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Relationships between Math Class Perceptions, Math Identification, and Choice of STEM Major: Racial and Gender Differences

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Abstract

STEM (Science, Technology, Engineering, and Mathematics) careers remain in high demand, and the United States continues to compete globally to expand its STEM workforce while addressing persistent racial and gender disparities. This study employed structural equation modeling (SEM) with multigroup analyses to examine the relationships among high school students' perceptions of their math classes, their math identification, and their decision to pursue math-intensive STEM majors. The theoretical framework integrated the MUSIC Model of Motivation (eMpowerment, Usefulness, Success, Interest, Caring) and domain identification theory. Data were drawn from 23,503 participants in the nationally representative High School Longitudinal Study (HSLS: 2009–2013). Analyses focused on differences by gender and race, with particular emphasis on Black female students. Results indicated that students' perceptions of success and interest in their math classes were positively associated with math identification, which in turn was positively related to their decision to pursue a STEM major. No statistically significant differences were found between Black females and their peers (Black males, White females, and White males) in the strength of these relationships. Implications for educators and schools seeking to increase the participation of Black female students in STEM fields are discussed.

Introduction

Despite national efforts to increase diversity, equity, and inclusion in STEM (Science, Technology, Engineering, and Mathematics; NSTC, 2018), women—particularly women of color—continue to be underrepresented in STEM (Corbett & Hill, 2015; NSB & NSF, 2020). Because math often acts as a gateway to STEM careers (Cribbs et al., 2015), we examined how girls' beliefs about math, particularly their identification with math, might help explain these disparities. This study investigated the relationships between high school students' perceptions of their math classes, their identification with math, math achievement, and STEM major choices, and whether these relationships were invariant across race/ethnicity and gender. We focused on Black female students, who are the most underrepresented in math-intensive STEM fields (NSF, 2019), and compared them with Black males, White females, and White males. The high school setting was selected due to a research gap at this level compared to college and beyond (Kim et al., 2018).

Literature Review

Mathematics and STEM Career Choice

Identification with math plays a key role in STEM career choice (Carlone & 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). Early math and science experiences influence students' long-term educational paths (NSB & NSF, 2019). High school attitudes toward math correlate with STEM degree pursuit (Lichtenberger & George-Jackson, 2013), and math-related motivational beliefs predict achievement and intentions to pursue a STEM career (Diemer et al., 2016; Fernandez et al., 2022; McKellar et al., 2018).

Students who view themselves as "math people" and believe that others see them as math people are more likely to show interest in STEM careers (Gottlieb, 2018). Confidence in math ability and valuing math predict interest in math-related careers (Lauermann et al., 2017). This identity is especially important for the success of women of color in STEM (Rodriguez et al., 2017). In addition, students' math achievement is directly related to their success in STEM (Lin et al., 2018) and is a good predictor of the likelihood that they will pursue a career in STEM (Lichtenberger & George-Jackson, 2013).

Black Girls' Experiences in STEM

Although some researchers have explored Black girls' experiences in secondary education (Collins et al., 2020; Davis, 2021; King & Pringle, 2018; Young et al., 2017), few studies investigate what drives their STEM career choices. Explanations for the underrepresentation of women in STEM range from lower interest (Heilbronner, 2013) to controversial claims about ability (Hill et al., 2010). Girls more often pursue life sciences and social sciences over math, engineering, or physics (Buschor et al., 2014).

Factors such as ability beliefs, interests, values, expectancy for success, socioeconomic status, and gender stereotypes shape students' STEM decisions (Buschor et al., 2014). Despite performing at the same level as their male counterparts, females tend to report lower expectancy for success in math and engineering (Robnett & Thoman, 2017). However, positive early math experiences can positively influence academic and career trajectories for women (McKellar et al., 2018; Mullet et al., 2017). Girls who feel confident in advanced math are more likely to pursue quantitative STEM careers (Nix et al., 2015; Perez-Felkner et al., 2012), although many still underestimate their abilities (Perez-Felkner et al., 2012). Interestingly, Seo et al. (2019) found smaller gender gaps in math self-concept among Black and Asian students, highlighting the need to examine both gender and ethnicity. A U.S. Department of Education report found girls across racial groups were less interested in math and science and took fewer STEM-related courses than boys (Cunningham et al., 2015). While research often focuses on females in general, few studies target Black females, raising the question: do different experiences shape Black girls' STEM choices? Our study addresses this question by examining how math class perceptions and identification relate to STEM intentions.

