2018). Hart et al. (2011) highlight the indicators of student engagement as students' feelings toward school or their teachers, their effort toward school activity, and their beliefs in their abilities. More academic engagement, which can be documented through things such as the effort students put toward their learning, can lead to higher achievement (Appleton et al., 2008). Although, the different components of the MUSIC model may not have the same level of correlation with effort, Jones (2019) found a positive relationship between college students' perception of the five components of the MUSIC model and the effort they put forth in their courses.

In a study of middle school students from the U.S and Iceland, students' MUSIC perceptions in their science classes had positive correlations with their science identification (Jones et al., 2017), which in turn, had a positive correlation with their science career goals. Students' MUSIC perceptions in a first-year engineering course have also been found to influence students' course effort, engineering identification and major declaration (Jones et al., 2016). In another study of students in a first-year engineering design course, students' MUSIC perceptions were found to be related to students' motivational beliefs in engineering, such as program belonging and program expectancy (Jones et al., 2014). Students' MUSIC perceptions and engineering identification were then associated with their career goals.

The influence of math in STEM career goals

Identification with math has been shown to influence STEM choice (Carlone and Johnson, 2007; Cass et al., 2011; Chemers et al., 2011; Godwin et al., 2013; Hazari et al., 2009; Stets et al., 2017; Syed et al., 2011). The path to a STEM major (and consequently a STEM occupation) usually begins with the math and science education students receive in K-12 (NSB: Elementary and Secondary Mathematics and Education, 2019). Lichtenberger and George-Jackson (2013) stated the importance of evaluating high school students' attitudes, thoughts, and actions towards math and science fields because there is a sequential path from high school to postsecondary degree in STEM. Students' motivational beliefs in math affect their achievement in math and subsequently their motivation to pursue a career path in a STEM field (Diemer et al., 2016; McKellar et al. 2018; Skaalvik et al., 2017). Gottlieb (2018) found that students in the 9th grade who self-identify as math persons and also think others see them as math persons were more likely to show interest in STEM careers.

In addition, students' math achievement is directly related to their success in STEM (Lin et al., 2018). Performance can vary, however, by personal demographics. Although girls and boys score about the same on 8th grade mathematics tests in the U.S., a gap exists between White students and Black and Hispanic students. By the time students are in middle school there are multiple factors, including gender, prior achievement, and perceptions of STEM, that influence their interest in STEM or STEM-related careers (Kang et al., 2018). Students who are successful in math in middle school tend to show more interest in STEM at the end of high school (Lin et al., 2018). Students' confidence in their competence in math and the importance that they place on math has been shown to predict math-related career interest (Lauermann et al. 2017). When it comes to career path, high achievement in math and science in secondary school is usually a good prediction that a student would more likely pursue a career in STEM (Lichtenberger & George-Jackson, 2013). Students who see themselves as "STEM people" rely on their identification with math to help them persist toward a STEM career. That identity is deemed essential by researchers for the success of women of color who are interested in STEM (Rodriguez et al., 2017). This research shows that a student's relationship with math could be a potential predictor of their relationship with STEM.

Black girls and STEM

A lot of literature focus on the experiences of Black females and their aspirations to pursue a STEM major after secondary school (Charleston et al., 2014; Thomas et al., 2018) . Some of the literature focuses on their experience with discrimination in math and science at the college level (McGee & Bentley, 2017). Although there is some research examining their experiences in middle school and high school (Collins et al., 2020; King & Pringle, 2018; Young et al., 2017), little of it focuses on the factors contributing to the STEM career decisions of Black girls. There are a multitude of factors (e.g., ability beliefs, interest, values, expectations for success, socioeconomic status, gender stereotypes) that affect a person's decision to study a discipline in STEM (Buschor et al., 2014). Therefore, it is not surprising that while researchers have lamented the lack of minority women in careers that focus on STEM, their findings in explaining this phenomenon range from a lack of women's interest in STEM careers (Heilbronner, 2013) to the controversial lack of ability in STEM as compared to men (Hill et al., 2010). When it comes to career interests, many studies show that students' career interests develop prior to attending college, usually in middle school or earlier (Kim et al., 2018). In the case of Black girls, even when they show interest, bias from teachers and lack of institutional support can contribute to their low rate in continuing to go forward with an interest in STEM (Hill et al., 2010).

One of the main factors that determines if students decide to pursue a career in STEM is their experience with math in their youth (Diemer et al. 2016; Lichtenberger & George-Jackson, 2013; McKellar et al. 2018). Although research has shown that there is not a gender difference in math achievement, girls continue to disproportionately pursue careers in the life sciences, medicine, and social sciences rather than occupations in engineering, mathematics, or physics (Buschor et al. 2014). Part of the reason can be attributed to the motivational beliefs of young women. Pre-college boys and college men tend to show higher self-concept in STEM than young women (Kim & Sax, 2018). Females face more threats to their motivational beliefs in math (McKellar et al., 2018). "Declines in motivational beliefs during adolescence, particularly for females, have lasting consequences for the life course and may help to explain the dearth of qualified women in STEM positions" (McKellar et al., 2018, p. 450).

Negative perceptions of ability in math appear to be more prevalent among girls than boys. Perez-Felkner et al. (2012) found that even girls taking advanced math courses had more negative self-assessments of their math abilities. Some researchers have found that positive perceptions of math ability, including advanced, complex math, were found to have a positive correlation with the intentions of girls to pursue a career in physics, engineering, computer science, and math (Nix et al., 2015; Perez-Felkner et al., 2012;). However, a study by Seo et al. (2019) found that gender differences in math self-concept were more pronounced among White and Hispanic students, but not among Black and Asian students. Seo et al. (2019) also found a weak relationship between math achievement and STEM career expectancy among minorities and women. This again emphasizes the importance of examining the psychological determinants of students' ability beliefs and career paths using both gender and ethnicity.

The expectations in the cultural environment, such as stereotypes about gender roles, seem to affect adolescents' expectations of their abilities to perform well on a task. Despite performing at the same level as their male counterparts, both women and girls seem to show lower expectancy for success in math and engineering (Robnett & Thoman 2017). The confidence students show in their ability to succeed in a domain is a driving force in succeeding in that domain and motivating one to pursue a major or career in that discipline (Eccles, 2007). Women's academic outcomes and career path are influenced by early positive academic experience (Mullet et al., 2017). Thus, a person's career trajectory will more likely follow a domain in which the person has found success and considers important.

In addition to having lower ability perceptions and expectancies than boys, a report by the U.S Department of Education showed that girls who graduated in 2009 were less likely than boys to report liking math and science and to report math or science as one of their favorite subjects. The girls' lack of interest in math and science as compared to boys remained significant across ethnic and racial groups (Cunningham et al., 2015). The report also showed a significantly higher percentage of boys across different ethnicities enrolled in courses for STEM credit than girls. The research shows the importance of exploring gender and racial differences in factors affecting interest in STEM and pursuing a career in STEM.

Research Questions

Domain identification has been shown to be related to students' career choice in fields such as engineering (Jones et al., 2013; Tendhar et al., 2018). When a student identifies with a domain, they are more likely to engage with the subject and put forth more effort, which leads to higher achievement. In the domain of math, it is expected that math identification can lead to STEM choice due to the sequential relationship between high school math and obtaining a postsecondary degree in STEM (Lichtenberger & George-Jackson, 2013). Math is considered a prerequisite for STEM majors. Based on the literature, I expect to find a positive relationship for students who are pursuing math-intensive STEM majors with math identification and performance in math. To study this general hypothesis, I developed the following specific hypotheses (*H*) related to my main research question. Figure 2 shows the conceptual model corresponding to the hypotheses below that were tested in this study.

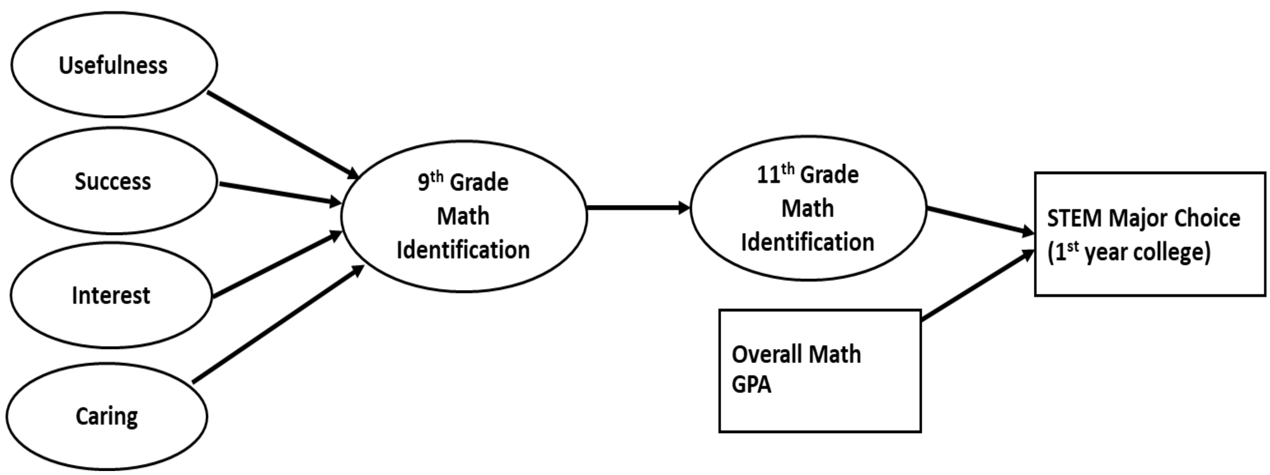

Figure 2: Math identification path to STEM choice model.

RQ1: To what extent are students' math class perceptions related to their math identification?

H1: Students' math class perceptions in 9th grade are related to their math identification in 9th grade.

H2: Students' math identification in 9th grade is related to their math identification in 11th grade.

RQ2: To what extent are students' STEM major choices predicted by the students' math class perceptions, their math identification, and their overall math GPA?

H3: Students' math identification and math achievement are both predictive of students' STEM major choice.

H4: Students' class perceptions indirectly predict students' STEM choice.

RQ3: Are the relationships in the model invariant across race/ethnicity and gender?

H5: The model in Figure 2 fits similarly across all four combinations of race/ethnicity and gender.

The first hypothesis focused on the relationship between students' math class perceptions and their math identification. Theoretically, students' perceptions of a class in a particular domain are believed to increase their identification within that domain (Osborne & Jones, 2011). Empirical studies have documented that students' MUSIC perceptions in science and engineering classes are associated with their identification in science and engineering (Jones et al. 2016; Jones et al., 2017). Therefore, I hypothesize that students' MUSIC perceptions of their math class in the 9th grade will be related to their math identification in the 9th grade.

The second hypothesis (that students' math identification in 9th grade is related to their math identification in 11th grade) is based on the belief that domain identification should be fairly consistent over time (Osborne & Jones, 2011). That is, I hypothesize that by the 9th grade, after many years of completing math classes in school, students should have a fairly stable math identification; and therefore, it should be consistent with their 11th grade math identification. Although students' perceptions of some psychological constructs—such as self-efficacy

(Bandura, 1986) and situational interest (Hidi & Renninger, 2006)—can fluctuate over short periods of time, domain identification is hypothesized to be more stable over time even though it can change over longer periods of time (Arens et al.,2019; see Osborne & Jones, 2011, for a discussion).

