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Math Attitudes and Achievement: The Moderating Role of Perceived Same-Ethnic Representation in Math Class

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Publication Date

2022

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UNIVERSITY OF CALIFORNIA

Los Angeles

Math Attitudes and Achievement: The Moderating Role of

Perceived Same-Ethnic Representation in Math Class

A thesis submitted in partial satisfaction of the

requirements for the degree Master of Art in Education

by

Piper Harris

2022

ABSTRACT OF THE THESIS

Math Attitudes and Achievement:

The Moderating Role of

Perceived Same-Ethnic Representation in Math Class

by

Piper Harris

Master of Art in Education

University of California, Los Angeles, 2022

Professor Sandra Graham, Chair

There exist considerable achievement gaps in mathematics, where White and Asian students outperform Black and Latinx students across a variety of mathematics assessments. Research demonstrates that students' beliefs about mathematics exert considerable influence on their performance in the subject: students with negative beliefs about math tend to perform significantly worse in mathematics than students with positive math beliefs. The present research investigated whether students' perceptions of same-ethnic peers in their math classrooms serves a protective role for the math achievement of students with negative beliefs about the subject. The findings show that students with more negative beliefs about mathematics (i.e. high anxiety, low belonging, low importance, and low perceived competence) receive significantly poorer math grades than students with positive math attitudes. Moreover, perceived same-ethnic

representation in math class had an unexpected moderating effect in the relationship between students' beliefs about math and their actual achievement. When African American students reported they did not belong in math, were not competent in the subject, or had a high level of math anxiety, their math grades worsened when they also perceived there to be a high proportion of same-ethnic peers in their math course. The findings suggest researchers should take a more nuanced approach to exploring the protective function of perceived racial/ethnic representation.

The thesis of Piper Harris is approved.

Connie L. Kasari

Rashmita S. Mistry

Sandra H Graham, Committee Chair

University of California, Los Angeles

2022

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Introduction

There exist considerable achievement gaps in mathematics across all grade levels, where White and Asian students significantly outperform Black and Latinx students on national mathematics assessments and are far more likely to be considered proficient or advanced in mathematics (NSF, 2014a; 2014b; 2014c; National Assessment of Educational Progress, 2017). These achievement gaps are also reflected at the classroom-level: studies frequently show the performance of Black and Latinx students in their math classrooms falls behind that of their White and Asian peers (Barbieri & Miller-Cotto, 2021; Else-Quest et al., 2013; Riegel-Crumb & Grodsky, 2010). Mathematics performance, specifically in Algebra 1, has important implications for students' development and life outcomes. Success in mathematics can determine whether students pursue higher-level math courses, which in turn impacts high school completion, college admittance, and their likelihood of pursuing a career in science, technology, engineering, and mathematics (STEM) (Long et al., 2012; Neild, 2009). Considering that there are no biological differences between the racial/ethnic groups that would account for such stark achievement differences in mathematics (Spekle, 2005), achievement gaps in math are not attributable to inherent aptitude or competency, but rather are likely the result of psychological and environmental factors that encourage some students' success in mathematics while hindering others'. Abundant research suggests that the beliefs students hold about mathematics contribute to achievement differences in the subject (Else-Quest et al., 2013; Evans et al., 2011; Herges et al., 2017; Ing & Nylund-Gibson, 2017; Zhang et al., 2019).

Research suggests that the beliefs students hold about a given subject have significant implications for their performance and willingness to engage (Eccles, 2005; Wigfield & Eccles, 1990; Wigfield & Eccles, 2002; Wigfield et al., 2009). Numerous studies have demonstrated that

students who hold negative beliefs about mathematics, such as believing they are not skilled at math, tend to have worse achievement in the subject than their peers with more positive perceptions (e.g. Else-Quest et al., 2013; Evans et al., 2011; Herges et al., 2017; Ing & Nylund-Gibson, 2017; Zhang et al., 2019). Considering the impact that students' attitudes toward math can have on their achievement, it is imperative to explore protective factors that can buffer against the effect of negative math beliefs on performance.

Math classroom racial/ethnic demographics may play a critical role in shaping students' beliefs about mathematics, and consequently their performance in the subject. Research has shown that students hold more positive attitudes about math when they perceive a high proportion of same-ethnic peers in their math classes (Graham & Morales-Chicas, 2015). However, the predictive utility of math classroom perceived racial/ethnic representation on performance in math has not been thoroughly explored. Nearly all studies that explore the relationship between racial/ethnic representation, math attitudes, and achievement focus on school-level demographics rather than classroom-level. Additionally, no studies to date have examined the interactive effects between math attitudes and perceived math class racial/ethnic representation in predicting math performance. The purpose of the present study is to explore how 9th grade students' beliefs about mathematics shape their achievement in the subject, and whether this relationship is influenced by the proportion of same-ethnic peers they believe to be in their math classroom. This research is imperative for understanding the factors that contribute to achievement differences in mathematics between racial/ethnic groups, as well as identifying a protective factor that may increase underrepresented individuals' engagement with and achievement in mathematics.

Background Literature

Abundant research has found math attitudes to be a significant predictor of achievement in math: when students have more negative beliefs about math, they are less likely to succeed in and engage with mathematics (Else-Quest et al., 2013; Evans et al., 2011; Eccles & Wigfield, 2002; Herges et al., 2017). There are myriad beliefs individuals can hold about mathematics, such as how closely one identifies math with their self-concept, or how well they expect to do on mathematics tasks. Research has found that students who regard mathematics as valuable or perceive themselves as skilled in the subject tend to display more persistence in the subject, select more advanced math courses, and receive higher grades in mathematics compared to students who do not perceive math to be valuable or think they are not competent (Else-Quest et al., 2013; Jiang et al., 2020). Similarly, the extent to which students feel like they belong in math can have significant consequences for their interest, engagement, and performance in the subject (Master et al., 2016). For example, when students feel like they belong in math contexts, they exhibit greater learning in algebra (Barbieri & Miller-Cotto, 2021). The level of anxiety students feel toward mathematical tasks can also have a considerable influence on their math performance (Ma, 1999; Meece et al., 1990; Zhang et al., 2019). Abundant literature shows feelings of math anxiety can impede students' ability to succeed and perform well in math (Ashkraft & Krause, 2007; Carey et al., 2016; Erturan & Jansen, 2015; Miller & Bischel, 2004). While the relationship between math attitudes and performance is well documented, there is little research exploring how classroom demographics might relate to and interact with the role of students' beliefs about math in predicting achievement.

Additional research is also needed to examine racial/ethnic differences in math attitudes, as there is conflicting evidence in the current literature regarding whether students' race/ethnicity influences the beliefs they hold about mathematics. Else-Quest and colleagues (2013) did not find there to be a significant effect of ethnicity on how much students value math or expect to succeed in the subject. Conversely, Graham and Morales-Chicas (2015) found that White students perceive math to be less valuable than African American, Latinx, and Asian students, but did not find racial/ethnic differences in the extent to which students feel competent or able to succeed in math. Similarly, a study by Barbieri & Miller-Cotto (2012) revealed that Latinx and Black students feel a significantly lower sense of belonging to mathematics than their White and Asian peers, but Graham and Morales-Chicas (2015) did not find students' race/ethnicity to significantly impact their feelings of belonging in math. Considering the mixed findings regarding racial/ethnic differences in students' math attitudes, it is imperative to further research this topic as such differences may contribute to the achievement gap in mathematics between students of different races/ethnicities.

Another demographic factor that can influence the beliefs students hold about mathematics is their gender. Research shows that females often hold more negative attitudes toward mathematics than males (Else-Quest et al., 2013; Evans et al., 2011; Fredericks & Eccles, 2002; Graham & Morales-Chicas, 2015; Mata et al., 2012). Numerous studies, some with multi-ethnic samples, have found that boys perceive math as more important (Else-Quest et al., 2013; Fredricks & Eccles, 2002), believe they have higher competence in math (Evans et al., 2011; Else-Quest et al., 2013; Fredricks & Eccles, 2002), feel a greater sense of belonging in math (Graham & Morales-Chicas, 2015), and have less anxiety towards math than girls (Graham & Morales-Chicas, 2015; Huang et al., 2019). Finally, the math course students are enrolled in may

also influence students' attitudes toward mathematics. Graham and Morales-Chicas (2015) found that 9th grade students enrolled in more advanced math courses, such as Algebra 2 or Geometry, felt a greater sense of belonging to math and regarded math as more valuable than their peers in Algebra 1.

