UNIVERSITY OF CALIFORNIA

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Bridging the Gap:
The Influence of Teacher-Student Racial/Ethnic Matching in Addressing Science, Technology, Engineering, and Mathematics Underrepresentation among High School Students of Color

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Education

by

Jeffrey Yo

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ABSTRACT OF THE DISSERTATION

Bridging the Gap:

The Influence of Teacher-Student Racial/Ethnic Matching

in Addressing Science, Technology, Engineering, and

Mathematics Underrepresentation among High School

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Professor Rashmita S. Mistry, Chair

Black, Latine, and Indigenous students continue to face inequities in high school Science, Technology, Engineering, and Mathematics (STEM) outcomes in the United States (US). Racial disparities between teachers and students contribute to this issue, as teachers of color represent less than thirty percent of public-school educators, while most US youth are of color. Although prior research has emphasized the importance of racial/ethnic matching between teachers and students, limited knowledge exists about how matching can assist high school students of color in STEM high school outcomes (e.g., STEM course enrollment, math/science GPA). Additionally, previous research has traditionally focused on Black and White teachers and students, overlooking diverse teacher-student pairings (e.g., Black teacher with Latine students). Therefore, my two-study dissertation explored the mechanisms by which teacher-student racial/ethnic matching influences STEM outcomes for high school students of color, including diverse groupings of specific teacher-student pairs. Study 1 investigated the mechanisms by which racial/ethnic teacher-student match is associated with high school students of color's math and science GPA, via a structural equation model using data from the High School Longitudinal Study of 2009. Results revealed a nonsignificant or negative association between teacher-student racial/ethnic matches and student GPA, as well as teacher-led factors and student engagement. However, student engagement and teacher-led factors were significantly associated with student GPA, independent of teacher-student racial/ethnic matches. Study 2 continued this investigation and analyzed interview data of high school math and science teachers of color to explore how they perceive and work with students of color. Participants spoke to employing an intersectional approach when engaging and teaching their students, leveraging not only their racial/ethnic identity but also other identities such as language, gender, immigration status, and socioeconomic class. Overall, results emphasize the importance of nuance, suggesting that improving STEM outcomes for students of color requires consideration of multiple factors beyond race, such as enhancing the school environment, improving teacher practices and dispositions, and connecting with students of color through shared identities in addition to race/ethnicity. By recognizing this complexity, policies and practices can best support students of color and ultimately help reduce the racial underrepresentation in STEM.

The dissertation of Jeffrey Yo is approved.

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GENERAL INTRODUCTION

In the United States (US), Black, Latine[1], and Indigenous populations continue to be underrepresented in STEM (Science, Technology, Engineering, and Mathematics) careers and academic pathways (National Center for Science and Engineering Statistics, 2023). Although the reasons for the racial disparity in STEM are varied and complex, one likely contributor is the inequitable K-12 education system for different racial groups. Part of this inequity can be attributed to mismatch in the racial/ethnic backgrounds between K-12 students and their teachers (Villegas & Irvine, 2010). While children of color constitute the majority of youth in the US, the majority of public K-12 teachers are White; teachers of color represent less than thirty percent of educators in public elementary and secondary schools (de Brey et al., 2019). This is striking given that the US is projected to be almost two-thirds non-White by 2060 (Vespa et al., 2020). Without significant interventions in teacher of color recruitment and retention, the racial discrepancy between the growing US child population and the predominantly White teaching population will continue to widen.

Although addressing racial disparities in STEM is complex because the root causes of these disparities lie in structural racism and systemic inequities, policymakers have been exploring various solutions to help rectify the situation. One promising solution is to address the lack of diversity in the teaching workforce, as research has shown the benefits of teacher-student racial/ethnic match in improving academic outcomes (Dee, 2005; Egalite et al., 2015; Goldhaber & Hansen, 2010; Yarnell & Bohrnstedt, 2018). Students of color who have a teacher who shares

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[1] Use of racial/ethnic terms varies throughout the literature review to align with the definitions used in the cited articles, such as using "Hispanic" instead of "Latinx" or "Latino/a" of "Latine", "Black" instead of "African American", "Asian" instead of "Asian/Pacific Islander", and "Indigenous" as opposed to "Alaskan Native/American Indian" as well as "Native Hawaiian/Pacific Islander."

the same racial/ethnic background perform better in long-run attainment outcomes (e.g., high school graduation) and intermediate-term outcomes (e.g., higher attendance, reduced suspensions) (Dee, 2004, 2005; Gershenson et al., 2021a).

What is not as well-known is how a racial/ethnic match can assist high school students of color in their STEM outcomes, such as enrollment in STEM-related courses, math and science grade point average (GPA), and aspirations to pursue a STEM career following graduation. Current research suggests that adult role models who share the same racial/ethnic match with a student of color can help address the underrepresentation in STEM fields (Kricorian et al., 2020). However, more research is needed to see whether math and science teachers of color can serve as role models for high school underrepresented minority (URM; Black, Indigenous, and Latine) students, given how formative high school can be for students in their STEM preparation, STEM identity, and aspirations for a STEM career, which are all major precursors to STEM workforce participation (Museus et al., 2011).

The literature is also unclear about the mechanisms that drive the benefits of a teacher-student racial/ethnic match. Although many factors, such as teacher behavior and role model effects, have been hypothesized to explain the effects of a match, there is limited literature that directly tests these mechanisms, especially in improving STEM related outcomes in high school (e.g., math and science grades, career aspirations in STEM). Furthermore, much of the racial/ethnic matching literature has traditionally focused on Black students and White teachers. Yet, as the United States becomes increasingly diverse, further research on the effects of teacher-student racial/ethnic matching on children from diverse racial and ethnic backgrounds is necessary. Additionally, the literature on teacher-student racial/ethnic mismatches is less clear when it comes to partial matches (i.e., teacher of color paired with a student of color from different racial/ethnic background), which is important for understanding how teachers of color can best serve children of color.

To address current literature gaps, my dissertation explored and investigated the processes by which teacher-student racial/ethnic matching, including partial matches, influences STEM outcomes for high school students of color. First, in my general literature overview, I provide an orientation to the racial disparities in STEM-related outcomes among high school students, highlighting trends in academic achievement, graduation rates, and access to STEM courses and programs. I then turn to a discussion about the importance of teacher-student racial/ethnic match, focusing on the benefits it gives to students and the ways it can help address STEM underrepresentation. Then, I discuss the current limitations in the teacher-student racial/ethnic match literature, such as the mechanisms driving the benefits of a teacher-student racial/ethnic match for students, as well as literature discussing the non-direct match between teachers and students of color. Lastly, I summarize the main objectives of Study 1 and Study 2.

Minority STEM Underrepresentation in High School

As the traditional culmination of formal K-12 education, high school plays a pivotal role in preparing students for further opportunities, including higher education and the workforce. High school is also a crucial time for student development, as teachers can support adolescents in shaping their identities and career aspirations (Bicer et al., 2020; Verhoeven et al., 2019). Despite having a stronger sense of self, high school students remain impressionable to the influence of adults and teachers on their identities (Verhoeven et al., 2019).

Given the importance of high school for students, both in its structural role in society and how it serves students in adolescence, it is disheartening to notice the racial disparities in high school. To start, there continues to be an educational debt in high school graduation rates. In

2018-2019 school year, 80%, 82%, and 74% of Black, Latine, and American Indian/Alaska Native high school students, respectively, received a high school diploma, which is much lower than White (89%) and Asian/Pacific Islander students (93%) and the national average (86%) (Irwin et al., 2022). This fact is also reflected in the racial disparities in college enrollment; the overall college enrollment rate of 18- to 24-year-olds among Hispanic (60%) and Black (54%) students is lower than the national average (63%) and far less than White (67%) and Asian (86%) students (Irwin et al., 2022).

Not only are there lower numbers of URM students graduating from high school and attending college compared to White and Asian students, but URMs who do graduate and attend college are less likely to pursue and graduate with a STEM major. This further lowers the number of URMs in the STEM career pipeline. For instance, in 2020, the proportion of URMs who earned bachelor's degrees in Science and Engineering was significantly lower than their share of the 18- to 34-year-old population, accounting for only 26% of degree recipients (National Center for Science and Engineering Statistics, 2023). In contrast, White and Asian students earned 58% and 12% of these degrees, respectively, which is a higher proportion than their share of the 18- to 34-year-old population (54% and 6%, respectively) (National Center for Science and Engineering Statistics, 2023). Furthermore, compared to 58% of White students, only 34% of African-American and 43% of Latine students who declare a STEM major actually persist in earning their STEM degrees (Riegle-Crumb et al., 2019).

Much of these inequities link back to disparities in high school regarding URM students' preparation for STEM classes and aspirations to pursue STEM as a college major and career. For instance, Black, Latine, and Indigenous students are underrepresented in high school STEM enrollment; although Black/African American students make up 16% of high school students overall, only 13% are enrolled in advanced math courses. Similarly, Hispanic/Latine students make up 24% of high school enrollment but only 19% enrolled in advanced math courses (United States Department of Education, 2018). While Indigenous students make up 1.4 percent of high school enrollment and advanced math enrollment, their small numbers reflect underrepresentation in general (United States Department of Education, 2018).

Alongside disparities in STEM preparation during high school, there are notable variations in STEM aspirations between URM students and White or Asian students (Mau & Li, 2018; Saw et al., 2018). Mau and Li (2018) used logistic regression analyses to investigate predictors of STEM career aspirations in the ninth-grade wave of the High School Longitudinal Study of 2009 (HSLS:09), a nationally representative dataset, and found that minority students were significantly less likely than White students to aspire a STEM career. Saw and colleagues (2018) utilized the HSLS:09 to investigate disparities in STEM career aspirations across gender, race/ethnicity, and socioeconomic status, finding that Black and Hispanic students had lower rates of interest and persistence in STEM professions from 9th grade to late 11th grade, with only 6.8% of Blacks and 8.2% of Hispanics aspiring to a career in STEM by the end of 11th grade, compared to 10.8% of Whites and 9.5% of Asians.

Additionally, URM students may struggle in developing and sustaining a positive STEM identity due to the way STEM is presented and taught to them at school (Aschbacher et al., 2010). As an example, Aschbacher et al. (2010) conducted a qualitative study in which they surveyed and interviewed a diverse group of 33 high school students to investigate their STEM attitudes and identification with STEM. They found that African American and Latine students perceived their teachers to have lower expectations of them compared to their peers, as well as an unwillingness to accommodate their learning needs, leading to feelings of exclusion and difficulties fitting into STEM. In essence, the racial underrepresentation in STEM is a reflection of systemic issues that extend throughout society, manifesting in outcomes such as lower workforce participation, fewer STEM college degrees, and negative attitudes towards STEM in high school.

Benefits of Teacher-student Racial/Ethnic Match

Research suggests that a racial/ethnic match between teachers and students can benefit students of color as early as elementary school. Egalite and colleagues (2015), used data from a large administrative dataset of third to 10th grade students from the Florida Department of Education and found that matching was associated with significant reading achievement for Black and White students, especially in the elementary school years, as well as significant math achievement for Asian/Pacific Islander, Black and White students. Yarnell and Bohrnstedt (2018) found that Black male and female fourth grade students, when matched with a Black teacher, had significantly higher reading scores.

Furthermore, some studies suggest that a teacher-student racial/ethnic mismatch reduces teacher's perception of externalizing behavior (e.g., child arguing, disruptive activity) (Bates & Glick, 2013; Gottfried et al., 2019; Wright et al., 2017). For instance, Bates and Glick (2013) examined the association between teacher-student racial match and teacher perceptions of their students' externalizing behaviors among Hispanic-white, Black, Asian, and non-Hispanic White elementary students. While they found persistent racial/ethnic differences in ratings of student behaviors that were consistent with societal expectations (e.g., Black students most likely to be rated as having greatest externalizing issues and Asian students the least), teachers assigned to the same racial/ethnic group as the student resulted in evaluations that were less consistent with societal views. Bates and Glick's finding suggest that teacher-student racial/ethnic match may help teachers from falling prey to deficit-based stereotypes of people of color, to the benefit of the URM students.

The teacher-student racial/ethnic match literature also covers teacher's perceptions beyond socioemotional outcomes, such as teachers' perceptions of student achievement and relationship quality (i.e., closeness). For instance, Banerjee's (2019) multilevel analysis of the kindergarten and first grade waves of the Early Childhood Longitudinal Survey (ECLS-K) dataset for Black, White, and Latine students found that, for Latine students, a teacher-student racial/ethnic match has a strong positive and significant effect on their placement in higher reading ability groups. Yiu (2013) found that teacher-student racial/ethnic match for first through fifth grade students had a positive influence on teacher-perceived closeness for Black students, but no influence for Asian and Hispanic students.

Not only does teacher-student racial/ethnic match play a role in teachers' perceptions of their students, but a same racial/ethnic match also plays a role in students' perceptions of their teachers (Cherng & Halpin, 2016; Egalite & Kisida, 2018). Egalite and Kisida (2018) analyzed fourth through eighth grade survey data from six US school districts and found that students who shared the same racial characteristics as their teachers reported higher quality teacher-student communication, greater interests in their school, and felt more cared for by their teachers, and higher college aspirations compared to unmatched students. Furthermore, students who share both racial and gender characteristics tend to have the greatest positive perception. In fact, elementary school students who experience a gender and racial-ethnic match with their teachers are more likely to say that the teacher explains difficult concepts clearly and that they understand what they need to learn; middle school students who match their teacher on race/ethnicity and gender are also more likely to think about college and attribute that thinking to their teacher.

