Journal of Women and Minorities in Science and Engineering 27(4):59–90 (2021)

MATH CHALLENGES, STRENGTHS, AND ACHIEVEMENT: TOWARD A THEORY OF STRAIN-INDUCED PERFORMANCE-PERCEPTION MISALIGNMENT FOR RACIALLY MARGINALIZED STUDENTS

Krystal L. Williams & Sarah Chavada Davis*

The University of Alabama, 301 Graves Hall, Box 870302, Tuscaloosa, AL 35487

*Address all correspondence to: Krystal L. Williams, The University of Alabama, 301 Graves Hall, Box 870302, Tuscaloosa, AL 35487; Tel.: +(205) 348-2823; Fax: +(302) 288-8416, E-mail: Krystal.L.Williams@ua.edu

In the midst of an expanding knowledge-based economy, there remains a policy emphasis on increasing the number of professionals in science, technology, engineering, and mathematics (STEM) within the United States. In addition to a general interest in increasing STEM pathways for all students, there have been concentrated efforts to expand opportunities and STEM-related academic achievement for Black and Latinx students because of their underrepresentation in many of these fields. This critical quantitative study employs large-scale national data to examine an important outcome for Black and Latinx students' STEM academic trajectories—their math achievement during high school. A strength-based role strain and adaptation approach is employed to investigate how students' math challenges and math-related multilevel strengths (i.e., positive psychological attributes and social supports) combine to influence their math achievement. Furthermore, we examine how the relationship between students' strengths and achievement may be moderated by their prior math challenges. The findings suggest that some aspects of Black and Latinx students' strengths (e.g., math identity, math self-efficacy, and math-related social support) are positively related to their achievement; however, in some instances, the nature of these relationships may differ according to students' prior math challenges. Based upon these findings, the authors advance a theory of strain-induced performance–perception misalignment that emphasizes how students' prior math challenges may create a barrier to the potential benefits of positive math-related psychological orientations. Implications for the following are discussed: theory; educational practice regarding social supports and the need to change educators' psychological dispositions; and opportunity gaps and STEM education policy.

KEY WORDS: *critical quantitative research, math achievement, Black students, Latinx students, STEM education, student role strain and adaptation, psychological disposition, math identity, math self-efficacy, math social support*

1. INTRODUCTION

In the midst of an expanding knowledge-based economy, there has been a persistent policy emphasis on increasing the number of professionals in science, technology, engineering, and mathematics (STEM) within the United States in order for the country to remain a thought-leader in technology and innovation. For example, in 2018, the National Science and Technology Council Committee on STEM Education published a five-year federal strategy to improve STEM education nationally (National Science and Technology Council, 2018). This plan outlined various federal activities and in-

vestments to meet the following objectives: improve national STEM literacy; increase diversity, equity, and inclusion in STEM; and prepare the future STEM workforce.

In addition to a general interest in increasing pathways into STEM professions for all students, there have been concentrated efforts to expand opportunities for Black and Latinx students in particular because of their historic underrepresentation in many of these fields. For example, engineering education statistics data suggest a substantial increase in the percentage of engineering degrees awarded to Black and Latinx students from 2010 to 2015, with undergraduate engineering degrees conferred to Black graduates increasing by 35% and degrees awarded to Latinx graduates increasing by 79%. Despite these increases, in 2015, Black graduates earned only 4% of all undergraduate engineering awards, and Latinx graduates earned only 11% (Anderson et al., 2018). Because of these longstanding representation challenges, federal organizations such as the National Science Foundation have made broadening STEM participation for underrepresented groups a policy priority (National Science Foundation, 2008).

While a number of efforts to bolster the STEM workforce have emerged at the postsecondary level, pathways into STEM careers generally begin before students enter college (French et al., 2005; Gottfried and Plasman, 2018; Means et al., 2018; Zhang et al., 2004). Black and Latinx students' experiences within K-12 systems provide the necessary foundation for STEM major choice in college and later careers in STEM professions. Accordingly, initiatives to bolster STEM pathways should consider a K-16 lens that connects educational outcomes in both K-12 and collegiate settings. One area of importance regarding STEM pathways for Black and Latinx students is their achievement in STEM areas during high school, which can serve as a gatekeeper to STEM major choice upon college entry. Research notes that these students generally have lower high school preparation in STEM subjects (Flores, 2007; Morgan et al., 2016), often because of educational opportunity gaps within the under-resourced schools that many attend (Ladson-Billings, 2006; Milner, 2012). In addition, an emerging body of STEM education research seeks to better understand successful outcomes for racially marginalized students in non-deficit ways that examine how the strengths these students bring to learning environments may help to promote success despite prior challenges or strains (Burt et al., 2019; Howell et al., 2019; Williams, 2014a,b; Williams et al., 2016, 2019, 2020).

Building upon this body of research, this study employs role strain and adaptation framing to critically examine how Black and Latinx students' challenges and strengths combine to influence their achievement in a subject that is foundational to many STEM majors and careers: mathematics (Hagedorn and DuBray, 2010; National Council of Teachers of Mathematics, 2018). Guided by the Bowman role strain and adaptation model (BRSAM) (Bowman, 2006), this research examines how the prior math challenges (i.e., math-related strain) that Black and Latinx students bring to educational settings relates to their later math achievement (Bowman, 2006). From a strength-based perspective, this study also examines how these students' personal and social (i.e., multilevel) strengths may influence achievement in addition to their math strain. Moreover, this research seeks to better understand how the relationship between Black and Latinx students' multilevel strengths and achievement may differ based upon their prior math challenges. Existing

STEM education research notes the influence of both math strain and strengths on math achievement, and how the relationships between strengths and achievement may differ based upon students' prior math outcomes (Williams, 2020). As a complement to this broader research, this study focuses on Black and Latinx students in particular because of their underrepresentation in a number of STEM areas, and a long-standing need to understand the experiences of these racially marginalized groups in order to broaden their STEM participation. Furthermore, it takes a critical approach by employing a conceptual framework particularly relevant for understanding the experiences of underrepresented students as suggested in other critical quantitative research regarding racially marginalized students in STEM (Williams, 2014b). The following research questions are explored:

1. How do Black and Latinx students' math-related strain and multilevel strengths relate to their math achievement in high school?
2. Does the relationship between Black and Latinx students' math-related multilevel strengths and math achievement differ based upon their math-related strain?

2. LITERATURE REVIEW

Racial differences in math achievement have often been discussed with an emphasis on disparities between Black and Latinx students compared to their White and Asian peers. Existing literature suggests that a number of factors help to explain these disparities. For example, one aspect of existing literature notes Black and Latinx students' preparation barriers and inequities (Adams et al., 2017; Flores, 2007); however, other research highlights the assets that these students bring to educational spaces that can help to promote math achievement such as positive math-related psychological orientations, as well as support from family, friends, and school representatives (Williams et al., 2016, 2019). The following discussion outlines existing literature regarding math proficiency barriers for Black and Latinx students, as well as the positive influences of their math-related dispositions and support systems on their math success.

2.1 Opportunity Gaps and Math Proficiency Barriers for Black and Latinx Students

Research notes important linkages between students' preparation and achievement, especially in mathematics (McGee and Pearman, 2014). Studies indicate that prior math performance is positively associated with later math achievement for both Black students (Strayhorn, 2010) and Latinx students (Carpenter, 2008; Stevens et al., 2004). Moreover, a lack of proficiency in mathematics can result in later math challenges that can have lasting effects. Early proficiency is largely a function of the content to which students are exposed. Course rigor and prior achievement levels are critical elements in order to better understand later math outcomes (Davenport et al., 2013; Tyson et al., 2007). Within the literature on math achievement and racially marginalized students, there is substantial evidence that Black and Latinx students' ability to do well in mathematics is often hindered by educational opportunity gaps. There are significant disparities in early exposure to rig-

orous math content that often put Black and Latinx students at a severe disadvantage (Dalton et al., 2007; Ingels and Dalton, 2008; Morton and Riegle-Crumb, 2019). For example, Flores (2007) investigated course-taking patterns and math achievement among Black and Latinx high school students and found that they had fewer opportunities to enroll in advanced math courses compared to their White peers. Other studies conducted by Adams et al. (2017) noted that exclusionary practices in math course taking represent a critical barrier to student achievement and interest in STEM-related programs in high school and college. Multiple studies point out that early access to rigorous content promotes early math proficiency, which is a significant predictor of students' later high school math achievement (Adams et al., 2017; Covington et al., 2019). It follows that lower levels of early math proficiency operate as a barrier to Black and Latinx students' future math success. Research also notes the positive relationship between math achievement and longer-term outcomes such as STEM persistence—particularly for Black students with high levels of prior math training (Andersen and Ward, 2014).

2.2 Positive Math-Related Psychological Dispositions and Math Achievement

In addition to prior exposure and proficiency, several studies have investigated relationships between students' psychological dispositions and their math achievement and related STEM outcomes (Anderson and Ward, 2014; Ramirez et al., 2015; Safavian and Conley, 2016; Young et al., 2019; Williams et al., 2016, 2019, 2020). The findings generally note that students' thoughts about mathematics and their related behaviors influence their math success. Erturan and Jansen (2015) found that, regardless of racial/ethnic background, students with low levels of math self-confidence often develop math avoidance behaviors, which are influential in their subsequent math performance. When students are anxious about their math competence (Erturan and Jansen, 2015) and/or their math self-efficacy (i.e., ability to do well in math), their overall performance on both classroom and standardized math assessments can suffer (Ramirez et al., 2015).

While negative psychological dispositions may lead to maladaptive behavior and reduced math outcomes, positive dispositions can have the opposite effect. Having higher levels of math self-concept (i.e., how they feel about themselves as math learners), math interest (i.e., enjoyment of math tasks), math identity (i.e., identification as a math person), and math value/utility (i.e., positive thoughts about the future benefits of learning math) can help in promoting students' math success (Erturan and Jansen, 2015; Gottfried et al., 2007; Linder et al., 2015; Murayama et al., 2013; Williams, 2020). For instance, analyses of data on Latinx students in both middle and high school suggest a positive association between their math self-efficacy beliefs and their math achievement (Kitsantas et al., 2011; Safavian and Conley, 2016). Research notes similar relationships for Black students (Kitsantas et al., 2011). The connection between positive dispositions and successful outcomes in math is further substantiated by findings that math self-concept is a strong positive predictor of math achievement (Wang and Degol, 2013) and evidence that math self-efficacy and math identity are also positively associated with this outcome (Kotok, 2017).