The third hypothesis considers the role that math identification plays in students' decision to select a major in STEM and takes into consideration math achievement in STEM choice. Studies with undergraduate students in engineering have found that students' identification is related to their major and career intentions (Jones et al., 2014; Jones et al., 2016). These findings are consistent with studies that have examined students' values as part of expectancy-value theory (Eccles et al., 1983). For example, students' math expectancies and values have been shown to be related to their choice to take more math courses (Eccles et al., 1983). Researchers have noted that achievement can lead to career intentions in STEM (Chittum & Jones, 2017; Diemer et al. 2016; Jones et al. 2014; Jones et al. 2016; Mckellar et al. 2018). I will compare the relationship between math achievement and STEM choice to the relationship between math identification and STEM choice. Compared to math achievement, I expect math identification to be more strongly associated with students' intentions to major in math intensive STEM majors because other studies with engineering students have documented similar patterns (Jones et al., 2016).

Given the relationship between math class perceptions and math identification, the fourth hypothesis expects to find an indirect relationship between math class perceptions and STEM choice through math identification. The fifth hypothesis indicates that the model in Figure 2 fits similarly across the different demographic group combinations: Black females, Black males, White females, and White males. I hypothesize that the interrelationship among math perceptions and math identification and its effect on STEM choice will be invariant across gender and ethnicity. I am not aware of any research that has identified differences across these groups for the relationships in this model.

Methodology

Participants

The participants for this study were included in the High School Longitudinal Study, 2009 – 2013 (HSLS 2009), a national survey conducted by the National Center for Education Statistics (NCES). The HSLS 2009 dataset was collected to be representative of all 9th graders in the U.S. in 2009. The public dataset was downloaded from the Inter-university Consortium for Political and Social Research (www.icpsr.umich.edu). I selected this dataset because it included the variables needed to answer my research questions, and it focused on high school students' post-secondary plans with an emphasis on STEM. The original HSLS 2009 data was obtained from a study that started with a sample of 25,206 students from 944 public and private high schools in the U.S. The public-use dataset used in this study included respondents from the base-year in fall 2009, the first follow-up in spring 2012, and updated data from 2013. The 2013 update is separate from a second follow-up which was not included in this dataset. The final dataset used in this analysis included 23,503 students (51% males and 49% females). Four groups were selected for a multigroup analysis: Black females (n = 1172), Black males (n = 1276), White females (n = 6357), and White males (n = 6594).

Data Selection

The variables selected for students math class perceptions were from the base-year (9th grade, fall 2009) and first follow-up of the survey (11th grade, spring 2012). The student achievement (e.g., high school grades) and postsecondary plan variables were from summer and fall of 2013 (referred to as the 2013 update).

HSLS 2009 is a longitudinal national study that uses a complex survey design. Analytic weights and balanced repeated replicate (BRR) weights (Ingels et al., 2011) were applied for population representation, to account for nonresponse, and to adjust for standard errors. I used the analytic weight W2W1STU, which is associated with students who responded to the base-year and first follow up. It accounts for nonresponse in the base-year and first follow up and it provides estimates for the population of ninth-grade students in 2009. I also used the analytical weight W3W1W2STUTR, which is associated with students who responded to the base-year and first follow up, and have information in the 2013 update and high school transcript information. It adjusts for transcript non-response and provides estimates for the ninth-grade student population in 2009. I used the BRR weights, W2W1STU001-W2W1STU200, associated with analytic weight W2W1STU; and the BRR weights, W3W1W2STUTR001-W3W1W2STUTR200, associated with analytic weight W3W1W2STUTR. The BRR weights are used for estimation of standard errors.

Measures

Class perceptions. In searching the variables in the HSLS 2009 survey, I was able to identify variables that served as indicators for four of the five components of the MUSIC model (*Usefulness, Success, Interest, and Caring*) that aligned with students' perceptions of their experience in math class in the 9^{th} grade (see Table 1 for the scale items). Items related to the fifth component of the MUSIC model (eMpowerment) were not found in the HSLS 2009 survey; therefore, I could not include it in this study. To measure the four MUSIC components, I selected three scales that were already created in the survey: math course utility (as a measure of usefulness perceptions), math self-efficacy (as a measure of success perceptions), and math course interest (as a measure of situational interest, which is the interest or enjoyment one experiences during an activity). I created the “teacher caring” scale (as a measure of caring) using three items that referred to the students’ perceptions of their math teacher’s treatment of students in the class. Students responded to all the items using these Likert-format options: *1= Strongly Agree, 2 = Agree, 3 = Disagree,* and *4 = Strongly Disagree.* I reverse coded all of the items (except for one in the interest scale that was already reverse coded: “You think this class is boring”) so that higher ratings indicated a higher positive agreement.

Table 1

Scale Items and Variables Included in the Study

Math Identification scale (9th grade, α = .84)

- "You see yourself as a math person"
- "Others see you as a math person"

Math Identification scale (11th grade, α = .88)

- "You see yourself as a math person"
- "Others see you as a math person"

Class Usefulness scale (math class utility scale, 9th grade, α = .78)

- "What students learn in this course…"
    - "is useful for everyday life"
    - "will be useful for college"
    - "will be useful for a future career"

Class Success scale (math class self-efficacy scale, 9th grade, α = .90)

- "You are confident that you can do an excellent job on tests in this course."
- "You are certain that you can understand the most difficult material presented in the textbook used in this course"
- "You are certain that you can master the skills being taught in this course"
- "You are confident that you can do an excellent job on assignments in this course"

Class Interest scale (math class interest scale, 9th grade, α = .73)

- "You are enjoying this class very much"
- "You think this class is boring"

Teacher Caring scale (9th grade, α = .90

- "Your math teacher…"
    - "values and listens to students' ideas"
    - "treats students with respect"
    - "treats every student fairly"
    - "thinks every student can be successful"

Math grades

- Overall math GPA

Math-intensive STEM Major intentions (Choice)

1 = Math-intensive STEM majors
0 = Other majors

*Math identification***.** The math identification variable was created by the HSLS 2009 survey developers both in the 9^{th} and 11^{th} grades using the same two items (see Table 1). All the responses were measured using these Likert-format options: *1= Strongly Agree, 2 = Agree, 3 =*

Disagree, 4 = Strongly Disagree. These items were reverse coded so that higher values indicate greater math identification.

*Math-intensive STEM major intentions***.** The main outcome variable for this study was the intention of the students to select a math-intensive STEM major in college. Students were asked to select from 60 categories of majors. Some of the categories included multiple disciplines with similar content (e.g., philosophy, religious studies). I divided the students' responses about their intended major into a dichotomous variable: 1 = Math intensive majors (computer and information sciences and support services, engineering, math and statistics, and physical sciences) and 0 = all other majors. The responses that comprised this variable were collected during the 2013 update in the fall of 2013.

*Math GPA***.** I used the students' cumulative math grades as the measure of their achievement. The cumulative math grades, which included students' grades in all of their math courses in high school, were collected in the fall of 2013 from the high school transcripts; that was the fall semester following their senior year of high school.

Reliability of the Scales. To assess the reliability of the scales, I used Cronbach's alpha as a measure of internal consistency of the scales and all of them are greater than .73 (see Table 1), which is acceptable (Cohen, 1988). The Cronbach alphas represent all students in the dataset.

Analysis

I conducted multiple analyses for this study. The first was a confirmatory factor analysis (CFA) for the four class MUSIC perceptions (*Usefulness, Success, Interest,* and *Caring*). The second analysis (labeled "Identification model") used a SEM to analyze the relationship between MUSIC and math identification, focusing on the math identification in 9th grade and math identification in 11th grade using all students in the dataset. Third, I conducted three versions of a

SEM (labeled the “Choice model”) that focused on students’ STEM choice and examined the relationships from MUSIC to math identification to STEM choice, while controlling for math achievement. The first version of the Choice model included all students, however, the Choice variable only included students who were attending college at the time of the 2013 update. The second version that I conducted was a multiple-groups analysis for the same Choice model for the four gender/race groups. This analysis included analyzing the four models separately to verify model fit for each group. The third version of the Choice model was a multigroup analysis where the groups were analyzed simultaneously to investigate the invariance of the model among the groups.

Mplus (version 8.7) was used for all analyses. Mplus uses pairwise deletion and only removes those observations that have missing values on all the variables selected for each analysis. Therefore, the variables do not have identical sample sizes. All the analyses used analytic weights and replicate weights. The analytic weights adjust for population estimation and non-response bias. The use of replicate weights provides unbiased standard errors. For determining a good model fit for each analysis, I used multiple fit indices with their recommended cutoff criteria. Kline (2016) cautions researchers to not fall into the notion that there is a magical number that provides everything you need to know about a model fit. I used the Chi-square (χ^2) model fit index with its accompanied degree of freedom (*df*). The cutoff for a good fit for the χ^2 is $p > .05$ or a ratio of $\chi^2/df \leq 3$. The other recommended measures of model fit for the other indices are the comparative fit index (CFI) ≥ .95, Tucker-Lewis index (TLI) ≥ .96, root mean square error of approximation (RMSEA) < .06 with 90% confidence interval, and standardized root mean square residual (SRMR) < .08 (Schreiber et al., 2006). The Chi-square test of model fit and other fit indices were not available when replicate weights were added to the analysis, only the SRMR was available. Therefore, all the models were estimated twice, first with the analytic weights to get multiple fit indices, then with analytic weights plus the replicate weights for all other results with adjusted standard errors.

Research Question 1

The first research question asked to what extent students' math class perceptions are related to their math identification. To respond to that question, I conducted a SEM which included the latent variables for the four class perceptions (i.e., usefulness, success, interest, and caring) and math identification. All observed variables had at least 18,000 respondents. Mplus 8.7 used the default pairwise deletion in the analysis. This analysis was run to determine the relationship between the MUSIC elements and math identification in the 9th grade and the relationship between 9th grade math identification and 11th grade math identification. I conducted the SEM with the analytic weight W2W1STU which adjusts for population estimates and non-response in the base year and first follow up. Mplus uses robust maximum likelihood (MLR) estimation with this weight. Chi-square and multiple fit indices are available for the analysis with the analytic weight. Then I included the affiliated replicate weights W2W1STU001-200 which are used for variance estimation providing unbiased estimates of the standard errors. Mplus uses maximum likelihood (ML) estimation with the replicate weights. The Chi-square is not available when the replicate weights are included, only the SRMR is available with the replicate weights. The rationale for the analysis was to determine math identification's consistency across time. If math identification does not persist from 9th grade to 11th grade, then it would not be as useful in the analysis to determine the effect that math identification has on the STEM decisions.

Research Question 2

Research question two asked to what extent students' STEM major choices are predicted by their math class perceptions, math identification, and their overall GPA. To respond to that question, I ran a SEM to determine the magnitude of the relationship from class perceptions to math identification and determine the direct and indirect effects of MUSIC on STEM Choice and math identification on STEM Choice controlling for achievement (measured using cumulative math GPA). The analysis included respondents from base-year (9^{th} grade), first follow up (11^{th} grade), and the 2013 update. All observed variables had over 18,000 respondents, except for the number of respondents for the choice of major, the outcome variable Choice, which had 11,639 respondents. The analysis used the analytic weight W3W1W2STUTR which was recommended for use with any analysis that included data collected in the 2013 update with student transcripts. The analytic weight is used for population estimate and adjusts for non-response for base year, first follow up, 2013 update, and transcript non-response. Chi-square and multiple model fit indices are available with the analytic weight. After running the analysis with the analytic weight, I added the affiliated replicate weights W3W1W2STUTR001-200 (Ingels et al. 2015) for variance estimation. The Chi-square is not available when replicate weights are used, only the SRMR index is available. I use the default means and variance adjusted weighted least squares (WLSMV) estimation (Kline, 2016). The model included math class perceptions in the 9^{th} grade, math identification from 9^{th} grade, math identification from 11^{th} grade, students' choice of STEM major, and students' math achievement (cumulative math GPA) in high school. The model was run to determine model fit for all students who identified a major. Establishing a good model fit for all the students with a major identified would allow for a base of reference when conducting a multiple groups analysis (Wang & Wang, 2020) for the groups of interest simultaneously.