Perceived Racial/Ethnic Representation in Math

Racial/ethnic representation within educational contexts has important implications for students' academic experiences. Research suggests that when students perceive more same-ethnic peers at school, they have greater feelings of belonging (Benner & Graham, 2009; Fuller-Rowell & Doan, 2010), or in other words, they feel a greater sense of inclusion, acceptance, and support within the school environment (Goodenow & Grady, 1993). Feelings of belonging are in turn linked with a number of academic outcomes, including students' expectancies for success, effort, and perceived value of academic tasks (Goodenow & Grady, 1993; Gillen-O'Neel & Fuligni, 2013). Having peers of the same race/ethnicity has also been linked with perceptions of discrimination, such that perceiving more same-ethnic peers at school has been associated with lower feelings of being discriminated against (Benner & Graham, 2013; Seaton & Yip, 2009). Such findings suggest that perceptions of same-ethnic peers at school can be particularly beneficial for students from Black and Latinx backgrounds, as these students tend to have more challenging school experiences, such as being victims of discrimination, and also experience a more difficult transition to high school (Benner & Graham, 2009; Benner & Graham, 2013). In this sense, perceiving many same-ethnic peers in school contexts can serve a protective function for racial/ethnic minorities against disadvantageous educational outcomes.

Perceiving peers of the same race/ethnicity at school also appears to benefit students' math outcomes specifically. Conway-Turner and colleagues (2020) demonstrated that as the

percent of same-ethnic peers at school increased, students' math scores increased as well. However, less is known about how students' perceptions of racial/ethnic demographics at the classroom-level influence their outcomes in mathematics. It is critical to further examine perceived representation within math classrooms, as they are often contexts where students struggle to feel a sense of belonging due to the individualistic and competitive nature characteristic of traditional math courses (Barbieri & Miller-Cotto, 2021). Existing research suggests perceiving peers of the same race/ethnicity as oneself has benefits for students' math outcomes by improving their beliefs about math. Graham and Morales-Chicas (2015) found that when students perceive a high percentage of students in their math class who they believe to be the same race/ethnicity as themselves, these students exhibited more positive attitudes toward math, such as feeling a greater sense of belonging in math or perceiving themselves to be more proficient in the subject. Because the perception of same-ethnic peers in one's math class is significantly associated with math attitudes, which are significantly linked to math performance, it is possible that the perception of same-ethnic peers in math classes can significantly influence the relationship between math attitudes and achievement and serve as a protective factor for students who have negative beliefs about math. Research has not yet explored this relationship, indicating the necessity of investigating the relationship between math attitudes, achievement, and perceived same-ethnic representation in math classes.

Current Study

The present research sought to understand factors that may contribute to achievement gaps in mathematics by exploring how students' beliefs about and perceived racial/ethnic representation in math class impact their performance in the subject, and whether racial/ethnic differences exist in students' attitudes toward math. To achieve this goal, the current study

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examined whether ethnically diverse 9th grade students' attitudes toward math predict their achievement in mathematics (as measured by their math grades), and whether this relationship is moderated by perceiving a high proportion of same-ethnic peers in their math class. This study also explored whether students' beliefs about mathematics vary as a function of their racial/ethnic identification. The research questions are as follows: 1) Do students' beliefs about mathematics vary based on their racial/ethnic group, gender, and math course enrollment? 2) How do students' beliefs about mathematics and perceived same-ethnic representation in mathematics class influence their academic performance in the subject? 3) Does perceiving a high proportion of same-ethnic peers in math class buffer against the effects of negative math attitudes on math achievement? There were no specific hypotheses regarding differences in students' beliefs about mathematics due to race/ethnicity, given the inconsistent findings in prior research. Students in advanced math courses were hypothesized to report higher feelings of belonging in math and perceive math as more important than students in Algebra 1, but no specific predictions were made regarding differences in perceived math competence or math anxiety, in line with the findings of Graham and Morales-Chicas (2015). Females were expected to have more negative beliefs about math than males (i.e. higher math anxiety, lower perceived math competence, lower math belonging, and lower math importance). Students' beliefs about mathematics were hypothesized to significantly predict their performance, where students who report high math anxiety, low math belonging, low perceived math competence, and low math importance will receive lower grades than students with more positive beliefs about math. Perceived same-ethnic representation in math class was expected to positively predict performance, where students who believe there is a high proportion of same-ethnic peers in math class receive higher math grades than students who perceive a low proportion of same-ethnic

peers. Finally, math class perceived same-ethnic representation was expected to moderate the relationship between math attitudes and performance, such that perceiving a high proportion of same-ethnic peers will reduce the effects of negative math attitudes (i.e. high anxiety, low belonging, low perceived competence, low importance) on performance.

This study was conducted with 9th grade students for several reasons. Research suggests that students' beliefs about mathematics change most in the period between 7th to 10th grade, after which attitudes become more entrenched and difficult to change (Ing & Nylund-Gibson, 2017). Moreover, students' beliefs about mathematics tend to become more negative as they get older (Fredricks & Eccles, 2002; Mata et al., 2012), particularly during the transition from middle to high school (Ing & Nylund-Gibson, 2017). Thus, it is important for this research to target 9th grade students in the hopes of identifying factors that may have beneficial effects on their math beliefs, such as classroom racial/ethnic representation, while attitudes are still malleable. The findings of this research can shed light on the factors that contribute to the disproportionate underrepresentation of females and people of color in the STEM field by exploring whether classroom demographics contribute to mathematics performance. Understanding how classroom processes influence students' success in math is critical, considering that performance in math is a gateway to high school completion, college admittance, and participation in STEM careers (Chen, 2009; Neild, 2009; Long et al., 2012).

Methods

Participants

This study utilized data from the UCLA High School Diversity Project (UCLA HSDP), a longitudinal, large-scale study that surveyed 5,996 students from urban, ethnically diverse California high schools (51.6% female). Based on self report, the racial/ethnic breakdown of the

initial sample was 33% Latinx, 24% White, 15% Asian, 11% African American, with the remaining 17% of participants identifying as Middle Eastern, Pacific Islander, American Indian, Filipino, South Asian, multiethnic/biracial, or other. Approximately 3579 participants completed the survey in 9th grade (M_{age}=14.8 yrs, SD=0.57). Only students who fell into the four major pan-ethnic groups (e.g. Latinx, White, Asian, African American) and were enrolled in Algebra 1, Algebra 2, or Geometry with complete data were included in the sample for this research (N=2726, 53.7% female). According to self-reports from participants, the racial/ethnic composition of this sample was 40% Latinx, 29% White, 18% Asian, and 13% African American.

Procedure

Three consecutive yearly cohorts of students were recruited for this study in the spring semester of 9th grade (N=3579). The study was administered using electronic surveys on lab-issued Apple iPads and took approximately 1 hour to complete. Two graduate students handed out the iPads and instructions and they circulated around the classroom to answer questions as students completed the survey on their own. Written parent consent was obtained for all participants. All participants signed assent forms prior to completing the surveys, which included the purpose of the study, potential risks and benefits, and guidelines for participation. Following completion of the survey, participants were provided with a $10 cash honorarium.

Measures

Math Attitudes

Students' attitudes towards math were measured by 18 items presented on 5-point Likert scales ranging from 1 = *no way!* To 5 = *for sure yes!*. Participants indicated their level of agreement with each question while considering their current math class. Based on an earlier

factor analysis with a subset of the current sample (Graham &Morales-Chicas, 2015). four factors comprising distinct math attitudes were identified. The first factor, labeled *Perceived Math Competence* included four items (e.g. "I'm good at math" and "I solve math problems without too much difficulty") ($\alpha = 0.75$). The second factor, which included six items (e.g. "I have good friends in my math class" and "I feel respected in math class") was labeled *Math Belonging* ($\alpha = 0.80$). The third factor, labeled *Math Importance*, was comprised of five items (e.g. "High school math is helpful no matter what job I have" and "I want to take as much math as I can when I'm in school") ($\alpha = 0.81$). Finally, the fourth factor consisted of three survey items (e.g. "Studying math makes me feel nervous" and "I feel stressed out during math class") and was labeled *Math Anxiety* ($\alpha = 0.69$).