Research suggests that the benefits of a teacher-student racial/ethnic match extend beyond the elementary school years and benefit students of color in secondary school settings. To elaborate, Egalite and colleagues (2015) show that teacher-student racial/ethnic match has a positive association with math achievement for Asian/Pacific Islander students in the middle/high school years. Hart (2020) reports that staffing at least one Black high school teacher in an advanced-track course leads to a two percent increase in the proportion of Black students taking advanced courses.

The literature also shows the positive influence a teacher-student race/ethnic match has on teacher perceptions and expectations of their students in high school (Fox, 2016; Gershenson et al., 2018; Kozlowski, 2015; McGrady & Reynolds, 2013). Using the Education Longitudinal Study of 2002 (ELS:02) to investigate if teacher-student racial/ethnic match impacted teachers' recommendations for advanced courses and college attendance, Fox (2016) found that same-race matching decreased the White-Black race gap in teacher expectations for Black high schools students pursuing college by 70%. Gershenson et al. (2017) also confirm this same-race effect for Black students as they find that non-Black high school teachers have significantly lower educational expectations for Black students than Black high school teachers. McGrady and Reynolds (2013), who also used the ELS:02, found similar results; White high school teachers often evaluated Black students more negatively than White students regarding their scholastic ability and classroom behavior, but same-race teachers sometimes rated Hispanic and Black high school students more positively. Furthermore, Hispanics and Black students were not more likely to receive worse ratings from non-White teachers (McGrady & Reynolds, 2013).

The teacher-student racial/ethnic match scholarship also suggests that having a teacher of the same race/ethnicity as the student can protect against negative teacher qualities that can harm academic performance, such as the teacher's lack of teaching experience. Goldhaber and Hansen (2010) investigated the predictive validity of teacher licensure tests on student achievement by race, and found that Black students in fourth to sixth grade benefit from a same-race teacher match in standardized reading and math tests, regardless of the teacher's performance on the licensure test (Goldhaber & Hansen, 2010). Joshi and colleagues (2018) obtained a similar finding where, in their analysis of the effects of teacher-student race matching on academic achievement for Tennessee students in Grades 3 through 8, they found that students paired with mid-performing teachers (i.e., teachers in the middle two quartiles of teacher effectiveness) who shared the same race experienced a benefit to their test scores. Thus, the research here suggests that a teacher-student racial/ethnic match may play a protective role in reducing the risks associated with teacher mediocre performance and inexperience.

Limitations in the Literature

While there has been evidence about the benefits of teacher-student racial/ethnic match, it is unclear (1) what mechanisms are driving the benefits of teacher-student racial/ethnic match, (2) whether these benefits occur in the context of partial racial-ethnic matches (i.e., non-White teachers paired with non-White students but are not a direct match), and (3) how teacher-student racial/ethnic match plays out in the high school context, especially for STEM and STEM related outcomes. In the following sections, I will elaborate on each of these limitations.

Teacher-student Racial/ethnic Match Mechanisms

Although extant research has shown the benefits of a racial/ethnic match, the literature is unclear about the mechanisms that drive the benefits of a teacher-student racial/ethnic match. Although a teacher sharing the same race/ethnicity as a student of color can benefit the student, the specific reasons for these effects are not yet fully understood.

A few quantitative studies, however, have incorporated some relational measures that provide insight to the ways a teacher-student racial/ethnic match influences a child's development (Battey et al., 2018; Rasheed et al., 2020; Yiu, 2013). Yiu (2013) found that the race and gender match between teachers and students influenced teacher-student closeness among a diverse sample of 754 teachers and 16,084 first through fifth grade children. In other words, a racial match for Black teacher-student pairs was found to influence teachers' perceptions of closeness such that Black teachers felt closer to their Black students compared to other students. However, a teacher-student racial/ethnic match did not change teacher perceptions of closeness for Asian and Hispanic students. Rasheed et al. (2020) found that a teacher-student match was not associated with teacher perceptions of closeness or conflict although a teacher-student racial mismatch involving a Latine teacher and Black student, and vice versa, was negatively associated with these relationship measures.

In their analysis of twenty-five predominately White and Black US middle school math classrooms, Battey and colleagues (2018) incorporate a multilevel analysis to examine the extent to which a teacher-student racial match influences the quality of teacher interactions towards students across five dimensions (i.e., addressing behavior, framing math ability, acknowledging student contributions, attending to language and culture, setting the emotional tone). They found that White teachers in predominantly Black classrooms interacted with their students more negatively in terms of addressing behavior, acknowledging student contributions, and setting a tone compared to White and Black teachers in predominantly White and Black classrooms, respectively (Battey et al., 2018).

Battey and colleagues' (2018) findings also suggest a more nuanced perspective on teacher-student match. For instance, in predominantly Black classrooms, although a smaller proportion of Black teachers had negative interactions with their students compared to White teachers, those negative interactions had a strongly negative association with students' math achievement. Furthermore, White and Black teachers' ability to positively set expectations around emotions and classroom behaviors had a positive association on Black students' math scores, which suggests that both White and Black teachers can have a critical influence on Black student achievement (Battey et al., 2018).

Several mixed-methods and qualitative studies have also investigated the potential mechanisms underlying the advantages of a teacher-student racial/ethnic match (Ford & Sassi, 2014; Reese et al., 2014). Ford and Sassi's (2014) qualitative study incorporated ethnographic methods and discourse analysis to compare the ways two high school English teachers, one White and one Black, built productive relationships and learning environments with their Black students. In their comparative analysis, they found that the African American teacher was able to command an authoritative but caring (i.e., "warm demander") atmosphere more naturally by drawing upon shared experiences, history, and traditions in her teaching. The White teacher, who did not share the same history or background as her students, was able to build rapport with her students by cultivating alliances in combating racism, such as challenging racist practices (e.g., critiquing racist policies surrounding testing, sharing authority by deferring to student knowledge of racial politics when discussing race), and incorporating culturally appropriate modes of communication and pedagogical practices (Ford & Sassi, 2014). Through their analysis, Ford and Sassi (2014) also argue that while White teachers can become effective teachers at times when teaching Black students, given that they do not share the same racial heritage as their students, they may not be able to be complete "warm demanders" as Black teachers.

Reese and colleagues' (2014) mixed-method approach in studying emotionally supportive classroom contexts for Latine children in rural early elementary school, also found culturally relevant practices among teachers who matched the same race/ethnicity as the students. In their study, Latine teachers were more likely to engage in interactions with Latine children that helped create supportive classroom environments (Reese et al., 2014). For instance, Latine teachers were more likely to use the children's home language as a resource to clarify concepts and establish mutually respectful and warm relationships (Reese et al., 2014). In essence, the research suggests that teachers who share the same race or ethnicity as their students are more likely to leverage some of their shared history and culture when teaching and building relationships, which may bring insight to some of the benefits associated with a teacher-student racial/ethnic match.

In summary, while there is emerging literature that explores the potential mechanisms (e.g., teacher beliefs, interactions, and pedagogy) behind a teacher-student racial/ethnic match, there is no clear consensus on the ways in which these mechanisms operate, particularly across different racial groups (e.g., Black students compared to Latine students).

Partial Racial/Ethnic Match Between Teachers and Students

Another literature gap relates to the extent to which the concept of a teacher-student racial/ethnic match applies to diverse teacher-student pairings (e.g., Black teacher with Latine students). As America becomes increasingly more diverse, it is important to know not just how students of color benefit from teachers who shares their same race/ethnicity but also from teachers of color who do not come from the same racial/ethnic background. Yet, the literature involving this partial racial/ethnic match is small and does not provide consistent findings.

Some literature shows evidence that a partial match benefits students of color. For instance, in their analysis of fourth through ninth graders' perspectives of their English and Math teachers, Cherng and Halpin (2016) found that students of color have more positive ratings of their Latine and Black teachers compared to their White peers. More specifically, students of color rated their Latine teachers more positively on all seven teacher quality outcomes. Students of color also perceived their Black teachers to hold them to higher academic standards, support their efforts, help organize content, explain ideas more clearly, and provide more useful feedback than their White teachers (Cherng & Halpin, 2016). From the teacher's perspective, Yiu (2013) found that Asian teachers felt the closest to their students of color, compared to White, Black, and Latine teachers.

Other studies, however, suggest mixed or even negative associations. In Rasheed et al.'s (2020) study examining the effects of matching on teacher-reported child outcomes in a diverse sample of teachers and students taken from 36 elementary schools, the researchers found that Latine teachers rated Black children worse on their academic and social outcomes compared to Latine children. However, no evidence was found that Black teachers rated Latine students worse compared to Latine teachers (Rasheed et al., 2020). Yiu (2013) also reported mixed findings; although Asian teachers felt closest to their students of color compared to White teachers, Black and Latine teachers felt less close to their students of color compared to White teachers. Given these mixed and varied findings, more research is needed to see the associations and consequences of teacher-student mismatches involving teachers of color on student color's academic and socioemotional outcomes.

High School STEM Context

Lastly, less research attention has focused on understanding teacher-student racial/ethnic match in the high school context, particularly regarding STEM. Although there are longitudinal teacher-student racial/ethnic match studies that include the high school years (Fox, 2016; Gershenson et al., 2018; Hart, 2020; Kozlowski, 2015; McGrady & Reynolds, 2013), the bulk of the literature has focused on the elementary school years. Furthermore, very little of this literature discusses STEM related outcomes (for exception, see Hart, 2020). Additionally, although there is literature that focuses on STEM related outcomes in high school for URM students (Mau & Li, 2018; Saw et al., 2018), an extensive review of the literature found no studies that specifically explores teacher-student racial ethnic in the context of STEM. Yet, this literature gap is important to be filled, especially as many administrators and related stakeholders consider recruiting and retaining STEM teachers of color as a strategy to address the racial divide in STEM high school academic outcomes in the United States.

Dissertation Aims

To address these research gaps, this 2-study dissertation 1) investigated the pathways by which racial/ethnic teacher-student match is associated with high school students of color's educational engagement and STEM outcomes and 2) identified processes that drive the benefits of a teacher-student racial/ethnic match.

For Study 1 of this dissertation, I used the High School Longitudinal Study of 2009 (HSLS:09), which contains survey responses from a nationally representative sample of high school students and math and science teachers, to investigate the pathways by which racial/ethnic teacher-student match may be associated with high school students of color's STEM-related outcomes. Using a structural equation model, I examined the mechanisms by which racial/ethnic teacher-student match is associated with high school students of color's STEM outcomes.

Study 2 looked further into these processes by further analyzing the mechanisms behind a teacher-student racial/ethnic match. This study explored teachers of color's perceptions and experiences working with students of color, including students who differ from the teacher's own racial identity using interview data from high school math and science teachers of color teaching in Los Angeles Unified School District (LAUSD) Community Schools. Through a phenomenological and narrative analysis, I explored how teachers of color perceive their students and examined the influence of both the teachers' racial/ethnic identity and school context on these perceptions, and any resulting adjustments to their pedagogy and interactions.

STUDY 1

Unpacking the Mechanisms of Teacher-student Racial/Ethnic Matches: Insights for High School Students of Color

Although there is considerable evidence for the positive impact of a teacher-student racial/ethnic match (Banerjee, 2019; Egalite et al., 2015; Gershenson et al., 2018), the specific mechanisms that underpin this relationship remain unclear. The benefits of a teacher-student racial/ethnic match likely result from a complex interplay of factors, encompassing both teacher and student characteristics. Teachers who share the same racial/ethnic background as their students hold higher expectations for their students (Gershenson et al., 2018) and may incorporate more culturally responsive teaching practices (Villegas & Irvine, 2010). Students may also be more engaged, feel greater identification with the teacher, and interact more effectively with teachers who share their racial background (Cherng & Halpin, 2016; Redding, 2019).

To address this gap in the literature, this study examined how teacher and student factors interact to produce the benefits of a teacher-student racial/ethnic match for high school students of color. By shedding light on these complex dynamics, the study aimed to deepen our understanding of the various pathways that drive the benefits of a teacher-student racial/ethnic match.

Possible Pathways Driving Teacher-student Racial/ethnic Match

When examining the various pathways that contribute to the benefits of a teacher-student racial/ethnic match, researchers have identified several common mechanisms. These mechanisms include teacher-led factors (e.g., teacher expectations, self-efficacy) as well as student responsiveness, such as identifying and engaging with the teacher (Redding, 2019).

Teacher-led Factors

Teacher-led factors refer to the ways in which teachers' characteristics and beliefs influence their behavior to benefit their students. Studies indicate that when teachers and students of color share the same racial/ethnic background, compared to when students of color are taught by a White teacher, the teacher is more likely to exhibit important characteristics such as higher expectations for their students and greater self-efficacy, which in turn can lead to better student academic outcomes (Fox, 2016; Gershenson et al., 2018; Kozlowski, 2015; McGrady & Reynolds, 2013).