Domain Identification

To explain how students' self-perceptions influence their academic choices, we draw on domain identification theory. Domain identification is the extent to which individuals view a domain as an important part of who they are; that is, the extent to which they view the domain as part of their self (Osborne & Jones, 2011; Jones et al., 2016). Domain identification is important because it can affect students' choices, effort, persistence, behaviors, and academic outcomes (Jones et al., 2015; Puente et al., 2021; see Osborne & Jones, 2011, for more explanation). For example, students pursuing careers in STEM have shown that identities in domains such as math, engineering, or science play an important part in their academic performance and choice (Carlone & 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). Because our study investigates whether identification with math helps explain racial and gender disparities in STEM outcomes, domain identification provides a critical theoretical foundation.

The MUSIC Model of Motivation

Understanding *why* students identify with math requires not only examining their beliefs, but also the classroom contexts that shape those beliefs. Students' experiences in school can either strengthen or undermine their identification with academic domains (Osborne & Jones, 2011). Researchers have demonstrated that the motivational climate in courses—operationalized as their perceptions of empowerment, usefulness, success, interest, and caring (the initial sounds form the acronym MUSIC) —is an important predictor of their identification with the domain of the course. These perceptions are summarized in the MUSIC Model of Motivation (Jones, 2009, 2018), which specifies that students are more likely to be motivated in a class when they believe that they are *empowered* during the learning activities (i.e., they have control and choices), believe that the class is *useful* to their life goals, believe they can *succeed* in the class, find the class *interesting* and enjoyable, and believe that the teacher and their peers in the class *care* about them and their success.

Positive MUSIC perceptions have been linked to greater effort, achievement, and domain identification (Chittum & Jones, 2017; Jones et al., 2014; Jones et al., 2016; Jones et al., 2017). For example, students who believe they can succeed in math (success perceptions) and that it connects to their goals (usefulness perceptions) are more motivated to achieve in math (McKellar et al., 2018). In college engineering courses, MUSIC perceptions have predicted course effort, identification, and major choice (Jones et al., 2016), as well as program belonging and program expectancy for success (Jones et al., 2014). By examining how students' MUSIC perceptions in math class relate to their math identification and STEM aspirations, we aim to understand factors that support or hinder underrepresented students' STEM pathways in high school.

Research Questions

Based on the associations between students' motivational class perceptions, identification with math, and STEM choices, we developed the following three research questions and associated hypotheses (H) related to the conceptual model shown in Figure 1.

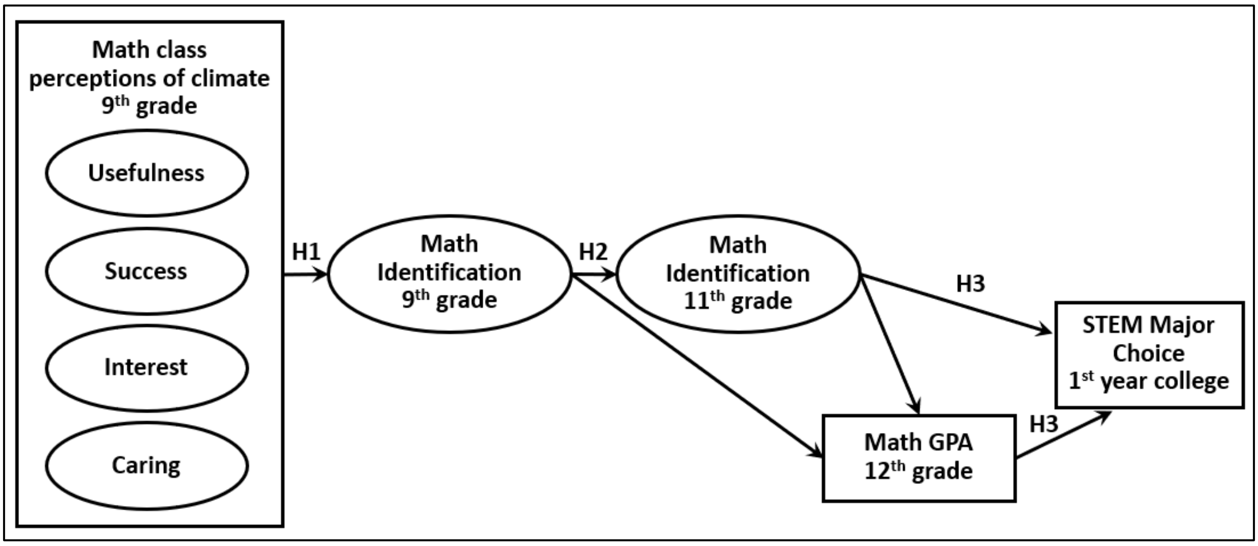

Figure 1. Hypothesized Relationships Among Study Variables

RQ1: To what extent do students' math class perceptions of the motivational climate predict their math identification?