2.3 Social Support and Successful Math Outcomes

Students' social support systems are also critical to their math success. Peer influence has long been demonstrated to be influential (Hossler and Stage, 1992). A longitudinal study of high school students illustrates this point in finding that students' friends helped to shape their math course-taking decisions and achievement outcomes (Gottfried et al., 2017). Family members are also important (Gottfried et al., 2017; Kurban and Cabrera, 2020). When students have opportunities to confer with parents about their math courses and other academic experiences, their math achievement is generally higher (Williams, 2020; Williams et al., 2016). Research notes that parents of racially marginalized students have high educational expectations and when parents are academically involved during high school, students generally have greater academic success (Hossler and Stage, 1992; Gottfried et al., 2017; Kurban and Cabrera, 2020). Studies concerning specific racial/ethnic groups note the important role that parents play in supporting successful math outcomes for Latinx students (Azmitia et al., 2009) and Black students (Berry et al., 2011; Strayhorn, 2010) at various points along their academic trajectories. In general, the literature suggests that these crucial interactions greatly influence how racially marginalized students perceive the value of math, and help to foster their interest in higher academic aspirations (Gottfried et al., 2017; Young et al., 2019).

While support from highly valued individuals (e.g., peers and family members) can help to promote math success, students' involvement in supportive math groups are also important. Participation in math-related social groups is positively related to higher levels of math identity, math self-efficacy, and math interest (Williams, 2020), each of which is positively related to achievement as previously discussed. Participation in informal math activities can serve as learning opportunities for students and increase their perceptions of their individual math abilities (Hughes, 2015; Young et al., 2019).

In summary, the literature provides insights about students' math preparation, psychological attributes, and social supports, as well as their later success in mathematics. This study expands this body of work by examining how these factors combine to influence students' math achievement in high school. Furthermore, we examine these relationships for Black and Latinx students given the need to improve math outcomes for this specific demographic and improve their overall STEM participation.

3. CONCEPTUAL FRAMEWORK

This study utilizes a unique strength-based framework to examine how Black and Latinx students' prior math exposure, personal strengths, and support systems combine to influence their math achievement. The Bowman role strain and adaptation model provides conceptual guidance about the manner in which various psychological and social (i.e., psychosocial) factors may combine to affect math success for Black and Latinx students in STEM (Bowman, 2006, 2013). The concept of role strain has been utilized within a number of disciplines including psychology, sociology, and education (e.g., Bowman, 1990, 2006; Burt et al., 2018, 2019; Mendenhall et al., 2013; Smedley et al., 1993; Wil-

liams, 2014a,b, 2020; Williams et al., 2016, 2019). From a sociological perspective, role strain theory has been utilized to describe the difficulties that an individual may encounter meeting obligations associated with a specific life role (Goode, 1960). Within education literature, the concept of role strain has been used to explicate the difficulties that many individuals face in the student role, and how those difficulties can potentially hinder academic success (Bowman, 2013; Williams, 2014a,b, 2020; Williams et al., 2016, 2019). Student role strain represents the objective challenges that individuals encounter in their student role, as well as their subjective reactions to those objective challenges (Bowman, 2013; Williams, 2014a,b). In this study, we examine student role strain in mathematics, which represents challenges students experience in this particular content area. Existing studies have noted that math-specific student role strain can reduce positive outcomes in this subject (Williams et al., 2016, 2019).

Expanding upon existing role strain literature, the BRSAM (Bowman, 2006, 2013) provides a critical framework for understanding how students' strains and strengths combine to impact their outcomes in various domains including educational achievement. Figure 1 illustrates this model. The overall model demonstrates how various elements including different social forces (e.g., structured inequalities related to social stratification), life course and biological factors, coping strategies, etc., can combine to influence important educational outcomes such as math achievement. However, the aspect of the model most germane to this study is its emphasis on student role strain and multilevel strengths. As suggested by the title, the Bowman model acknowledges the challenges or strains students encounter in academic spaces that can hinder success. These challenges can manifest in both objective and subjective domains. For example, an objective difficulty in math can occur when a student has a low level of math content understanding.

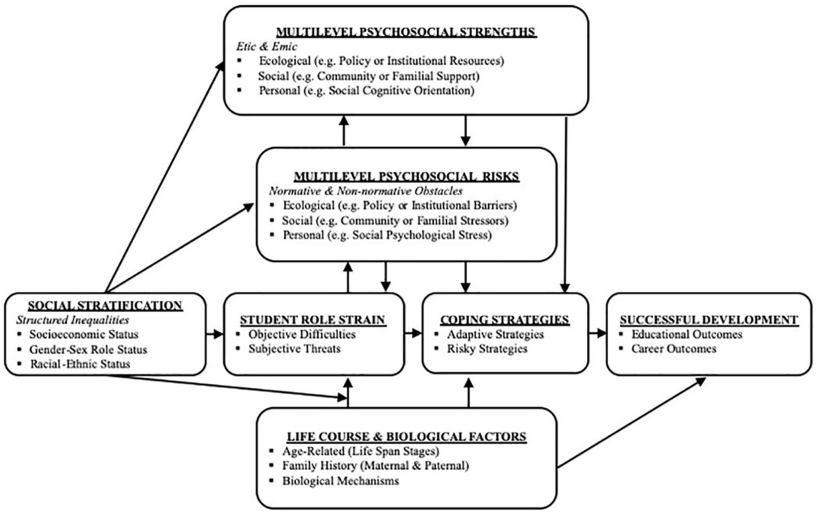

FIG. 1: Bowman role strain and adaptation model [reprinted from Burt et al. (2019), with permission from SAGE]

A related subjective threat could be the student becoming academically discouraged in math coursework. As a strength-based framework, the BRSAM also acknowledges that students are able to employ various strengths, which can promote adaptive coping and thereby help to foster successful outcomes despite strains. These strengths exist at multiple levels and can include positive personal attributes, as well as social support from peers, families, educators, and other individuals highly regarded within students' lives. Accordingly, the BRSAM provides an integrative approach for understanding how students' academic challenges and multilevel strengths operate in concert to influence key education outcomes.

Guided by the BRSAM, this study explores how the role strain and multilevel strengths that Black and Latinx students bring to educational environments relate to their high school math achievement. Additionally, these analyses examine how the relationships between multilevel strengths and math achievement may differ based upon strain. Because this study focuses on math specifically, student strain and strengths that are directly related to this content area are considered.

4. METHODS

4.1 Sample and Data

This research uses data from the High School Longitudinal Study of 2009 (HSLS:09)—a large-scale school-based longitudinal study conducted by the National Center for Education Statistics (NCES). One unique aspect of HSLS:09 is that it includes specific information about students' experiences in math and science (Ingles et al., 2013). Furthermore, it consists of a nationally representative sample of students within the United States who started ninth grade in 2009. The HSLS:09 data were collected using a two-stage stratified random sampling procedure to identify students at public and private schools within the United States. One thousand nine hundred eligible schools were identified during the first stage of sampling. Endorsements were provided by various nationally recognized organizations that work closely with school administrators, counselors, teachers, students, and parents (e.g., American Association of School Administrators, the American Federation of Teachers, and the National Education Association) to bolster school recruitment efforts. School administrators, diocese, and superintendents from the sampled schools provided approval from appropriate school representatives to initiate recruitment of student participants. After study approval, about one-half of eligible schools participated in the study (Ingles et al., 2013). During the second stage of the sampling procedure, enrollment lists were used to randomly sample students. Once identified, over 80% of students ultimately participated in the study. Initial surveys were administered to students in the ninth grade during the first semester of 2009. Follow-up surveys were administered in 2012 during the second semester of students' 11th grade year and in 2016—three years after most would have graduated.

Base-year and first-year follow-up data are used in the present study to examine the association between Black and Latinx students' math-related strain and strengths and

math achievement in high school. Independent and control variables originate from the base-year survey data, and the outcome measure comes from the follow-up survey administered during 11th grade. The sample for the study was limited to students who met the following criteria: 1) students who had data from the base-year and first-year follow-up surveys; 2) students who had achievement scores on the 11th grade mathematics assessment; and 3) students who self-identified as Black or Latinx. We focus on mono-racial students who specifically identify as Black or Latinx, given the policy emphasis on broadening participation for these groups and evidence that racial self-identification for multiracial students may differ based upon context (Harris and Sim, 2002). Accordingly, there is a need to appreciate the unique educational experiences of mono-racial and multi-racial students (Burke and Kao, 2013; Harris, 2017).

This study uses a design-based approach to conduct single-level (i.e., student-level) analysis while accounting for homogeneous clusters within the data (Hahs-Vaughn, 2005; Thomas and Heck, 2001). Because of the complex sampling design of the study, a design-effect adjusted weight was used in the SPSS software program. The unweighted sample for this study is 4,855. The analytic sample size is $N = 1{,}407$ after using a design-effect adjusted weight. Results are generalizable to the 2009 cohort of ninth grade students who were also in the 11th grade in 2012.

4.2 Measures

As previously discussed, this study examines theoretical relationships suggested by the Bowman role strain and adaptation model about the relationships between Black and Latinx students' role strain, strengths, and achievement. Math-related student role strain is operationalized using a measure of students' math proficiency during ninth grade. Moreover, various measures are employed to examine students' math-related multilevel strengths at individual and social levels. Also, these analyses account for important student background characteristics. Table 1 includes important variable description and coding information employed throughout this study. The outcome and continuous measures have been standardized to allow the reader some insight about effect size.

4.2.1 Outcome: Math Achievement

Black and Latinx students' math achievement is the outcome of interest in these analyses. This outcome is operationalized based upon students' scores on a standardized math exam administered during the 11th grade. This math assessment specifically focuses on students' understanding of algebraic content (Ingles et al., 2013).