Numerous studies have demonstrated that teacher expectations play a crucial role in shaping academic achievement among children (S. W. Lee et al., 2015; Mistry et al., 2009; Rosenthal & Jacobson, 1968), including in STEM academic outcomes during high school. Lee and colleagues (2015), in their analysis of the Longitudinal Study of American Youth (LSAY) 1987 data, found that students who reported higher levels of teacher expectation were 1.13 times more likely to choose a STEM major, 1.20 times more likely to complete a STEM degree, and 1.26 times more likely to enter a STEM profession. Similarly, Mistry et al. (2009) reported that teacher expectations had a longer-lasting impact on low-income students' achievement than parental expectations in their analysis of the simultaneous influences of mothers' and teachers' educational expectations and youth's achievement on school performance.

Research has also highlighted the role of teacher self-efficacy in enhancing students' academic performance and motivation (Perera & John, 2020; Throndsen & Turmo, 2013; Zee & Koomen, 2016; Zhou et al., 2020). Studies have suggested that teachers with higher self-efficacy are more likely to create an instructional environment that facilitates student mastery of content, which in turn, leads to better academic outcomes (Zee & Koomen, 2016). For example, teachers with high self-efficacy may adopt student-centered instructional approaches (Nie et al., 2013), create classroom structures that promote mastery goals (Cho & Shim, 2013), and provide more learning support to their students (Holzberger et al., 2013). These practices are likely to enhance students' academic performance and self-efficacy.

Teacher collective responsibility, or the degree to which teachers assume responsibility for their students' academic success, is another factor that has been linked to positive student outcomes, including improved math achievement (Lee & Loeb, 2000; Park et al., 2019). Lee and Loeb (2000) investigated whether teachers' attitudes and sense of responsibility towards student learning differed based on the size of the school, and discovered that higher levels of collective responsibility among teachers were positively linked to increased math achievement in students, even after controlling for the effect of school size. Similarly, Park et al. (2019) found that collective responsibility among teachers was positively associated with teacher expectations, which, in turn, had a positive association on student achievement.

Student Responsiveness

In addition to teacher factors, student factors also contribute to the benefits of a teacher-student racial/ethnic match. One way in which this occurs is through the internalization of high expectations by students of color, who modify their expectations and behaviors in response to a teacher of the same race/ethnicity who communicates high expectations (Cherng & Halpin, 2016; Ferguson, 2003). For instance, Cherng and Halpin (2016) found that Black students felt more engaged with course material, were more motivated, and had a stronger relationship when assigned to a Black teacher as compared with a White teacher.

Additionally, students of color may feel more comfortable reaching out to a teacher who shares their cultural background, values, and beliefs (Cherng & Halpin, 2016; Kozlowski, 2015).

This role model effect is evident in the STEM context; Kricorian et al. (2020) found that 66% of respondents in their survey of college and graduate students who primarily served women of color knew someone of the same race who served as their role model. Respondents also suggested that meeting STEM professionals of their own ethnicity, as well as exposure to media depicting STEM professionals of the same ethnicity, would be effective in encouraging them to pursue STEM.

URM students may also identify more positively with a teacher of the same race/ethnicity, which can reduce their susceptibility to the stereotype threat. As URM students are susceptible to stereotype threat, which can lead to lower performance in STEM-related tasks, tests, and courses (Corra & Lovaglia, 2012; Totonchi et al., 2021; Woodcock et al., 2012), seeing a teacher of color who has overcome racial barriers may help to mitigate the threat's negative effects. URM students may not feel the same evaluative pressure and may replace negative group stereotypes with a more self-affirming attitude (Redding, 2019).

Reconciling Mechanisms Behind a Teacher-student Racial/Ethnic Match

Although the literature suggests that both teachers and students play a role in the benefits of a teacher-student racial/ethnic match, the specific mechanisms behind these effects remain unclear. Researchers have yet to determine the extent to which the benefits result from changes in teacher behavior versus student responsiveness (Redding, 2019); it is unclear whether teacher-led factors account for a larger proportion of the benefits compared to student responsiveness.

Developmentally, understanding the mechanisms of a teacher-student racial/ethnic match among adolescents is particularly challenging. While young children are less susceptible to negative group stereotypes and therefore more likely to benefit from teacher-led factors in a racial/ethnic match (Ambady et al., 2001), the role of student responsiveness becomes more critical during adolescence. The adolescent period is marked by greater exploration and identification with one's racial/ethnic identity, making role models more influential in students' aspirations and development (Quintana, 2007). Therefore, students of color may benefit from having teachers of the same racial/ethnic background via the role model pathway (Redding, 2019). However, adolescence is also a time where peer relationships are crucial and student-teacher relationships may weaken relative to the elementary years, making the importance of student responsiveness, as well as teacher-led factors, in high school unclear.

To understand how mechanisms behind a teacher-student racial/ethnic match play out for high school students of color, this study examined the extent to which a teacher-student racial/ethnic match influenced students through teacher-led factors and factors related to student responsiveness.

Theoretical Framework: Bioecological Theory and Cultural Synchrony Hypothesis

This study employed a bioecological framework (Bronfenbrenner & Morris, 2006) and the cultural synchrony hypothesis (Irvine, 1990) to investigate how teacher and student factors influence the benefits of a teacher-student racial/ethnic match. Bioecological theory suggests that children's development is shaped by proximal processes, which are recurring and lasting interactions between children and individuals such as teachers, parents, and peers (Bronfenbrenner & Morris, 2006). These interactions are bidirectional, iterative, and increase in complexity over time. This proximal process is influenced by the child's immediate context, such as their classroom, which is situated within larger interconnected contexts, such as their school, neighborhood, and community.

The potential mechanisms underlying the benefits of a teacher-student racial/ethnic match can be situated within the proximal process between the teacher and child. When students see a teacher of a similar racial/ethnic background, they may feel more comfortable and be more motivated to engage with the teacher. This can lead to a positive feedback loop where the teacher responds with increased effort and better teaching, resulting in higher-quality instruction that translates to improved academic achievement for the student.

The cultural synchrony hypothesis framework adds nuance to the quality of the proximal process. The cultural synchrony hypothesis posits that cultural unfamiliarity and misunderstanding can lead teachers to rely on negative stereotypes about their students (Irvine, 1990), which helps to explain racial/ethnic disparities in educational outcomes. For instance, teachers who are unfamiliar with the cultures and learning styles of their racially/ethnically diverse students may struggle to communicate effectively and may hold preconceived notions about their academic engagement and ability. Conversely, teachers who share the same racial/ethnic background or come from a minoritized background like their students may approach them with a shared cultural understanding, leading to more positive attitudes about their academic potential and more culturally responsive teaching practices.

Using both frameworks, this study examined the proximal processes that underlie the benefits of a teacher-student racial/ethnic match, by focusing on the various pathways that are hypothesized to drive these effects.

The Current Study

Utilizing the High School Longitudinal Study of 2009 (HSLS:09), a nationally representative sample of ninth grade students in 2009 to 2016, this study used linear regression and structural equation modeling (SEM) to investigate the pathways by which racial/ethnic teacher-student match may be associated with high school students of color’s educational engagement and STEM outcomes. The primary research questions were:

1. Is there a beneficial association for student math and science GPA of a teacher-student racial/ethnic match among high school students of color and their math and science teachers?
2. To what extent do school factors, teacher factors, student perceptions, and student engagement account for the relationship between a teacher-student racial/ethnic match and high school students of color's STEM GPA?
3. To what extent are these relationships moderated by students' racial/ethnic background?

My hypothesis was that the relationship between high school STEM GPA of students of color and racial/ethnic teacher-student match would be influenced by teacher factors, student engagement, and student perceptions. In particular, I expect that a teacher-student racial/ethnic match would lead to higher teacher factors, increase student engagement, and more positive student perceptions, which in turn lead to higher GPA. Additionally, I hypothesized that the association of a teach-child racial/ethnic match on these pathways and student outcomes would be moderated based on the child and teacher's racial/ethnic group. In particular, I hypothesized greater positive associations between teacher-student racial/ethnic match and STEM GPA, teacher-led factors, student engagement, and student STEM perceptions for Black and Hispanic students compared to Asian students. I also hypothesized greater positive associations between STEM GPA on student engagement and student STEM perceptions for or Black and Hispanic students compared to Asian students.

Data Source

The study used data from the High School Longitudinal Study, 2009-2013 (HSLS:09), a nationally representative sample of 9th graders (n = 21,356) from 944 schools across the United States. The HSLS:09 study focused on how students choose STEM (science, technology, engineering, math) courses, majors, and careers as well as the educational and social experiences that affect students' trajectories in high school and after graduation (Ingels et al., 2013). Students were surveyed in grade 9 in the 2009 base year, in 2012 when the students were in grade 11, in 2013 for a postsecondary update, and in 2016 when students may be continuing through postsecondary education. In 2013, the update survey provided information on student sample members' high school completion status, high school transcripts, applications, registration at postsecondary institutions, financial aid and enrollment cost, and employment. In the 2009 base year, the response rates were 85.1% for students, 69.9% for math teachers, and 64.7% for science teachers. In the following waves, the response rate for the students were 81.8% in 2012, 73.7% in 2013, and 69.0% in 2016 (Duprey et al., 2018).

Analytic Sample

As teachers were only surveyed during the 2009 base year, this study only incorporated students from the base-year who also had valid transcripts in the 2013 wave. Furthermore, as this study only focused on teacher-student racial/ethnic match for monoracial students of color, no White or Multiracial students are included in the student. In the fall of 2009, this sample (*n* = 3,760) was 51% boys and 49% girls, with an average age of 15.01 years (*SD* = 0.82 years). Twenty-eight percent of the students identified as Black, 45% Hispanic, 24% Asian, 2% American Indian/Native American, and 1% Native Hawaiian/Pacific Islander. 61% spoke English as their first language, while 24% spoke a non-English language as their first language, and 15% came from a dual language household (i.e., both English and a non-English language). 55% of children came from families that were 185% above the poverty line. The majority (84%) had a White math teacher, 7% Black, 5% Hispanic, and 4% Asian in ninth grade. Furthermore, 83% had a White science teacher, 7% Black, 6% Hispanic, and 3% Asian in ninth grade. 28% of students attended schools in cities, 37% in suburbs, 11% in towns, and 24% in rural areas; and 41% went to schools in the South, 27% in the Midwest, 17% in the West, and 14% in the Northeast (see Table 1.1).

Constructs and Measures

Teacher-student Racial Ethnic Match.

Students of color and teachers reported their racial/ethnic group by selecting one of several racial/ethnic categories (i.e.., White, Black or African American, Asian, Native Hawaiian or Other Pacific Islander, and Hispanic). Students or teachers who mark more than one category were marked as multiracial. As this study only focused on monoracial students of color, students who only selected "White" are or were marked as multiracial were excluded from the analytic sample. Dummy variables were created indicating if a student of color is taught by a teacher who shares the same race/ethnicity or of a different racial/ethnic background. Race/ethnic match dummy variables were created based upon the students' race/ethnicity when compared to their math and science teachers. These dummy variables will be created separately for math and science teachers leading to a total of four dummy variables.

STEM Related Outcomes

Math and Science GPA.

High school Grade Point Average (GPA), which is the average of all a student's grades in school, is a common way to measure high school students' academic performance. The HSLS:09 contains several student GPA composite variables, which were calculated in various ways (i.e., overall, academic courses, by subject, etc.). To assess the students' STEM outcomes, I utilized the math and science GPA variables from the HSLS:09 dataset, which specifically capture the students' grades in their math and science courses to calculate their respective GPAs during the 2013 wave.

Teacher-level Measures.

This study incorporated six HSLS:09's teacher psychological scales, which were created from the subject-specific questionnaire responses by the HSLS design team (Ingels et al., 2013). These scales are sorted into three general types: teacher group-level expectations, teacher self-efficacy, and teacher's perspectives of collective responsibility. Items (1 = *strongly agree*; 4 = *strongly disagree*) were used to create these scales.

Teacher group-level expectations assessed the extent to which math and science teachers agreed with statements about their peer mathematics and science teachers in the school (e.g., "set high standards for teaching," "set high standards for students' learning"; eight items; α_m[2] = 0.86, α_s = 0.86 for math and science teachers, respectively). Teacher self-efficacy items asked teachers to judge their own ability to teach and influence their students (e.g., "the amount a student can learn is primarily related to family background"; six items; α_m = 0.71, α_s = 0.68). Teacher collective responsibility incorporated items that measured mathematics and science teachers' perceptions of collective responsibility at the school (e.g., "Teachers at school feel responsible when students in this school fail"; seven items; α_m = 0.89, α_s = 0.89). See Appendix C for more details about the items used to create these scales.

Student-level Measures.

Seven of HSLS:09's student psychological scales were incorporated as student-level measures: student's math identity, science identity, math utility, science utility, science self-efficacy, math self-efficacy, math course interest, science course interest, school belonging, and

[2] α_m and α_s refer to the alpha values involving the math and science teacher, respectively.

school engagement (see Appendix C). Almost all items used a 4-point Likert-type scale (1 = *strongly agree/Never*; 4 = *strongly disagree/Often*).