H1: Students' math class perceptions in 9th grade predict their math identification in 9th grade.

H2: Students' math identification in 9th grade predicts their math identification in 11th grade.

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

H3: Students' math identification and math GPA predict their STEM major choice.

H4: Students' class perceptions indirectly predict their STEM major choice.

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

H5: The model in Figure 1 fits similarly across all four combinations of race/ethnicity (Black and White) and gender (Female and Male).

The first hypothesis focused on the relationships between students' math class perceptions of the motivational climate (i.e., MUSIC perceptions) and their math identification in the same grade. Theoretically, students' MUSIC perceptions should be related to their identification within that domain (Osborne & Jones, 2011), and 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). Although empowerment was theorized to contribute to identification, a direct measure of empowerment was not available in the dataset used.

The second hypothesis posited that math identification should be fairly consistent over time (Osborne & Jones, 2011). By the 9th grade, students have many years of experience in math class, and thus, we expected their 9th-grade math identification to align with their 11th-grade math identification. Unlike self-efficacy (Bandura, 1994) or situational interest (Hidi & Renninger, 2006), which can fluctuate over short periods, domain identification tends to be more stable, though subject to change over longer spans (Arens et al., 2019).

The third hypothesis addressed the role that math identification and achievement play in a student's decision to select a STEM major. Studies with undergraduate engineering students have found that students' identification is related to their major and career intentions (Jones et al., 2014; Jones et al., 2016), consistent with expectancy-value theory findings on math values and course selection (Eccles & Wigfield, 2020). Achievement has also been shown to influence STEM intentions (Chittum & Jones, 2017; Diemer et al., 2016; Jones et al., 2014; Jones et al., 2016; McKellar et al., 2018). However, we expected math identification to be a stronger predictor of STEM major choice than achievement, as supported by studies in engineering contexts (Jones et al., 2016).

The fourth hypothesis proposed an indirect relationship between math class climate perceptions and STEM choice, mediated by math identification. The fifth hypothesis was that the interrelationship among math perceptions and math identification and its effect on STEM choice will be invariant across gender and ethnicity, as existing research has not identified such group differences.

Methodology

Participants

The participants for this study were selected from the High School Longitudinal Study, 2009–2013 (Ingels et al., 2013), which was included in a national survey that was conducted by the National Center for Education Statistics (NCES). The HSLS 2009 dataset (www.icpsr.umich.edu) was collected to be representative of all 9th graders in the U.S. in 2009. The original HSLS 2009 data were obtained from a study that started with a sample of 25,206 students from 944 public and private high schools in the US. The public-use dataset used in this study included respondents from (a) the base-year in Fall 2009, (b) the first follow-up in spring 2012, and (c) updated data from 2013. The dataset from which the study was selected 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 the first follow-up of the survey (11th grade, Spring 2012). The student achievement (i.e., high school grades) and post-secondary plan variables were from Summer 2013 and Fall 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.

Measures

Motivational Class Perceptions

We measured students' ninth-grade motivational class perceptions with variables that corresponded to four of the five components of the MUSIC model: *Usefulness, Success, Interest, and Caring* (*eMpowerment* was not measured because none of the variables in the HSLS 2009 survey measured this construct). Three of these scales were already created in the survey: math course utility (as a measure of Usefulness), math self-efficacy (as a measure of Success), and math course interest (as a measure of situational Interest). We 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. All of the items are provided in Table 1.

Table 1. Scale Items and Variables Included in the Study

Scale name in this study	Scale name in HSLS 2009	Scale items	Grade	α
Class Usefulness scale	Math Course Utility	• What students learn in this course: o is useful for everyday life o will be useful for college o will be useful for a future career	9	.78
Class Success scale	Math Self-Efficacy scale	• 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	9	.90
Class Interest scale	Math Course Interest scale	• You are enjoying this class very much • You think this class is boring	9	.73
Teacher Caring scale	N/A	• Your math teacher… o values and listens to students' ideas o treats students with respect o treats every student fairly o thinks every student can be successful	9	.90
Math Identification scale	N/A	• You see yourself as a math person • Others see you as a math person	9 11	.84 .88

Note. Students responded to all the items using these Likert-format options: *1= Strongly Agree, 2 = Agree, 3 = Disagree,* and *4 = Strongly Disagree.* All of the items were reverse-coded (except for one Interest item that was already reverse-coded: "You think this class is boring") so that higher ratings indicated a higher positive agreement.