4.2.2 Math-Related Student Role Strain

Math-related student role strain is measured using information about Black and Latinx students' math proficiency during the ninth grade. This construct is operationalized using NCES-derived math proficiency probability scores. The math proficiency probabil-

TABLE 1: Variable description and coding information

Independent Variable	Variable Description	Variable Type	Variable Coding	Source
	Background Characteristics			
Female	Student's gender	Dichotomous	1 = female; 0 = male	BY survey
Socioeconomic status	Family socio-economic background	Continuous		BY survey
Black	Racial/ethnic background	Dichotomous	1 = Black; 0 = Latinx	BY survey
	Math-Related Student Role Strain			
High math strain	Low level of algebraic proficiency during ninth grade	Dichotomous	1 = high math strain; 0 = low math strain	BY survey
	Math-Related Multilevel Strengths			
Math identity	Degree to which student relates to or has a personal association with math as a subject	Continuous		BY survey
Math self-efficacy	Students' beliefs in their ability to do math	Continuous		BY survey
Math interest	Students' interest in math	Continuous		BY survey
Math utility	Degree to which students perceive math course would be helpful in life, college, or their future careers	Continuous		BY survey
General math-related social support	Degree to which student consulted with parents, peers, favorite teacher, and school counselor about math course-taking	Continuous		BY survey
Math-related social group	Student participation in various math-related social groups since the beginning of high school	Dichotomous	1 = participated in math club, math competition, math summer programs, math study groups, and math tutoring; 0 = did not participate	First FU survey
	Outcome Variable			
Eleventh grade math achievement	Eleventh grade math assessment score	Continuous		First FU survey

BY, base year survey; FU, follow-up survey.

ity score represents the probability that students would pass a particular proficiency level in algebra. This score is derived from students' base-year (i.e., ninth grade) mathematics scores on the algebra assessment. There are five proficiency levels in the base year survey, with algebraic expressions representing the lowest level (i.e., Level 1). An understanding of algebraic expressions includes skills such as students being able to evaluate simple algebraic expressions and to translate between verbal and symbolic representations of expressions (Ingles et al., 2013). The five proficiency levels are structured hierarchically such that mastery at a higher level implies proficiency at each lower level.

In this study, math-related student role strain is operationalized based upon a student having a low likelihood of understanding algebraic expressions. To capture this, a dichotomous measure was created to identify students with high math strain (e.g., those with a low probability of proficiency). In this study, students with high math strain are those whose probability of proficiency in algebraic expressions is 50% or less. These students are coded with a value of 1 on the math strain measure. Students with a probability of proficiency greater than 50% are coded with a value of 0.

4.2.3 Personal Strengths: Positive Psychological Math Orientations

Black and Latinx students' personal strengths are one aspect of the multilevel strengths (MLS) considered in this study. These strengths are measured based upon their positive psychological orientations toward mathematics. These include measures of their math self-efficacy, math identity, math interest, and math utility. Each construct is measured using NCES composites from the base-year survey. The NCES-created composites are continuous and centered at 0, with higher values indicating more positive beliefs. Also, each has a fair to high level of internal consistency, with a Cronbach's alpha minimum of 0.65 (Ingles et al., 2013). An increase in students' scores on a given construct indicates a higher positive psychological orientation toward mathematics.

Math self-efficacy is measured by survey items concerning students' personal beliefs in their math abilities. Students were asked to rate their level of agreement on a 4-point Likert scale (i.e., "strongly agree" to "strongly disagree") with statements such as the following: "you are confident that you can do an excellent job on tests in your current math course"; "you are certain that you can understand the most difficult material presented in the textbook used in this course"; and "you are certain that you can master the skills being taught in this course." In addition to math self-efficacy, *math identity* is considered as a personal strength. Math identity indicates the degree to which students relate to or have a personal association with math as a subject. Survey items used to create this construct include students' responses to statements such as: "you see yourself as a math person" and "others see you as a math person." Again, participant responses were provided on a 4-point Likert scale ranging from "strongly agree" to "strongly disagree."

Along with self-efficacy and identity, measures for students' math interest and math utility are also included. *Math interest* represents students' attitudes about or perceptions of the subject and includes students' level of agreement to statements such as: "you are

enjoying your current math course very much"; "you think your current math course is a waste of your time"; and "you think your current math course is boring." Additionally, *math utility* provides insight about the degree to which students perceive that their high school math course would be helpful in life, college, or their future career. Students were asked to rate their level of agreement with statements such as: "your current math course is useful for everyday life"; "your current math course will be useful for college"; and "your current math course will be useful for a future career." Responses for the math interest and math utility items were also measured on a 4-point Likert scale ranging from "strongly agree" to "strongly disagree."

4.2.4 Social Strengths: Math-Related Supports

Math-related social supports are also examined as a complement to Black and Latinx students' personal strengths. This study focuses on two types of social supports: the general math support received about their math course selection process and the targeted supports received through participation in math-related social clubs. General support in math is operationalized by students' math-related interactions with individuals such as their parents, peers, a favorite teacher, and a school counselor. Students indicated whether they consulted with each of these individuals about which math courses to take. These items were averaged to create a general math support composite score, and the construct was measured with a high degree of internal consistency ($\alpha = 0.96$). In terms of targeted math supports, this research examined students' participation in math-related social clubs and similar activities. To operationalize this construct, survey items were used that inquired about students' retroactive participation in the following activities since the beginning of the first semester in 2009: math clubs, math competitions, math summer programs, math study groups, and math tutoring. We used these items to create a dichotomous measure, where "0" indicated non-participation for each of these activities, and "1" indicated participation in at least one of these activities.

4.2.5 Background Characteristics

To examine how Black and Latinx students' ninth grade math-related strains and multilevel strengths relate to their 11th grade math achievement, it is important to account for key background characteristics that may also relate to math scores. Consequently, this study included measures of students' gender and family socio-economic status (SES). Regarding gender, the original variable in the data was recoded such that females and males were given values of 1 and 0, respectively. An NCES-created SES composite measure was included to account for individual math achievement differences that may result due to students' social and economic backgrounds. This measure captures students' socio-economic status based on their parents' or guardians' education, parents' or guardians' occupation, and their family income (Ingels et al., 2013). Higher values on this composite indicate higher socio-economic status.

4.3 Analytic Approach

The data for this study were collected using a complex sampling design, where schools were randomly selected initially and students within those schools were then randomly selected. In order to account for this aspect of the sampling process, design-effect adjusted weights were utilized. This approach was appropriate because single-level (i.e., student-level) analyses were conducted (Hahs-Vaughn, 2005; Thomas and Heck, 2001). Descriptive analyses were used to better understand key characteristics of the sample. Overall descriptive statistics were examined. Additionally, differences in key measures based on students' level of math strain were investigated. Chi-square or *t*-tests were employed to examine differences between Black and Latinx students with high and low math strain in 11th grade math achievement, as well as their differences in background characteristics, math-related role strain, and math-related personal and social (i.e., multilevel) strengths. Also, correlation coefficients were calculated as an initial exploration of relationships between these measures. Thereafter, multiple regressions analyses were conducted to examine how students' math-related strains and strengths relate to their math achievement while including other important background characteristics in the model. For this aspect of the study, ordinary least-squares (OLS) regression was an appropriate analytic technique because the outcome for this study—11th grade math achievement—is continuous (Chatterjee and Hadi, 2015). A total of seven OLS regression models were conducted in this study. The first model is displayed in Eq. (1) and examines the main effects of Black and Latinx students' math-related role strain and MLS on their 11th grade math achievement after accounting for important demographic characteristics:

$$\begin{aligned} \text{11th grade math achievement} = {} & \beta_0 + \beta_1\ \text{high math strain} + \beta_2\ \text{math identity} \\ & + \beta_3\ \text{math self-efficacy} + \beta_4\ \text{math interest} + \beta_5\ \text{math utility} \\ & + \beta_6\ \text{general math support} + \beta_7\ \text{math-related social groups} \\ & + \beta_8\ \text{female} + \beta_9\ \text{SES} + \varepsilon \end{aligned} \tag{1}$$

Equation (2) represents Models 2–7. In each of these models, an interaction term is added to Eq. (1) to examine potential moderating effects of high math strain on the relationship between a particular MLS and 11th grade math achievement. An interaction term between the measure for high math strain and each MLS was created and separate models were estimated, each considering a single interaction term:

$$\begin{aligned} \text{11th grade math achievement} = {} & \beta_0 + \beta_1\ \text{high math strain} + \beta_2\ \text{math identity} \\ & + \beta_3\ \text{math self-efficacy} + \beta_4\ \text{math interest} + \beta_5\ \text{math utility} \\ & + \beta_6\ \text{general math support} + \beta_7\ \text{math-related social groups} \\ & + \beta_8\ \text{female} + \beta_9\ \text{SES} + \beta_{10}\ \text{MLS measure} \times \text{high math strain} + \varepsilon \end{aligned} \tag{2}$$

where MLS measure = math identity, math self-efficacy, math interest, math utility, general math support, or math-related social groups.

To facilitate the interpretation of moderating effects, plots were created for significant interaction terms to illustrate the effects. Only models with a significant change in the *R*-square value were interpreted (Jaccard and Turrisi, 2003). A small number of measures within the models were missing data. Results from Little's missing completely at random test suggest that data were missing completely at random. Accordingly, list-wise deletion was employed in these analyses. Because this study uses large-scale national data, this approach is feasible without potential power issues.

5. AUTHORS' POSITIONALITIES

The authors of this study were sensitive toward facets of their own backgrounds that may have shaped or informed various aspects of this research. Both authors identify as Black or African American, and approached this work in a manner informed by their lived experiences and racialized socio-political orientations. Although this study is a collaboration among scholars from different disciplinary backgrounds, each of the authors has a vested interest in scholarship concerning racially marginalized students' experiences in STEM fields from a strength-based perspective—a primary emphasis in the BRSAM.

The first author is a product of STEM-focused educational systems, having attended K-12 schools that had a heavy emphasis on math and science preparation, as well as related career paths. These experiences established a foundation for this author's postsecondary training. The first author has undergraduate and graduate degrees in mathematics, along with a body of research concerning STEM education issues at the secondary and postsecondary levels. Furthermore, the first author has professional experiences teaching mathematics to students from racially minoritized groups. This author's personal training in mathematics, and involvement with educating other racially minoritized students in STEM, helped to shape the author's understanding of the various structural challenges that these students encounter in math-related educational pursuits, as well as how their outcomes may be influenced by aspects of their math concept and support systems.