Math Achievement

Students' math achievement was measured by averaging students' Fall and Spring grades in their 9th grade math class on a scale from 0 (receiving an F in the class) to 4 (receiving an A in the class). Grades were obtained using school record data.

Math Level

Students self-reported the name of their 9th grade math class. According to these responses, 38% of students were enrolled in Algebra or Algebra 1, 37% were enrolled in Geometry, 20% were enrolled in Algebra 2 or Advanced Algebra, and the remaining 5% were enrolled in courses such as Pre-Algebra, Trigonometry, Calculus, etc. Two levels of math were then generated based on the responses, where students enrolled in *Algebra 1* (*n*=1101) were categorized as such, and students enrolled in Algebra 2 or Geometry were classified as *Advanced Math* (*n*=1656). The remaining 5% of students enrolled in other math courses (e.g. calculus, pre-algebra) were excluded from analyses, as responses could not be reliably classified or

categorized and the number of participants enrolled in other math courses was not large enough to allow for meaningful comparison.

Results

Descriptive Analysis

A 4 (race/ethnicity) x 2 (gender) x 2 (math level) factorial ANOVA was conducted on math grades and each math attitude. Means and standard deviations for math grades and each math attitude as a function of gender, race/ethnicity, and math level are shown in Table 1. Because of the large number of analyses testing main effects and interactions, only findings significant at $p<.01$ are reported. There were main effects of gender for all four attitudes toward math, such that females reported lower belonging, lower perceived competence, less importance, and higher anxiety than males: $F(1, 2720) = 11.12, 9.87, 14.66, 19.44$ respectively for belonging, competence, importance, and anxiety (all ps $<.01$). Moreover, there was a main effect of gender for math grades, such that females obtained higher grades in math than did males: $F(1, 2720) = 17.56, p<.001$). There were also significant main effects of math level for math achievement: $F(1, 2720) = 100.06$, math belonging: $F(1, 2720) = 7.22$, perceived math competence: $F(1, 2720) = 7.35$, and math importance $F(1, 2720) = 33.07$ (all ps $<.01$). Students enrolled in advanced math courses received higher grades in math, expressed greater feelings of belonging in their math class, perceived themselves as more competent in math, and regarded math as more important than did students enrolled in Algebra 1.

Main effects of race/ethnicity for math achievement also emerged: $F(1, 2720) = 47.04$, $p<.001$. White and Asian students significantly outperformed African American and Latinx students in their math grades. There were no statistically significant differences between the math grades of White and Asian students, or African American and Latinx students. There were

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also main effects of race/ethnicity for math belonging: $F(1, 2720) = 4.22$ and math importance: $F(1, 2720) = 18.92$ (both $ps <.01$). However, Tukey post-hoc analyses did not reveal significant differences in math belonging between any two racial/ethnic groups. Regarding racial/ethnic differences in students' perceived importance of math, White students ($M=3.03$) regarded math as less important than African American ($M=3.26$), Asian ($M=3.26$), or Latinx students ($M=3.34$) (all $ps<.01$). African American, Asian, and Latinx students did not significantly differ from one another in their perceptions of math importance. There were no 2- or 3-way interactions involving gender, math level, or race/ethnicity and any math attitudes or students' math grades.

Table 3 shows correlations between the four math attitude measures, perceived same-ethnic representation in math, and math achievement, combined across gender, racial/ethnic groups, and math level. Math belonging, importance, and perceived competence were all positively related to one another, and each was negatively associated with anxiety, such that the more students felt like they belonged in their math class, perceived themselves as competent in math, or regarded math as important, the less math anxiety they felt. Math class perceived same-ethnic representation was positively correlated with belonging: as students perceived more same-ethnic peers in their math class, their feelings of belonging increased. Math grades were positively correlated with math belonging, perceived competence, and importance, and negatively correlated with math anxiety. In other words, having more positive attitudes toward (i.e. greater belonging, higher perceived competence, higher importance, and lower anxiety) was associated with higher math grades. Math grades and math perceived same-ethnic representation were not significantly related to one another.

Multiple Linear Regression Analysis

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Multiple linear regression analysis was used to examine whether students' attitudes toward math (i.e. belonging, importance, anxiety, and perceived competence) predicted their math grades, and whether this relationship was moderated by participant race/ethnicity and the proportion of same-ethnic peers the students perceived in their math classes. Assumptions of multiple linear regression were met, as residuals were normally distributed and there was no evidence indicating heteroscedasticity. Participants' gender, socioeconomic status (measured by parent education level), and math level were controlled by including them as covariates. Four models were tested to examine whether math grades varied as a function of each math attitude and their race/ethnicity and math class perceived same-ethnic representation. The findings for math anxiety and perceived math competence are displayed in Table 4. The findings for math belonging and math importance are displayed in Table 5.

There was a significant main effect of math anxiety on math grades: students with high feelings of anxiety towards math received lower grades in math than their peers with low anxiety (B=-0.34, p<.001). There was also a main effect of math class perceived same-ethnic representation on math grades, such that perceiving a greater proportion of same-ethnic peers in math class was associated with higher math grades (B=-0.05, p<.01). A significant 2-way interaction emerged between math anxiety and math perceived same-ethnic representation: contrary to the buffering hypothesis, having high math anxiety was linked with lower mathematics grades, especially for students who perceived a *high proportion* of same-ethnic peers in their math class (B=-0.045, p<.01; see Figure 1).

The second regression model tested whether students' perceived competence predicted their performance in math, and whether their perceived same-ethnic representation in math influenced this relationship. There were main effects of math competence and perceived same-

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ethnic math class representation: $B=0.55$ and $B=0.16$ for math competence and perceived same-ethnic representation respectively (both $ps <.01$). As perceived competence and the proportion same-ethnic peers increased, students received higher math grades. There was a significant 2-way interaction between math competence and perceived same-ethnic representation: Again, contrary to my hypothesis, students who did not believe themselves to be competent in math were more likely to receive lower math grades, especially when they felt there was a *high proportion* of same-ethnic peers in their math classroom ($B=0.04$, $p<.01$; see Figure 2).

The third model tested the interaction between math belonging and math class perceived same-ethnic representation in predicting students' math achievement. There was a main effect of math belonging on math grades: students who reported low feelings of inclusion and acceptance within their math class received poor grades compared to their peers who did feel a sense of belonging ($B=0.25$, $p<.01$). There was also a main effect of math perceived same-ethnic representation, where students who perceived a *high proportion* of same-ethnic peers in math were more likely to receive lower grades ($B=-0.16$, $p<.01$). A significant 2-way interaction between math belonging and math class perceived same-ethnic representation was obtained ($B=0.06$, $p<.01$). Students with low feelings of belonging who perceived a large proportion of same-ethnic peers in math class had lower math grades than students with low math belonging who perceived a small proportion of same-ethnic peers (see Figure 3).

The fourth model examined the relationships between math importance, perceived same-ethnic representation in math, and math achievement. There was a significant main effect of math importance, such that students who regarded math as being valuable had a greater likelihood of receiving high math grades than their peers who did not feel that math is important ($B=0.31$, $p<.001$). There was no significant main effect of math perceived same-ethnic

representation or a significant 2-way interaction between math importance and math perceived same-ethnic representation in this model.

To better understand the relationships between math attitudes, perceived same-ethnic representation in math, and math achievement, additional analyses were run to examine whether any covariates played a significant role in this relationship. Four multiple linear regression analyses were conducted to explore whether the relationship between each math attitude and math achievement varied as a function of students' race/ethnicity. Racial/ethnic groups were dummy coded before inclusion in analyses, with White students serving as the reference group to which other racial/ethnic groups are compared. There was a significant 2-way interaction between math anxiety and Latinx/White students (B=-0.16, p<.01). Latinx students with high math anxiety received significantly lower math grades than their white peers with high math anxiety (see Figure 4). A similar 2-way interaction emerged between perceived math competence and Latinx/White students (B=0.304, p<.001). Latinx students who did not believe they were competent or skilled in math were more likely to receive poor math grades than White students with the same beliefs (see Figure 5). Furthermore, there was a significant 2-way interaction between math importance and Latinx/White students (B=0.25, p<.001). Latinx students' math grades were more likely to suffer as a function of perceiving math as unimportant compared to White students with similar perceptions (see Figure 6). No significant 2-way interactions were found between math anxiety, perceived math competence or math importance and any of the other racial/ethnic groups (i.e. Black and Asian students). There were also no significant 2-way interactions between math belonging and any dichotomized racial/ethnic group.