Math (two items; $r = 0.72$) and science (two items; $r = 0.72$) identity assessed the extent to which the student or others sees him or herself as a math or science person. Math (three items; $\alpha = 0.78$) and science utility (three items; $\alpha = 0.75$) incorporated items that asked students about their perceptions of the usefulness of the respective subject in everyday life, college, and future careers. Science (four items; $\alpha = 0.88$) and math (four items; $\alpha = 0.90$) self-efficacy included items measuring student's belief in their capacity in learning the respective subject (e.g., "You are confident that you can do an excellent job on tests in this course"). Math (six items; $\alpha = 0.75$) and science (six items; $\alpha = 0.73$) course interest included items that measure the extent the student enjoys the math/science course (e.g., "You are enjoying this class very much").

School belonging (five items; $\alpha = 0.72$) measured student's safety, connection, and comfort in the school (e.g., "You feel safe at this school"). School engagement (four items; $\alpha = 0.67$) measured student's preparation and engagement in school (e.g., "How often do you go to class without your homework done?") using a 4-point Likert-type scale (1 = *Never*; 4 = *Often*). Besides HSLS:09's student psychological scales, the study also incorporated the number of hours a student spends on math and science homework during a typical school day. See Appendix C for more details about the items used to create these scales.

Covariates

Analyses included child, teacher, and school level covariates collected at baseline. Child covariates included the child's gender (1 = female), age, socioeconomic status, and the student's dual-first language (i.e., first language is English, non-English, both English and non-English). Teacher covariates included teacher's gender, highest degree earned, years of teaching any subject to grade levels 9-12, and whether they received a teaching certification. I also included urbanicity as covariates in all analyses.

Analytic Plan

Descriptive analyses were first conducted with the analytic sample. I analyzed the various counts and percentages of teacher-student pairs based upon the students' and teachers' race/ethnicity. Following descriptives, I used structural equation modeling (SEM) to investigate the pathways by which racial/ethnic teacher-student match may be associated with high school students of color's math and science GPA. SEM allowed me to examine latent constructs (e.g., student perceptions, teacher factors) and model the relationships of these constructs with each other and with observed variables (Weston & Gore, 2006).

These models include both latent and observed variables, which are used to determine the various factors (e.g., teacher perceptions, role models) that may account for the relationship between teacher-student racial/ethnic match and positive STEM outcomes. A total of four structural models were specified to examine how a direct match influences student GPA: two for student-level factors and two for teacher-level factors (see Figures 1.2 - 1.5). Each model comprised one or more latent constructs and two single variables. The math/science teacher model included Math/Science Teacher Factors as the latent constructs, whereas the math/science teacher model includes Student Math/Science Perceptions and Student Engagement as the latent constructs. Following SEM notation conventions (Wang & Wang, 2019), circles represent the latent variables while squares signify manifest variables. The two observed (manifest) variables include the dummy variable that represents whether the teacher-student ethnic/race match is a direct match and the student GPA. Table 1.2 provides a summary of the constructs and their corresponding indicators, and Table 1.3 provides the descriptive statistics.

To examine these models, I used a three-step modeling approach where I first conducted a confirmatory factor analysis (CFA) on my analytic sample to test the factor structure of my latent variables in my hypothesized models. Second, I evaluated the fit of my hypothesized mediation models through structural equation modeling (SEM). Third, to determine whether our structural models were moderated across student racial/ethnic group, I conducted multigroup SEM analyses by student racial/ethnic group, comparing models in which all paths were constrained to be equal across the student racial/ethnic group was compared against the unconstrained model in which all paths are allowed to vary across groups.

To evaluate the model fit, I used the comparative fit index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square (SRMS). CFI estimates the extent to which the model provides an appropriate fit to the data; CFI values at or greater than 0.95 indicate a strong model fit (Brown, 2015). RMSEA also determines fit and accommodates large sample sizes in its evaluation; RMSEA values between 0.00 and 0.05 indicate good fit, 0.05-0.08 indicate acceptable fit, and values greater than 0.10 suggest a poor fit (Byrne, 2011; Hu & Bentler, 1999). I also consider SRMR values less than or equal to 0.08 to indicate a good model fit (Hu & Bentler, 1999). As the chi-square statistic is sensitive to sample size, the large size of my analytic sample renders this fit indice undiagnosable in accessing model fit and hence was not considered in the CFA and SEM analyses. The CFA and SEM were fitted to the data using R (version 4.1.3) software's lavaan package (version 0.6-12). The fit statistics, path coefficients, and t-test statistics were examined to evaluate the model.

Missing Data

Missing data ranged from 0% to 23.11% at the variable level (see Table 1.3). A large portion of the missingness lies mostly in the teacher variables, which have larger nonresponse rates and ranged from 6.52% to 23.11% in missing cases. Full information maximum likelihood was used to further maximize the sample size.

Results

Descriptive Analyses

Table 1.4 provides a frequency count of the various types of teacher-student racial/ethnic pairs in my analytic sample. Comparing across the counts and percentages, for each student racial/ethnic subgroup, the largest student-teacher pairing was with a white teacher. For instance, among Black students, 82% and 80% of them were taught by a White math and science teacher, respectively.

Among Black students, following White teachers, the next most common pair was with Black teachers as 13% and 14% of Black students were taught by Black math and science teachers, respectively. For Asian and Hispanic students, following White teachers, a greater or equal proportion of students were taught by teachers of color who did not share their same race as opposed to a teacher who shared their same race and ethnicity. For instance, among Hispanic students, 9% were taught by non-Hispanic math and science teachers of color, while 8% and 9% were taught by Hispanic math and science teachers, respectively. For Asian students, 6% and 7% were taught by non-Asian teachers of color in math and science, exceeding the 3% taught by Asian math and science teachers. This suggests that, among Asian and Hispanic students, few were taught by math or science teachers of their own race/ethnicity.

It is also important to note that very few American Indian/Alaskan Native and Native Hawaiian/Pacific Islander students in this sample were taught by teachers of color and neither of these groups had direct matches in this analytic sample. Given the small sample sizes, American

Indian/Alaskan Native and Native Hawaiian/Pacific Islander students were not included in subsequent analyses.

Confirmatory Factor Analyses: Establishing Proposed Latent Factors

Before testing the structural models, I sought to establish the viability of my proposed latent factors through the use of confirmatory factor analysis (CFA) measurement models. Running CFAs allowed me to see whether the selected scale scores had significant loadings on the latent variables as well as whether the model fit statistics, standardized factor loadings, error variance, and composite reliability coefficients were adequately measured by the observed indicators.

Four measurement models were tested: (1) math teacher factors; (2) science teacher factors; (3) student engagement and student math perceptions; and (4) student engagement and student science perceptions. Based on requirements for SEM analyses (Kline, 1998), one variable loading for each factor was set equal to 1.0 in order to set the metric for that factor; as a result, significance values are not calculated for these variable loadings. All four measurement models fit very well and all variable loadings on the hypothesized latent factors were strong and significant. The variable loadings on latent factors and the fit indices for each model are summarized in Table 1.5.

The measurement models for math and science teacher factors include measured variables of math and science teachers' group-level expectations, self-efficacy, and collective responsibility. For both teacher measurement models, teacher group-level expectations loaded the highest on the Teacher Factor latent construct ($\beta_{math} = 0.82$, $p < .01$; $\beta_{science} = 0.74$, $p < .01$), followed by group-level collective responsibility ($\beta_{math} = 0.69$, $p < .01$; $\beta_{science} = 0.70$, $p < .01$), and group-level self-efficacy ($\beta_{math} = 0.29$, $p < .01$; $\beta_{science} = 0.21$, $p < .01$).

A second set of measurement models assessed the student factors (i.e., student math perceptions, student science perceptions, student engagement). The latent factor of student math perceptions was indicated by student math identity and math utility, math self-efficacy, and math course interest (see Table 1.5). Similarly, the student science perceptions latent factor was indicated by student science identity and science utility, science self-efficacy, and science course interest. The student engagement latent factor for the student math and student science models were indicated by school belonging, school engagement, and the number of hours the works on homework per week for math and science, respectively. In both student measurement models, the latent factors were significantly intercorrelated, with a strong association found between student math perceptions and student engagement (r = 0.64, p <.01), as well as student science perceptions and student engagement (r = 0.65, p <.01).

Although from this point forward I restrict my discussion and the models presented in the figures to the structural models, the configuration of variables on latent factors established above in the measurement models are included in the models below.

Testing and Specification of Hypothesized Models

Research Question #1: Examining the Association Between a Teacher-Student Racial/Ethnic Match and Student Math and Science GPA

To examine my first research question, testing whether there is a beneficial relationship between student math/science GPA and teacher-student racial/ethnic match, I first ran a linear regression between these two variables, examining the strength, direction and significance of this association for the sample overall and by racial/ethnic group. Results are presented in Tables 1.6 and 1.7 for math and science, respectively. Overall, the results indicated a negative association between a teacher-student racial/ethnic match and student GPAs in math and science (B_{math} = -

0.320, p <.01; $B_{science}$ = -0.214, p <.01). In other words, in the full analytic sample, students sharing the same race/ethnicity as their math or science teacher are predicted to have math and science GPAs 0.32 and 0.214 points lower, respectively, than if their teachers did not share their race/ethnicity.

After adding in the covariates the association of between a racial/ethnic match and student GPA, the magnitude of a match lessened between students and math teachers but remained negative and significant (B = -0.131, p <.05). However, the association of a match for student and science teachers became nonsignificant (see Table 1.6).

When running regression models on three subsamples by student racial/ethnic groups, no association between teacher-student racial/ethnic match and math GPA was found for Asian and Black students, even when including covariates in the model (see Tables 1.6 and 1.7). Among Hispanic students, however, there is a significant negative association between a teacher-student racial/ethnic match and math GPA, even when covariates were included (B = -0.231, p <.05). This suggests that the negative association between Teacher-student Racial/ethnic Match and Student Math and Science GPA is primarily observed among Hispanic students in this sample.

Research Question #2: Exploring the extent to which teacher factors, student perceptions, and student engagement account for the relationship between a match and student GPA

Analyzing the paths in my structural models helped me explore whether the extent to which teacher factors, student perceptions, and student engagement account for the relationship between a racial/ethnic match and student GPA.

Assess teacher factors' influence on student GPA. The results of the Math Teacher and Science Teacher Factor Models are presented in Figures 1.2 and 1.3, respectively. Each model included direct paths linking teacher-student race/ethnic match to student GPA, as well as indirect paths through Teacher Factors. Additionally, child and teacher covariates were included, each with paths to the math and science teacher factors and student GPA.

For the Math Teacher Model, the model fitted the data adequately well (CFI = .838, RMSEA = .054, SRMR = .031). To improve model fit, I conducted modification indices and assessed whether any reasonable adjustments (e.g., covarying items measures within a latent construct) would help improve model fit. Covarying the measures within the Math Teacher Factor latent construct (i.e., teacher group-level expectations, teacher self-efficacy, teacher's perspectives of collective responsibility) with each other improved the model fit (CFI = .922, RMSEA = .039, SRMR = .022).

For the Science Teacher model, the model initially fit the data adequately well (CFI = .821, RMSEA = .052, SRMR = .031). After reviewing the modification indices, I covaried the measures within the Science Teacher Factor latent construct (i.e., teacher group-level expectations, teacher self-efficacy, teacher's perspectives of collective responsibility), which improved the model fit (CFI = .907, RMSEA = .039, SRMS = .022).

Overall, the model results suggest that teacher factors do not account for much of the association between a teacher-student match and student GPA. In the math teacher model, there was a significant positive association between math teacher factors and math GPA ($\beta = 0.52$, $p<.01$), but a nonsignificant association between student-math teacher racial/ethnic match and math teacher factors ($\beta = 0.05$, $p = 0.45$). I continued to observe a negative association between student-math teacher racial/ethnic match and math GPA ($\beta = -0.08$, $p<.05$). In the science teacher model, only the pathway between science teacher factors and science GPA is significant ($\beta = 0.54$, $p<.01$).

Student Factor Models. The results of the Math and Science Student Factor Models are presented in Figures 1.4 and 1.5, respectively. Each model included direct paths from linking teacher-student race/ethnic match to student GPA, as well as indirect paths through student engagement and student math or science perspectives. Child and teacher covariates were also included, each with paths to the models' latent factors and student GPA. Each model was done separately for the math and science models.

For the math student model, the model fit the data adequately well (CFI = .848, RMSEA = .048, SRMR = .034). Based on modification indices, I covaried the measures within the student engagement latent construct (i.e., school engagement, school belonging, and math homework hours) with each other as well as some of the measures within the student math perceptions latent construct (i.e., covarying math identity with math self-efficacy, covarying math utility with math course interest). This improved the model fit slightly (CFI = .883, RMSEA = .044, SRMR = .030).

For the science student model, the model fit the data adequately well (CFI = .880, RMSEA = .043, SRMR = .031). Based on modification indices, I covaried science utility identity with math self-efficacy and math utility with math course interest. This improved the model fit slightly (CFI = .887, RMSEA = .042, SRMR = .030).

In assessing the extent to which the two student factors explain the association between teacher-student racial/ethnic match and student GPA, both models indicate that student factors do not account for the association between a teacher-student match and student GPA.