The second author's expertise lies at the intersection of psychology and education. Both of these lenses informed the research process in salient ways and shaped the types of questions pursued. This author's broader research interests focus on internal and external factors that support racially marginalized students' educational pursuits, with an emphasis on psychological and social factors that help to strengthen achievement outcomes for these students. This interest stems from the author's personal educational experiences and observations about the following: various social and institutional factors many racially marginalized students encounter, which function as barriers to success as they navigate educational systems; and the important role of academic and social supports to help these students be successful.

Collectively, each author approaches this research with a keen understanding of the ways in which various parts of the study may be informed by their backgrounds and

prior professional experiences. Each of these aspects of their personal identities inform their desire to better understand how Black and Latinx students' challenges and supports combine to influence an important achievement outcome for these students in a critical STEM area.

6. PROTECTION OF VULNERABLE POPULATIONS

Various steps were taken to protect vulnerable populations throughout this study. The findings make use of data at the aggregate level. No individual's outcomes or school level data are discussed that could make individual students identifiable. Furthermore, this study relies on publicly available national data that are accessible via NCES. In making these large-scale data publicly available, NCES has taken a number of steps to ensure that individual students are not identifiable (Ingles et al., 2013). This includes redacting any sensitive information from the overall data set at the individual and school levels.

7. FINDINGS

7.1 Descriptive Statistics and Correlations

Table 2 includes descriptive statistics for the overall sample of Black and Latinx students in this study, along with descriptive insights based upon their level of math strain. Fifty-one percent of students in this study were female and 38% were Black. About one-fifth of the sample had a high level of math strain and 28% participated in a math-related social group. A number of differences emerged between students with low and high math strain. In general, students with high math strain had lower 11th grade math achievement [$M = 43.11$, standard deviation (SD) = 12.03] compared to their peers with low math strain [$M = 62.23$, SD = 16.21, $t(509) = 21.68$, $p < 0.001$]. In terms of background characteristics, there was a lower percentage of students with high math strain identified as female compared to low strain students [X^2 (1, $N = 1407$) = 9.47, $p < 0.01$]. Black students comprised a higher proportion of the pool of high strain students compared to low strain students [X^2 (1, $N = 1407$) = 24.64, $p < 0.001$]. Also, high math strain students generally had lower SES ($M = -0.67$, SD = 0.52) compared to low strain students [$M = -0.39$, SD = 0.67, $t(483) = 7.51$, $p < 0.001$]. With regard to math-related multilevel strengths, high math strain students generally had reduced psychological orientations toward mathematics compared to their low strain peers. For example, Black and Latinx students with high math strain had lower levels of math identity ($M = -0.38$, SD = 0.96) compared to students with low math strain [$M = 0.06$, SD = 0.97, $t(1379) = 6.46$, $p < 0.001$]. Furthermore, students with high math strain indicated lower levels of general math-related social support ($M = 0.21$, SD = 0.23) compared to students with low math strain [$M = 0.27$, SD = 0.26, $t(340) = 3.76$, $p < 0.001$].

Table 3 includes correlational information about the background characteristics, math-related student role strain, and MLS for the overall sample of Black and Latinx

TABLE 2: Descriptive statistics by level of math strain

Variable	All (N = 1407)		Math Strain				Significance
			Low Math Strain (N = 1143)		High Main Strain (N = 264)		
	Mean	SD	Mean	SD	Mean	SD	
Outcome							
Eleventh grade math achievement	58.64	17.21	62.23	16.21	43.11	12.03	***
Background Characteristics							
Female	0.51	—	0.53	—	0.42	—	**
Socioeconomic status	−0.44	0.65	-0.39	0.67	−0.67	0.52	***
Black	0.38	—	0.35	—	0.52	—	***
Math-Related Student Role Strain							
High math strain	0.19	—	—	—	—	—	
Math-Related Multilevel Strengths							
Math identity	−0.02	0.98	0.06	0.97	−0.38	0.96	***
Math self-efficacy	0.00	0.98	0.06	0.94	−0.31	1.09	***
Math interest	0.04	0.99	0.10	0.98	−0.25	0.99	***
Math utility	0.16	1.00	0.18	0.96	0.09	1.15	
General math-related social support	0.26	0.26	0.27	0.26	0.21	0.23	***
Math-related social group	0.28	—	0.27	—	0.28	—	

Significance: ~ $p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Note: standard deviations are not reported for dichotomous measures.

TABLE 3: Correlations among study variables

Variable	Measurement																			
	2	***p***	**3**	***p***	**4**	***p***	**5**	***p***	**6**	***p***	**7**	***p***	**8**	***p***	**9**	***p***	**10**	***p***	**11**	***p***
1. Eleventh grade math achievement	0.01		0.26	***	−0.13	***	−0.38	***	0.25	***	0.22	***	0.13	***	−0.03		0.21	***	0.06	~
2. Female	—		0.04		0.02		−0.06	~	0.01		−0.06	~	0.02		0.00		0.04		0.09	**
3. Socio-economic status			—		0.16	***	−0.14	***	0.06	~	0.09	**	0.00		−0.06	~	0.19	***	0.07	*
4. Black					—		0.14	***	0.07	*	0.13	***	0.05		0.14	***	−0.02		0.08	*
5. High math strain							—		−0.17	***	−0.17	***	−0.13	***	−0.03		−0.08	*	0.02	
6. Math identity									—		0.54	***	0.52	***	0.23	***	0.18	***	0.07	*
7. Math self-efficacy											—		0.53	***	0.35	***	0.13	***	0.03	
8. Math interest													—		0.35	***	0.14		0.05	***
9. Math utility															—		0.04		0.03	
10. General math-related social support																	—		0.11	**
11. Math-related social group																			—	

Significance: ~$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

students in this study. In terms of background characteristics, Black and Latinx students' SES had a small positive correlation with the outcome ($r = 0.26$, $p < 0.001$). Also, Black students generally had lower 11th grade math achievement compared to the Latinx students in the study ($r = -0.13$, $p < 0.001$). However, gender was not related to the 11th grade math achievement outcome—a finding supported by other studies that note how long-standing gender gaps in math achievement have improved over time (Cheema and Galluzzo, 2013; Hyde et al., 2008).

Most measures of Black and Latinx students' ninth grade math-related strain and strengths were correlated with their 11th grade math achievement. Having high math-related strain was moderately and negatively correlated with the outcome ($r = -0.38$, $p < 0.001$); however, most of the indicators for Black and Latinx students' MLS were positively associated with their 11th grade math score. Concerning Black and Latinx students' psychological dispositions, the measures for students' math identity, math self-efficacy, and math interest had weak positive relationships with the outcome ($r = 0.25$, $p < 0.001$, $r = 0.22$, $p < 0.001$, and $r = 0.13$, $p < 0.001$, respectively). In terms of Black and Latinx students' math-related social supports, their general math-related support had a small positive correlation with their math score ($r = 0.21$, $p < 0.001$), and there was a negligible positive correlation between their participation in a math-related social group and their math achievement ($r = 0.06$, $p < 0.10$).

7.2 Math-Related Strain, Multilevel Strengths, and Math Achievement for Black and Latinx Students

Table 4 indicates how Black and Latinx students' ninth grade strain and strengths related to their 11th grade math achievement while accounting for important background characteristics. Model 1 highlights the main effects between these factors and the outcome. Results from the linear regression suggest a significant association between students' background characteristics, math-related student role strain, MLS, and 11th grade math score [F (10,948) = 33.83, $p < 0.001$, $R^2 = 0.26$]. On average, Black and Latinx students with high math strain in ninth grade, had 11th grade math achievement scores that were almost a standard deviation lower than those without such strain (B = −0.80, $p < 0.001$).

While high math strain was negatively related to Black and Latinx students' math achievement, a number of their math strengths were positively related to the outcome. These positive relationships manifested even after accounting for students' math strain, which suggests that they can be (generally) beneficial despite students' challenges. In terms of personal attributes, Black and Latinx students with greater math identity in ninth grade also had higher 11th grade math scores (B = 0.14, $p < 0.001$). Similarly, those with higher math self-efficacy generally had higher math achievement (B = 0.12, $p < 0.01$). Interestingly, Black and Latinx students' ninth grade math interest was not significantly related to their 11th grade math score [B = −0.03, p = not significant (n.s.)] and their math utility was negatively related to achievement (B = −0.07, $p < 0.05$). At the social level, Black and Latinx students with general math-related social support in ninth grade had higher math scores in 11th grade (B = 0.11, $p < 0.001$); however, there

TABLE 4: Moderated regression analyses assessing the influence of math-related role strain and strengths on 11th grade math achievement for Black and Latinx students

Independent Variable	Model (Number and Description)																				
	1: Main Effect			2: Identity Interaction			3: Self-Efficacy Interaction			4: Interest Interaction			5: Utility Interaction			6: Social Support Interaction			7: Social Group Interaction		
	B	*p*	SE	B	*p*	SE	B	*p*	SE	B	*p*	SE	B	*p*	SE	B	*p*	SE	B	*p*	SE
Background Characteristics																					
Female	−0.03		0.06	−0.03		0.06	−0.02		0.06	−0.02		0.06	−0.02		0.06	−0.03		0.06	−0.03		0.06
Socioeconomic status[a]	0.20	***	0.03	0.19	***	0.03	0.19	***	0.03	0.20	***	0.03	0.20	***	0.03	0.20	***	0.03	0.20	***	0.03
Black	−0.29	***	0.06	−0.29	***	0.06	−0.29	***	0.06	−0.29	***	0.06	−0.30	***	0.06	−0.29	***	0.06	−0.29	***	0.06
Math-Related Student Role Strain																					
High math strain	−0.80	***	0.08	−0.87	***	0.09	−0.88	***	0.09	−0.84	***	0.08	−0.80	***	0.08	−0.80	***	0.08	−0.79	***	0.10
Math-Related Multilevel Strengths																					
Math identity[a]	0.14	***	0.04	0.17	***	0.04	0.14	***	0.04	0.14	***	0.04	0.14	***	0.04	0.14	***	0.04	0.14	***	0.04
Math self-efficacy[a]	0.12	**	0.04	0.13	***	0.04	0.17	***	0.04	0.13	***	0.04	0.13	***	0.04	0.12	**	0.04	0.12	**	0.04
Math interest[a]	−0.03		0.04	−0.03		0.04	−0.03		0.04	−0.01		0.04	−0.03		0.04	−0.03		0.04	−0.03		0.04
Math utility[a]	−0.07	*	0.03	−0.07	*	0.03	−0.06	*	0.03	−0.07	*	0.03	−0.05		0.03	−0.07	*	0.03	−0.07	*	0.03
General math-related social support[a]	0.11	***	0.03	0.11	***	0.03	0.11	***	0.03	0.11	***	0.03	0.11	***	0.03	0.11	***	0.03	0.11	***	0.03
Math-related social group	0.10		0.06	0.10		0.06	0.09		0.06	0.10		0.06	0.09		0.06	0.10		0.06	0.10		0.07
Math identity × high math strain				−0.18	*	0.08															
Math self-efficacy × high math strain							−0.25	***	0.07												
Math interest × high math strain										−0.14	~	0.08									
Math utility × high math strain													−0.14	*	0.07						
General math-related social support × high math strain																0.02		0.08			