Research Question 3

Research question three asked if the relationships in the Choice model were invariant across race/ethnicity and gender. One objective of the study was to compare differences across groups to examine the role that math identification plays in Black female students' decisions to choose a math intensive STEM major. I selected the four groups, Black female, Black male, White female, and White male. First, I ran the Choice model for each group of interest separately using the '*Useobservations*' command in Mplus. This tested the model fit for each group separately as a stand-alone analysis. I ran the model with the analytic weight W3W1W2STUTR and then added affiliated replicate weights W3W1W2STUTR001-200 using the default WLSMV estimation. Respondents were from base-year (9th grade), first follow-up (11th grade), and 2013 update. There were (n = 1170) Black female respondents including (n = 604) for the choice variable; (n = 1270) Black male respondents including (n = 513) for the choice variable; (n = 6,353) White female respondents including (n = 3,592) for the choice variable; (n = 6,591) White male respondents including (n = 3,148) for the choice variable. I then ran a configural model of the Choice model using a multigroup analysis command in Mplus "*Grouping is.*" Multigroup SEM was used to test invariance across groups. A multiple groups analysis consists of a series of model estimations that impose different model constraints to test for invariance, for example, in the measurement of latent variables, factor variance, or path coefficients across different groups (Wang & Wang, 2012). The analysis was run with the analytic weight W3W1W2STUTR recommended for use with data collected in the 2013 update with student transcripts. The analytic weight adjusts for population estimate and for non-response for base year, first follow up, 2013 update, and transcript non-response. Chi-square and multiple model fit indices are available with the analytic weight. Then I added the affiliated replicate weights

W3W1W2STUTR001-200 and ran the model again. The replicate weights are used to adjust the standard errors. The Chi-square is not available when replicate weights are included, only the SRMR index is available. I used the Mplus default WLSMV estimation. Figure 3 shows the SEM model tested in this study.

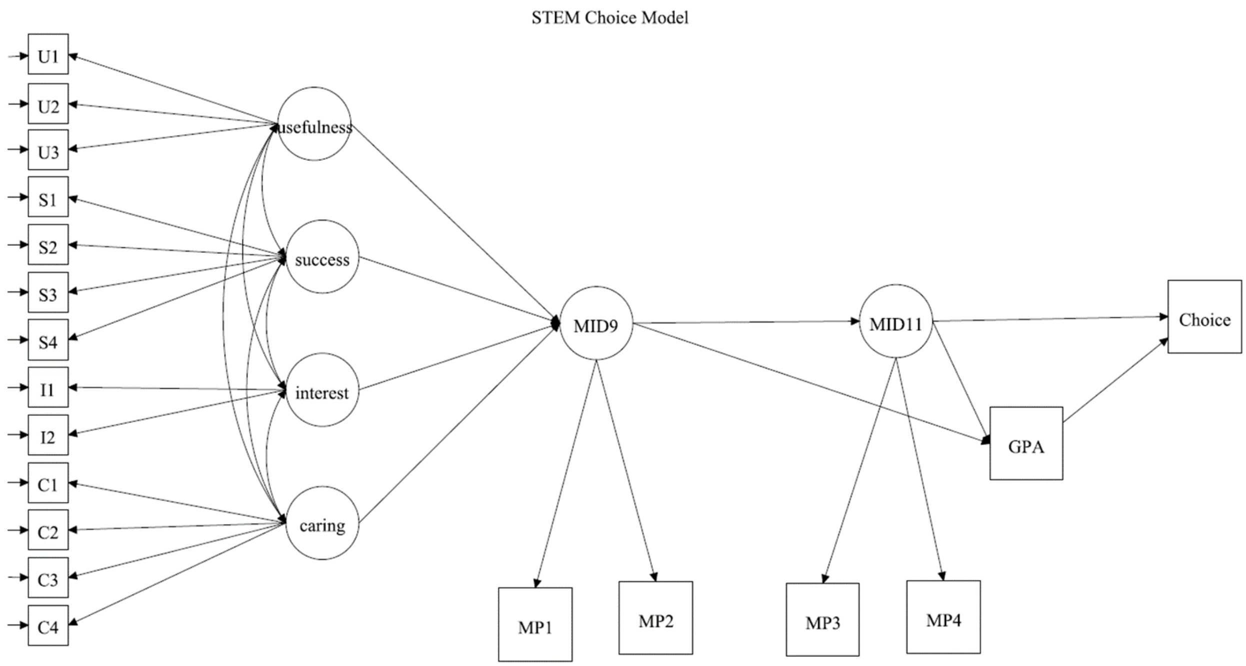

Figure 3: STEM Choice Model

I compared the path coefficients for math identification and the path coefficients for STEM choice among the four groups of interest: Black females, Black males, White females, and White males, to determine if there was a significant difference in the path coefficients leading to the intention to major in a math intensive STEM discipline for Black females when compared to the other groups. To investigate the differences across the groups, I calculated a Z-score difference (Paternoster et al. 1998) for the standardized path coefficients using the standard errors with the replicate weights to test for invariance for all the pair combinations among the four groups.

Results

Confirmatory Factor Analysis (CFA) for Class Perceptions

To begin, I ran a CFA to measure how well the math class perception items aligned with the four MUSIC components (i.e., usefulness, success, interest, and caring). Respondents were from the base-year (9th grade). All observed variables had at least 18,000 respondents. I used the analytic weight W2W1STU using the defaulted robust maximum likelihood (MLR) estimator (Kline, 2016). Running the CFA with the analytic weight first adjusted for population estimates and non-response. To adjust the standard error of the factor loadings, I added the replicate weights W2W1STU001-W2W1STU200 using the defaulted maximum likelihood (ML) estimator (Kline, 2016). The CFA with the analytic weight resulted in multiple fit indices, χ^2 = 425.332 (59), $p < .001$, CFI = .986, TLI = .981, SRMR = .024, and RMSEA = .018 (.016, .020). The fit indices were acceptable (Kline, 2016; Schreiber et al. 2006), which indicated a good model fit. All of the latent variables had a standardized pattern coefficient ≥ .70 except for one that was .65. A pattern coefficient ≥ .70 indicates that the latent variable explains > 49% of the variance in the observed variable (Kline, 2016). This can be interpreted that the 13 items are good representations of the four MUSIC components (*usefulness, success, interest, and caring*) (see Table 2). The standard errors reflect the standard errors after adding the replicate weights to the analysis. The results for the CFA indicated that the four MUSIC scales (*Usefulness, Success, Interest, and Caring*), align well with the items representing students' perceptions of their math class in the 9th grade. Establishing a good fit and high pattern coefficients from the latent variables on the indicators is a necessary step to move forward with further analyses.

Table 2

CFA Estimates for Usefulness, Success, Interest, and Caring

Latent Variables and Indicators	Measurements with analytic and replicate weights			
	Unstandardized Estimate	SE	Standardized Estimate	SE
Usefulness				
U1-*Math course is useful for everyday life*	1	0.000	.699***	0.011
U2-*Math course will be useful for college*	0.797***	0.019	.725***	0.010
U3-*Math course is useful for future career*	1.120***	0.025	.821***	0.010
Success				
S1-*Can do excellent job on math test*	1	0.000	.853***	0.007
S2-*Can understand math textbook*	0.979***	0.014	.770***	0.007
S3-Can master skills in math course	0.935***	0.013	.829***	0.007
S4-*Can do excellent job on math assignment*	0.950***	0.013	.857***	0.007
Interest				
I1-*Enjoying math course very much*	1	0.000	.879***	0.011
I2-*Thinks math course is boring*	0.795***	0.022	.651***	0.013
Caring				
C1-Math teacher values/listens to students' ideas	1	0.000	.800***	0.008
C2-*Math teacher treats students with respect*	1.033***	0.017	.898***	0.006
C3-*Math teacher treats every student fairly*	1.124***	0.020	.874***	0.007
C4-*Math teacher thinks all students can be successful*	0.837***	0.017	.735***	0.014

$*p \leq .05$, $**p \leq .01$, $***p \leq .001$

Table 3 provides weighted descriptive statistics for the observed indicators and variables for all 23,503 respondents in the Choice model. The Choice variable had 11,639 respondents, all other variables had at least 18,000 respondents. Table 3 used the W3W1W2STUTR Analytic Weight which adjusts for non-response for base year, first follow up, 2013 update, and transcript non-response.

Table 3

Correlations, Means, and Standard Deviations with W3W1W2STUTR Analytic Weight

		U1	U2	U3	S1	S2	S3	S4	MP1	MP2	MP3	MP4	I1	I2	C1	C2	C3	C4	CH	GPA
1	U1	_																		
2	U2	0.48	_																	
3	U3	0.58	0.59	_																
4	S1	0.26	0.27	0.26	_															
5	S2	0.24	0.22	0.24	0.68	_														
6	S3	0.25	0.29	0.28	0.69	0.67	_													
7	S4	0.26	0.28	0.28	0.75	0.64	0.73	_												
8	MP1	0.21	0.23	0.27	0.50	0.49	0.47	0.47	_											
9	MP2	0.16	0.22	0.25	0.46	0.44	0.44	0.44	0.72	_										
10	MP3	0.10	0.13	0.17	0.35	0.33	0.32	0.31	0.54	0.45	_									
11	MP4	0.08	0.12	0.15	0.33	0.31	0.31	0.31	0.48	0.48	0.79	_								
12	I1	0.35	0.31	0.34	0.49	0.43	0.46	0.49	0.47	0.42	0.28	0.26	_							
13	I2	0.28	0.24	0.27	0.31	0.26	0.30	0.32	0.32	0.29	0.19	0.17	0.58	_						
14	C1	0.21	0.20	0.20	0.25	0.22	0.25	0.27	0.17	0.18	0.09	0.08	0.41	0.35	_					
15	C2	0.20	0.22	0.19	0.22	0.21	0.24	0.26	0.16	0.18	0.08	0.07	0.37	0.32	0.73	_				
16	C3	0.20	0.20	0.18	0.21	0.20	0.23	0.25	0.16	0.17	0.08	0.07	0.37	0.33	0.69	0.79	_			
17	C4	0.21	0.23	0.22	0.22	0.18	0.23	0.25	0.15	0.16	0.06	0.06	0.34	0.29	0.60	0.67	0.65	_		
18	CH	0.03	0.13	0.18	0.23	0.25	0.24	0.20	0.31	0.29	0.40	0.37	0.13	0.08	0.07	0.07	0.08	0.05	_	
19	GPA	-0.03	0.06	0.03	0.30	0.25	0.27	0.31	0.31	0.33	0.37	0.38	0.21	0.15	0.11	0.11	0.10	0.07	0.23	_
	Mean	2.89	3.43	3.17	2.97	2.73	2.99	3.07	2.52	2.53	2.38	2.43	2.77	2.66	3.13	3.26	3.19	3.33	1.07+	2.32
	SD	0.82	0.63	0.78	0.76	0.82	0.72	0.71	0.95	0.91	0.99	0.92	0.83	0.90	0.71	0.65	0.73	0.66	++	0.94

+Dichotomous variable ++No standard deviation for a dichotomous variable.