In the math student model, there was a significant and positive association between student engagement with math GPA (β = 0.78, $p < .01$). However, the paths linking student-math teacher racial/ethnic match to student engagement, student science perceptions, and student math perception to math GPA path were all non-significant at the $\alpha = 0.01$ level.

In the science student model, there was a significant and negative association between student-science teacher racial/ethnic match and science GPA ($\beta = -0.06$, $p<.01$). There was also a significant association between student engagement and science GPA ($\beta = 0.50$, $p<.01$). However, the paths linking student-science teacher racial/ethnic match to student engagement, student science perceptions, and student engagement to science GPA path were all non-significant. These findings suggest no evidence of student engagement and science perceptions influencing the association between a teacher-student racial/ethnic match and student math or science GPA.

Research Question #3: Exploring Moderation by Student Race/Ethnicity through Multigroup Analyses

To determine whether the associations presented in the previous analyses varied across student race/ethnic groups, I conducted a multigroup analysis of these structural models to determine whether the associations among these factors vary in strength or direction based upon racial/ethnic group.

A multigroup SEM analysis analyzes several cross-group coefficients simultaneously. Among the teacher models, I examined the associations between a match and student math/science GPA, between a match and math/science teacher factors, as well as between math/science teacher factors with math/science GPA. In the student models, I investigated the associations between a match and math/science GPA, student engagement, and student math/science perceptions, as well as the associations between math/science GPA and student math/science perceptions, and student engagement. For these models, I examined whether allowing paths to vary across racial/ethnic groups provides an understanding of the associations in the hypothesized models.

Establishing Metric and Scalar Invariance. Prior to running a multigroup analyses, I first sought to establish metric and scalar invariance among my models, such that the factorial structure holds across groups, and the factor loadings, as well as the intercepts in my models were assumed to be equal across groups. To test for metric invariance, for all four models (e.g., teacher math, teacher science, student math, student science), I compared measurement models where loadings were constrained to be equal across student racial/ethnic groups or to measurement models where loadings allowed to vary across groups. In these model comparisons, except for the math teacher model, all constrained models had significantly worse model fit than the unconstrained models.

As a result, I iteratively examined loadings that would likely affect model fit when released, released selected loadings, and then compared the partially constrained model to the unconstrained model to observe any drop in model fit. If the partially constrained model was not significantly different from the unconstrained model based on the chi-square test, I concluded partial metric invariance based on the released loadings. Consequently, I unconstrained certain loadings so that these models can be partially measurement invariant (see Table 1.8).

After establishing metric and partial metric invariance, I tested scalar invariance by comparing between models with constrained loadings and partially constrained loadings with models where intercepts, along with the loadings from the metric and partially metric invariant models, were constrained. Looking at the difference chi-square between these models, all constrained models showed significantly worse model fit than the unconstrained models.

As a result, similar to how I determined partial metric invariance, I iteratively examined intercepts that would likely affect model fit when released, released selected intercepts, and then compared the partially constrained model to the unconstrained model to observe any drop in model fit. If the partially constrained model was not significantly different from the unconstrained model based on a chi-square difference test, I concluded partial scalar invariance based on the released intercepts. Hence, I unconstrained certain intercepts so that these models can be partially scalar invariant (see Table 1.8).

Testing for Moderation through Structural Invariance. After establishing partial measurement invariance for my models, I tested whether these partially measurement invariant models were structurally invariant across student racial/ethnic groups. To do so, I compared the versions of these models in which all structural paths were constrained to be equal across student racial/ethnic groups to their more unconstrained model in which all paths were allowed to vary across groups. If the constrained and unconstrained models were statistically different in model fit, I then analyzed these models by selectively constraining or freeing subsets of paths to pinpoint the sources of nonequivalence.

For both the math and science teacher models, comparisons between constrained and unconstrained path models revealed significant fit differences (math: $\chi^2_{\text{difference}}$ (54, 3384) = 102.45; science: $\chi^2_{\text{difference}}$ (54, 3376) = 108.94), indicating that the association among one or more paths in these models differed across student race/ethnicity. Consequently, for both models, I created three subsequent models, each constraining one of the following pathways: (1) teacher-student racial/ethnic match to teacher factors, (2) teacher factors to student math/science GPA, and (3) teacher-student racial/ethnic match to student math/science GPA. If the constrained and unconstrained models were statistically different in model fit, the constrained pathway could be the source of moderation across student race/ethnicity.

In subsequent models for both the math and science teacher models, each of the three models had identical fit statistics to the unconstrained model (math: CFI = .95, RMSEA = .026, SRMR = .021; science: CFI = .89, RMSEA = .037, SRMR = .025). In the math teacher model, only the model freeing the math teacher factors to math GPA pathway showed a statistically significant difference from the unconstrained model ($\chi^2_{\text{difference}}$ (2, 3384) = 9.56, p < .01), while in the science teacher model, none of models were statistically different from the unconstrained model. As a result, these findings only support a multigroup math teacher model where the pathway from math teacher factors to math GPA can vary by student race/ethnicity.

For the student math model, the constrained path model did not significantly differ from the unconstrained model ($\chi^2_{\text{difference}}$ (82, 3639) = 101.06, p = 0.075), indicating that the paths do not differ across groups. However, for the student science model, the constrained path model showed significantly worse fit compared to the unconstrained model, $\chi^2_{\text{difference}}$ (82, 3639) = 135.89, p < .01, indicating that one or more paths in this model differed across student race/ethnicity.

As a result, for the student science model, I created five subsequent models, each constraining one of the following pathways: (1) teacher-student racial/ethnic match to student engagement, (2) teacher-student racial/ethnic match to student science perceptions, (3) teacher-student racial/ethnic match to science GPA, (4) student engagement to science GPA, and (5) student science perceptions to science GPA. If any of the constrained models were statistically different in model fit from the unconstrained model, the constrained pathway could be the source of moderation across student race/ethnicity.

For the student science model, although all constrained models yielded the same fit statistics as the unconstrained model (CFI = .91, RMSEA = .035, SRMR = .029), two showed significant differences in chi-square difference tests: student engagement to science GPA, $\chi^2_{difference}$ (2, 3639) = 16.23, $p < .01$; and student science perceptions to science GPA, $\chi^2_{difference}$ (2, 3639) = 39.98, $p < .01$. These findings support a multigroup model where student engagement to science GPA and student science perceptions to science GPA structural paths are freed to vary by student race/ethnicity.

Multigroup SEM Analyses of Moderation Models. The results of the teacher math and student science unconstrained multigroup models are presented in Tables 1.9 and 1.10, respectively. For the teacher math unconstrained multigroup model, there is consistency across student race/ethnic groups, as the coefficient for the math teacher factors to math GPA pathway are similar in direction and are not significant. However, despite a significant chi-square difference between the unconstrained and constrained multigroup models, the non-significance of these paths across groups suggests no moderation along the math teacher factors to the math GPA pathway.

For the student science unconstrained multigroup model, variations across groups existed between student science perceptions and science GPA and between student engagement and science GPA. Specifically, only the Asian student group exhibited a significant and positive association for the student science perceptions and science GPA pathway ($\beta = .211$, p <.01), while the Black and Hispanic student pathways show non-significant associations. Similarly, for the student engagement and science GPA pathway, both the Hispanic ($\beta = .363$, p <.01) and Black ($\beta = .387$, p <.01) student groups exhibit a positive and significant association, whereas the Asian student group shows a non-significant association. These findings suggest that the associations of student science perceptions and student engagement with science GPA differ across racial/ethnic groups.

Discussion

In this paper, I examined the relationship between teacher-student racial/ethnic match and student STEM GPA for high school students of color. I also examined the extent to which teacher and student factors account for this relationship and whether these pathways vary across student racial/ethnic groups. Through linear regression, structural equation modeling, and multigroup analysis, I found that teacher-student racial/ethnic match either had a negative or non-significant association with student GPA. Additionally, teacher-led factors, student perceptions, and student engagement did not serve as pathways through which teacher-student racial/ethnic match influences student GPA, and this pattern was mainly consistent across student racial/ethnic groups.

My findings differ from the literature showing benefits for students of color when matched with teachers of the same racial/ethnic background (Egalite et al., 2015; Goldhaber & Hansen, 2010; Yarnell & Bohrnstedt, 2018). Instead, they align with research indicating null effects, raising questions about prioritizing teacher-student racial/ethnic matches for students (Banerjee, 2018; Gottfried et al., 2019; Joshi et al., 2018).

While not the first study to report non-positive findings regarding student-teacher racial/ethnic matches, these results prompt questions about the non-significant or even negative association between such matches and student GPA. These findings suggest that racial/ethnic match might not be the primary factor for STEM outcomes among students of color, given significant positive associations between student engagement and teacher-led factors with math/science GPA in the models, despite the nonsignificant associations between these factors and the match itself.

For instance, despite not having a significant association with teacher-student racial/ethnic match, student engagement showed a significant positive association with student GPA in both the student math and student science models. This suggests that this association may not be related to teacher racial/ethnic identity. Factors such as school engagement and school belonging, which compose the student engagement latent variable, may be influenced by other aspects of the school environment, such as peer engagement, school climate, and school diversity. This aligns with adolescent development literature, which highlights how students during adolescence focus more on peers rather than teachers and other adult figures, thus being more influenced by them (Verhoeven et al., 2019).

The positive significant association between teacher-led factors and student math/science GPA, aligns with literature demonstrating how teacher characteristics such as high expectations, self-efficacy, and a sense of responsibility positively influence student outcomes (Lee et al., 2015; Park et al., 2019; Perera & John, 2020). The non-significant association between teacher-led factors and teacher-student racial alignment may also suggest that teacher-led factors are not as racially determined as assumed, offering potential for improving STEM outcomes regardless of the teacher's race/ethnicity. This supports the idea that improving teaching practices, regardless of teacher race, can enhance student outcomes universally, as supported by existing literature (Comstock et al., 2023; Gay, 2002a).

Despite expectations from existing literature, the absence of association between a teacher-student racial/ethnic match and these factors and outcomes is surprising. While it's plausible that teacher-led factors outweigh the teacher's own race in predicting student outcomes, it's also possible that the teacher’s racial/ethnic identity does play a role. However, limitations in my study design may have hindered detection of these relationships, as discussed in the following section.

Limitations and Future Directions

In addition to conceptual and theoretical factors influencing my findings, limitations in the study design may also play a role. Firstly, as a correlational study, the directionality among teacher-student racial/ethnic match, STEM GPA, teacher factors, student STEM perceptions, and student engagement cannot be determined. Secondly, while efforts were made to account for other influencing factors, it's possible that certain unmeasured variables could impact these associations, such as the socio-economic status of schools where teachers of color may be more likely to teach. Although covariates were incorporated, future studies could employ designs like randomized control trials or quasi-experiments for better causal inference.

Another caveat is the limited variance within teacher-student racial/ethnic matches in my model. While this data source facilitated exploration of teacher-student racial/ethnic matching, it's noteworthy that most teachers are white. When examining match types by subgroup, over eighty percent of students are taught by a white teacher in each subgroup (see Table 1.4). Additionally, the proportion of students with a direct match is small, with only 8% of Hispanic, 13% of Black, and 3% of Asian students having a direct match. This lack of variance may have made it harder to detect an association between a teacher-student racial/ethnic match with student GPA as well as the other latent factors. Future research should aim to replicate this study with a sample having a larger proportion of direct matches to examine potential differences in results.

Another potential limitation is the use of student GPA as the outcome variable. Although literature links student GPA with various future outcomes like college and career success (Sawyer, 2013), GPA is multifaceted, influenced by factors such as content knowledge and student behavior (e.g., class participation, assignment completion). For example, negative associations with GPA, like when higher teacher expectations lead to lower GPAs due to the increased standards set by teachers (Gershenson, 2020), may indicate positive outcomes. Additionally, grade inflation in recent years raises concerns about the reliability of GPAs as a measure (Gershenson, 2020). Furthermore, GPA may not fully reflect a student's academic success. For example, a tenth grader with a B in Calculus may have more STEM potential than one with an A in remedial math, yet the former's GPA would be lower. Incorporating GPA as an outcome measure poses challenges; future studies should explore alternative outcome measures, such as standardized test scores, college outcomes, and psychosocial measures (e.g., school belonging, math identity), to better investigate the impact of teacher-student racial/ethnic match on student outcomes.

Another limitation stems from using only the public-use version of the HSLS:09 dataset, which lacked access to specific school-level covariates (e.g., racial/ethnic diversity, percentage of students on free/reduced lunch). Consequently, this study could not consider school-level factors that might affect the relationship between teacher-student racial/ethnic match and student outcomes. Future studies should more deliberately incorporate school factors when examining the influence of teacher-student racial/ethnic match on students.

Additionally, the public-use dataset suppressed school identification numbers, making it impossible to account for data nesting, such as using clustered standard errors. Future research should account for this potential clustering by using methods like clustered standard errors or multi-level modeling.

Timing is also an issue as both the independent variable and the latent factor are measured at the first wave of my study, making it less possible to test the causal pathway between a match and the latent factors. Future studies should adopt a longitudinal approach to better distinguish causal pathways between a match, latent factors, and outcomes, enhancing our understanding of the causal logic behind teacher-student racial/ethnic matches and these outcomes.