TABLE 4: (*continued*)

Math-related social group × high math strain																			−0.03		0.17
Constant	0.20	***	0.05	0.20	***	0.05	0.20	***	0.05	0.20	***	0.05	0.20	***	0.05	0.20	***	0.05	0.20	***	0.05
Fit Statistics																					
R-square (R^2)	0.263	***		0.267	***		0.272	***		0.265	***		0.266	***		0.263	***		0.263	***	
Change in *R*-square (ΔR^2)				0.004	*		0.009	***		0.002	~		0.003	*		0.000			0.000		

[a]Variable is standardized (mean = 0; SD = 1); unstandardized coefficients reported.
Significance: ~$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

was no statistically significant relationship between their involvement in a math-related social group and their math achievement (B = 0.10, p = n.s.).

7.3 Black and Latinx Students' Math Achievement and the Moderating Effects of Math Strain on Math-Related Strengths

In addition to the main effects of math-related strain and MLS on Black and Latinx students' math achievement, moderating relationships were examined. Building upon the descriptive statistics in Table 2, this study examines if the relationship between math-related MLS and 11th grade math achievement differs for Black and Latinx students with high or low levels of math strain. Table 4 (Models 2–7) includes the results of these analyses. In some instances, the relationships between math-related MLS and 11th grade math achievement were not moderated by the level of math strain that Black and Latinx students had during ninth grade. However, significant interactions emerged when examining math identity, math self-efficacy, and math utility. Figures 2–4 illustrate these interactions for better interpretation.

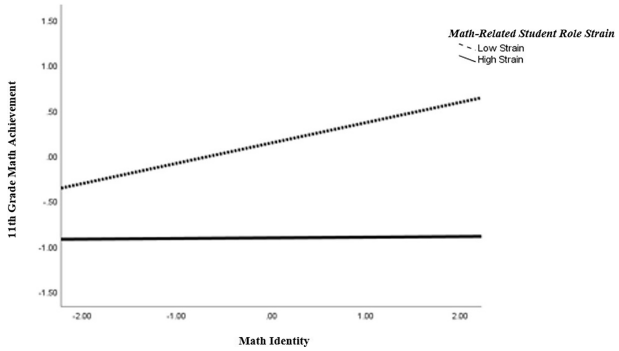

FIG. 2: Moderating effects of math-related student role strain on relationship between Black and Latinx students' math identity and 11th grade math achievement

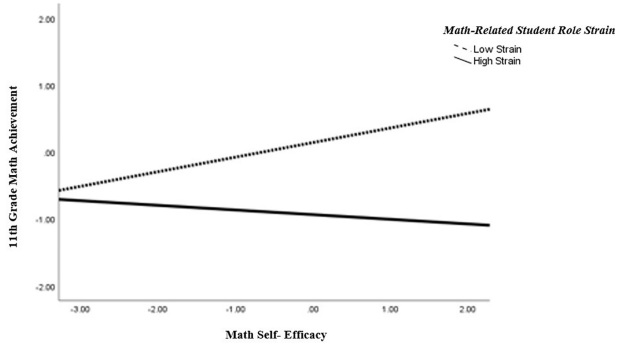

FIG. 3: Moderating effects of math-related student role strain on relationship between Black and Latinx students' math self-efficacy and 11th grade math achievement

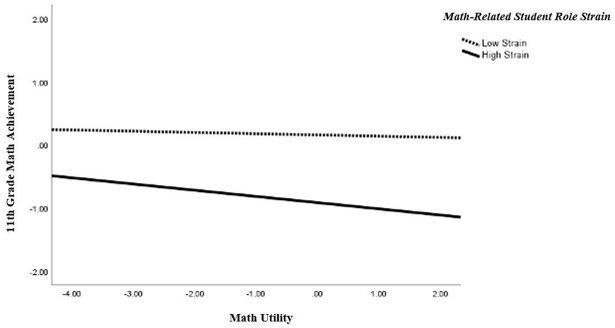

FIG. 4: Moderating effects of math-related student role strain on relationship between Black and Latinx students' math utility and 11th grade math achievement

Figure 2 illustrates how math identity relates to 11th grade math achievement for students with low and high levels of math strain. The data suggest a positive relationship between math identity and math achievement for Black and Latinx students who had low ninth grade math-related strain; however, no relationship between math identity and achievement manifested for Black and Latinx students with high math strain. Thus, only Black and Latinx students with low math strain appear to benefit from high levels of math identity as shown in Fig. 2.

Figure 3 shows the interaction between math self-efficacy and strain. While a positive relationship between math self-efficacy and achievement emerges for low strain students, the inverse is true for Black and Latinx students with high strain. For high strain students, the data suggest that as their math self-efficacy increases, their 11th grade math achievement decreases.

Figure 4 illustrates the moderating effect of math strain on the relationship between math utility and 11th grade math achievement. While the main effects model (i.e., Model 1) suggests an overall negative relationship between utility and achievement, a closer examination of the interaction term provides additional information. For Black and Latinx students with high levels of math strain, their level of math achievement decreases as their conception of math utility increases. For students with low levels of strain, no relationship between math utility and achievement is apparent.

8. DISCUSSION

The findings from this study underscore the importance of Black and Latinx students' ninth grade math-related strain and multilevel strengths in better understanding their math achievement during 11th grade. The data suggest that entering high school with math academic challenges (i.e., strains) can have a lasting impact on later achievement. Despite the negative relationship between math strain during ninth and 11th grade math achievement, the multilevel strengths that Black and Latinx students bring to educational settings are also important to consider. However, the findings point to a pressing need to understand the interplay between students' strengths and strains.

Our study suggests that some aspects of students' math-related dispositions can help to foster math achievement; however, the results indicate that these relationships are not universal for all Black and Latinx students. Students with higher math identity and math self-efficacy during ninth grade generally had higher math scores in 11th grade. However, similar to other research (Williams, 2020), this study suggests differences in the relationship between each of these personal strengths and math achievement based on prior math challenges. In terms of math identity, the positive returns from high levels of identification only manifested for Black and Latinx students with low prior math strain. No relationship between math identity and achievement manifested for those with prior math challenges. Regarding math self-efficacy, this psychosocial disposition was positively related to achievement for students that did not have prior math challenges; however, the inverse was true for high strain students. For Black and Latinx students with prior math challenges, as their math self-efficacy belief increased, their achievement decreased. These findings add a different perspective about the benefits of these attributes for (some) Black and Latinx students, and complicate movements to strongly emphasize these student characteristics (i.e., a focus on the person) without equal emphasis on the preparation opportunity barriers that Black and Latinx students often encounter (i.e., a focus on larger structural issues).

Regarding math utility, another interesting relationship emerged that suggests a distinct difference between Black and Latinx students with high and low levels of math strain. Students with higher conceptions about the utility of mathematics during ninth grade generally had lower math achievement in 11th grade. Examining this relationship for low and high strain students, separately, offers some nuance. Although no apparent relationship exists between math utility conceptions and achievement for students with low levels of strain, a negative relationship between utility and achievement manifests for students with prior math challenges. Accordingly, among students with high strain, the more that they perceive math to be useful in life, college and their future careers, the lower their levels of achievement during 11th grade. This finding further highlights a need to better understand the relationships between math-related psychosocial dispositions and math achievement with more refinement, as subsequently discussed.

In terms of social supports, Black and Latinx students who indicated higher levels of support from peers, family, and school officials about math course taking (i.e., general math-related support) during ninth grade had higher math scores later in high school. This positive association was consistent regardless of students' prior challenges in mathematics. Nonetheless, these students' participation in math-related social groups (e.g., math clubs, study groups, competitions, etc.) was not significantly related to their math scores.

Overall, these findings not only illustrate the importance of considering math achievement in the context of Black and Latinx students' strengths and strains, they also offer compelling implications for theory, educational practice, and STEM education policy. The following discussion outlines some of these implications in detail.

8.1 Theoretical Insights: Strain-Induced Perception–Performance Misalignment as an Achievement Impediment

The literature concerning math-related psychological orientations such as math self-efficacy and math identity generally frames these as positive attributes that can help to foster student success in mathematics (Kotok, 2017; Williams, 2020; Williams et al., 2016). From a strength-based perspective, this research focuses on the positive impacts of such dispositions and suggests that they may help to foster successful outcomes. To be sure, in this paper, we acknowledge these attributes are important factors that can help students to be successful in various domains. However, we suggest a need to better understand how they operate to promote math achievement and for whom. In this study, math identity and math self-efficacy appear to be positively associated with math achievement, but there are some important nuances worth considering. The data suggest that these positive relationships are not universal; in fact, they generally manifest for Black and Latinx students who do not have prior math proficiency challenges. Furthermore, for students with high math strain, our findings suggest a negative relationship between achievement and students' conception of math's utility in everyday life, college, and the future. We argue that these relationships are indicative of a *strain-induced perception–performance misalignment*, where students' prior math challenges create a unique barrier to the potential benefits of positive math-related psychological orientations.