U1 = Student believes math course is useful for life, **U2** = Student believes math course is useful for college, **U3** = Student believes math course is useful for career, **S1** = Student is confident they can do well on math test, **S2** = Student confident they can understand content in math book, **S3** = Student confident in math skills, **S4** = Student confident they can do well on math course assignments, **MP1** = Student sees self as math person (9th grade), **MP2** = Others see student as math person (9th grade), **MP3** = Student sees self a math person in 11th grade, **MP4** = Others see student as math person in 11th grade, **I1** = Student is enjoying 9th grade math course, **I2** = Student thinks math course is boring, **C1** = 9th grade math course teacher values students' ideas, **C2** = Math teacher treat students with respect, **C3** = Math teacher treats every student fairly, **C4** = Math teacher thinks all students can be successful **CH**= Math Related STEM Majors, **GPA**= Cumulative Math GP

Research Question 1

For all the results, I discuss the standardized coefficients; unstandardized coefficients are also presented in respective tables. For the first research question, I wanted to establish the influence of class perceptions on domain identification and the stability of domain identification over time. I estimated the structural model for math identification to measure the effect of the latent MUSIC components on math identification in the 9th grade and the effect of math identification in the 9th grade on math identification in the 11th grade. The results of the fit indices for the structural model with the analytic weight met the recommended thresholds for an acceptable model fit: χ^2 = 797.439(108), p < .001, CFI = .984, TLI = .979, SRMR = .023, and RMSEA = .017 (.015, .018). Table 4 shows the relationship among the latent variables. The standard errors reflect standard errors with the replicate weights.

Table 4

Estimates for Math Identification Path Coefficients

Model paths	Unstandardized Estimate	SE	Standardized Estimate	SE
USEFULNESS --> MID9	0.035	0.023	0.023	0.016
SUCCESS --> MID9	0.599***	0.027	0.454***	0.020
INTEREST --> MID9	0.401***	0.030	0.348***	0.023
CARING --> MID9	-0.163***	0.023	-0.112***	0.016
MID9 --> MID11	0.667***	0.015	0.633***	0.011

**p ≤ .05, **p ≤ .01, *p ≤ .001*

Note. MID9 = Math Identification in 9th Grade. MID11 = Math Identification in 11th Grade

The standardized estimates show that three of the four perceptions, *Success, Interest,* and *Caring* had a statistically significant relationship with math identification in the 9th grade. *Success* and *Interest* had positive and statistically significant relationships with math identification. In contrast, *Caring* had a negative statistically significant relationship with math identification. Usefulness did not have a statistically significant relationship with math identification in 9th grade. Math identification in the 9th grade had a positive statistically significant relationship with math identification in the 11th grade.

Research Question 2

To answer the second question, I had to establish the Choice model. The model shown in Figure 3 has the students' choice of STEM as the outcome variable and includes the pathway for students' choice of major controlling for achievement. The analysis was run with the analytic weight (W3W1W2STUTR) and replicate weights (W3W1W2STUTR001-200) for students in the 2013 update. The results of the fit indices with the analytic weights indicated a good model fit: χ^2 = 1126.415 (139) p < .001, CFI = .955, TLI = .945, SRMR = .027, and RMSEA = .017 (.016, .018). The standard errors for the path coefficients reflect standard errors with the replicate weights (Table 5).

Table 5

Path coefficients for STEM Choice with 2013 update weights

Paths	Unstandardized Coefficients	S.E	Standardized Coefficients	S.E
USEFULNESS --> MID9	-0.050	0.030	-0.034	0.021
SUCCESS --> MID9	0.712***	0.029	0.552***	0.021
INTEREST --> MID9	0.345***	0.034	0.306***	0.028
CARING --> MID9	-0.166***	0.028	-0.119***	0.020
MID9TH --> MID11	0.675***	0.021	0.650***	0.017
MID9TH --> GPA	0.265***	0.030	0.235***	0.027
MID11TH --> GPA	0.306***	0.030	0.281***	0.025
MID11TH --> CHOICE	0.551***	0.043	0.477***	0.033
GPA --> CHOICE	0.048	0.034	0.045	0.032
MID9-->GPA-->CHOICE	0.013	0.009	0.011	0.008
MID9-->MID11-->CHOICE	0.372***	0.032	0.310***	0.026
MID11-->GPA-->CHOICE	0.015	0.010	0.013	0.009

** $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$*

Two class perceptions, Success and Interest, had positive, statistically significant relationships with 9th grade math identification. Caring has a negative statistically significant relationship with math identification in the 9^{th} grade and Usefulness did not have a statistically significant relationship with math identification. The relationship between math identification in the 9^{th} grade and math identification in the 11^{th} grade was positive and statistically significant. Math identification in both 9^{th} grade and 11^{th} grade had a small positive and statistically significant relationship with overall GPA. There was a positive and statistically significant relationship between math identification in the 11^{th} grade and STEM Choice as well as a positive and statistically significant indirect effect from math identification in 9^{th} grade to math identification in 11^{th} grade to STEM choice (see Table 5). GPA did not have a statistically significant relationship with STEM Choice. There were no statistically significant relationships for the indirect effect from math identification in 9^{th} grade to GPA to STEM choice and the indirect effect from math identification in 11^{th} grade to GPA to STEM (see Table 5).

In addition to the indirect effects of math identification on Choice, indirect effects of the MUSIC elements on Choice were also calculated (see Table 6).There were a total of 12 indirect paths from the four MUSIC elements to Choice. Of the 12 indirect paths, three were statistically significant and they all followed the same pattern (class perception to math identification in 9^{th} grade to math identification in 11^{th} grade to Choice). The statistically significant indirect paths from success and interest were positive while the indirect statistically significant path from caring is negative. These patterns provided additional evidence to suggest a relationship between MUSIC and Choice.

Table 6

Indirect Path Coefficients from MUSIC to Choice

Paths	Unstandardized Coefficients	S.E	Standardized Coefficients	S.E
Usefulness→MID9→GPA→Choice	-0.001	0.001	0	0.000
Usefulness→MID9→MID11→Choice	-0.018	0.012	-0.011	0.007
Usefulness→MID9→MID11→GPA→Choice	0.000	0.001	0	0.000
Success→MID9→GPA→Choice	0.009	0.007	0.006	0.004
Success→MID9→MID11→Choice	0.265***	0.025	.171***	0.016
Success→MID9→MID11→GPA→Choice	0.007	0.005	0.005	0.003
Interest→MID9→GPA→Choice	0.004	0.003	0.003	0.002
Interest→MID9→MID11→Choice	0.128***	0.017	.095***	0.012
Interest→MID9→MID11→GPA→Choice	0.003	0.002	0.003	0.002
Caring→MID9→GPA→Choice	-0.002	0.002	-0.001	0.001
Caring→MID9→MID11→Choice	-.062***	0.011	-0.037***	0.007
Caring→MID9→MID11→GPA→Choice	-0.002	0.001	-0.001	0.001

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Research Question 3

Question 3 was posed to determine if the Choice model remained invariant across the four different groups race/ethnicity and gender combinations. First, I tested the model for each group individually to evaluate model fit for each group. Table 7 shows the fit indices for each of the four groups individually. Each model was estimated with analytic weight W3W1W2STUTR to determine model fit indices. The replicate weights W3W1W2STUTR001-200 were then added to adjust the standard errors. The Chi-square and other fit indices are available with the analytic weight, however, they are not available with the replicate weights, only the SRMR is available with the replicate weights. The fit indices for each group are within the threshold of an acceptable model to explain students' path from motivational beliefs to math identification to the decision to select a math intensive STEM major.

Table 7

Fit indexes for STEM model by Individual group

Group	χ^2	CFI	TLI	SRMR	RMSEA
Black Females	190.537 (139), p < .01	.952	.941	.047	.018 (.011, .014)
Black Males	140.636 (139), p > .05	.997	.996	.040	.003 (.000, .014)
White Females	510.645 (139), p < .001	.968	.960	.028	.021 (.019, .022)
White Males	587.133 (139), p < .001	.957	.947	.026	.022 (.020, .024)

My interest in the model was to determine if there was a significant difference among the four groups when explaining student STEM choice from high school as they enter college. The number of students who selected STEM were: Black females (*n* = 33), Black males (*n* = 77), White females (*n* = 222), White males (*n* = 837). After examining each group individually, I estimated a configural model in which the four groups (Black females, Black males, White females, and White males) were estimated simultaneously (Wang & Wang, 2020). The fit indices for the configural model with the analytic weight indicated a good model fit: χ^2 = 1248.991(622), *p* < .001; CFI = .970; TLI = .967; SRMR = .032; and RMSEA = .016 (.015, .017) (see Table 8). The standard errors for the path coefficients reflect standard errors calculated with the replicate weights.

Table 8

Path coefficient for configural Choice Model

		Unstandardized Path Coefficients						
Paths	**Black Female**		**Black Male**		**White Female**		**White Male**	
	Coeff	S.E	Coeff	SE	Coeff	SE	Coeff	SE
MID11--> CHOICE	0.494	*0.414*	0.334*	*0.145*	0.357***	*0.069*	0.505***	*0.045*
GPA --> CHOICE	-0.013	*0.233*	0.017	*0.172*	0.320***	*0.058*	0.099*	*0.040*
MID9 --> MID11	0.495***	*0.094*	0.681***	*0.096*	0.661***	*0.033*	0.707***	*0.027*
MID9 --> GPA	0.143	*0.115*	0.310	*0.160*	0.302***	*0.036*	0.288***	*0.044*
MID11 --> GPA	0.430***	*0.134*	0.199	*0.123*	0.277***	*0.029*	0.334***	*0.037*
Usefulness --> MID9	0.051	*0.154*	-0.273	*0.152*	-0.019	*0.049*	0.028	*0.046*
Success --> MID9	0.780***	*0.159*	0.589***	*0.159*	0.732***	*0.045*	0.668***	*0.045*
Interest --> MID9	0.428*	*0.170*	0.607**	*0.227*	0.345***	*0.057*	0.347***	*0.055*
Caring --> MID9	-0.287	*0.155*	-0.186	*0.106*	-0.142***	*0.041*	-0.149**	*0.049*
MID9--> GPA --> CHOICE	-0.002	0.030	0.005	0.065	0.097***	0.020	0.028*	0.013
MID9-->MID11-->CHOICE	0.244	0.220	0.227*	0.098	0.236***	0.046	0.357***	0.035
MID11-->GPA-->CHOICE	-0.086	0.180	0.003	0.041	0.089***	0.020	0.033**	0.013
		Standardized Path Coefficients						
MID11--> CHOICE	0.437	*0.306*	0.278**	*0.112*	0.322***	*0.061*	0.448***	*0.037*
GPA --> CHOICE	-0.012	*0.209*	0.015	*0.151*	0.286***	*0.052*	0.091*	*0.037*
MID9 --> MID11	0.506***	*0.081*	0.667***	*0.082*	0.619***	*0.024*	0.664***	*0.024*
MID9 --> GPA	0.143	*0.110*	0.287*	*0.132*	0.286***	*0.032*	0.260***	*0.038*
MID11 --> GPA	0.423***	*0.106*	0.189	*0.112*	0.279***	*0.029*	0.321***	*0.033*
Usefulness --> MID9	0.030	*0.091*	-0.179	*0.092*	-0.012	*0.031*	0.020	*0.032*
Success --> MID9	0.531***	*0.105*	0.465***	*0.133*	0.550***	*0.033*	0.521***	*0.033*
Interest --> MID9	0.367**	*0.141*	0.533**	*0.172*	0.288***	*0.047*	0.311***	*0.047*
Caring --> MID9	-0.180	*0.098*	-0.177	*0.095*	-0.098***	*0.028*	-0.106**	*0.035*
MID9-->GPA-->CHOICE	-0.002	*0.027*	0.004	*0.052*	0.082***	*0.017*	0.024*	*0.010*
MID9-->MID11-->CHOICE	0.221	*0.193*	0.186*	*0.082*	0.199***	*0.038*	0.297***	*0.029*
MID11-->GPA-->CHOICE	-0.005	*0.136*	0.003	*0.034*	0.080***	*0.018*	0.029**	*.012*