Lastly, the study's use of a direct match between a student and teacher may be too blunt of a measure. A binary indicator may miss the nuances in interactions between teachers of color and students of color. In addition, as this dataset only includes teacher data from the first wave, accurately detecting the effect of a teacher-student racial/ethnic match is challenging, especially when the outcome measure is from the third wave, three years later. This limitation biases the effect of a racial/ethnic match towards zero (i.e., not a direct match). For example, a student without a match in the first wave might have a match in subsequent waves but would still be marked as not having a match by Wave 3. Future research should include teacher data at shorter time points (e.g., annually) to better account for the effect of a teacher-student racial/ethnic match. Moreover, studies should adopt a more nuanced approach, such as qualitative research exploring how teachers of color interact with students of the same race/ethnicity.

Implications

Taken together, findings carry significant implications for policy and organizations, particularly in supporting teachers to serve students of color in STEM. As my results suggest, while teacher-led factors and student engagement positively influence student math and science

GPA, teacher-student racial/ethnic match does not. This implies two key messages. First, teacher race is not strongly linked to teacher outcomes, emphasizing the need for policymakers and stakeholders to promote effective teaching practices such as culturally responsive teaching and high expectations, regardless of teacher-student racial/ethnic alignment. Second, considering the adolescent developmental stage of high school students, where peers may hold greater influence compared to earlier developmental stages, administrators should focus on policies beyond the classroom (e.g., school climate).

On the other hand, the lack of association between teachers of color and teacher-led factors is concerning, especially as it goes counter to previous literature. It is unclear whether the results reflect the absence of a teacher-student racial/ethnic match effect or limitations in this study's design. Hence, these findings underscore the need for further exploration, particularly to understand how the racial/ethnic identity of teachers influences their teaching practices. Future research, possibly through qualitative methods, could reveal nuanced processes underlying the benefits of a teacher-student racial/ethnic match.

Conclusion

This study investigated the mechanisms underlying the perceived benefits of teacher-student racial/ethnic matches, focusing on hypothesized pathways moderated by students' racial/ethnic identities. While literature often highlights the advantages of teachers sharing the same race as their students (Dee, 2004; Egalite & Kisida, 2018), my results offer different evidence, suggesting that this association may not strongly improve student outcomes. Although findings may suggest teacher race should be considered alongside other factors rather than having the greatest priority, given design limitations, it remains inconclusive whether teacher-student racial/ethnic matches are beneficial for students of color or are related to teacher-led factors, teaching, and student perceptions and engagement. These findings prompt further exploration; although this quantitative study may not capture the nuanced processes related to the benefits of teacher-student racial/ethnic matches, qualitative exploration could offer insights and better capture these nuanced processes, which is the focus of the next chapter.

Figure 1.1 Conceptual Model

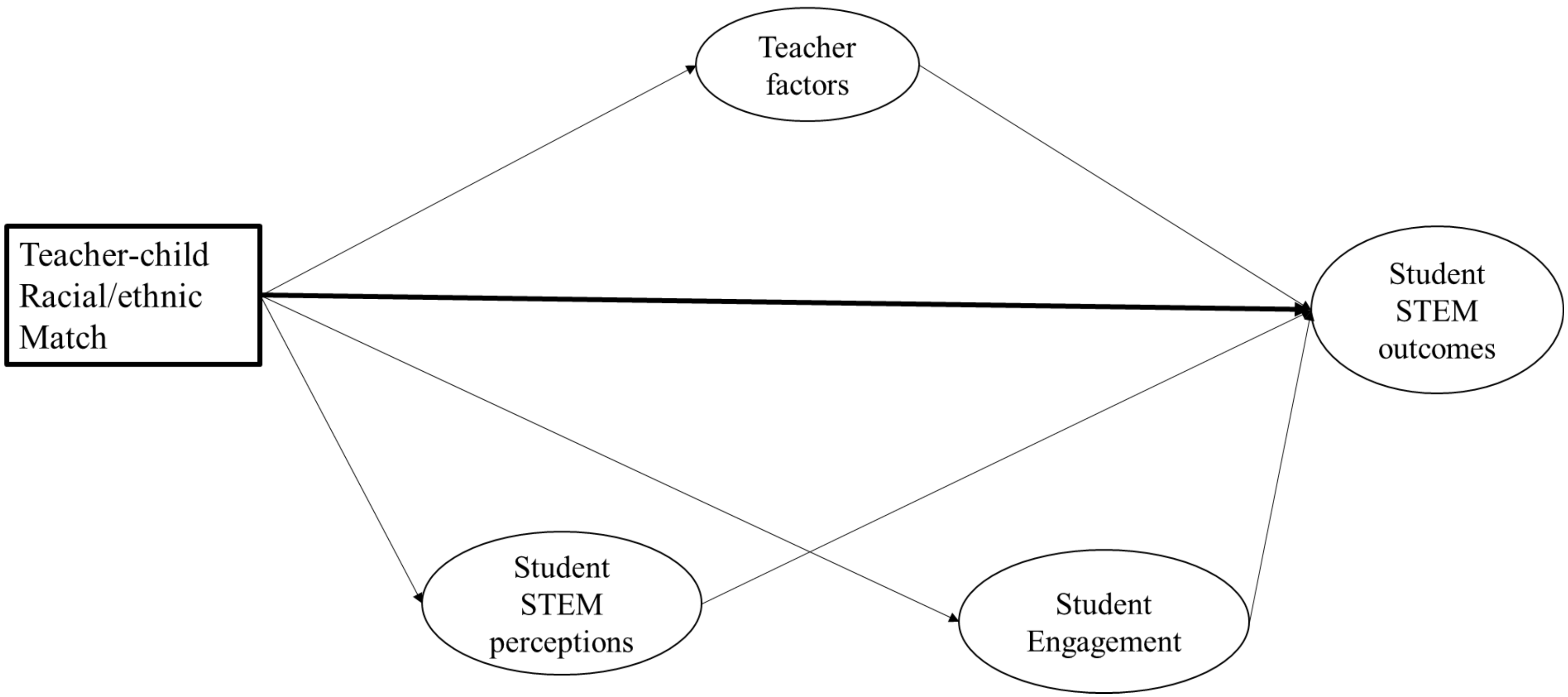
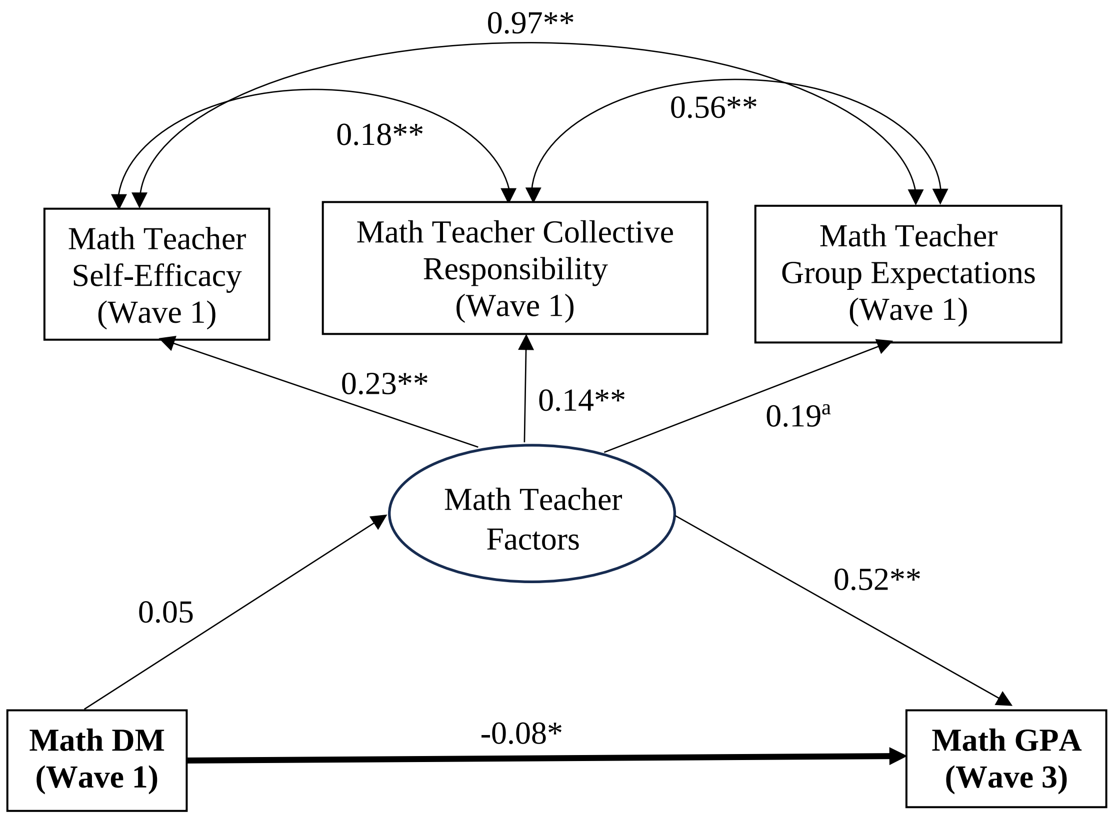


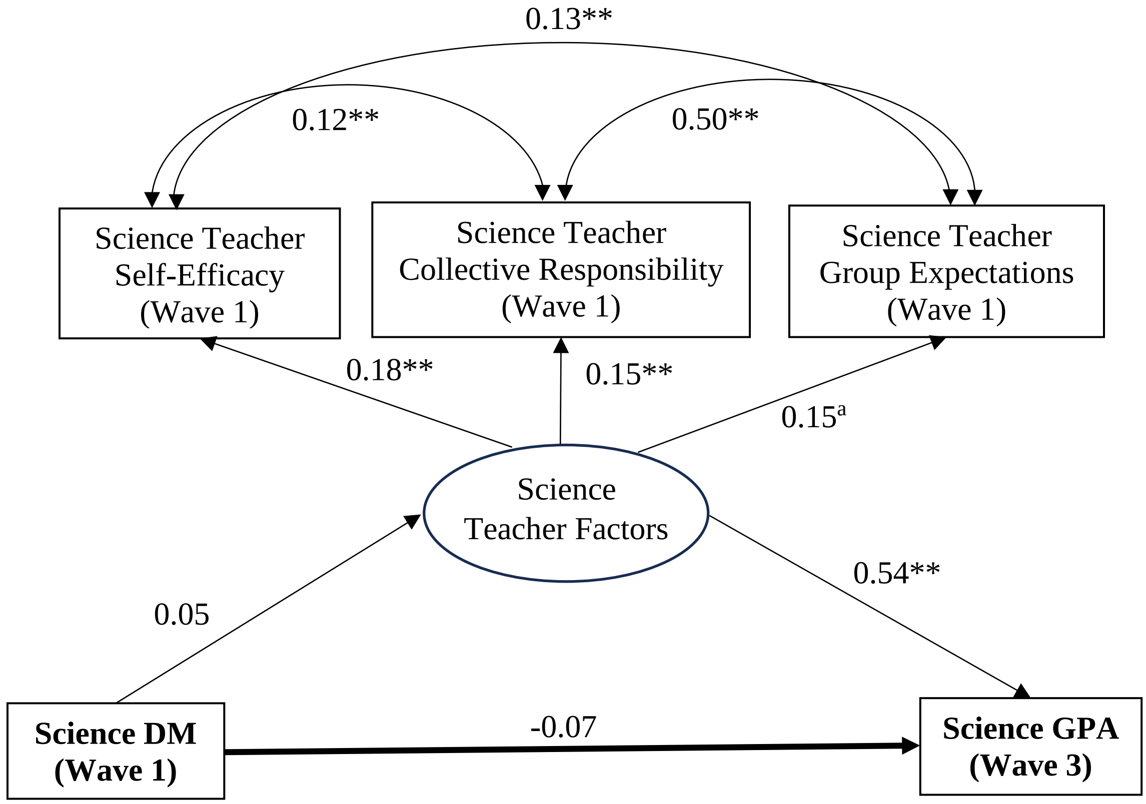
Figure 1.2. Observed Math Teacher Model



Note: Covariates are not shown. N = 3,384.