There was a significant 2-way interaction between perceived same-ethnic representation in math and African American/White students (B=-0.13, p<.01). African American students who

perceived a large proportion of same-ethnic peers in their math classroom received lower grades in math than their white peers who perceived a high proportion of same-ethnic peers (see Figure 7).

3-way interactions were also explored between each math attitude, math class perceived same-ethnic representation, and students' race/ethnicity. A significant 3-way interaction emerged between math anxiety, math class perceived same-ethnic representation, and African American/White students (B=-0.14, $p<.01$). African American students who had high math anxiety and perceived a high proportion of same-ethnic peers in their math class received lower math grades than White students with the same anxiety and perception of same-ethnic peers (see Figure 8). No other 2- or 3- way interactions were found to be significant between students' math anxiety, perceived same-ethnic math representation, and race/ethnicity.

Discussion

The findings of this research shed light on the beliefs students' hold about mathematics, how these beliefs shape students' achievement in the subject, and whether students' attitudes toward and performance in mathematics vary based on their gender, race/ethnicity, and math level. Moreover, this study investigated the potential protective functions of perceiving same-ethnic peers in math class for buffering against the effect of negative math attitudes on achievement. The results of this study show that females receive significantly higher math grades than their male peers, despite having more negative beliefs about mathematics across all attitudes measured in this study. Specifically, females tended to have greater feelings of anxiety around math, exhibit lower feelings of math belonging, regard themselves as having low competence in math, and perceive math as being less valuable than did the males. This is consistent with the current literature on gender differences in math attitudes and achievement, which shows that

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females receive higher grades in mathematics courses and assessments than their male counterparts, but that they also exhibit more negative beliefs about mathematics than do males (Else-Quest et al., 2013; Evans et al., 2011; Fredericks & Eccles, 2002; Graham & Morales-Chicas, 2015).

There were also significant disparities in the mathematics attitudes and performance of students in different math course levels. Students enrolled in Algebra 1 received poorer grades in mathematics and reported lower feelings of belonging, perceived competence, and importance compared to students enrolled in Geometry or Algebra 2, also classified as *Advanced Math* in this study. Prior research has shown that students in advanced math courses have more positive beliefs about mathematics than students in lower level courses (Graham & Morales-Chicas, 2015), however, the present study extends this body of research by showing that students in more advanced math courses also perceive themselves to have greater competencies in math than their counterparts in lower math courses. Considering that students in advanced math courses received higher math grades than their peers in Algebra 1, this finding is likely attributable to the positive association between students' beliefs about their competencies and their actual performance (Else-Quest et al., 2013; Jiang et al., 2020).

The present study revealed racial/ethnic differences in mathematics achievement: White and Asian students received significantly higher grades in mathematics than African American students and Latinx students. Data from NSF (2019) support this finding, demonstrating that White and Asian high school students receive higher grades in mathematics courses compared to Black and Latinx students. Abundant research shows similar patterns of achievement in mathematics across racial/ethnic groups (e.g. Barbieri & Miller-Cotto; Else-Quest et al., 2013; Riegel-Crumb & Grodsky, 2010). While differences in math performance across racial/ethnic

boundaries are well documented, the results of this research provided new insights into whether students' race/ethnicity also shapes their perceptions of mathematics. White students regarded math as being less valuable than Asian, Black, and Latinx students, consistent with the findings from Graham & Morales-Chicas (2015) conducted on a subset of data used in the current study. However, this finding conflicts with that of Else-Quest and colleagues (2013), which did not show that students of different racial/ethnic groups place different levels of value on math. No racial/ethnic differences emerged in the other mathematics attitudes tested in this study, suggesting that students from different racial/ethnic groups possess similar feelings of anxiety, perceived competence, and belonging in mathematics. These findings align with research showing that students' race/ethnicity does not influence their perceived competence or anxiety in mathematics (Else-Quest et al., 2013; Graham & Morales-Chicas, 2015), but contradicts research from Barbieri & Miller-Cotto (2021) which contends that African American and Latinx students feel less like they belong in mathematics than their White and Asian peers. One explanation for the inconsistent findings regarding racial/ethnic differences in mathematics beliefs are the measurements used to assess math attitudes, as studies use diverse scales and survey items to measure the same constructs. Additional research should consider exploring which measurements are used to capture the same math attitudes, and whether the form of measurement influences whether researchers find racial/ethnic differences in students' beliefs about mathematics.

Results of this study highlight the significance of students' beliefs about mathematics for their achievement in the subject. Each math attitude was significantly associated with achievement, in that holding more negative beliefs about mathematics (i.e. higher math anxiety, lower math belonging, lower perceived importance of math, and lower perceived competence)

was related to decreased achievement in the subject. This finding is in line with a large body of research which demonstrates that students who hold unfavorable perceptions of mathematics exhibit poorer performance compared to students who regard math in a more positive light (Else-Quest et al., 2013; Evans et al., 2011; Eccles & Wigfield, 2002; Herges et al., 2017).

Perceived Same-Ethnic Representation: Risk or Protective Factor?

The present research produced interesting and unexpected results regarding the moderating function of math class perceived same-ethnic representation in the relationship between students' beliefs about math and their actual performance. I expected students' perceptions of math class same-ethnic representation to minimize the effects of negative math attitudes on achievement, however, the opposite pattern was obtained for African American students compared to White students. When African American students reported they did not belong in math, were not competent in the subject, or had a high level of math anxiety, their math grades worsened when they also perceived there to be a high proportion of same-ethnic peers in their math course. Such results suggest that the effects of classroom same-ethnic representation for students' academic outcomes are more nuanced than labeling it as a "protective" factor. Other contextual factors may influence the relationship between math beliefs, perceived same-ethnic representation in math class, and achievement.

Societal stereotypes about the mathematics abilities of students from different racial/ethnic groups may lend understanding to the complex relationship between math class same-ethnic representation and math achievement. Empirical evidence has documented stereotypes that insinuate African American and Latinx students are less skilled and competent in math compared to white and Asian students (Evans et al., 2011; Ghavami & Peplau, 2012). These negative stereotypes about math competency are often explicitly and implicitly endorsed

by students across adolescence (Cvencek et al., 2011; Muzzatti & Agnoli, 2007; Steffens et al., 2010). For example, Evans and colleagues (2011) found that Black adolescents in 7th and 8th grade endorse the idea that White students are more competent and skilled in math than Black students. Research has shown that when individuals identify with a group being negatively stereotyped and are placed in contexts where the stereotype is salient, such as math classrooms, they experience a self-evaluative threat which can consequently impair their performance on academic tasks (Spencer et al., 2016; Steele & Aronson 1995; Steffens et al., 2010; Plante et al., 2013). Perceiving a large proportion of same-ethnic peers in math class may reinforce stereotypes about inferior mathematics ability for students from racial/ethnic groups that are historically underrepresented in STEM, especially when considering that African American students in this study were significantly more likely to be enrolled in lower level math courses than their White and Asian peers ($F(1, 2720) = 47.22$, p<.001). Moreover, having more same-ethnic peers may exacerbate the risk of adverse math beliefs on achievement for students in less competitive or rigorous math courses.

Despite participants being enrolled in schools selected due to their racial/ethnic diversity, segregation was observed at the classroom level. African American and Latinx students were significantly more likely to be enrolled in Algebra 1 compared to White and Asian students. Similarly, students' race/ethnicity influenced their likelihood of perceiving a high proportion of same-ethnic peers in their math course: $F(1, 2720) = 12.48$, p<.001. Table 6 displays mean differences in perceived proportions of same-ethnic peers in math class across racial/ethnic groups and math level. African American and Latinx students reported greater same-ethnic representation in their Algebra 1 class compared to advanced math courses (Algebra 2 or Geometry), while Asian and White students were more likely to report seeing a high proportion

of same-ethnic peers in advanced math classes compared to Algebra 1. Such findings suggest that the level of math students are enrolled in is not independent of the proportion of same-ethnic peers they perceive in their math class. Thus, African American and Latinx students enrolled in less advanced math courses with many peers of the same race/ethnicity may be especially aware of the stereotype that students of their racial/ethnic background are not as skilled in mathematics as other students, which can in turn impede their performance in math courses. Future research should explore whether students' endorsement of the stereotype that some racial/ethnic groups are more advanced than others influences the relationship between their math beliefs, perceived math classroom same-ethnic representation, and math achievement. Research should also test whether such stereotype endorsement differs based on students' race/ethnicity, math level, and classroom racial/ethnic composition.