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

As seen in Table 8, math identification in 11th grade had a positive and statistically significant relationship with Choice for three out of the four groups except for Black females, for which there was not a statistically significant relationship. The lack of statistical significance for Black females in the relationship between math identification in 11th grade with Choice may be due to the small number of Black females who selected STEM (n = 33) and due to using replicate weights which tend to provide higher standard errors. Achievement had no statistically significant relationship with Choice for Black females and Black males, but achievement had a positive and statistically significant relationship with Choice for White females and White males. Math identification in 9th grade had a positive and statistically significant relationship with math identification in 11th grade for all four groups. Math identification in 9th grade had positive statistically significant relationship with achievement for all groups except for Black females, while math identification in 11th grade had positive statistically significant relationship with all groups except Black males. Indirect relationships for math identification showed that indirect effects for math identification in 9th grade to Choice via GPA was positive and statistically significant for both White females and White males, but not for Black females and Black males. The indirect effect for math identification in 9th grade to Choice via math identification in 11th grade was positive and statistically significant for three of the four groups except for Black females. The indirect effect for math identification in 11th grade to Choice via GPA was positive and statistically significant for both White females and White males, but not for Black females and Black males.

As with the previous models, the perceptions of *success* and *interest* had positive and statistically significant relationships with math identification in 9th grade for all four groups, while the perception of *usefulness* did not have a statistically significant relationship with math identification in 9th grade for any of the four groups. Caring had no statistically significant relationship with math identification in 9th grade for either Black females or Black males, but had a negative statistically relationships with math identification in 9th grade for both White females and White males. Although not statistically significant, the coefficients for caring to math identification in 9th grade and the standard errors are higher for Black females and Black males than White females and White males. This difference could be due to abnormality in sampling distribution for Black females and Black males in the dataset.

In addition to the relationship among the class perceptions and math identification. I calculated the indirect effects of class perception on STEM choice (see Table 9). Three indirect paths to Choice were tested for each MUSIC variable. The perceptions of *Success, Interest*, and *Caring* had statistically significant indirect effects for all three paths for White males only, although the *Caring* path was negative. *Success* and *Interest* had positive and statistically significant indirect effects for all three paths to Choice for both White males and White females. Caring had a negative and statistically significant indirect effects for two of the paths for White females (Caring to math identification in 9th grade to math identification in 11th grade to Choice; Caring to math identification in 9th grade to math identification in 11th grade to GPA to Choice). The indirect path from *Interest* to math identification in 9th grade to math identification in 11th grade to Choice had a positive and statistically significant effect for Black males. All of the other indirect paths for the MUSIC components to Choice did not have a statistically significant effect for Black females and Black males.

Table 9

Indirect path coefficients from MUSIC to Choice for Configural Model

	Unstandardized Indirect Path Coefficients							
Paths	**Black Female (BF)**		**Black Male (BM)**		**White Female (WF)**		**White Male (WM)**	
	Coeff	S.E	Coeff	S.E	Coeff	S.E	Coeff	S.E
Use-->M9-->GPA-->Choice	0	0.005	-0.001	0.019	-0.002	0.005	0.001	0.002
Use-->M9-->M11-->Choice	0.012	0.053	-0.062	0.043	-0.004	0.012	0.010	0.016
Use-->M9-->M11-->GPA-->Choice	0	0.015	-0.001	0.008	-0.001	0.003	0.001	0.001
Success-->M9-->GPA-->Choice	-0.001	0.025	0.003	0.033	0.071***	0.016	0.019*	0.008
Success-->M9-->M11-->Choice	0.191	0.169	0.134	0.072	0.172***	0.035	0.239***	0.029
Success-->M9-->M11-->GPA-->Choice	-0.002	0.07	0.001	0.015	0.043***	0.011	0.016**	0.006
Interest-->M9-->GPA-->Choice	-0.001	0.014	0.003	0.046	0.033***	0.009	0.010*	0.005
Interest-->M9-->M11-->Choice	0.105	0.102	0.138	0.078	0.081***	0.022	0.124***	0.022
Interest-->M9-->M11-->GPA-->Choice	-0.001	0.041	0.001	0.019	0.020***	0.006	0.008*	0.004
Caring-->M9-->GPA-->Choice	0.001	0.01	0.00	0.018	-0.014**	0.004	-0.004	0.002
Caring-->M9-->M11-->Choice	-0.07	0.081	-0.04	0.03	-0.033**	0.011	-0.053**	0.018
Caring-->M9-->M11-->GPA-->Choice	0.00	0.032	0.00	0.007	-0.008**	0.003	-0.003*	0.002
	Standardized Indirect Path Coefficients							
Use-->M9-->GPA-->Choice	0	0.003	-0.001	0.01	-0.001	0.003	0.000	0.615
Use-->M9-->M11-->Choice	0.007	0.028	-0.033	0.022	-0.002	0.007	0.006	0.010
Use-->M9-->M11-->GPA-->Choice	0	0.008	0	0.004	-0.001	0.002	0.000	0.001
Success-->M9-->GPA-->Choice	-0.001	0.015	0.002	0.02	0.045***	0.010	0.012*	0.005
Success-->M9-->M11-->Choice	0.117	0.105	0.086	0.048	0.11***	0.022	0.155***	0.019
Success-->M9-->M11-->GPA-->Choice	-0.001	0.043	0.001	0.01	0.027***	0.007	0.010**	0.004
Interest-->M9-->GPA-->Choice	-0.001	0.01	0.002	0.032	0.024***	0.000	0.007*	0.042
Interest-->M9-->M11-->Choice	0.081	0.078	0.099*	0.051	0.057***	0.015	0.092***	0.016
Interest-->M9-->M11-->GPA-->Choice	-0.001	0.031	0.001	0.013	0.014***	0.004	0.006*	0.003
Caring-->M9-->GPA-->Choice	0	0.006	-0.001	0.013	-0.008**	0.003	-0.003	0.001
Caring-->M9-->M11-->Choice	-0.04	0.047	-0.033	0.022	-0.019**	0.007	-0.032**	0.011
Caring-->M9-->M11-->GPA-->Choice	0	0.018	0	0.945	-0.005**	0.002	-0.002*	0.001

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

One of the main objectives of the study was to identify differences among the four groups, with an emphasis on Black females. To detect statistically significant differences, I used a z-score cutoff of 1.96, which is associated with a $p \leq .05$ level of statistical significance. Table 10 shows the unstandardized and standardized z-scores. Z-scores of 1.96 or higher are in bold and italicized. Here, I discuss the standardized scores. Overall, Black females did not show any statistically significant differences from the other three groups in the relationship of their perceptions of math class with math identification or the relationships of math identification with Choice and GPA with Choice. As for the other groups, Black males had a statistically significant difference with White males ($z = 2.043$, $p < .05$) for the path from usefulness to math identification in the 9th grade. White males and White females showed a statistically significant difference ($z = 3.055$, $p < .01$) from GPA to Choice. The z-score differences showed that there were more statistically significant differences among the other pairs of groups than between Black females and the other three groups for the direct paths. However, when reviewing the differences in indirect effects, Black females had statistically significant differences with White females for the indirect path from math identification in 9th grade to GPA to Choice ($z = 2.633$), for the indirect path from *success* to math identification in 9th grade to GPA to Choice ($z = 2.552$), and for the indirect path from *interest* to math identification in 9th grade to GPA to Choice ($z = 2.500$). Also in the indirect effects, Black males had statistically significant differences with White females for the path from math identification in 11th grade to GPA to Choice ($z = 2.002$), and for the path from *success* to math identification in 9th grade to math identification in 11th grade to GPA to Choice ($z = 2.130$). White females had statistically significant differences with White males for five indirect paths, the most of any of the other pairs. White females and Whites males had statistically significant difference for the path for math identification in 9th to GPA to Choice (z = 2.941), for math identification in 11th grade to GPA to Choice (z = 2.050), for math identification in 9th grade to math identification in 11th grade to Choice (z = 2.357), for success to math identification in 9th grade to GPA to Choice (z = 2.952), and success to math identification in 9th grade to math identification in 11th grade to GPA to Choice (z = 2.109). Although technically not statistically significant at a .05 level, there were some differences of note 1.65 < z < 1.96 ($p < .10$) that may warrant further investigation. The z-scores are italicized and highlighted. These differences are between Black females and White males for the path from math identification in 9th grade to math identification in 11th grade (z = 1.870); between Black males and White females for the paths from GPA to Choice (z = 1.697), *usefulness* to math identification in 9th grade (z = 1.720), and the indirect path *success* to math identification in 9th grade to GPA to Choice. Another difference that could be investigated is that between White females and White males for the path math identification in 11th grade to Choice (z = 1.766)

Table 10

Z score for difference in path coefficients

	Unstandardized Scores					
Paths	**BF and BM**	**BF and WF**	**BF and WM**	**BM and WF**	**BM and WM**	**WF and WM**
MID11--> CHOICE	0.365	0.326	0.026	0.143	1.126	1.797
GPA --> CHOICE	0.104	1.387	0.474	1.669	0.464	**3.137**
MID9 --> MID11	1.384	1.666	**2.168**	0.197	0.261	1.079
MID9 --> GPA	0.848	1.319	1.178	0.049	0.133	0.246
MID11 --> GPA	1.270	1.116	0.691	0.617	1.051	1.212
Useful--> MID9	1.497	0.433	0.143	1.590	1.895	0.699
Success --> MID9	0.849	0.290	0.678	0.865	0.478	1.006
Interest --> MID9	0.631	0.463	0.453	1.119	1.113	0.025
Caring --> MID9	0.538	0.904	0.849	0.387	0.317	0.110
MID9--> GPA --> CHOICE	0.098	***2.746***	0.918	1.353	0.347	***2.893***
MID9-->MID11-->CHOICE	0.071	0.036	0.507	0.083	1.249	***2.093***
MID11-->GPA-->CHOICE	0.482	0.966	0.659	1.885	0.697	***2.348***
Useful-->M9-->GPA-->Choice	0.051	0.283	0.186	0.051	0.105	0.557
Useful-->M9-->M11-->Choice	1.084	0.294	0.036	1.299	1.569	0.700
Useful-->M9-->M11-->GPA-->Choice	0.059	0.065	0.067	0.000	0.248	0.632
Success-->M9-->GPA-->Choice	0.097	***2.426***	0.762	1.854	0.471	2.907
Success-->M9-->M11-->Choice	0.310	0.110	0.280	0.475	1.353	1.474
Success-->M9-->M11-->GPA-->Choice	0.042	0.635	0.256	***2.258***	0.928	***2.155***
Interest-->M9-->GPA-->Choice	0.083	***2.043***	0.740	0.640	0.151	***2.234***
Interest-->M9-->M11-->Choice	0.257	0.230	0.182	0.703	0.173	1.382
Interest-->M9-->M11-->GPA-->Choice	0.044	0.507	0.218	0.954	0.361	1.664
Caring-->M9-->GPA-->Choice	0.097	1.393	0.490	0.705	0.166	***2.236***
Caring-->M9-->M11-->Choice	0.324	0.453	0.205	0.282	0.314	0.948
Caring-->M9-->M11-->GPA-->Choice	0.031	0.280	0.125	1.050	0.412	1.387