While a number of studies note the benefits of math identity to promote successful math outcomes (McGee and Pearman, 2014; Williams, 2020; Williams et al., 2016) and math identification has become a central focus of STEM discussions about increasing student success, our analyses suggest a need to qualify the positive impacts that may exist. The findings from this study propose that math identity operates as a benefit only for Black and Latinx students who enter the classroom with a certain level of math proficiency upon which to build. Accordingly, a focus on math identity without an equal focus on students' objective challenges is unlikely to produce the desired results. Furthermore, focusing on the degree to which Black and Latinx students are math identified and not focusing on the various math barriers they often encounter (Ladson-Billings, 2006; Moses and Cobb, 2002) overlooks structural issues that can hinder success (i.e., the things that contribute to strain) (Martin et al., 2010), and places the onus on students to align themselves with a field that is often critiqued for racial biases (Davis and Martin, 2008; Ridgeway and McGee, 2018; Wagner et al., 2020), which can create unwelcoming environments that disrupt identification development for Black and Latinx students. Research notes a better need to acknowledge how marginalized students' understanding of the environment and social landscape impacts their academic achievement and attitudes (Gray et al., 2018; Mickelson, 1990; Oyserman et al., 2006).

The detrimental impact of the perception–performance misalignment between math self-efficacy and math achievement also merits attention. Other research provides additional support for the moderating effect of prior math knowledge on the positive relationship between math self-efficacy and achievement. Prior research indicates that

math self-efficacy beliefs are most beneficial for students with high levels of prior math achievement (Williams, 2020). In this study, the positive relationship between math self-efficacy and achievement manifests for students who have low math strain. However, combining high strain and high efficacy beliefs can actually be detrimental to achievement for Black and Latinx students. The reasons for this relationship merit further consideration.

One potential reason could relate to measurement issues. Perhaps the typical measures of math self-efficacy are not sufficient for students with high levels of math difficulties. A key aspect of an individual's self-efficacy is his/her/their belief in the ability to be efficacious within a given circumstance. Self-efficacy is often defined as "judgments of how well one can execute courses of action required to deal with prospective situations" (Bandura, 1982, p. 122), which emphasizes context. It is possible that the necessary contextual information about mathematics is not appropriately operationalized for Black and Latinx students who are battling math difficulties (or barriers). Given that high and low strain students differ on a number of key characteristics that are related to math outcomes (e.g., SES and math supports), it is feasible that they may also experience the math learning environment differently. Another plausible explanation relates to students' math opportunity structures. Research notes the importance of connecting students with the resources necessary for them to actualize the possible selves that they envision (Oyserman et al., 2006). There could be important disconnections between high strain students' perceptions of their abilities and the resources at their disposal to do well at math. This overarching idea is not far-fetched given that proper access to adequate preparation is one key resource that is obviously a barrier for many students with high math strain.

The concept of perception–performance misalignment manifests differently when examining the relationship between math utility, strain, and achievement. Similar to other research (Williams, 2020), the main effects model discussed previously suggests a negative relationship between math utility and achievement. However, this study illustrates how the nature of that relationship may differ for Black and Latinx students with high and low levels of math strain. Among students with low strain, those that thought math was useful, and those without similar beliefs, had comparable levels of math achievement. Nevertheless, among students with high math strain, the greater their math utility beliefs, the lower were their levels of math achievement. Again, the authors offer a couple of feasible explanations. One possible explanation relates to the stressful nature of academic environments for many students. Perhaps combining high math strain and strong ideas about the utility of mathematics creates a psychological barrier or a form of academic discouragement that ultimately interferes with math achievement. Another plausible explanation relates to students' read of the academic environment. Perhaps the learning opportunity barriers that many high strain students are experiencing in mathematics are more pronounced or apparent for those who believe that math will be useful for key parts of their lives. It is possible that such an understanding of barriers within the educational environment may be operating in ways that reduce achievement given research that highlights the key role that

students' broader conceptions of opportunity can have on their academic outcomes (Mickelson, 1990; Oyserman et al., 2006). A detailed exploration of these types of perception–performance misalignments is beyond the scope of this study, but these findings illustrate an interesting dynamic that others should consider when seeking to better understand Black and Latinx students' psychological dispositions and their achievement outcomes.

8.2 Educational Barriers, Social Supports, and Educators' Psychological Dispositions: Implications for Education Practice

In addition to personal strengths, the findings suggest that the general math-related support Black and Latinx students have at the beginning of high school may also affect their math achievement closer to graduation. However, in this study, too few of these students received this form of support (i.e., engagement with parents, peers, teachers, or school counselors about math course taking). In fact, nearly three-fourths of Black and Latinx students did not indicate such support during ninth grade. Educational practice should focus on increasing opportunities for these students to gain critical insights about the sequence of math courses they will take. This is especially important given the way in which each successive math course in high school often builds upon courses taken previously. While peer interactions and insights from parents may be helpful for establishing a larger community of support, it is imperative that students are also able to consult with high-quality mathematics teachers and academic counselors for guidance about future mathematics course options and to clarify misconceptions students may have about math courses. To better accomplish this, a number of long-standing structural issues in mathematics must first be addressed—namely, the biases that many racially marginalized students encounter when interacting with teachers and counselors (Battey et al., 2021; Copur-Gencturk et al., 2020; Francis et al., 2019). While these biases are undoubtedly reflective of larger societal issues, there are specific steps that could inform practice and help to alleviate these issues. One way to accomplish this is via mindset-driven praxis. While mindset-driven practices are often framed in terms of helping students to confront challenges in adaptive ways that focus on development (Dweck, 2008, 2015; Sun, 2018), we argue for a need to reprogram *educators'* mindsets about Black and Latinx students' potential. In doing so, we encourage teachers and administrators to recognize students' ability to learn difficult content with support and practice, as opposed to situating math skills as an innate characteristic. Such an approach could help educators to reimagine students' potential and general mathematics abilities despite any prior math challenges students may have had. Incorporating these types of efforts into the educational setting is especially important for creating academic spaces that are supportive of Black and Latinx students, who often receive discouraging messages about their STEM abilities, do not see positive representations of themselves in the curriculum, or are otherwise "othered" within the learning environment (Yosso et al., 2009; Upton and Tanenbaum, 2014).

8.3 Opportunity Gaps, Social Supports, and STEM Education Policy

One final critical finding from this study emphasizes the need to improve Black and Latinx students' math understanding prior to entering high school—specifically their understanding of algebraic concepts given the focus of the HSLS:09 math assessment. Current research illustrates the ways in which these students' low math preparation is reflective of a larger opportunity gap in mathematics for Black and Latinx students (Ladson-Billings, 2006). A number of students do not have access to algebra content prior to high school, although algebra is a gateway to taking higher-level math courses. In fact, over 40% of schools in the United States do not offer Algebra I during 8th grade (U.S. Department of Education, 2018). Recent estimates suggest that, while nearly one-quarter of all students complete an initial algebra course before high school, only 13% of Latinx students and 12% of Black students do so (U.S. Department of Education, 2018). This is important to consider because completing an initial algebra class before high school puts students on the trajectory to complete calculus before high school graduation, which will help them to pursue STEM majors in college. However, research suggests that access to algebra before high school is only part of the dilemma. Even among schools where algebra is available during 8th grade, there are often lags in course enrollment (U.S. Department of Education, 2018).

With this in mind, additional policy efforts are needed to ensure adequate access to algebraic content before high school, and to increase enrollment in those courses. One way to accomplish this could be to increase public funding to K-12 systems to improve: 1) students' understanding of the math content needed to be able to take algebra before entering high school; and 2) access to algebra courses in 8th grade, and thereby reduce math preparation opportunity gaps. Another approach could involve increasing financial support to equip the schools that Black and Latinx students attend with high-quality math teachers, as well as counselors to ensure that enrollment in higher level math courses does not continue to lag behind their availability within schools. While federal statistics can help to increase awareness of these issues on a national level—particularly for Black and Latinx students—collaborative efforts from federal, state, and local policymakers are essential given the influence of state and local governments on educational policy efforts. Nonetheless, the U.S. Department of Education and other federal agencies could provide targeted funding to advance these initiatives given the federal government's traditional role of filling in gaps when critical national needs surface (U.S. Department of Education, n.d.). Because of the rise in the digital revolution and the current economy's heavy reliance on technology and innovation, increasing the number of students in STEM—particularly Black and Latinx students in what will soon be a majority "minority" country (U.S. Census Bureau, 2015)—constitutes a critical national need.

9. CONCLUSIONS

This critical quantitative study employed role strain and adaptation framing to examine how Black and Latinx students' math-related strains and strengths combine to influence their math achievement at an important point in students' STEM trajectories (i.e., high

school). This framework was useful in this study given its relevance for understanding the experiences of underrepresented students and its emphasis not only on students' challenges (and related social context), but also their supports. In general, the findings not only underscore the importance of collectively considering these factors to understand Black and Latinx students' math achievement—but also the need to closely examine these relationships with some nuance.

This research highlights the importance of social supports to help promote Black and Latinx students' math achievement; however, it emphasizes the need to increase these students' access to such supports. Our findings also note that, while some attributes may help to foster math achievement, the positive effects may be muted or non-existent for many Black and Latinx students who have math proficiency challenges. Accordingly, we advance the concept of *strain-induced perception–performance misalignment* to represent instances where students' prior math challenges function as a barrier to the potential benefits of positive math-related psychological orientations. In doing so, we proffer that such misalignments are reflective of larger structural issues that hinder Black and Latinx students' math success. While this study attempts to better explicate how students' personal and social strengths relate to achievement, as well as some of the complexities within these relationships, it also highlights the importance of students' prior math achievement and a need to address early opportunity gaps that can hinder later success. Strength-based research that centers positive social and psychological factors should do so while simultaneously addressing the various structural barriers that manifest before entering high school and hinder math preparation. Other scholars note the importance of exploring these types of questions (Martin et al., 2010), and critique an over-emphasis on racially marginalized students' individual traits at the expense of a broader discussion of institutional barriers (Love, 2019). Failure to give equal attention to strengths and structural challenges can ultimately hinder the benefits of positive math-related dispositions and supports, which are often lauded as avenues to help advance students' math success.

ACKNOWLEDGMENTS

We thank Dr. Angela Johnson for her editorial feedback on this research. We also thank Dr. Jane Daquin for her insightful feedback regarding the research design and study development. This research was supported by a grant from the American Educational Research Association (AERA), which receives funds for its "AERA Grants Program" from the National Science Foundation (NSF) under the Division of Research on Learning (DRL) Award NSF-DRL 1749275. The opinions reflect those of the authors and do not necessarily reflect those of AERA or NSF.