Math Identification

The math identification variable was included in the HSLS 2009 survey for both 9th and 11th grades using the same two items (see Table 1).

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. Because some of the categories included multiple disciplines with similar content (e.g., philosophy, religious studies), we 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 Fall 2013.

Math GPA

To measure achievement, we used students' cumulative math grades from their high school transcripts in Fall 2013, which included grades from all of their math courses in high school.

Analysis

To ensure that the four MUSIC constructs were distinct, we conducted a confirmatory factor analysis (CFA) that included the items for the four class MUSIC scales (Usefulness, Success, Interest, and Caring). The second analysis (labeled "Identification model") used a SEM to analyze the relationships between MUSIC and math identification, focusing on math identification in 9th grade and math identification in 11th grade using all students in the dataset. Third, we 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 we 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 appropriate 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. Mplus uses robust maximum likelihood (MLR) estimation with analytic weights and maximum likelihood (ML) estimation with the replicate weights. To examine the model fit for each analysis, we used multiple fit indices with their recommended cutoff criteria. We used the Chi-square (χ^2) model fit index with its accompanying degrees 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) $\geq .95$, 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). When estimating the models in Mplus, the Chi-square test of model fit and other fit indices were not available when replicate weights were applied in the analyses; only the SRMR was available. Therefore, all models were estimated twice, first with the analytic weights to obtain all of the fit indices listed above, then with analytic weights plus the associated replicate weights to obtain 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, we conducted a SEM that 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. This model was estimated to determine the relationship between the MUSIC components and math identification in the 9th grade and the relationship between 9th-grade math identification and 11th-grade math identification. We estimated the SEM with the analytic weight W2W1STU, which is associated with students who responded to the base-year and first follow-up. This analytic weight is used to account for nonresponse in the base-year and first follow-up, and it provides estimates for the population of ninth-grade students in 2009. Then we included the appropriate replicate weights W2W1STU001-200 (Ingels et al. 2015). The rationale for this analysis was to determine the consistency of math identification 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, we estimated 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 the base year (9th grade), first follow-up (11th 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 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. These weights adjust for transcript non-response for the ninth-grade student population in 2009. After running the analysis with the analytic weight, we added the associated replicate weights W3W1W2STUTR001-200 (Ingels et al. 2015) for variance estimation. Because STEM Choice is a dichotomous variable, we used the means and variance adjusted weighted least squares (WLSMV) estimation procedure. The model included math class perceptions in the 9th grade, math identification from 9th grade, math identification from 11th grade, students' choice of STEM major, and students' math achievement (cumulative math GPA) in high school. The model was used 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. Figure 2 shows the SEM model tested in this study. 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. We selected the four groups: Black female, Black male, White female, and White male. First, we estimated the Choice model for each group of interest separately. This tested the model fit for each group separately as a stand-alone analysis. Respondents were from the base-year (9th grade), first follow-up (11th grade), and the 2013 update. There were 1,170 Black female respondents (including 604 for the choice variable), 1,270 Black male respondents (including 513 for the choice variable), 6,353 White female respondents (including 3,592 for the choice variable), and 6,591 White male respondents (including 3,148 for the choice variable).