Continued on next page →

	Standardized Scores					
Paths	**BF and BM**	**BF and WF**	**BF and WM**	**BM and WF**	**BM and WM**	**WF and WM**
MID11--> CHOICE	0.488	0.369	0.036	0.345	1.441	*1.766*
GPA --> CHOICE	0.105	1.384	0.485	*1.697*	0.489	***3.055***
MID9 --> MID11	1.397	1.338	*1.870*	0.562	0.035	1.326
MID9 --> GPA	0.838	1.248	1.005	0.007	0.197	0.523
MID11 --> GPA	1.517	1.310	0.919	0.778	1.131	0.956
Useful --> MID9	1.615	0.437	0.104	*1.720*	***2.043***	0.718
Success --> MID9	0.389	0.173	0.091	0.620	0.409	0.621
Interest --> MID9	0.746	0.532	0.377	1.374	1.245	0.346
Caring --> MID9	0.022	0.805	0.711	0.798	0.701	0.178
MID9--> GPA --> CHOICE	0.102	***2.633***	0.903	1.426	0.378	***2.941***
MID9-->MID11-->CHOICE	0.167	0.112	0.389	0.144	1.276	***2.050***
MID11-->GPA-->CHOICE	0.057	0.620	0.249	***2.002***	0.721	***2.357***
Useful-->M9-->GPA-->Choice	0.096	0.236	0.000	0.000	0.002	0.002
Useful-->M9-->M11-->Choice	1.123	0.312	0.034	1.343	1.614	0.655
Useful-->M9-->M11-->GPA-->Choice	0.000	0.121	0.000	0.224	0.000	0.447
Success-->M9-->GPA-->Choice	0.120	***2.552***	0.822	*1.923*	0.485	***2.952***
Success-->M9-->M11-->Choice	0.269	0.065	0.356	0.455	1.337	1.548
Success-->M9-->M11-->GPA-->Choice	0.045	0.643	0.255	***2.130***	0.836	***2.109***
Interest-->M9-->GPA-->Choice	0.089	***2.500***	0.185	0.688	0.095	0.405
Interest-->M9-->M11-->Choice	0.193	0.302	0.138	0.790	0.131	1.596
Interest-->M9-->M11-->GPA-->Choice	0.059	0.480	0.225	0.956	0.375	1.600
Caring-->M9-->GPA-->Choice	0.070	1.193	0.493	0.525	0.153	1.581
Caring-->M9-->M11-->Choice	0.135	0.442	0.166	0.606	0.041	0.997
Caring-->M9-->M11-->GPA-->Choice	0.000	0.276	0.111	0.005	0.002	1.342

Discussion

The purpose of this study was to examine the effects of math class perceptions on math identification, and subsequently, the effect of math identification on STEM choice while controlling for academic achievement. This section includes a discussion of each of the research questions and related hypotheses.

Research Question 1

The first research question was as follows: To what extent are students' math class perceptions (i.e., perceptions of usefulness, success, interest, and caring) related to their math identification? The first hypothesis (*H1*) was that students' math class perceptions in 9th grade are related to their math identification in the 9th grade. Success and interest perceptions in 9th grade math class were positively related to students' math identification in 9th grade and caring was negatively related to it. The result for usefulness was not significant. The positive relationship of success with math identification follows a similar result as Jones et. al. (2014) who used SEM analysis to determine that undergraduate students' success perceptions in a first-year engineering design course were positively related to their engineering identification. In another study with middle school students, Jones et al. (2017) also found that success had a positive relationship with science identification for U.S students (but not Icelandic students). The similar results between this study and these other studies suggests that success perceptions can be used to predict domain identification, in this case math identification. Students' beliefs that they can be successful in a subject is seen as a key factor in the students' decision to continue to engage with school subjects (Eccles et al., 1983, Eccles & Wigfield, 2020). When given a choice in the course selection process, this usually means that the students tend to enroll in courses with subjects they believe they can succeed in.

Interest also had a positive statistically significant relationship with 9th grade math identification. The situational interest measured in this study is a precursor to longer-term individual interest that is associated with increased knowledge, value, and affect (Hidi & Renninger, 2006). The findings suggest that situational interest can lead to individual interest. During that transition to individual interest, students begin to develop identification with the subject (Jones et al., 2015). When students have a lower situational interest in a class, they are bored in the class. Without the development of situational interest, a student cannot develop individual interest, and identification is less likely. In another study that evaluates the effects of the MUSIC components on domain identification, interest did not have a statistically significant effect on domain identification (Jones et al., 2016). In their study, they focused on college students in a first-year engineering course to determine MUSIC influence on engineering identification. This study is different from the study in Jones et al. (2016) in many ways. The current study used a different domain (math), involved more than one class, and the classes included different topics because the students were not all taking the same level of math in the 9^{th} grade.

The standardized effect of *usefulness* on math identification in the 9^{th} grade is not statistically significant. Some studies showed that students' perception of the *usefulness* in engineering courses had a positive relationship with engineering identification (Jones et al., 2014, Jones et al., 2016). The items affiliated with usefulness in this study asked students about their perception of how useful their 9^{th} grade math course is to everyday life, for attending college, or for a future career. The questions did not explicitly ask whether the students felt the course is useful for their individual life, their own college plans, or their own career aspirations. It could be that the students' responses primarily reflected their perceptions of the usefulness of the math course for the general student population, but not for them individually. The result for usefulness in the math identification analysis suggests that believing a subject is useful in the general sense does not necessarily translate into students perceiving that subject is part of who they are (i.e., part of their math identity).

Caring had a negative, statistically significant relationship with 9^{th} grade math identification. The items measuring "caring" only asked the students about their perception of the teacher's attitude toward students in the class. Like the questions measuring usefulness, the questionnaire did not specifically refer to the students' perceptions of how the teacher treats them individually. It also did not ask about the students' perceptions of their peers in the course. Students who believe that their teachers and/or classmates care about their success in a course tend to show better academic engagement (Jones, 2018). In Jones et al. (2017) and Chittum and Jones (2017), caring had a positive relationship with science identification. Students in these studies were asked about the teacher's attitude towards them specifically. Thus, to explain the negative relationship caring has with math identification, it could be that students who are less likely to identify with math are more likely to rely on the teacher's treatment of students to get through the course. These students may be low performing students, and therefore not likely to identify with math. Believing that the teacher cares about all students in the course may help them in asking questions and seeking more support from the teacher to improve their performance. Therefore, they may be more attentive to the teacher's treatment of students in the math course and their responses may be slightly more positive on teacher's treatment of students. On the other hand, students who are more likely to identify with math, may not pay so much attention to the teacher's treatment of the students in the course because they may not be seeking the teacher's support as much as those who are less likely to identify with math. The responses of the students who are more likely to identify with math may then be more neutral or slighly negative.

The second hypothesis (*H2*) for Research Question 1 was that students' math identification in 9th grade is related to math identification in the 11th grade. As shown in Table 4, the standardized path coefficient from math identification in the 9th grade to math identification in the 11th grade has a positive and statistically significant relationship with math identification in the 11th grade. This is not surprising as domain identification can lead to better performance which strengthens identification in that domain (Jones & Osborne, 2011). Domain identification theory predicts that students' performance in math can lead to more confidence in their ability to perform well in the domain, which can then maintain their level of math identification as long as students continue to succeed over time.

Research Question 2

The second research question was as follows: To what extent are students' STEM major choices predicted by the students' math class perceptions, their math identification, and their overall math GPA? The first hypothesis for questions 2 (*H3*) stated that students' math identification and math achievement are both predictive of students' STEM choice. Looking at the path coefficients for the Choice model (Table 5), the relationships of the MUSIC components to math identification in the 9th grade continue to follow the similar pattern as they did for the math identification model. The relationship of math identifcation in the 9th grade to math identification in the 11th grade also follows a similar pattern as in the math identification model. For the first hypothesis, the path coefficients examined were the path coefficients to achievement and the path coefficient to choice.

The path coefficient to achievement is important because domain identifcation has been linked to increased engagement and performance (Jones et al., 2013). Studies have shown that performance in a domain can influence one's career choice (Riegle-Crumb et al., 2010). Both math identification in 9th grade and math identification in the 11th grade had positive and statistically significant relationships with students' academic achievement. Showing a positive relationship between math identification and achievement is consistent with theory (Jones et al. 2016, Osborne & Jones, 2011), identification with academics tends to lead to more engagement and movitation to succeed.

Identification with academics has been shown to foster more engagement in school (Osborne & Jones, 2011). The standardized path coefficient in the Choice model shows that math identification in the 11^{th} grade has a positive and statistically significant relationship with STEM choice (Table 5). This result is consistent with other studies showing identification with a subject leading to persistence in that subject (Jones et al., 2013). The relationship here shows math identification having a positive statistically significant relationship with intention to major in a math-intensive major, not strictly a math major. That pattern agrees with other scholars that have shown that science identity positively correlates with STEM career choice (Carlone & Johnson, 2007; Hazari et al., 2013). Therefore, math identification can be used as an indicator for selecting a math-intensive STEM major. The students in this study did not all take the same math courses in the same sequence and some students took more advanced math courses than others. Therefore, the analysis reflects math identification more broadly as opposed to identification with a narrow topic in math. Given the broader math topics covered in this study, I think it adds more value to the relationship of math identification with the decision to major in math intensive majors.

Being good in math is considered a prerequisite for students who intend to pursue STEM disciplines (Lichtenberger & George-Jackson, 2013). In this analysis, achievement in math was not statistically related to STEM choice. This result implies that after controlling for identification, math performance does not have a relationship with their decisions to pursue a math intensive STEM major. The indirect effects from 9^{th} grade math identification to achievement to choice, and 11^{th} grade math identification to achievement to choice were not statistically significant either, which reinforces achievement's negligible effect on STEM choice after controlling for identification. This finding does not align with other studies that have shown a relationship for high performance in math and pursuing a career in STEM (Diemer et al. 2016; Chittum & Jones, 2017; Jones et al. 2014; Jones et al., 2016; Mckellar et al. 2018), perhaps because those studies did not control for other variables. Although it has been shown that promoting success can lead to identification (Osborne & Jones, 2011), that does not mean success in a subject always leads to the student pursuing a major related to that subject.