Differential expectations and treatment from teachers may also explain the nuanced relationship between same-ethnic representation in math and math achievement. Teachers' prejudicial attitudes about racial/ethnic groups often impact students' achievement via the differential expectations they hold of their students (Van den Bergh et al., 2010), which have critical implications for students' academic engagement and success (Urhahne et al., 2011; Valdes et al., 2021). Research suggests that teachers often have greater expectations of students who are high achievers in mathematics compared to lower achieving students (Hinnant et al., 2009). Moreover, literature has shown that teachers have higher expectations of White and Asian students compared to African American and Latinx students with similar achievement levels, especially in ethnically diverse classrooms where students perceive biased teacher expectations (McKown & Weinstein, 2008).

Given that African American and Latinx students historically underperform in mathematics compared to White and Asian students (Barbieri & Miller-Cotto, 2021; Else-Quest et al., 2013; Riegel-Crumb & Grodsky, 2010), these students may be subject to negative expectations from their teachers, especially if they are in less advanced math classrooms with a large percentage of same-ethnic peers. These negative perceptions from teachers can consequently have detrimental effects for these students' math achievement. Research has shown that students from negatively stereotyped racial/ethnic groups are especially susceptible to negative expectancies from their teachers (Jussim et al. 1996; McKown & Weinstein, 2002). For example, studies have demonstrated that African American students are particularly vulnerable to the effects of negative expectations from their teachers (McKown & Weinstein 2002) and that teacher expectations have a stronger link on student performance for African American students than White students (Jussim et al., 1996). Similarly, McKown & Weinstein (2008) demonstrated that in classrooms where students' perceive biased treatment from teachers, teachers' differential expectations of students substantially contributed to the "ethnic achievement gap" where Black and Latinx students underperformed compared to White and Asian students. Future studies should explore the role of teachers' implicit stereotypes about and differential expectations of their students in shaping the relationship between students' math beliefs, perceived same-ethnic representation in math class, and math achievement.

This study makes a number of significant contributions to the literature on math attitudes and achievement. First, this research sheds light on racial/ethnic differences in the attitudes students' hold toward mathematics, since prior research has demonstrated inconsistent findings on this issue. Better understanding of racial/ethnic differences in math attitudes is important for addressing the factors that contribute to engagement and achievement disparities for

underrepresented racial/ethnic minorities in STEM. The present study also investigated the implications that perception of same-ethnic peers in math class has for achievement in mathematics and produced novel findings which suggest researchers should take a more nuanced approach to understanding the effects of same-ethnic peers for students' academic and mathematics outcomes. Through exploring the role of math class perceived same-ethnic representation in shaping students' beliefs about and performance in mathematics, this study identifies an area for interventions and policies to target in endeavors to support diverse students' success in mathematics. Working towards increasing diversity and representation in mathematics ultimately helps advance social and economic equality for individuals from disadvantaged and marginalized backgrounds.

Limitations and Future Directions

The present study has several limitations. The questionnaire used to explore students' math attitudes in the present study was developed for the UCLA Diversity Project and included a relatively small number of survey items per each attitude. This may decrease the robustness and sizes of the effects. Future studies should consider using established measures of math attitudes that include a greater number of survey items capturing each belief toward mathematics. For example, a meta-analysis by Zhang and colleagues (2019) suggests that the most commonly used math anxiety scales were the MARS and AMAs. Using such scales in future research may produce more robust findings. Another limitation of this study is that math classroom racial/ethnic representation was measured using students' perceptions of the percentage of same-ethnic peers, which may differ from the actual racial/ethnic demographics of the classroom. Future research should consider using school enrollment data to calculate the actual percentage of students from each racial/ethnic group within math classrooms and examine whether this

influences students' perceptions of and achievement in mathematics. Research may also consider exploring whether there are differences in students' perceptions of same-ethnic peers in their math class and the actual percentage of same-ethnic peers to determine whether students' perceptions or the actual composition of classroom same-ethnic representation is more impactful for math outcomes.

Additional research is necessary to explore whether the findings of this study apply to other STEM courses or for students from racial/ethnic groups not included in the study. The present study explored the relationship between beliefs, achievement, and perceived same-ethnic representation within mathematics specifically. Considering that mathematics is only one aspect of STEM, more research is needed to explore whether similar findings are obtained in courses such as science or engineering, where there are also achievement differences between students of different racial/ethnic groups (NSF, 2014b; 2014c; NSF, 2016). Additionally, the present study did not explore the experiences and math outcomes of students from racial/ethnic backgrounds outside of the four major pan-ethnic groups. It is imperative for research to explore whether the findings of this study hold true for students from other racial/ethnic groups that also struggle with representation and achievement disparities in mathematics, such as Native Americans (NSF, 2014b; 2014c; NSF, 2016).

Table 1.

Means and standard deviations of each math attitude as a function of race/ethnicity, gender, and math level

Measure		Math Grade		Math Anxiety		Math Belonging		Math Competence		Math Importance	
		M		*M*		*M*		*M*		*M*	
		(SD)		*(SD)*		*(SD)*		*(SD)*		*(SD)*	
		Alg. I	Adv	Alg. I	Adv	Alg. I	Adv	Alg. I	Adv	Alg. I	Adv
African American	M	1.59	2.46	2.51	2.58	3.77	3.75	3.61	3.64	3.24	3.35
		(1.15)	(1.12)	(0.80)	(0.99)	(0.69)	(0.75)	(0.75)	(0.88)	(0.80)	(0.84)
	F	2.08	2.61	2.57	2.60	3.73	3.60	3.57	3.56	3.14	3.34
		(1.23)	(1.20)	(0.88)	(0.95)	(0.73)	(0.81)	(0.80)	(0.85)	(0.83)	(0.86)
Asian	M	2.53	2.96	2.58	2.58	3.56	3.69	3.36	3.63	3.19	3.46
		(1.21)	(0.99)	(0.66)	(0.78)	(0.43)	(0.61)	(0.68)	(0.67)	(0.67)	(0.77)
	F	2.86	3.29	2.60	2.76	3.55	3.61	3.48	3.50	3.12	3.28
		(1.10)	(0.87)	(0.82)	(0.76)	(0.78)	(0.67)	(0.81)	(0.69)	(0.83)	(0.83)
Latinx	M	1.91	2.52	2.51	2.52	3.71	3.85	3.52	3.71	3.28	3.59
		(1.27)	(1.16)	(0.80)	(0.82)	(0.62)	(0.59)	(0.71)	(0.76)	(0.78)	(0.86)
	F	2.18	2.53	2.87	2.82	3.59	3.71	3.33	3.48	3.14	3.35
		(1.22)	(1.19)	(0.95)	(0.88)	(0.72)	(0.70)	(0.84)	(0.79)	(0.84)	(0.80)
White	M	2.39	3.09	2.47	2.49	3.59	3.82	3.61	3.71	2.99	3.33
		(1.00)	(0.84)	(0.79)	(0.79)	(0.70)	(0.56)	(0.82)	(0.69)	(0.83)	(0.88)
	F	2.59	3.24	2.75	2.75	3.45	3.63	3.43	3.50	2.77	3.05
		(1.07)	(0.83)	(1.06)	(0.91)	(0.81)	(0.68)	(0.87)	(0.78)	(0.97)	(0.90)

Note: Alg I = Algebra 1, Adv = Advanced Level Math; M = Male, F = Female

Table 2.

Correlations between variables

Measure	1	2	3	4	5	6
1. Math Grades	-					
2. Math Perceived Same-Ethnic Representation	-.003	-				
3. Math Anxiety	-.347**	.016	-			
4. Math Belonging	.245**	.077**	-.508**	-		
5. Math Importance	.277**	.022	-.399**	.467**	-	
6. Math Competence	.461**	.024	-.547**	.536**	.502**	-

Note: * = p < .05, ** = p < .01, *** = p <.001

Table 3.