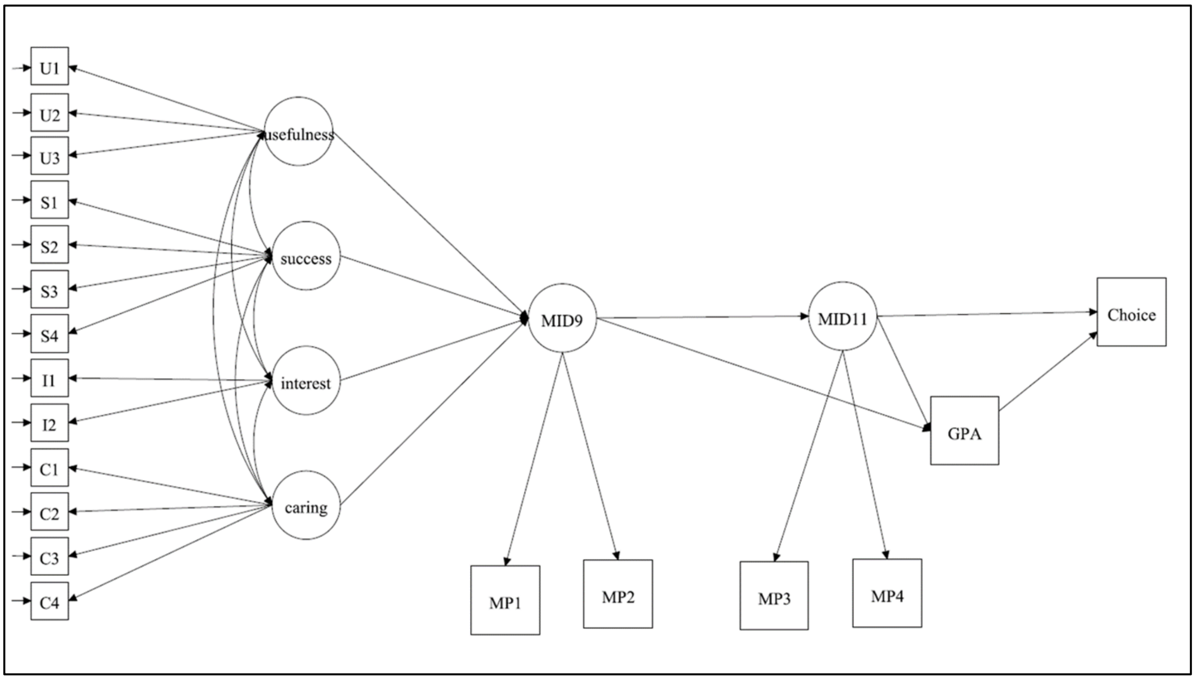

Figure 2. STEM Choice Model

We then estimated a configural model in which the models for the four groups were estimated simultaneously in a single model. 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 analyses for research question 3 were conducted using the analytic weight W3W1W2STUTR and the associated replicate weights W3W1W2STUTR001-200. The WLSMV estimation method was used. We 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, we 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 pairwise combinations among the four groups.

Results

Confirmatory Factor Analysis for Class Motivational Climate Perceptions

To begin, we 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) in the 9th grade. All observed variables had at least 18,000 respondents. The CFA provided multiple fit indices: $\chi^2 = 425.332$ (59), $p < .001$, CFI = .986, TLI = .981, SRMR = .024, and RMSEA = .018 (.016, .020). These fit indices indicated good model fit (Kline, 2016; Schreiber et al., 2006). 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 as the 13 items are good representations of the four MUSIC components (Usefulness, Success, Interest, and Caring) (see Table 2). The results for the CFA indicated that the four MUSIC scales aligned well with the items representing students' perceptions of their math class in the 9th grade. Table 3 provides weighted descriptive statistics for the observed indicators and variables for all 23,503 respondents in the Choice model.

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

Latent Variables and Indicators	Measurements with analytic and replicate weights			
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

*Note: *p ≤ .05, **p ≤ .01, ***p ≤ .001*; Analytic weight W2W1STU and associated Balanced Repeated Replicate weights W2W1STU001-W2W1STU200 were used for these analyses.

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	0.14	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	0.35	0.94

Note: Analytic weight W3W1W2STUTR and associated Balanced Repeated Replicate weights W3W1W2STUTR001-W3W1W2STUTR200 were used for these analyses. The correlation coefficients associated with choice of STEM major (CH) are point-biserial correlations; all other correlations are Pearson correlations. **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

To examine the relationships between class perceptions and math identification, and to investigate the stability of math identification from 9th to 11th grade, we 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 fit indices associated with the model met the recommended thresholds for good model fit: $\chi^2 = 797.439(108)$, $p < .001$, CFI = .984, TLI = .979, SRMR = .023, and RMSEA = .017 (.015, .018). Table 4 shows the relationships among the latent variables.

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

Note. Analytic weight W2W1STU and associated Balanced Repeated Replicate weights W2W1STU001-W2W1STU200 were used for these analyses. MID9 = Math Identification in 9th Grade. MID11 = Math Identification in 11th Grade. **p ≤ .05, **p ≤ .01, *p ≤ .001*

The standardized estimates show that three of the four MUSIC perceptions (Success, Interest, and Caring) predicted math identification in the 9th grade. Success and Interest were positively related to math identification, and Caring was negatively related to math identification. Math identification in the 9th grade positively predicted math identification in the 11th grade.