The second hypothesis for Research Question 2 (*H4*) stated that students' math class perceptions have indirect effect on STEM choice. The perceptions of success and interest each had a positive statistically significant relationship with Choice through 9^{th} grade math identification and 11^{th} grade math identification. However, indirect effects that included achievement were not statistically significant. These results indicate that class perception of success and interest can be predictive of students' intentions to major in STEM. These results align with other studies (Chittum & Jones, 2017; Jones et al., 2016; Jones et al., 2014) showing how MUSIC perceptions influence identification and identification's subsequent influence on career goals. The perception of caring had a negative statistically significant relationship with Choice through 9^{th} grade math identification and 11^{th} grade math identification. Like success and interest, caring did not have a statistically indirect relationship with Choice that included achievement. Math identification in 9^{th} grade and 11^{th} grade remains the paths through which the relationships are significant. These results indicate that math identification plays a more important role in this model for STEM Choice than achievement. The perception of usefulness did not have a statistically significant indirect relationship with Choice. The perception of usefulness not having a statistically significant indirect relationship remains consistent with the other relationships. The non-effects of usefulness does not align with other studies (Jones et al.

2014; Jones et al. 2016) for which usefulness had a positive relationship with identification, and subsequently, career goals.

Research Question 3

The primary group of interest in this study was Black females and their decisions to pursue a major in a math-intensive STEM discipline. As shown in Table 8, the standardized results for the two path coefficients measuring the factors related to Choice (GPA to Choice, math identification in the 11^{th} grade to Choice), they were not statistically significant for Black females. The lack of statistical significance for math identification in 11^{th} grade to Choice is particularly important given the high number. However, the statistical significance could be affected by the low number of Black females who selected STEM (n = 33), and the application of replicate weights. These two results as reported can be interpreted that neither math identification nor achievement have a relationship with Black female students' decisions to pursue a major in math intensive STEM disciplines. The fact that achievement did not have a statistically significant relationship with Choice for Black females has some precedence. Seo et al. (2019) also found a weak relationship between math achievement and STEM career expectancy among minorities and women. But identification not having a statistically significant relationship with Choice for Black females does not align with some studies that have found that positive perceptions of math ability have a positive correlation with the intentions of girls to pursue a career in physics, engineering, computer science, and math (Nix et al., 2015; Perez-Felkner et al., 2012).

When reviewing the indirect effects to Choice for Black females (Tables 8 and 9) there were not any statistically significant indirect effects to Choice. This can be interpreted that other variables not included in this study could be more predictable of Black female students' STEM choice than the class perceptions and math identification. Female students have reported that initial interest in STEM started with school related activities (Maltese & Cooper, 2017). It could be a lack of exposure that Black female students have to school activities related to math-intensive STEM. I have not come across studies that measure Black females' career decisions in STEM as an outcome variable while using the MUSIC model or math identification. Most studies examine the factors that explain the discrepancies between Black female students' performance in math and other demographic groups or the social messages that may cause Black females to not identify with math or STEM. This highlights the reason I decided to approach this study from the vantage point of psychosocial factors affecting students' choice.

Black males on the other hand had a statistically significant relationship between math identification in 11^{th} grade and Choice, but did not have a statistically significant relationship between GPA and Choice. The fact that achievement did not show a statistically significant relationship with Choice for Black males is in line with Seo et al. (2019) who found a weak relationship between achievement and STEM career expectancy for minorities and females. Black males had only two statistically significant indirect effects to Choice (math identification in 9^{th} grade to math identification in 11^{th} grade to Choice, and interest to math identification in 9^{th} grade to math identification in 11^{th} grade to Choice). White females and White males on the other hand had statistically significant relationships for math identification in 11^{th} grade to Choice and for GPA to Choice. For the indirect effects to Choice, most of the indirect effects to Choice were positive and statistically signficant for White females and White males (see Tables 8 and 9). These results imply that class perception and GPA are better predictors for STEM Choice in this model for White females and White males than for Black females and Black males. Lin et al. (2018) found that math achievement had a direct relationship with success in

STEM. However, Kang et al. (2018) found that by the time students reach middle school, there are multiple factors in addition to performance that influence their interest in STEM careers.

The third research question explored if the relationships in the model were invariant across race/ethnicity and gender. Specifically, I was interested in whether the results for Black females were significantly different from other groups in the Choice model. I hypothesized that the model in Table 5 would fit similarly across all four combinations of race/ethinicity and gender. The Choice model was estimated for each group (see Table 8), and the fit indices indicated that the model was a good fit for each group individually. Once I established the model fits for each group of interest, my focus turned to analyzing the results of the configural Choice model. (see Table 8). The fit indices showed the model is a good fit for the groups simultaneously, which means that the path model in Figure 3 can be used to analyze the relationship from class perception to identification to STEM choice for all four groups. I used a z-test of difference to test for invariance among the groups. I compared all the groups to each other, which resulted in six pairs, (seeTable 8).

Of the four groups that were compared in this analysis, Black females was the only group that did not have any statistically significant path leading to STEM choice. However, the results of the z-test for invariance across groups (Table 10) indicated that there were no statistically significant differences between Black females and the other three groups for any of the path coefficients, for direct effects and for indirect effects. However, when comparing Black females to White males, the z-score ($z = 1870$) for the difference in the path coefficients suggested a potentially viable difference for math identification in 9^{th} grade to math identification in 11^{th} grade that may warrant further investigation in future research. Using multigroup structural equation modeling, Kang et al. (2018) found no statistically significant difference among different races/ethnicities in STEM identities. Given that Black females showed no statistically significant difference with other groups for any path coefficient implies that despite what some studies have revealed about the experiences of Black females in high school and in college in regard to math and science, or STEM in general, the factors related to their decisions to pursue a major in math-intensive STEM disciplines does not differ from other groups in this study.

The standardized results for the z-test for invariance found one pair with statistically significant differences for direct effects on STEM choice. There was a statistically significant difference between White females and White males for the direct path from GPA to choice ($z = 3.055$). That showed a difference between genders within the same race. There were other statistically significant differences that were found for indirect effects to Choice. These differences were between White females and Black males, and between White females and White males. These results suggest that differences in students' class perceptions can be predictive of STEM choice when comparing gender and race. However, given that Black females did not show differences with any other group, that is something that can be further investigated.

Limitations

The study findings must be interpreted within the context of the limitations. First, the study addressed math class perceptions. The math class perceptions analyzed for this study are for students' math course in the 9th grade. It is likely that not all 9th grade students nationwide are enrolled in the same type of math courses. Some students are more advanced and can take higher level math as early as freshman year. Therefore, the class perceptions are not in response to a particular math topic (i.e., Algebra, Trigonometry, or Calculus). On one hand, having multiple math topics allows the study to evaluate perceptions for math classes more broadly. On the other hand, this study was not able to determine the effect certain type of math has on students' class perceptions. For example, a students' perceptions of geometry may be different than their perceptions of trigonometry.

Second, similar to the math class perceptions, math identification captured math broadly, it did not focus on one particular math topic. For the aforementioned reasons, while most students in the same grade are probably enrolled in the same math course, all students nationwide are not necessarily enrolled in the same level math courses while in the same grade level. When measuring math identification, the two identifications could be influenced by the course topic.

Third, the study explored the relationship between math identification and STEM choice. The outcome variable (students' intended major in college) was collected during the students' first semester in college, and therefore, it is only measuring the intent of students who are already enrolled in college. Additionally, the students may change their minds about their majors later in their college career. Therefore, the variable does not necessarily measure the major that they will end up graduating with. Further analysis with information about the types of degrees these students end up obtaining will be important in showing the long-term effect of math identification on STEM choice.

Fourth, another limitation is that the study did not include the effects of out-of-classroom experiences (e.g., computer club, engineering club, summer programs, pre-college programs) on students' math identification. These out-of-the classroom experiences could have an effect on students' decisions to pursue a STEM major in math (Eastman et al., 2017). Controlling for extracurricular activities would help determine the extent to which course perception affect students' identification and intent for a major in the long term.

Fifth, the analysis did not control for socioeconomic status (SES), which can play a major role in early exposure to math and science activities outside of school (Betancur et al., 2018).

Early exposure at home with books and other materials that emphasize math, science, or technology can spark situational interest which can lead to individual interest in the domain (Hidi & Renninger, 2006). The SES could also have been determined by the schools' characteristics. Public schools for example, report the percentage of their students' population who are eligible for free or reduced lunch. That report is a way of determining the SES of the student population in that school. Categorizing schools by the population they serve in terms of SES classification could help determine how the school's economic characteristic affect students' perceptions and identification.

A sixth limitation that goes along with the fifth limitation is that racial/ethnic characteristics of the schools were not taken into consideration. Many high schools in the U.S. lack diversity. Urban schools tend to be majority Black and Hispanic, while suburban schools tend to more majority white. Black students can have different experiences based on the racial/ethnic makeup of their schools. This could have an effect on their perceptions of their classes and their identification with math.

Implications and Conclusions

The results of the study showed that the relationships between math identification and STEM choice, and between achievement and STEM choice for Black females were not different from other groups. The effects of class perceptions on math identification and the indirect effects of class perception on STEM choice also were not different between Black females and the other groups. What I conclude is that math class perceptions, identification, and achievement could not explain differences in STEM choice between Black females and three other groups: Black males, White males, and White females. It is possible that other factors could be influencing Black females' decisions to pursue a math-intensive STEM major. For example, encouragement from family and educators could have an influence on Black females to pursue STEM. It is important to highlight that the factors in this study provide an insight into their perceptions, but that they do not provide an insight into the considerations that go into their decisions to select a STEM major.

Because math identification is positively related to STEM choice, schools could place an emphasis on providing students with opportunities to take more math, perhaps more advanced math. If students are able to take higher level math and succeed, it could lead to higher self-concept which could lead to math identification. The schools should also provide students with enough support to help them succeed and work to incorporate teaching methods that elicit students' interest in math. Another implication is that not all perceptions of a math course are positively related with math identification. More studies could determine if some perceptions are more consistent in having a positive relationship with math identification. Furthermore, because math identification early in 9^{th} grade has a positive relationship with math identification in 11^{th} grade, helping students to form a stronger math identification early in high school (or even earlier) could have a long-term effect on their decisions to continue to study math in college or math-intensive disciplines in college. Therefore, it is critical that teachers help students believe that they can succeed in math and teach in ways that trigger and maintain students' interest in math.

The result that math GPA does not have much of a relationship with STEM choice is not completely inconsistent with other studies. This finding indicates that educators should not assume that a student who is good in math is likely to consider a STEM-related career. Instead, educators would be better served to focus on increasing students' identification with math through the means described in this study and other studies.