REFERENCES

Adams, T., Robinson, D., Covington, A., & Talley-Matthews, S. (2017). Fueling the STEMM pipeline: How historically Black colleges and universities improve the presence of African American scholars in STEMM. *Journal of Urban Learning, Teaching, and Research*, 13, 9–25.

Andersen, L., & Ward, T. J. (2014). Expectancy-value models for the STEM persistence plans of ninth-grade high-ability students: A comparison between Black, Hispanic, and White students. *Science Education*, 98(2), 216–42. DOI: 10.1002/sce.21092.

Anderson, E., Williams, K., Ponjuan, L., & Frierson, H. T. (2018). *The 2018 status report on engineering education: A snapshot of diversity in degrees conferred in engineering.* Association of Public and Land-Grant Universities. Retrieved from https://www.aplu.org/library/the-2018-status-report-on-engineering-education-a-snapshot-of-diversity-in-degrees-conferred-in-engineering/file.

Azmitia, M., Cooper, C. R., & Brown, J. R. (2009). Support and guidance from families, friends, and teachers in Latino early adolescents' math pathways. *The Journal of Early Adolescence*, 29(1), 142–69. DOI: 10.1177/0272431608324476.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist*, 37(2), 122–47. DOI: 10.1037/0003-066X.37.2.122.

Battey, D., Bartell, T., Webel, C., & Lowry, A. (2021). Understanding the impact of racial attitudes on preservice teachers' perceptions of children's mathematical thinking. *Journal for Research in Mathematics Education*, 52(1), 62–93. DOI: 10.5951/jresematheduc-2020-0207.

Berry, R. Q., III, Thunder, K., & McClain, O. L. (2011). Counter narratives: Examining the mathematics and racial identities of Black boys who are successful with school mathematics. *Journal of African American Males in Education*, 2(1), 10–23.

Bowman, P. J. (1990). Coping with provider role strain: Adaptive cultural resources among Black husband-fathers. *Journal of Black Psychology*, 16(2), 1–21. DOI: 10.1177/00957984900162002.

Bowman, P. J. (2006). Role strain and adaptation issues in the strength-based model: Diversity, multilevel, and life-span considerations. *The Counseling Psychologist*, 34(1), 118–33. DOI: 10.1177/0011000005282374.

Bowman, P. J. (2013). A strengths-based social psychological approach to resiliency: Cultural diversity, ecological, and life span issues. In S. Prince-Embury & D. H. Saklofske (Eds.), *Resilience in children, adolescents, and adults: Translating research into practice* (pp. 299–324). New York, NY: Springer.

Burke, R., & Kao, G. (2013). Bearing the burden of whiteness: The implications of racial self-identification for multiracial adolescents' school belonging and academic achievement. *Ethnic and Racial Studies*, 36(5), 747–73. DOI: 10.1080/01419870.2011.628998.

Burt, B. A., Williams, K. L., & Palmer, G. J. (2019). It takes a village: The role of emic and etic adaptive strengths in the persistence of Black men in engineering graduate programs. *American Educational Research Journal*, 56(1), 39–74. DOI: 10.3102/0002831218789595.

Burt, B. A., Williams, K. L., & Smith, W. A. (2018). Into the storm: Ecological and sociological impediments to Black males' persistence in engineering graduate programs. *American Educational Research Journal*, *55*(5), 965–1006. DOI: 10.3102/0002831218763587.

Carpenter, D. M., II. (2008). Expectations, aspirations, and achievement among Latino students of immigrant families. *Marriage & Family Review*, 43(1-2), 164–85. DOI: 10.1080/01494920802013078.

Chatterjee, S., & Hadi, A. S. (2015). *Regression analysis by example*. John Wiley & Sons.

Cheema, J. R., & Galluzzo, G. (2013). Analyzing the gender gap in math achievement: Evidence from a large-scale US sample. *Research in Education*, 90(1), 98–112. DOI: 10.7227/RIE.90.1.7.

Copur-Gencturk, Y., Cimpian, J. R., Lubienski, S. T., & Thacker, I. (2020). Teachers' bias against the mathematical ability of female, Black, and Hispanic students. *Educational Researcher*, 49(1), 30–43. DOI: 10.3102/0013189X19890577.

Covington, A. C., Sheppard, P., Flint, T. K., & Tackie, N. A. (2019). To what extent does hands-on exposure to algebraic thinking predict mathematics achievement for urban middle schoolers? *Journal of Educational Issues*, 5(1), 118–31. DOI: 10.5296/jei.v5i1.14460.

Dalton, B., Ingels, S. J., Downing, J., & Bozick, R. (2007). *Advanced mathematics and science coursetaking in the spring high schools senior classes of 1982, 1992, and 2004* (NCES Publication No. 2007-312). Retrieved from http://nces.ed.gov/pubs2007/2007312.pdf.

Davenport, E. C., Davison, M. L., Wu, Y.-C., Kim, S.-K., Kuang, H., Kwak, N., Chan, C.-K., & Ayodele, A. (2013). Number of courses, content of courses, and prior achievement related to ethnic achievement gaps in mathematics. *Journal of Educational Leadership in Action*, 2(1).

Davis, J., & Martin, D. B. (2008). Racism, assessment, and instructional practices: Implications for mathematics teachers of African American students. *Journal of Urban Mathematics Education*, 1(1), 10–34. DOI: 10.21423/jume-v1i1a14.

Dweck, C. S. (2008). *Mindset: The new psychology of success.* New York: Random House Digital, Inc.

Dweck, C. (2015). Carol Dweck revisits the growth mindset. *Education Week*, 35(5), 20–4.

Erturan, S., & Jansen, B. (2015). An investigation of boys' and girls' emotional experience of math, their math performance, and the relation between these variables. *European Journal of Psychology in Education*, 30(4), 421–35. DOI: 10.1007/s10212-015-0248-7.

Flores, A. (2007). Examining disparities in mathematics education: Achievement gap or opportunity gap? *The High School Journal*, 91(1), 29–42.

Francis, D. V., de Oliveira, A. C., & Dimmitt, C. (2019). Do school counselors exhibit bias in recommending students for advanced coursework? *The B.E. Journal of Economic Analysis & Policy*, 19(4), 1–17. DOI: 10.1515/bejeap-2018-0189.

French, B. F., Immekus, J. C., & Oakes, W. C. (2005). An examination of indicators of engineering students' success and persistence. *Journal of Engineering Education*, 94(4), 419–25. DOI: 10.1002/j.2168-9830.2005.tb00869.x.

Goode, W. J. (1960). A theory of role strain. *American Sociological Review*, 25(4), 483–96. DOI: 10.2307/2092933.

Gottfried, A. E., Marcoulides, G. A., Gottfried, A. W., Oliver, P. H., & Guerin, D. W. (2007). Multivariate latent change modeling of developmental decline in academic intrinsic math motivation and achievement: Childhood through adolescence. *International Journal of Behavioral Development*, 31(4), 317–27. DOI: 10.1177/0165025407077752.

Gottfried, M. A., Owens, A., Williams, D., Kim, H. Y., & Musto, M. (2017). Friends and family: A literature review on how high school social groups influence advanced math and science course taking. *Educational Policy and Analysis Archives*, 25(61). DOI: 10.14507/epaa.25.2857.

Gottfried, M. A., & Plasman, J. S. (2018). From secondary to postsecondary: Charting an engineering career and technical education pathway. *Journal of Engineering Education*, 107(4), 531–55. DOI: 10.1002/jee.20236.

Gray, D. L., Hope, E. C., & Matthews, J. S. (2018). Black and belonging at school: A case for interpersonal, instructional, and institutional opportunity structures. *Educational Psychologist*, 53(2), 97–113. DOI: 10.1080/00461520.2017.1421466.

Hagedorn, L. S., & DuBray, D. (2010). Math and science success and nonsuccess: Journeys within the community college. *Journal of Women and Minorities in Science and Engineering*, 16(1), 31–50. DOI: 10.1615/JWomenMinorScienEng.v16.i1.30.

Hahs-Vaughn, D. L. (2005). A primer for using and understanding weights with national datasets. *The Journal of Experimental Education*, 73(3), 221–48. DOI: 10.3200/JEXE.73.3.221-248.

Harris, D. R., & Sim, J. J. (2002). Who is multiracial? Assessing the complexity of lived race. *American Sociological Review*, 67(4), 614–627. DOI: 10.2307/3088948.

Harris, J. C. (2017). Multiracial college students' experiences with multiracial microaggressions. *Race Ethnicity and Education*, 20(4), 429–45. DOI: 10.1080/13613324.2016.1248836.

Hossler, D., & Stage, F. K. (1992). Family and high school experience influences on the postsecondary educational plans of ninth-grade students. *American Educational Research Journal*, 29(2), 425–51. DOI: 10.3102%2F00028312029002425.

Howell, D., Norris, A., & Williams, K. L. (2019). Towards Black gaze theory: How Black female teachers make Black students visible. *Urban Education Research & Policy Annuals,* 6(1), 20–30.

Hughes, R. (2015). An investigation into the longitudinal identity trajectories of women in science, technology, engineering, and mathematics. *Journal of Women and Minorities in Science and Engineering*, 21(3), 181–213. DOI: 10.1615/JWomenMinorScienEng.2015013035.

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008). Gender similarities characterize math performance. *Science*, 321(5888), 494–5. DOI: 10.1126/science.1160364.

Ingels, S. J., & Dalton, B. W. (2008). *Trends among high school seniors, 1972–2004* (NCES Publication No. 2008-320). National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubs2008/2008320.pdf.

Ingels, S. J., Pratt, D. J. Herget, D. R., Dever, J. A., Fritch, L. B., Ottem, R., Rogers, J. E., Kitmitto, S., Leinwand, S., & Christopher, E. (2013). *High school longitudinal study of 2009 (HSLS:09) base year to first follow-up data file documentation (NCES 2014-361)*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Jaccard, J., & Turrisi, R. (2003). *Interaction effects in multiple regression*. 2nd ed. Sage Publications. DOI: 10.4135/9781412984522.

Kitsantas, A., Cheema, J., & Ware, H. W. (2011). Mathematics achievement: The role of homework and self-efficacy beliefs. *Journal of Advanced Academics*, 22(2), 310–39. DOI: 10.1177/1932202X1102200206.