Regression Analyses Examining the Predictive Effects of Math Anxiety and Math Competence
and the Moderating Effects of Perceived Same-Ethnic Representation

		Model 1 (Anxiety)		Model 2 (Competence)	
		Math Grades (*N*=2726)		Math Grades (*N*=2726)	
		b	*SE*	*b*	*SE*
Intercept		2.95***	0.19	0.18	0.23
Parent Education		0.07***	0.02	0.08***	0.02
Math level (1=Advanced)		0.51***	0.05	0.44***	0.04
Ethnicity (0=White)					
	African American	-0.60***	0.07	-0.66***	0.07
	Asian	0.117	0.07	0.10	0.07
	Latinx	-0.38***	0.06	-0.38***	0.06
Sex (1= Female)		0.32***	0.04	0.35***	0.04
Math perceived same-ethnic representation (PSER)		0.12**	0.04	-0.16**	0.06
Math Anxiety		-0.34***	0.06	--	--
Math Competence		--	--	0.55**	0.06
PSER x Math Anxiety		-0.05**	0.02	--	--
PSER x Math Competence		--	--	0.04	0.02

*p<.05, **p<.01, ***p<.001.

Table 4.

Regression Analyses Examining the Predictive Effects of Math Belonging and Math Importance and the Moderating Effects of Perceived Same-Ethnic Representation

		Model 3 (Belonging)		Model 4 (Importance)	
		Math Grades		Math Grades	
		(*N*=2726)		(*N*=2726)	
		b	*SE*	*b*	*SE*
Intercept		1.19***	0.29	1.15***	0.22
Parent Education		0.09***	0.02	0.09***	0.02
Math level (1=Advanced)		0.49***	0.05	0.42***	0.05
Ethnicity (0=White)					
	African American	-0.63***	0.08	-0.68***	0.08
	Asian	0.12	0.08	0.016	0.08
	Latinx	-0.43***	0.06	-0.50***	0.06
Sex (1= Female)		0.27***	0.05	0.29***	0.05
Math perceived same-ethnic representation (PSER)		-0.22**	0.08	-0.07	0.06
Math Belonging		0.25**	0.08	--	--
Math Importance		--	--	0.31***	0.06
PSER x Math Belonging		0.06**	0.02	--	--
PSER x Math Importance		--	--	0.02	0.02

*p<.05, **p<.01, ***p<.001.

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Table 5.

Means and standard deviations of math class perceived same-ethnic representation as a function of race/ethnicity and math level

Measure	Perceived Same-Ethnic Representation in Math	
	M	
	(SD)	
	Alg. I	Adv
African American	3.03	2.74
	(0.11)	(0.18)
Asian	2.35	3.12
	(0.18)	(0.11)
Latinx	3.56	3.28
	(0.06)	(0.10)
White	3.25	3.74
	(0.10)	(0.10)

Note: Alg I = Algebra 1, Adv = Advanced Level Math; M = Male, F = Female
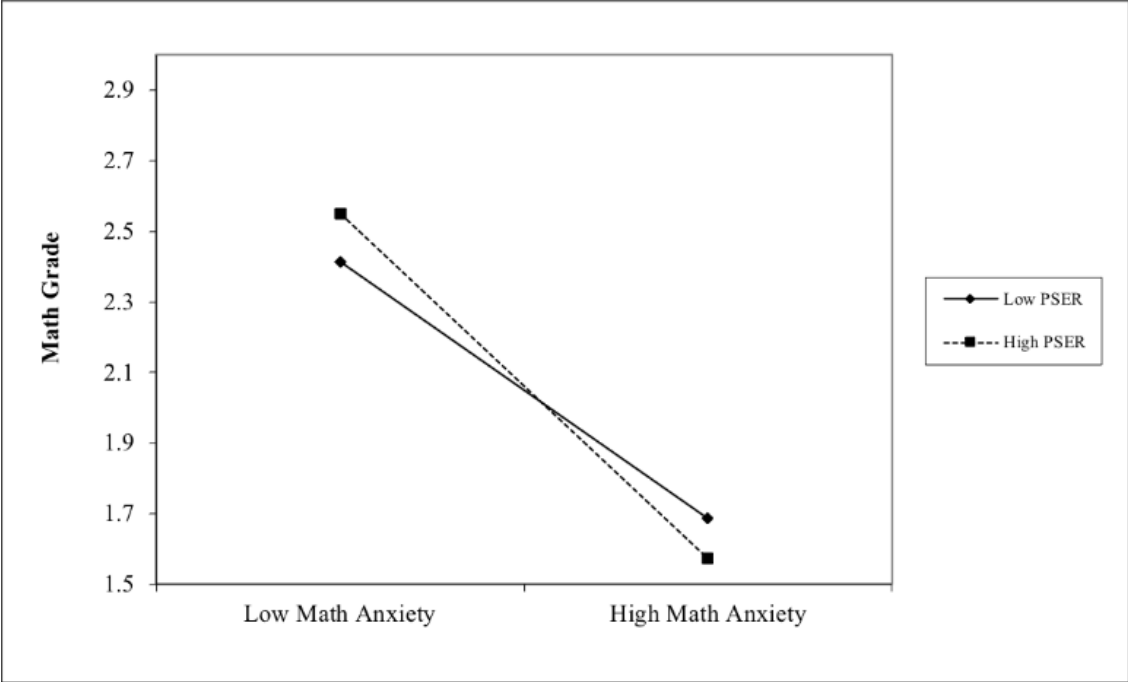
Figure 1. Two-way interaction between math anxiety and perceived same-ethnic math class representation for math performance
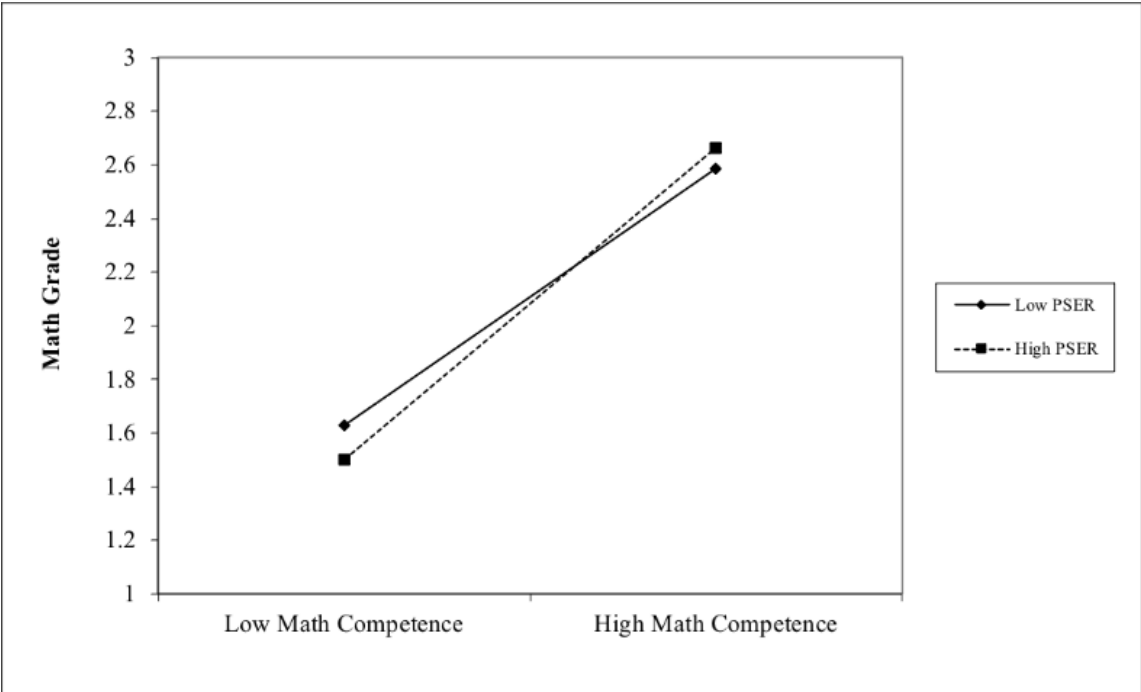