Research Question 2

To answer the second question, we first established the viability of the Choice model. The model shown in Figure 2 has the students' choice of STEM as the outcome variable and includes the pathway for students' choice of major, controlling for achievement. The fit indices associated with the Choice model indicated good model fit: $\chi^2 = 1126.415$ (139) $p < .001$, CFI = .955, TLI = .945, SRMR = .027, and RMSEA = .017 (.016, .018).

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

Paths	Unstandardized Coefficients	S.E	Standardized Coefficients	S.E
MID11→ GPA→ Choice	0.015	0.010	0.013	0.009

*Note. * p ≤ .05, ** p ≤ .01, *** p ≤ .001.* Analytic weight W3W1W2STUTR and associated Balanced Repeated Replicate weights W3W1W2STUTR001- W3W1W2STUTR200 were used for these analyses.

Two class perceptions, Success and Interest, had positive, statistically significant relationships with 9th-grade math identification. Caring had a negative, statistically significant relationship with math identification in the 9th grade, and Usefulness did not have a statistically significant relationship with math identification. The relationship between math identification in the 9th grade and math identification in the 11th grade was positive and statistically significant. Math identification in both 9th grade and 11th 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 11th grade and STEM Choice, and a positive and statistically significant indirect effect from math identification in 9th grade to math identification in 11th grade to STEM choice (see Table 5). GPA did not have a statistically significant relationship with STEM Choice.

Regarding the indirect effects, there were no statistically significant indirect effects from math identification in 9th grade to GPA to STEM choice, and the indirect effect from math identification in 11th 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 9th grade to math identification in 11th grade to Choice). The statistically significant indirect paths from Success and Interest were positive, while the statistically significant indirect path from Caring was 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	0.000	0.000
Usefulness→MID9→MID11→Choice	-0.018	0.012	-0.011	0.007
Usefulness→MID9→MID11→GPA→Choice	0.000	0.001	0.000	0.000
Success→MID9→GPA→Choice	0.009	0.007	0.006	0.004
Success→MID9→MID11→Choice	0.265***	0.025	0.171***	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	0.095***	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	-0.062***	0.011	-0.037***	0.007

Paths	Unstandardized Coefficients	S.E	Standardized Coefficients	S.E
Caring→MID9→MID11→GPA→Choice	-0.002	0.001	-0.001	0.001

*Note. * p ≤ .05, ** p ≤ .01, *** p ≤ .001.* Analytic weight W3W1W2STUTR and associated Balanced Repeated Replicate weights W3W1W2STUTR001- W3W1W2STUTR200 were used for these analyses.

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, we tested the model for each group individually to evaluate model fit for each group. The fit indices associated with the individual models for each group are presented in Table 7. These fit indices provide evidence of good model fit for all four groups, suggesting that the Choice model is an acceptable model to explain students' path from motivational beliefs to math identification to the decision to select a math-intensive STEM major (see Table 7; Correlations among the latent variables for the four groups are presented in Tables A1 and A2 in the Appendix).

Table 7. Fit Indexes for Choice 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)

Note. Analytic weight W3W1W2STUTR and associated Balanced Repeated Replicate weights W3W1W2STUTR001-W3W1W2STUTR200 were used for these analyses.

Our 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 was: Black females (*n* = 33), Black males (*n* = 77), White females (*n* = 222), White males (*n* = 837). We 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 weights indicated a good model fit: χ^2 = 1248.991(622), *p* < .001; CFI = .970; TLI = .967; SRMR = .032; and RMSEA = .016 (.015, .017).

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 (see Table 8). 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). 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 a positive statistically significant relationship with achievement for all groups except for Black females, while math identification in 11th grade had a positive statistically significant relationship with achievement for all groups except Black males.

Table 8. Path Coefficient for Configural Choice Model

	Unstandardized Path Coefficients							
Paths	Black Female		Black Male		White Female		White Male	
	Coeff	SE	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 for the indirect effects, the indirect effects for math identification in 9th grade to Choice via GPA were 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 negative statistically significant relationships with math identification in 9th grade for both White females and White males.

In addition to the relationship between class perceptions and math identification, we 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 effect 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.