Kotok, S. (2017). Unfulfilled potential: High-achieving minority students and the high school achievement gap in math. *The High School Journal*, 100(3), 183–202. DOI: 10.1353/hsj.2017.0007.

Kurban, E. R., & Cabrera, A. F. (2020). Building readiness and intention towards STEM fields of study: Using HSLS:09 and SEM to examine this complex process among high school students. *The Journal of Higher Education*, 91(4), 620–50. DOI: 10.1080/00221546.2019.1681348.

Ladson-Billings, G. (2006). From the achievement gap to the education debt: Understanding achievement in U.S. schools. *Educational Researcher*, 35(7), 3–12. DOI: 10.3102/0013189X035007003.

Linder, S. M., Smart, J. B., & Cribbs, J. (2015). A multi-method investigation of mathematics motivation for elementary age students. *School Science and Mathematics*, 115(8), 392–403. DOI: 10.1111/ssm.12146.

Love, B. L. (2019). 'Grit is in our DNA': Why teaching grit is inherently anti-Black. *Education Week*, 38, 21–32.

Martin, D. B., Gholson, M. L., & Leonard, J. (2010). Mathematics as gatekeeper: Power and privilege in the production of knowledge. *Journal of Urban Mathematics Education*, 3(2), 12–24. DOI: 10.21423/jume-v3i2a95

McGee, E. O., & Pearman, F. A., II. (2014). Risk and protective factors in mathematically talented Black male students: Snapshots from kindergarten through eighth grade. *Urban Education*, 49(4), 363–93. DOI: 10.1177/0042085914525791.

Means, B., Wang, H., Wei, X., Iwatani, E., & Peters, V. (2018). Broadening participation in STEM college majors: Effects of attending a STEM-focused high school. *AERA Open*, 4(4), 1–17. DOI: 10.1177/2332858418806305.

Mendenhall, R., Bowman, P. J., & Zhang, L. (2013). Single Black mothers' role strain and adaptation across the life course. *Journal of African American Studies*, 17(1), 74–98. DOI: 10.1007/s12111-012-9220-7.

Mickelson, R. A. (1990). The attitude-achievement paradox among Black adolescents. *Sociology of Education*, 63(1), 44–61. DOI: 10.2307/2112896.

Milner, H. R., IV. (2012). Beyond a test score: Explaining opportunity gaps in educational practice. *Journal of Black Studies*, 43(6), 693–718. DOI: 10.1177/0021934712442539.

Morgan, P. L., Farkas, G., Hillemeier, M. M., & Maczuga, S. (2016). Science achievement gaps begin very early, persist, and are largely explained by modifiable factors. *Educational Researcher*, 45(1), 18–35. DOI: 10.3102/0013189X16633182.

Morton, K., & Riegle-Crumb, C. (2019). Who gets in? Examining inequality in eighth-grade algebra. *Journal for Research in Mathematics Education*, 50(5), 529–54. DOI: 10.5951/jresematheduc.50.5.0529.

Moses, R., & Cobb, C. E. (2002). *Radical equations: Civil rights from Mississippi to the Algebra Project*. Boston, MA: Beacon Press.

Murayama, K., Pekrun, R., Lichtenfeld, S., & vom Hofe, R. (2013). Predicting long-term growth in students' mathematics achievement: The unique contributions of motivation and cognitive strategies. *Child Development*, 84(4), 1475–90. DOI: 10.1111/cdev.12036.

National Council of Teachers of Mathematics. (2018). *Building STEM education on a sound mathematical foundation*. Reston, VA: National Council of Teachers of Mathematics.

National Science and Technology Council. (2018). *Charting a course for success: America's strategy for STEM education*. Accessed 11 May 2021. Retrieved from https://www.energy.gov/sites/prod/files/2019/05/f62/STEM-Education-Strategic-Plan-2018.pdf.

National Science Foundation. (2008). *Broadening participation at the National Science Foundation: A framework for action.* National Science Foundation. Accessed 11 May 2021. Retrieved from https://www.nsf.gov/od/broadeningparticipation/nsf_frameworkforaction_0808.pdf.

Oyserman, D., Bybee, D., & Terry, K. (2006). Possible selves and academic outcomes: How and when possible selves impel action. *Journal of Personality and Social Psychology*, 91(1), 188–204. DOI: 10.1037/0022-3514.91.1.188.

Ramirez, G., Chang, H., Maloney, E. A., Levine, S. C., & Beilock, S. L. (2015). On the relationship between math anxiety and math achievement in early elementary school: The role of problem-solving strategies. *Journal of Experimental Child Psychology*, 141(1), 83–100. DOI: 10.1016/j.jecp.2015.07.014.

Ridgeway, M. L., & McGee, E. O. (2018). Black mathematics educators: Researching toward racial emancipation of Black students. *The Urban Review*, 50(2), 301–22. DOI: 10.1007/s11256-018-0452-2.

Safavian, N., & Conley, A. (2016). Expectancy-value beliefs of early-adolescent Hispanic and non-Hispanic youth: Predictors of mathematics achievement and enrollment. *AERA Open,* 2(4), 1–17. DOI: 10.1177/2332858416673357.

Smedley, B. D., Myers, H. F., & Harrell, S. P. (1993). Minority-status stresses and the college adjustment of ethnic minority freshmen. *The Journal of Higher Education*, 64(4), 434–52. DOI: 10.2307/2960051.

Stevens, T., Olivarez, A., Lan, W. Y., & Tallent-Runnels, M. K. (2004). Role of mathematics self-efficacy and motivation in mathematics performance across ethnicity. *The Journal of Educational Research*, 97(4), 208–22. DOI: 10.3200/JOER.97.4.208-222.

Strayhorn, T. L. (2010). The role of schools, families, and psychological variables on math achievement of Black high school students. *The High School Journal*, 93(4), 177–94.

Sun, K. L. (2018). Brief report: The role of mathematics teaching in fostering student growth mindset. *Journal for Research in Mathematics Education*, 49(3), 330–5. DOI: 10.5951/jresematheduc.49.3.0330.

Thomas, S. L., & Heck, R. H. (2001). Analysis of large-scale secondary data in higher education research: Potential perils associated with complex sampling designs. *Research in Higher Education*, 42(5), 517–40. DOI: 10.1023/A:1011098109834.

Tyson, W., Lee, R., Borman, K. M., & Hanson, M. A. (2007). Science, technology, engineering, and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment. *Journal of Education for Students Placed at Risk*, 12(3), 243–70. DOI: 10.1080/10824660701601266.

Upton, R., & Tanenbaum, C. (2014). The role of historically Black colleges and universities as pathways providers: Institutional pathways to the STEM PhD. *American Institutes for Research*. Accessed 11 May 2021. Retrieved from https://www.air.org/sites/default/files/downloads/report/Role%20of%20HBCUs%20in%20STEM%20PhDs%20for%20Black%20Students.pdf.

U.S. Census Bureau. (2015). *New Census Bureau report analyzes U.S. population projections* (Release No. CB15-TPS.16). Retrieved from https://www.census.gov/newsroom/press-releases/2015/cb15-tps16.html.

U.S. Department of Education. (2018). *A leak in the STEM pipeline: Taking algebra early.* Retrieved from https://www2.ed.gov/datastory/stem/algebra/index.html.

U.S. Department of Education. (n.d.). *The federal role in education.* Accessed 11 May 2021. Retrieved from https://www2.ed.gov/about/overview/fed/role.html#:~:text=Federal%20Role%20

in%20Education&text=Education%20is%20primarily%20a%20State,requirements%20for%20enrollment%20and%20graduation.

Wagner, D., Bakker, A., Meaney, T., Mesa, V., Prediger, S., & Van Dooren, W. (2020). What can we do against racism in mathematics education research? *Educational Studies in Mathematics*, 104(3), 299–311. DOI: 10.1007/s10649-020-09969-w.

Wang, M.-T., & Degol, J. (2013). Motivational pathways to STEM career choices: Using expectancy–value perspective to understand individual and gender differences in STEM fields. *Developmental Review*, 33(4), 304–40. DOI: 10.1016/j.dr.2013.08.001.

Williams, K. L. (2014a). *Financial impediments, academic challenges and pipeline intervention efficacy: A role strain and adaptation approach to successful STEM outcomes for underrepresented students* [Unpublished doctoral dissertation]. University of Michigan.

Williams, K. L. (2014b). Strains, strengths, and intervention outcomes: A critical examination of intervention efficacy for underrepresented groups. *New Directions for Institutional Research*, 2013(158), 9–22. DOI: 10.1002/ir.20042.

Williams, K. L. (2020). Contextualizing math-related strengths and math achievement: Positive math orientations, social supports and the moderating effects of prior math knowledge. *Journal for STEM Education Research*, 3, 317–42. DOI: 10.1007/s41979-020-00033-z.

Williams, K. L., Burt, B. A., & Hilton, A. A. (2016). Math achievement: A role strain and adaptive strengths approach. *Journal for Multicultural Education*, 10(3), 368–83. DOI: 10.1108/JME-01-2016-0005.

Williams, K. L., Coles, J. A., & Reynolds, P. (2020). (Re)creating the script: A framework of agency, accountability, and resisting deficit depictions of Black students in P-20 education. *The Journal of Negro Education*, 89(3), 249–66.

Williams, K. L., Mustafaa, F. N., & Burt, B. A. (2019). Black males and early math achievement: An examination of students' strengths and role strain with policy implications. *Journal of Women and Minorities in Science and Engineering*, 25(4), 325–52. DOI: 10.1615/JWomenMinorScienEng.2019024607.

Yosso, T. J., Smith W. A., Ceja, M., & Solorzano, D. G. (2009). Critical race theory, racial microaggressions, and campus racial climate for Latina/o undergraduates. *Harvard Educational Review*, 79(4), 659–691. DOI: 10.17763/haer.79.4.m6867014157m707l.

Young, J., Young, J., & Witherspoon, T. (2019). Informing informal STEM learning: Implications for mathematics identity in African American students. *Journal of Mathematics Education*, 12(1), 39–56.

Zhang, G., Anderson, T. J., Ohland, M. W., & Thorndyke, B. R. (2004). Identifying factors influencing engineering student graduation: A longitudinal and cross-institutional study. *Journal of Engineering Education*, 93(4), 313–20. DOI: 10.1002/j.2168-9830.2004.tb00820.x.