Figure 2. Two-way interaction between perceived math competence and perceived same-ethnic math class representation for math performance
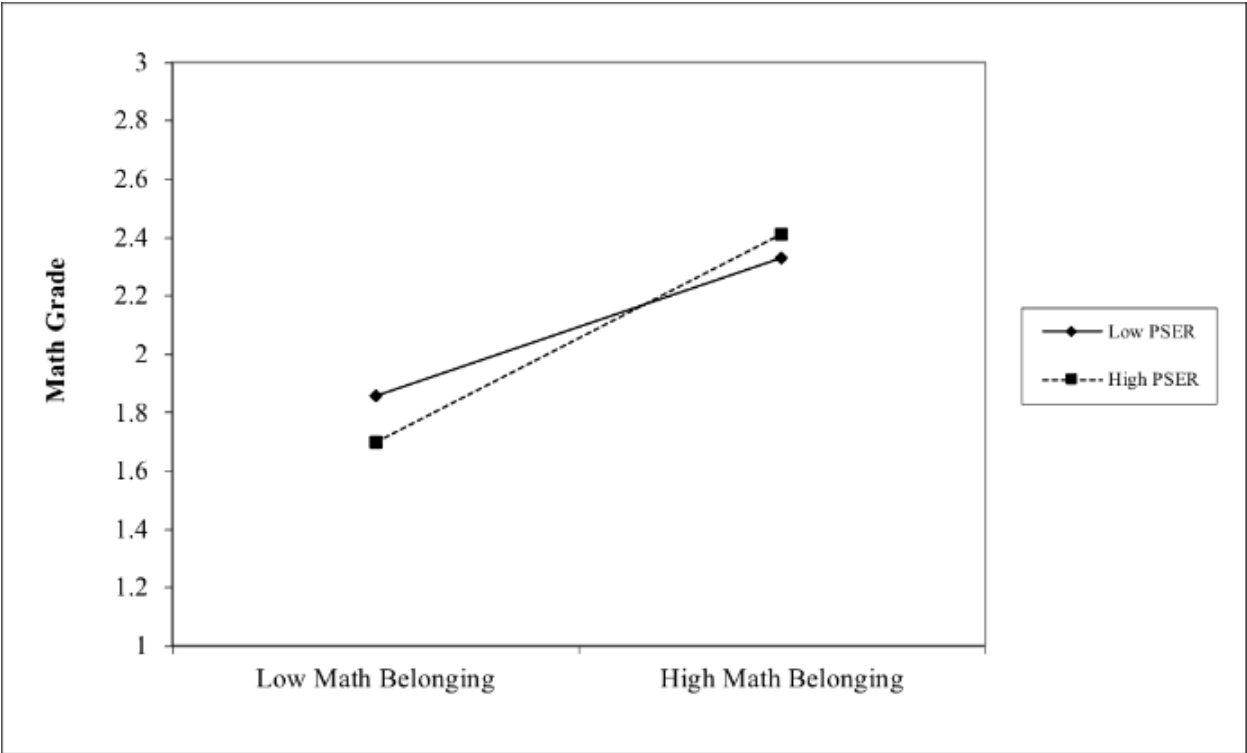
Figure 3. Two-way interaction between math belonging and perceived same-ethnic math class representation for math performance
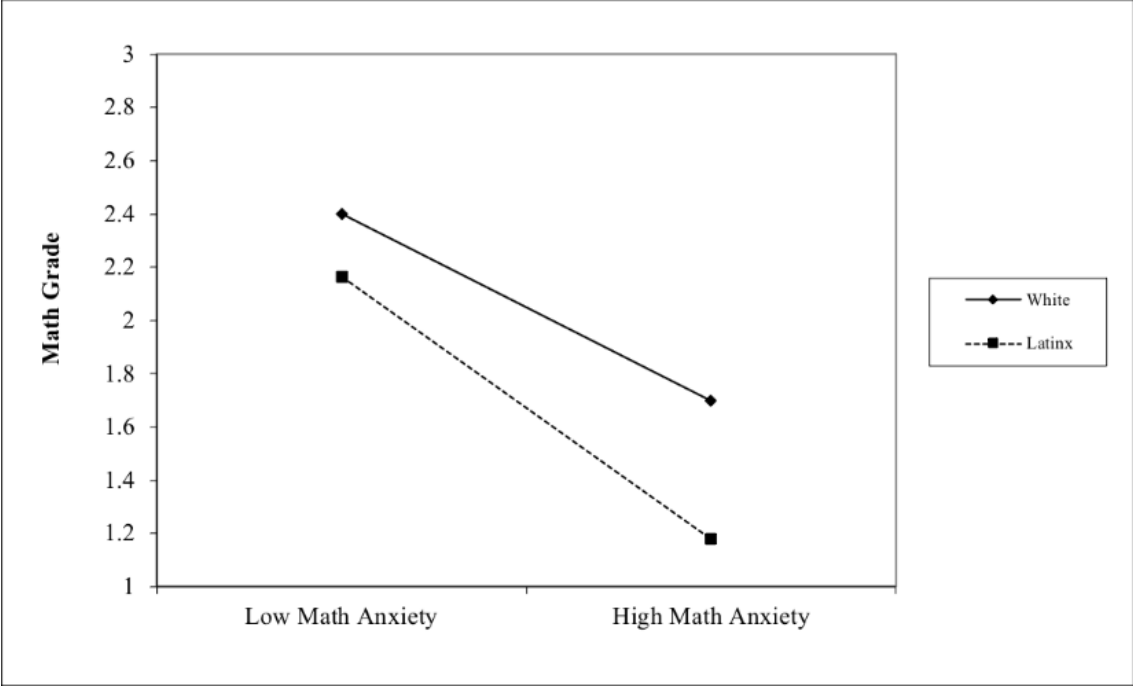
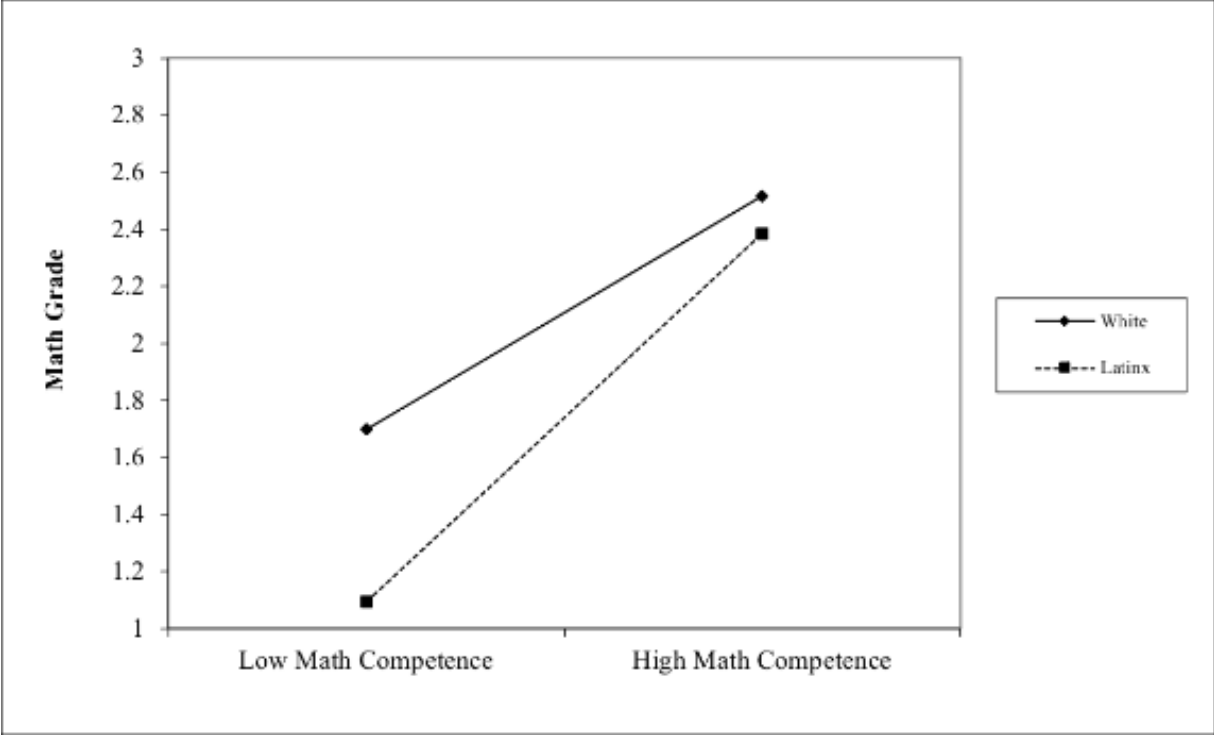*Figure 4.* Two-way interaction between math anxiety and race/ethnicity for math performance