[a]According to requirements for SEM analyses, one variable loading on each latent factor was set equal to 1.00 to set the metric for that factor. As a result, significance values are not calculated for these variable loadings. $^{*}p<.05$; $^{**}p<.01$

Figure 1.3. Observed Science Teacher Model



Note: Covariates are not shown. N = 3,376

[a]According to requirements for SEM analyses, one variable loading on each latent factor was set equal to 1.00 to set the metric for that factor. As a result, significance values are not calculated for these variable loadings. *p<.05; **p<.01

Figure 1.4. Observed Math Student Model

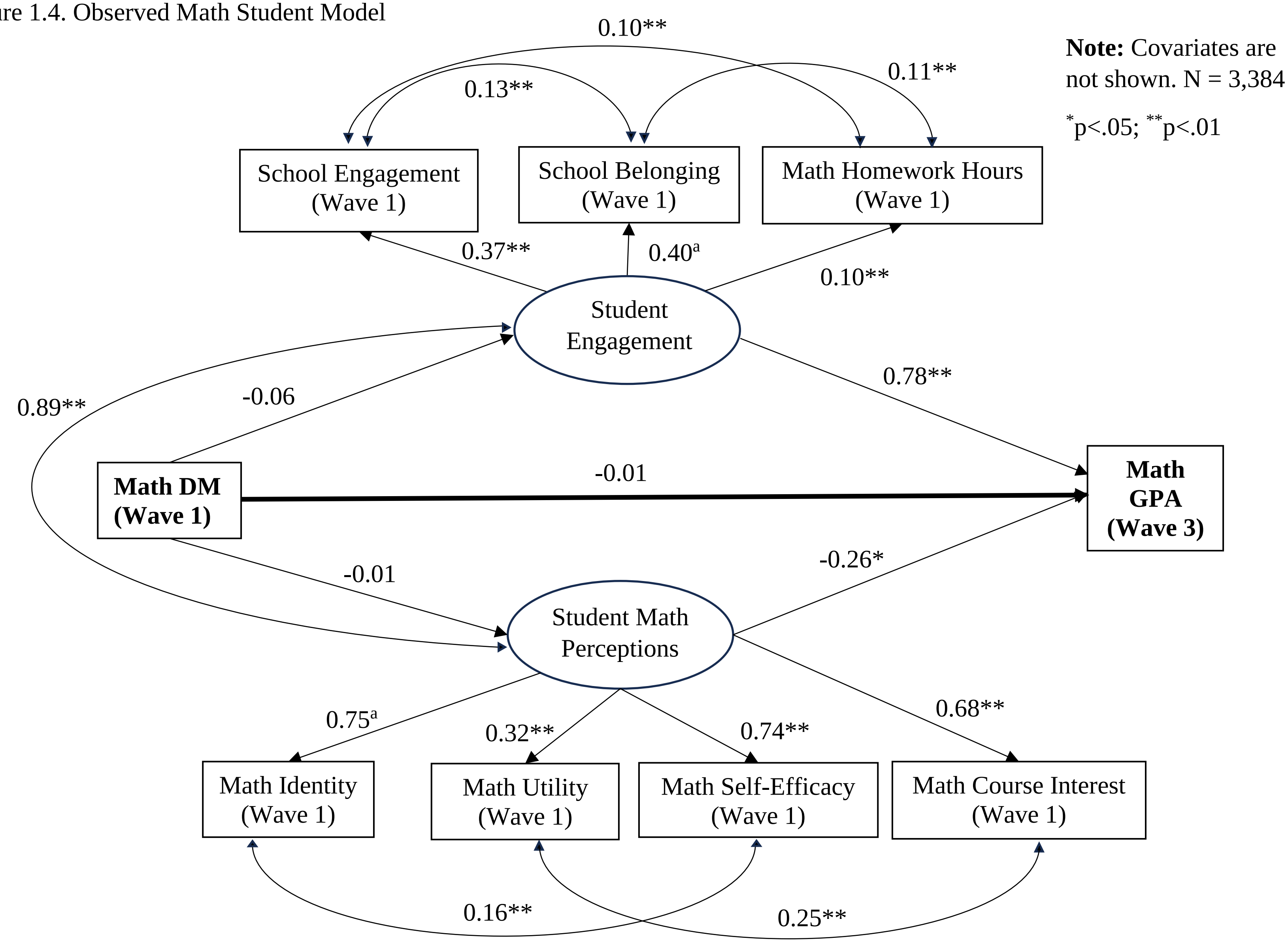
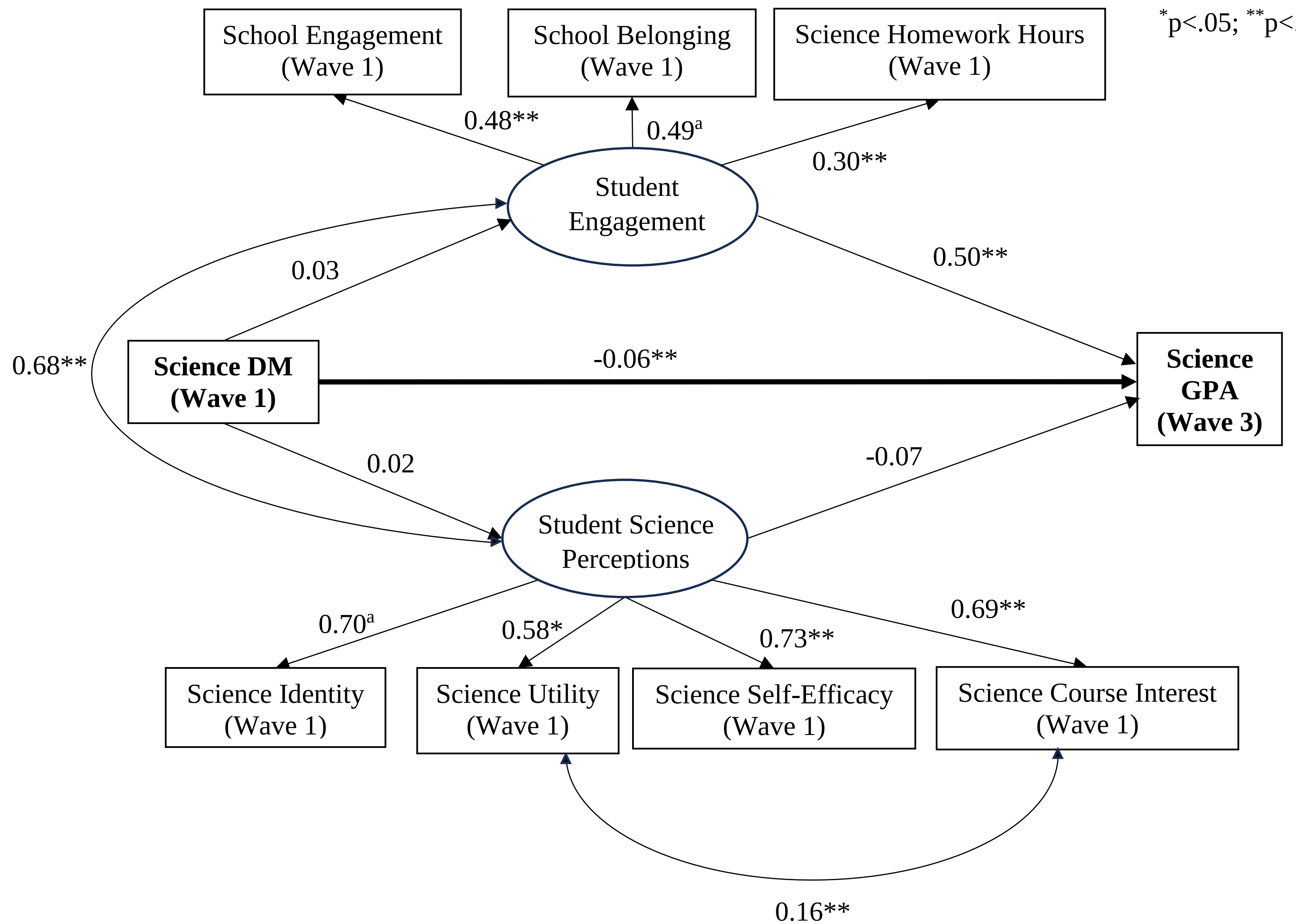


Figure 1.5. Observed Science Student Model



Note: Covariates are not shown. N = 3,376

[*]p<.05; [**]p<.01

Table 1.1. Distribution of the sample of HSLS:09 study and the sample for the present study

	Sample of HSLS:09 Data				Sample of Present Study			
	N	% in sample	Mean/%	SD	N	% in sample	Mean/%	SD
Total	23,503	100	100%		3,760	100	100%	
Child gender (female)	11,524	49.03	49%		1,848	49.15	49%	
Child age (in years)	23,317	99.21	15.00	0.81	3,743	99.55	15.01	0.82
Child race								
Amer. Indian/Alaska Native, non-Hispanic	165	0.70	1%		74	1.97	2%	
Asian, non-Hispanic	1,952	8.31	9%		906	24.10	24%	
Black/African-American, non-Hispanic	2,450	10.42	11%		1,037	27.58	28%	
Hispanic	3,797	16.16	17%		1,696	45.11	45%	
More than one race, non-Hispanic	1,941	8.26	9%				0%	
Native Hawaiian/ Pacific Islander, non-Hispanic	110	0.47	<1%		47	1.25	1%	
White, non-Hispanic	12,082	51.41	54%				0%	
First language								
English	17,863	76	83%		2,163	57.53	61%	
Non-English	2,201	9.36	10%		865	23.01	24%	
English and Non-English	1,355	5.77	6%		537	14.28	15%	
Family poverty level								
Below poverty threshold	2,671	11.36	16%		652	17.34	24%	
Between 0% to 130%	995	4.23	6%		234	6.22	9%	
Between 130% to 185%	1,892	8.05	11%		339	9.02	12%	
Above 185%	11,175	47.55	67%		1,509	40.13	55%	
Math teacher characteristics								
Gender (Female)	10,338	43.99	61%		2,309	61.41	61%	
Teacher race								
Asian, non-Hispanic	408	1.74	2%		133	3.54	4%	

Black/African-American, non-Hispanic	591	2.51	3%	250	6.65	7%
Hispanic	645	2.74	4%	190	5.05	5%
More than one race, non-Hispanic	238	1.01	1%	0	0	0%
Other race, non-Hispanic	38	0.16	<1%	15	0.40	<1%
White, non-Hispanic	15,104	64.26	89%	3,172	84.36	84%
Highest degree						
Bachelor's Degree	8,444	35.93	49%	1,889	50.24	50%
Master's Degree	8,028	34.16	47%	1,720	45.74	46%
Educational Specialist Diploma	376	1.60	2%	75	1.99	2%
Ph.D. or Professional Degree	219	0.93	1%	76	2.02	2%
Teacher certified in state	15,739	66.97	92%	3,430	91.22	91%
Science teacher characteristics						
Gender (Female)	8,760	37.27	56%	2,164	57.55	58%
Teacher race						
Asian, non-Hispanic	341	1.45	2%	129	3.43	3%
Black/African-American, non-Hispanic	660	2.81	4%	262	6.97	7%
Hispanic	550	2.34	4%	239	6.36	6%
More than one race, non-Hispanic	291	1.24	2%	0	0	0%
Other race, non-Hispanic	31	0.13	<1%	4	0.11	<1%
White, non-Hispanic	13,624	57.97	88%	3,126	83.14	83%
Highest degree						
Bachelor's Degree	6,762	28.77	43%	1,679	44.65	45%
Master's Degree	7,778	33.09	50%	1,848	49.15	49%
Educational Specialist Diploma	508	2.16	3%	105	2.79	3%
Ph.D. or Professional Degree	511	2.17	3%	128	3.40	3%
Teacher certified in state	14,435	61.42	93%	3,464	92.13	92%
Locale						

City	6,689	28.46	28%	1,071	28.48	28%
Suburb	8,467	36.03	36%	1,377	36.62	37%
Town	2,788	11.86	12%	417	11.09	11%
Rural	5,559	23.65	24%	895	23.80	24%
Region						
Northeast	3,662	15.58	16%	522	13.88	14%
Midwest	6,224	26.48	26%	1,030	27.39	27%
South	9,587	40.79	41%	1,560	41.49	41%
West	4,030	17.15	17%	648	17.23	17%
Teacher-student racial/ethnic match						
Math teacher						
Direct match	9,152	38.94	56%	301	8.01	8%
Partial match	1,303	5.54	8%	287	7.63	8%
Mismatch	6,010	25.57	37%	3,172	84.36	84%
Science teacher						
Direct match	8,323	35.41	55%	329	8.75	9%
Partial match	1,348	5.74	9%	305	8.11	8%
Mismatch	5,329	22.67	36%	3,126	83.14	83%

Table 1.2. List of constructs

Construct	Item	Description	Item name in HSLS:09 Dataset
Student STEM outcomes	SO1	Mathematics theta score	X1TXMTH
	SO2	Mathematics theta score	X2TXMTH
	SO3	GPA: mathematics	X3TGPAMAT
	SO4	GPA: science	X3TGPASCI
Student math perceptions	SM1	Scale of student's mathematics identity	X1MTHID
	SM2	Scale of student's mathematics utility	X1MTHUTI
	SM3	Scale of student's mathematics self-efficacy	X1MTHEFF
	SM4	Scale of student's interest in fall 2009 math course	X1MTHINT
Student science perceptions	SS1	Scale of student's science identity	X1SCIID
	SS2	Scale of student's science utility	X1SCIUTI
	SS3	Scale of student's science self-efficacy	X1SCIEFF
	SS4	Scale of student's interest in fall 2009 science course	X1SCIINT
Student engagement	SE1	Scale of student's sense of school belonging	X1SCHOOLBEL
	SE2	Scale of student's school engagement	X1SCHOOLENG
	SE3	Hours spent on math homework/studying on typical schoolday	S1HRMHOMEWK
	SE4	Hours spent on science homework/studying on typical schoolday	S1HRSHOMEWK
Math teacher factors	MT1	Scale of math teacher's perceptions of math teachers' expectations	X1TMEXP
	MT2	Scale of math teacher's self-efficacy	X1TMEFF
	MT3	Scale of math teacher's perceptions of collective responsibility	X1TMRESP
Science teacher factors	ST1	Scale of science teacher's perceptions of science teachers expectations	X1TSEXP
	ST2	Scale of science teacher's self-efficacy	X1TSEFF
	ST3	Scale of science teacher's perceptions of collective responsibility	X1TSRESP