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, we used a z-score cutoff of 1.96, which is associated with a $p < .05$ level of statistical significance. Table 10 shows the unstandardized and standardized z-scores. Z-scores of 1.96 or higher are bolded and italicized. Here, we 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, which was more than any of the other pairs. White females and Whites males had statistically significant differences for the paths for math identification in 9th grade 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).

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	0.000	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	0.000	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	0.000	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	0.000	0.008	0.000	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	0.000	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	0.000	0.018	0.000	0.945	-0.005**	0.002	-0.002*	0.001

$^{*} p \le .05$, $^{**} p \le .01$, $^{***} p \le .001$

Table 10. Z Score for Difference in Path Coefficients

Paths	BF and BM	BF and WF	BF and WM	BM and WF	BM and WM	WF and WM
Unstandardized Scores						
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
Standardized Scores						
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***

Paths	BF and BM	BF and WF	BF and WM	BM and WF	BM and WM	WF and WM
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

Note: BF = Black Females; BM = Black Males; WF = White Females; WM = White Males.

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. This hypothesis was partially confirmed in that Success and Interest were positively related to students' math identification in 9th grade. However, Caring was negatively related to math identification, and Usefulness was not statistically significantly related to it. The positive relationship of Success with math identification is similar to the results presented in 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 US students (but not Icelandic students). The similar results between this study and these other studies suggest that success perceptions can be used to predict domain identification.

Interest also had a statistically significant positive relationship with 9th-grade math identification. The situational interest measured in this study can be 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 because, during that transition to individual interest, students begin to develop identification with the subject (Jones et al., 2015).

Although some studies have shown that students' perception of usefulness in engineering courses had a positive relationship with engineering identification (Jones et al., 2014; Jones et al., 2016), we did not find a similar statistically significant relationship between usefulness and 9th-grade math identification in this study. The items used to measure usefulness in this study asked students about their perception of how useful their 9th-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 was 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. Our findings suggest that believing a subject is useful in the general sense does not necessarily translate into students perceiving that the subject is part of who they are (i.e., part of their math identity).

Caring was negatively related to 9th-grade math identification, possibly because the caring scale measured only general perceptions of how the teacher treated the class, not how students felt personally treated or supported by peers. Prior research shows that personalized perceptions of caring are more strongly linked to domain identification (Chittum & Jones, 2017; Jones et al., 2017). Students who are less identified with math may rely more on the teacher's general support and believe that their teachers are caring when they receive help. In this case, math identification would be negatively related to caring.

The second hypothesis (*H2*) for Research Question 1 was confirmed because students' math identification in 9th grade was significantly related to math identification in the 11th grade (see Table 4). This is not surprising as domain identification can lead to better performance, which strengthens identification in that domain (Osborne & Jones, 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 question 2 (*H3*) stated that students' math identification and math achievement are predictive of students' STEM choice. This hypothesis was partially confirmed because although math identification in 11th grade predicted students' STEM choice, achievement did not predict STEM choice. These findings demonstrate that math identification is more important than math achievement in predicting STEM choice and that it is a critical variable to consider when trying to understand who will select STEM majors.

This result is consistent with other studies showing identification with a subject leading to persistence in that subject (Jones et al., 2013; Jones et al., 2024). The relationship here shows that math identification has 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 who 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, this finding adds more value to the relationship of math identification with the decision to major in math-intensive majors.

Although being good in math is considered a prerequisite for students who intend to pursue STEM disciplines (Lichtenberger & George-Jackson, 2013), we documented that math achievement in high school was not predictive of students' STEM choice. The indirect effects from 9th-grade math identification to achievement to choice, and 11th-grade math identification to achievement to choice were not statistically significant either, which provides further evidence of the negligible effect of achievement on students' STEM choice after controlling for identification. This finding does not align with other studies that have shown a relationship between high performance in math and pursuing a career in STEM (Diemer 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 would indirectly predict their STEM choice. This hypothesis was partially confirmed because Success and Interest each had a positive, statistically significant relationship with Choice through 9th-grade math identification and 11th-grade math identification. These findings are consistent with other studies that have shown that MUSIC perceptions predict identification, and that identification can then predict career goals (Chittum & Jones, 2017; Jones et al., 2014; Jones et al., 2016). However, indirect effects that included achievement were not statistically significant, and thus, did not confirm H4. Furthermore, Caring was negatively related to STEM Choice through 9th-grade math identification and 11th-grade math identification, which is inconsistent with an expected positive relationship. Similar to Success and Interest, Caring was not indirectly related to Choice through achievement. Math identification in 9th grade and 11th grade remained the paths through which the relationships were significant.