Figure 5. Two-way interaction between perceived math competence and race/ethnicity for math performance
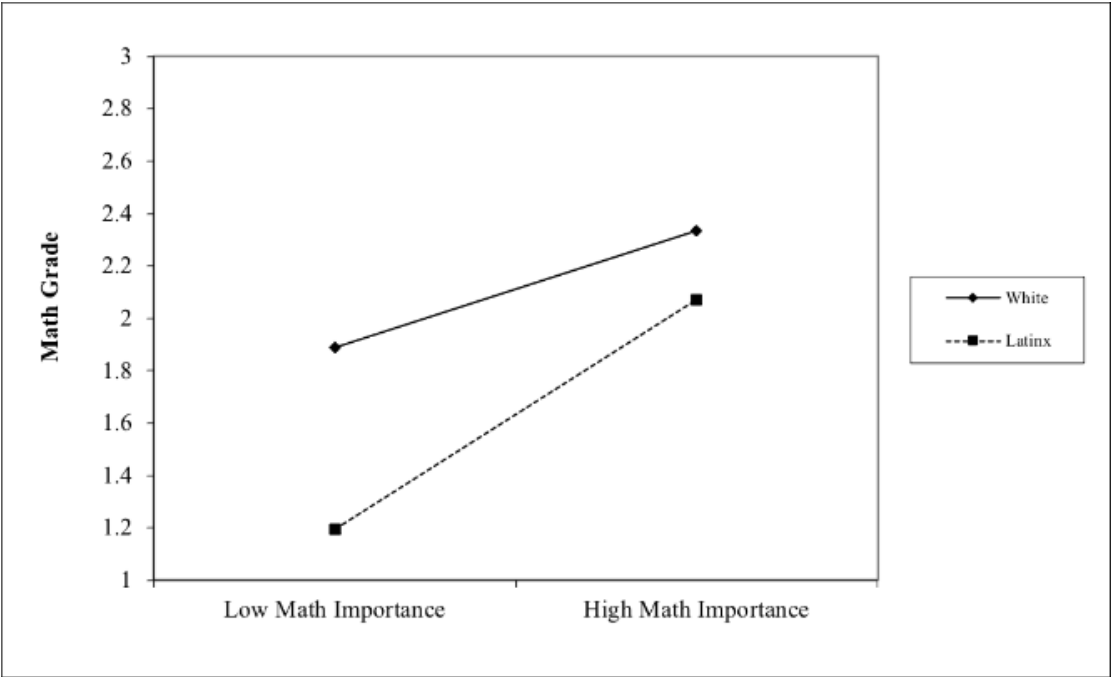
Figure 6. Two-way interaction between math importance and race/ethnicity for math performance
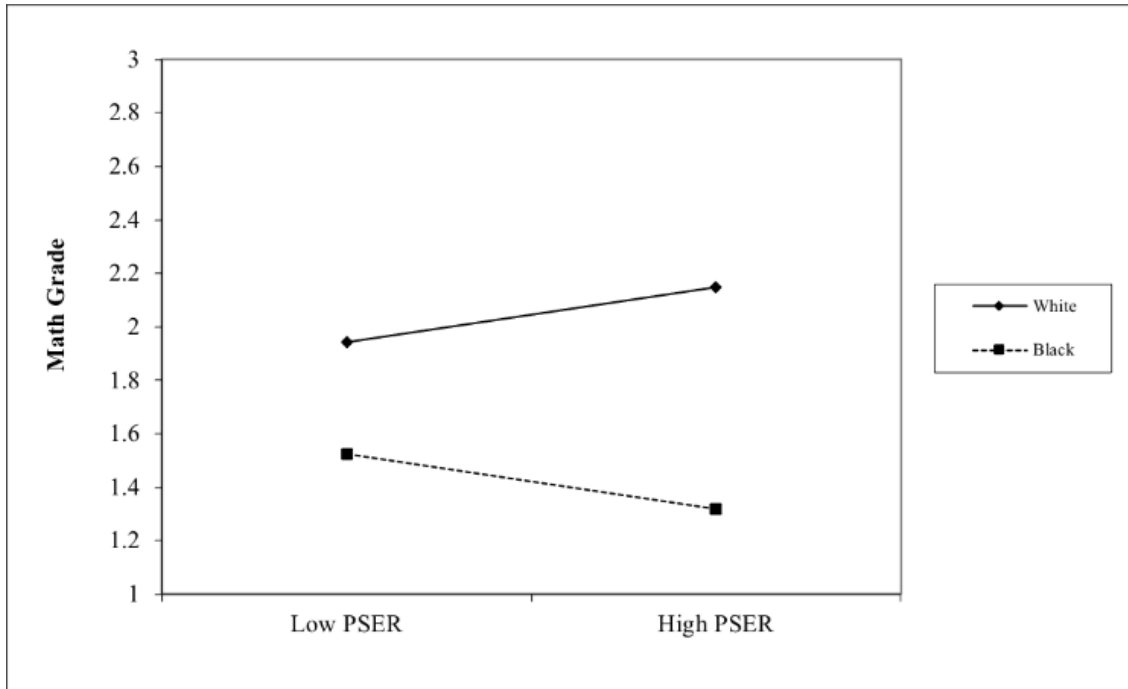
Figure 7. Two-way interaction between perceived same-ethnic math class representation and race/ethnicity for math performance
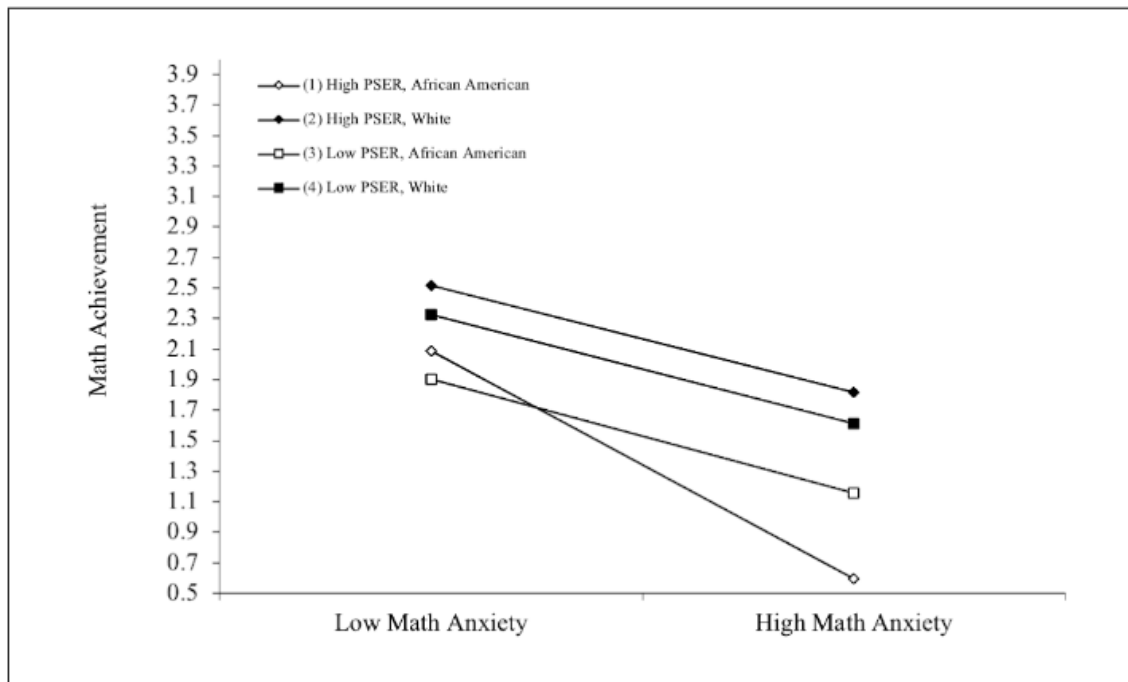

Figure 8. Three-way interaction between math anxiety, math class perceived same-ethnic representation, and race/ethnicity for math performance

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