Appendix A: Latent variable correlations for the four groups

Table A1:

Choice Model Latent Variable Correlations Black Females and Black Males

	1	2	3	4	5	6	7	8
1. Usefulness	--	.291***	.352***	.440***	.235**	.119**	.051	.084**
2. Success	.486***	--	.572***	.371***	.683***	.345***	.148*	.244***
3. Interest	.481***	.649***	--	.614***	.571***	.289***	.124	.204***
4. Caring	.395***	.527***	.564***	--	.256***	.129***	.055	.091**
5. MI9	.233**	.630***	.648***	.298***	--	.506***	.217*	.357*
6. MI11	.156**	.421***	.433***	.199***	.667***	--	.431*	.495***
7. Choice	.045	.121*	.124*	.057	.192*	.284**	--	.205
8. GPA	.097**	.261***	.268***	.123***	.413***	.381***	.121	--

Note: Correlations for Black females are above the diagonal, Black males are below the diagonal.
*p ≤ .05, ** p ≤ .01, ***p ≤ .001

Table A2:

Choice Model Latent Variable Correlations White Females and White Males

	1	2	3	4	5	6	7	8
1. Usefulness	--	.457	.528	.336	.358	.222	.118	.164
2. Success	.430	--	.636	.321	.696	.431	.230	.320
4. Interest	.544	.603	--	.561	.576	.357	.191	.265
4. Caring	.366	.308	.543	--	.236	.146	.078	.108
5. MI9	.374	.684	.578	.230	--	.619	.331	.459
6. MI11	.248	.654	.384	.153	.664	--	.452	.457
7. Choice	.127	.233	.197	.078	.340	.493	--	.433
8. GPA	.177	.324	.274	.109	.473	.494	.312	--

Note: Correlations for White females are above the diagonal, White males are below the diagonal.
All correlations were significant at p ≤ .001

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CHAPTER 4

Conclusion

Summary

This dissertation had two primary objectives. The first objective was to investigate the factors contributing to the low representation of women of color in STEM careers. In manuscript 1 (Chapter 2) I explored the factors that affect women's persistence in STEM, particularly the math-intensive STEM disciplines. This chapter established a pattern in women's underrepresentation in STEM that served as the impetus for the study in manuscript 2 (Chapter 3).

The second objective was to explore the influence of math class perceptions on math identification in high school and the relationship math identification in high school has with students' decisions to select a math intensive STEM major in college, with Black females as a focal point. In manuscript 2 (Chapter 3) I focused on the math class perceptions of students in 9^{th} grade, math identification in 9^{th} and 11^{th} grades, and their relationship with students' intention to major in STEM. The study used a domain identification model with the MUSIC model of motivation theory as a catalyst. This study is the only one to my knowledge that used a large national data set to analyze relationships between students' MUSIC perceptions, domain identification, and choice of college major.

From the literature, I found that STEM education has been a top priority for the U.S for several years (Granovskiy, 2018). A major concern has been the lack of diversity in STEM disciplines, especially the low representation of Black women (Main & Schimpf, 2017; National Science and Technology Council: Committee on STEM Education, December 2018). For that reason, the primary group that I wanted to pay attention to in this study was Black female students. Although STEM encompasses a lot of disciplines, for this dissertation I was interested in disciplines that are considered math intensive (i.e., computer science, math, engineering, and the physical sciences). The reason is that these are the STEM disciplines that show more discrepancy in both race and gender. For the purposes of this dissertation, STEM referred to these math intensive STEM disciplines. Although most research has focused on the reasons for the underrepresentation of Black female students, I wanted to identify students who intended to pursue a STEM degree and explore what relationship exist between their perceptions of their math classes, their perceptions of their math identification, and their decisions to study a STEM major. The intent for this approach was to show that despite the challenges that researchers have determined to have kept the numbers of Black females low in STEM disciplines, Black females do pursue STEM, and finding factors that are related to their decisions to pursue STEM in college could be valuable in the approaches schools and parents can take to increase the probability of having more Black females in STEM disciplines.

Manuscript 1 (Chapter 2)

In Chapter 2, I explored the factors that affect the underrepresentation of women (especially Black women) in STEM. I began by highlighting that research on the underrepresentation of women of color in STEM has been going on for over 40 years. Most notably since the publication of *The Double-Bind: The Price of Being a Minority Woman in Science* (Malcolm et al., 1976). I also provided an overview of STEM, including its wide application and career outlook in professions affiliated with STEM (U.S. Department of Commerce, 2017). I also explored the wide discrepancy between women of color (in particular, Black, Hispanic, Native American) and other groups when it comes to obtaining degrees in STEM. Throughout the chapter, I focused primarily on Black females because their representation is the smallest compared to their representation in the general population (NCSES, 2019; Tomaskovic-Devey & Han, 2018)

To understand the underrepresentation of Black women, it was important for me to start in the years prior to college. Thus, I explored research on the role that STEM education in the K-12 school system plays on opportunities or lack of opportunities for young Black females. What I found was that beginning in the early years, students are tracked into certain subjects. Black girls are usually tracked away from subjects or activities affiliated with STEM (Collins et al., 2020). These actions taken in the K-12 system have influenced the number of Black girls developing an interest in STEM (King & Pringle, 2018). In math and science, stereotypes about girls and Black students have been prevalent in American society (Blanton, 2000; Nisbett, 2011), which contributes to a lack of encouragement from the social environment for Black girls to engage in STEM activities.

The information in manuscript 1 (Chapter 2) highlights evidence that female students are not inherently less interested in STEM or less capable of handling the rigor of STEM subjects. Instead, they tend to face more social barriers to the opportunities to study STEM subjects, especially for Black female students, who face barriers both as female students and as Black students. These barriers begin before the students reach college. What can be concluded in this chapter is that in order to understand the low representation of women of color in STEM, it is important to understand the experiences of young female students. These experiences can affect their perceptions of STEM subjects and their intentions to pursue STEM careers.

Manuscript 2 (Chapter 3)

In the second manuscript, I used structural equation modeling (SEM) to analyze relationships between students' math class perceptions', math identification, and STEM major choice in college. Although I used multiple group SEM to compare four demographic groups, I was most interested in the findings for the Black female students. The research questions in this study were: (1) To what extent are students' math class perceptions related to their math identification? (2) To what extent are students' STEM major choices predicted by their math class perceptions, their math identification, and their overall math GPA? (3) Are the relationships in the model invariant across race/ethnicity and gender?

I used CFA to establish four of the five MUSIC variables as good indicators of students' perceptions of their math classes. I then established the positive relationship between these MUSIC variables and math identification. Next, I documented the relationship between math identification and intent to major in STEM while controlling for achievement. I also explored the indirect relationships among the four MUSIC variables and students' intent to select a STEM major. The analysis for students' intent to major in STEM was conducted for all students in college and again for four groups (Black females, Black males, White females, and White males) in college.

Overall, success and interest were the only two math class perceptions that had positive statistically significant relationships with math identification. Those relationships were consistent for all four groups (Black females, Black males, White females, and White males). Usefulness did not have a statistically significant relationship to math identification for the four groups. Caring was negatively related to math identification for White females and White males, and had no statistically significant relationship with math identification for Black females and Black males.

In general, there was a positive and statistically significant relationship between math identification and deciding to major in math-intensive STEM disciplines. When comparing the four groups (Black females, Black males, White females, and White males), the magnitude of this relationship was not found to differ across the groups. However, for Black females, this relationship did not reach the threshold ($p < .05$) for statistical significance. Further investigation will be necessary to reconcile this apparent inconsistency. The lack of statistical significance for Black females might be due to measurement issues associated with this variable for this particular group that will require further investigation to understand. However, in general, the lack of statistical difference across the groups suggests that the importance of math identification is consistent across all four groups.

The results also indicated that, for the most part, differences among the groups for the factors that have a direct relationship with the decisions to pursue math-intensive STEM majors are also minimal. The results demonstrated no statistically significant relationship between performance in math and making the decision to pursue a math-intensive STEM discipline as a major for Black females and Black males. The only difference was between White females and White males for the path from achievement to choice. Black females in particular did not show any statistically significant difference with other groups for any of the path coefficients in the model, including indirect paths for intent to major in a STEM discipline.

Manuscript 2 (Chapter 3) established an acceptable model that can be used to analyze the relationships among math class perceptions, math identification, and students' intent to major in a STEM discipline. The model can be applied to different genders and racial groups allowing for the analysis of differences among the groups. This model is consistent with the more general domain identification model (Osborne & Jones, 2011) and demonstrates how the MUSIC Model of Motivation is linked to math identification and can be used to study the persistence and career goals of high school students in STEM (e.g., Jones et al., 2014; Jones et al., 2016; Jones et al., 2017).

Overall Conclusions

Based on the two studies, I reached several conclusions about Black females' math identification and choice of a STEM major. First, from Chapter 2, I conclude that the intersection of race and gender creates an added challenge for Black female students that they probably would not experience if they had to deal with challenges that only impact one of these salient identities. These challenges originate from negative stereotypes of women and of Black students (e.g., low aptitude for math and science or lack of interest in STEM) and have been known for several decades. The negative stereotypes tend to start early in the K-12 school system.

Second, in Chapter 3, overall, math identification had a positive and statistically significant relationship with STEM choice, which reinforces the theoretical domain identification model that suggests that math identification should lead to STEM choice. Although for Black females the relationship between their math identification and their decisions to pursue a STEM major did not reach statistical significance, the overall magnitude of this relationship was no different from any other groups. As for their STEM decisions, the study in Chapter 3 demonstrated that while the math identification model was similar for Black females and other students, Chapter 2 documented that Black females may face other challenges that can affect their decisions to pursue a major in STEM (those factors were beyond the scope of the Chapter 3 study).

Another key conclusion is that math identification is an important predictor of students' college major goals, which is consistent with findings from other studies. Although academic performance in math is an important indicator in determining students' level of competence, the findings from this study suggest that it is not the most important factor in some students' decision making process in relation to majoring in STEM. In this particular study, math identification was a more important factor in predicting students' choice of STEM major than achievement. This implies that math identification encompasses more than good performance. The theory of domain identification states that the person perceives the domain (e.g., math) as part of who they are. Therefore, once students have established an identification with math, they are more likely to continue to engage with math or other subjects that require more math. Because math identification was positively related to STEM major choice, math identification is a construct that should continue to be part of studies that involve STEM career goals.

An additional result is that, in contrast to success and interest, which have positive statistically significant relationship with math identification for all four groups, caring had a statistically significant negative relationship with math identification for White females and White males, and no statistically significant relationship with math identification for Black females and Black males, which does not align with other studies in which caring was positively related to engineering identification (Jones et al., 2014; Jones et al., 2016). The negative relationship between the perception that the teacher cares and math identification should be investigated further. The perception of a caring teacher is expected to be positively associated with motivation in class (Jones 2009, 2018). Given the expected association between teacher caring and motivation, I would expect that caring would be positively related to identification with the subject.

Overall, I found that the relationships between students' math class perceptions, math identification, and STEM major decision are not significantly different across race and gender. Math identification plays a more important role in STEM decision than achievement, and underrepresentation of Black women in STEM can be attributed to social factors that begin in the K-12 school system. The implications of this overall conclusion are as follows. First, school leaders should make the extra effort to expand opportunities for Black female students in the K-12 school system to engage with more math by removing barriers that hinder their access. School officials need to be intentional in creating more space in advanced math and science classes to increase the enrollment of more Black female students in these courses. Black female students can benefit from participating in more out-of-class academic activities with extended exposure to STEM subjects. These activities can then reinforce their interest and encourage them to enroll in more STEM subjects. Therefore, addressing underrepresentation of Black females in STEM should start by ensuring that school activities and academic opportunities that are afforded to groups with high representation in STEM should be extended to groups with low representation to allow for equal access.

Second, it is generally accepted that teachers have a lot of influence on how students perceive a class. Teachers may have to consider different teaching methods that will appeal to a diverse student body. Although when working with diverse groups of students, it is expected that schools and teachers should be aware of and acknowledge the differences between genders and among ethnic/racial groups, these differences may not be the most important in students' career goals. Based on the results of this study, the relationships among the factors related to math class perceptions, math identification, and STEM major choice were not significantly different among the groups. In other words, regardless of students' gender or race/ethnicity, students' perceptions of success and interest in their math class were significantly related to their math identification over time, which was related to their STEM major choice. These findings suggest that teachers should work to help all students believe that they can succeed and interest them in the class activities.

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