These results indicate that math identification plays a more important role in this model for STEM Choice than achievement. Usefulness did not have a statistically significant indirect relationship with STEM Choice, which is consistent with the other indirect relationships.

Research Question 3

In this study, we were primarily interested in Black females and their decisions to pursue a major in a math-intensive STEM discipline. The hypothesis for Research Question 3 (*H5*) stated that the model in Figure 1 would fit similarly across all four combinations of race/ethnicity (Black and White) and gender (Female and Male).

Of the four groups that were compared in this analysis, the Black female group was the only one 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 or for indirect effects. These findings indicate that the factors related to Black females' decisions to pursue a major in math-intensive STEM disciplines do not differ from the three other groups in this study. These results are consistent with other studies that used multigroup structural equation modeling and found no statistically significant differences among different races/ethnicities in STEM identities (Kang et al., 2018).

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.

The standardized coefficients from math identification in 11th grade to STEM Choice (0.437) and from GPA to STEM Choice (-0.012) were not statistically significant for Black females (see Table 8). The lack of statistical significance for math identification in 11th grade to Choice is interesting because this value is actually higher than the coefficients for Black males (0.278) and White females (0.322), and almost as high as White males (0.448). The fact that the coefficient is not statistically significant for Black females could be due to the fact that there are not many Black females who chose STEM (n = 33). Further research with larger numbers of Black females is needed to verify our speculation.

The fact that achievement was not statistically significantly related to Choice for Black females has some precedence. As an example, Seo et al. (2019) also found a weak relationship between math achievement and STEM career expectancy among minorities and women. When reviewing the indirect effects to Choice for Black females (Tables 8 and 9), there were no statistically significant indirect effects to Choice. It may be that other variables not included in this study could be more predictive of Black female students' STEM choice than the class perceptions and math identification. Female students have reported that their 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.

Black males, on the other hand, had a statistically significant relationship between math identification in 11th grade and Choice, but did not have a statistically significant relationship between GPA and Choice. The fact that achievement was not statistically significantly related to 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 9th grade to math identification in 11th grade to Choice, and interest to math identification in 9th grade to math identification in 11th grade to Choice). White females and White males, on the other hand, had statistically significant relationships for math identification in 11th 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 significant 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.

Limitations

These findings should be considered in light of several limitations. First, the study relied on students' perceptions of their 9th-grade math class, but students may have been enrolled in different types of math courses (e.g., algebra, trigonometry, calculus). While this variation allowed for a broader assessment of math class perceptions, it limited our ability to examine differences tied to specific course content. Second, the STEM choice variable captured students' intended majors during their first semester of college, not their final declared majors. Future research should track students' actual degree completion to better assess long-term outcomes. Third, the study omitted certain factors that may influence domain identification. For example, extracurricular STEM experiences (e.g., clubs, summer programs) and socioeconomic status (SES) have been linked to early exposure and sustained interest in math and science (Eastman et al., 2017; Hidi & Renninger, 2006). Additionally, the racial/ethnic makeup of schools may play a role in shaping students' identification with math.

Conclusions

The results showed that the relationships between math identification and STEM choice, and between achievement and STEM choice, were the same for Black females and three other groups (Black males, White males, and White females). The effects of class perceptions on math identification and the indirect effects of class perception on STEM choice were also the same for Black females and the three other groups. Therefore, we conclude that math class perceptions, identification, and achievement do not explain differences in STEM choice between Black females and the three other groups. 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 emphasize providing students with opportunities to take more math, perhaps more advanced math. If students are able to take higher-level math classes and succeed, it could lead to higher math self-efficacy and self-concept (Bandura, 1994), which could lead to a higher math identification. Schools should also provide students with enough support to help them succeed, and work to incorporate teaching methods that elicit students' interest during class, because class interest also predicted math identification.

Because math identification in 9th grade has a positive relationship with math identification in 11th grade, helping students to form a stronger math identification early in high school (or even in middle school) could have a long-term effect on their decisions to continue to study a math-intensive discipline in college. The weak link between math GPA and STEM choice aligns with some prior findings and suggests that strong math performance alone does not predict STEM choice. Rather than assuming high-achieving students will pursue STEM, educators should focus on fostering students' identification with math.

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Appendix. 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.

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

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 $p \leq .001$.