Table 1.3. Descriptive statistics of observed variables

	Item	Description	N	Number Missing	% missing	Mean	SD
1	SO1	Mathematics theta score	3,570	190	5.05	0.01	1.01
2	SO2	Mathematics theta score	3,340	420	11.17	0.72	1.19
3	SO3	GPA: mathematics	3,760	0	0	2.26	1
4	SO4	GPA: science	3,760	0	0	2.31	0.98
5	SM1	Scale of student's mathematics identity	3,515	245	6.52	0.11	0.99
6	SM2	Scale of student's mathematics utility	3,131	629	16.73	0.16	0.97
7	SM3	Scale of student's mathematics self-efficacy	3,111	649	17.26	0.13	0.96
8	SM4	Scale of student's interest in fall 2009 math course	3,051	709	18.86	0.16	0.96
9	SS1	Scale of student's science identity	3,504	256	6.81	0	1.01
10	SS2	Scale of student's science utility	2,996	764	20.32	0.13	0.99
11	SS3	Scale of student's science self-efficacy	2,977	783	20.82	0.06	0.99
12	SS4	Scale of student's interest in fall 2009 science course	2,891	869	23.11	0.10	0.97
13	SE1	Scale of student's sense of school belonging	3,409	351	9.34	0.11	1
14	SE2	Scale of student's school engagement	3,460	300	7.98	0.04	1
15	SE3	Hours spent on math homework/studying on typical schoolday	3,116	644	17.13	0.59	0.83
16	SE4	Hours spent on science homework/studying on typical schoolday	2,959	801	21.30	0.61	0.83
17	MT1	Scale of math teacher's perceptions of math teachers' expectations	3,416	344	9.15	0.11	0.98
18	MT2	Scale of math teacher's self-efficacy	3,313	447	11.89	0.10	0.97
19	MT3	Scale of math teacher's perceptions of collective responsibility	3,289	471	12.53	0.12	1.05
20	ST1	Scale of science teacher's perceptions of science teachers expectations	3,367	393	10.45	0.10	1
21	ST2	Scale of science teacher's self-efficacy	3,267	493	13.11	0.11	1.02
22	ST3	Scale of science teacher's perceptions of collective responsibility	3,277	483	12.85	0.04	0.97
23	SES	Socio-economic status composite	3,570	190	5.05	-0.09	0.84
24	AGE		3,743	17	0.45	15.01	0.82
25	MTYRS	Years math teacher has taught any subject to grade levels 9-12	3,695	65	1.73	10.04	8.48

26	STYRS	Years science teacher has taught any subject to grade levels 9-12	3,690	70	1.86	10.21	7.83

Table 1.4 Frequency Counts and Percentages of the Teacher-Student Racial/Ethnic Pairs

Race/Ethnicity			**Math Teacher**			**Science Teacher**		
Student	**Teacher**	**Total**	**N**	**%**	**% By Subgroup**	**N**	**%**	**% By Subgroup**
American Indian/ Alaskan Native	Asian	74			0	1	0.03	1
	Black		3	0.08	4	3	0.08	4
	Hispanic		2	0.05	3	1	0.03	1
	White		69	1.84	93	69	1.84	93
Asian	Asian	906	31	0.82	3	29	0.77	3
	Black		21	0.56	2	23	0.61	3
	Hispanic		26	0.69	3	40	1.06	4
	Other		7	0.19	1	1	0.03	0
	White		821	21.84	91	813	21.62	90
Black	Asian	1037	31	0.82	3	20	0.53	2
	Black		132	3.51	13	145	3.86	14
	Hispanic		24	0.64	2	41	1.09	4
	Other		2	0.05	0			0
	White		848	22.55	82	831	22.1	80
Hispanic	Asian	1696	68	1.81	4	75	1.99	4
	Black		93	2.47	5	91	2.42	5
	Hispanic		138	3.67	8	155	4.12	9
	Other		5	0.13	0	3	0.08	0
	White		1,392	37.02	82	1,372	36.49	81
Native Hawaiian /Pacific Islander	Asian	47	3	0.08	6	4	0.11	9
	Black		1	0.03	2			0
	Other		1	0.03	2			0
	White		42	1.12	89	41	1.09	87
	Hispanic				0	2	0.05	4
Total		**3,760**	**3,760**	**100**		**3,760**	**100**	

Table 1.5. Summary of Confirmatory Factor Analysis Measurement Models

	B	***β***
Measurement Model 1: Teacher factors (math)		
Variable loadings on latent factors		
Math teacher factors → math teacher expectations	1.00[a]	0.82
Math teacher factors → math teacher collective responsibility	0.90***	0.69
Math teacher factors → math teacher self-efficacy	0.35***	0.29
Sample Size: 3,480		
Model Fit: CFI = 1.000, RMSEA = .000, AIC = 26,938, χ^2 (*df* = 3) = 1,491		
Measurement Model 2: Teacher factors (science)		
Variable loadings on latent factors		
Science teacher factors → science teacher expectations	1.00[a]	0.74
Science teacher factors → science teacher collective responsibility	0.91***	0.70
Science teacher factors → science teacher self-efficacy	0.29***	0.21
Sample Size: 3,434		
Model Fit: CFI = 1.000, RMSEA = .000, AIC = 26,944, χ^2 (*df* = 3) = 1,121		
Measurement Model 3: Student factors (math)		
Variable loadings on latent factors		
Student math perceptions → student math identity	1.00[a]	0.69
Student math perceptions → student math utility	0.68***	0.48
Student math perceptions → student math self-efficacy	1.03***	0.72
Student math perceptions → student math course interest	1.04***	0.73
Student engagement → school belonging	1.00[a]	0.68
Student engagement → school engagement	0.62***	0.42
Student engagement → math homework hours	0.24***	0.20
Covariance		
Student math perceptions with student engagement	0.29***	0.64
Sample Size: 3,560		
Model Fit: CFI = .947, RMSEA = .067, AIC = 59,120, χ^2 (*df* = 13) = 220		
Measurement Model 4: Student factors (science)		
Variable loadings on latent factors		
Student science perceptions → student science identity	1.00[a]	0.65
Student science perceptions → student science utility	0.96***	0.63
Student science perceptions → student science self-efficacy	1.06***	0.70
Student science perceptions → student science course interest	1.11***	0.74
Student engagement → school belonging	1.00[a]	0.64
Student engagement → school engagement	0.66***	0.42
Student engagement → science homework hours	0.40***	0.30
Covariance		

Student science perceptions with student engagement	0.27^{***}	0.65
Sample Size: 3,560		
Model Fit: CFI = .970, RMSEA = .051, AIC = 57,784, χ^2 (*df* = 13) = 133		

Note: AIC = Akaike information criterion; CFI = Comparative Fit Index; RMSEA = root mean square error of approximation; SEM = structural equation modeling. [a]According to requirements for SEM analyses, one variable loading on each latent factor was set equal to 1.00 to set the metric for that factor. As a result, significance values are not calculated for these variable loadings. $^{***}p<.01$.

Table 1.6. Regressions on Students Math GPA on having Racial/Ethnic Match between the Student and Math Teacher

	Analytic Sample		Asian Students		Black Students		Hispanic Students	
	Null Model *B* *(SE B)*	Full Model *B* *(SE B)*	Null Model *B* *(SE B)*	Full Model *B* *(SE B)*	Null Model *B* *(SE B)*	Full Model *B* *(SE B)*	Null Model *B* *(SE B)*	Full Model *B* *(SE B)*
Intercept	2.300**	3.868**	2.969**	3.844**	1.982**	4.505**	2.109**	3.836**
	(0.017)	(0.287)	(0.029)	(0.602)	(0.030)	(0.525)	(0.024)	(0.416)
Teacher-Student Match	-0.320**	-0.131*	-0.081	-0.035	-0.081	-0.051	-0.257**	-0.231**
	(0.060)	(0.055)	(0.158)	(0.163)	(0.085)	(0.085)	(0.083)	(0.082)
Student Sex (Female)		0.231**		0.176**		0.229**		0.252**
		(0.030)		(0.058)		(0.056)		(0.044)
First Language: Not English		0.171**		0.150*		0.386*		0.180**
		(0.039)		(0.068)		(0.164)		(0.052)
First Language: English & Another Language		0.068		0.079		0.049		0.060
		(0.045)		(0.074)		(0.184)		(0.062)
Student Age		-0.127**		-0.084*		-0.162**		-0.116**
		(0.018)		(0.039)		(0.033)		(0.027)
Suburb		0.002		0.120+		-0.068		-0.014
		(0.037)		(0.070)		(0.072)		(0.056)
Town		0.036		0.149		-0.006		0.019
		(0.053)		(0.110)		(0.094)		(0.080)
Rural		0.086*		0.174*		0.172*		-0.017
		(0.041)		(0.080)		(0.078)		(0.062)

Teacher Sex (Female)		0.040		0.033		0.022		0.058
		(0.030)		(0.060)		(0.058)		(0.045)
Teacher Highest Degree		0.054^{+}		0.068		0.051		0.038
		(0.028)		(0.055)		(0.053)		(0.042)
Teacher is Certified		-0.165**		-0.120		-0.275**		-0.090
		(0.056)		(0.118)		(0.104)		(0.081)
Years Teaching		0.003		0.007^{+}		0.003		0.001
		(0.002)		(0.004)		(0.004)		(0.003)
Asian		0.718**						
		(0.048)						
Hispanic		0.120**						
		(0.038)						
Child SES		0.317**		0.250**		0.306**		0.378**
		(0.020)		(0.033)		(0.039)		(0.032)
Observations	3,639	3,375	906	831	1,037	949	1,696	1,595
R^2	0.008	0.266	0.0003	0.110	0.001	0.145	0.006	0.136
Adjusted R^2	0.008	0.263	-0.001	0.096	-0.0001	0.133	0.005	0.129
Residual Std. Error	0.995 (df = 3637)	0.856 (df = 3359)	0.867 (df = 904)	0.824 (df = 817)	0.914 (df = 1035)	0.846 (df = 935)	0.937 (df = 1694)	0.877 (df = 1581)
F Statistic	28.529** (df = 1; 3637)	81.147** (df = 15; 3359)	0.265 (df = 1; 904)	7.791** (df = 13; 817)	0.900 (df = 1; 1035)	12.193** (df = 13; 935)	9.556** (df = 1; 1694)	19.194** (df = 13; 1581)

Note: $^{+}$p<0.1; *p<0.05; **p<0.01

Table 1.7. Regressions on Students Science GPA on having Racial/Ethnic Match between the Student and Science Teacher

	Analytic Sample		Asian Students		Black Students		Hispanic Students	
	Null Model *B* *(SE B)*	Full Model *B* *(SE B)*	Null Model *B* *(SE B)*	Full Model *B* *(SE B)*	Null Model *B* *(SE B)*	Full Model *B* *(SE B)*	Null Model *B* *(SE B)*	Full Model *B* *(SE B)*
Intercept	2.340**	4.464**	2.963**	4.131**	2.080**	4.733**	2.135**	4.668**
	(0.017)	(0.279)	(0.029)	(0.591)	(0.030)	(0.506)	(0.024)	(0.406)
Teacher-Student Match	-0.214**	-0.070	0.244	0.128	-0.124	-0.079	-0.054	-0.083
	(0.056)	(0.051)	(0.160)	(0.165)	(0.080)	(0.079)	(0.078)	(0.075)
Student Sex (Female)		0.233**		0.194**		0.275**		0.235**
		(0.029)		(0.057)		(0.054)		(0.043)
First Language: Not English		0.065+		0.047		0.170		0.075
		(0.038)		(0.067)		(0.158)		(0.051)
First Language: English & Another Language		0.072		0.100		0.019		0.056
		(0.044)		(0.072)		(0.178)		(0.061)
Student Age		-0.157**		-0.110**		-0.173**		-0.157**
		(0.018)		(0.038)		(0.032)		(0.026)
Suburb		-0.015		0.015		-0.029		-0.009
		(0.036)		(0.069)		(0.070)		(0.055)
Town		0.075		0.048		0.070		0.104
		(0.052)		(0.109)		(0.092)		(0.079)
Rural		0.035		0.169*		0.136+		-0.081
		(0.040)		(0.078)		(0.076)		(0.060)

Teacher Sex (Female)		0.094**		0.116*		-0.006		0.145**
		(0.030)		(0.059)		(0.057)		(0.044)
Teacher Highest Degree		0.062*		0.082		0.034		0.067^{+}
		(0.026)		(0.051)		(0.051)		(0.039)
Teacher is Certified		-0.239**		0.011		-0.262*		-0.305**
		(0.055)		(0.119)		(0.102)		(0.080)
Years Teaching		0.002		0.004		0.005		-0.0004
		(0.002)		(0.004)		(0.003)		(0.003)
Asian		0.657**						
		(0.047)						
Hispanic		0.117**						
		(0.037)						
Child SES		0.323**		0.283**		0.324**		0.346**
		(0.019)		(0.032)		(0.037)		(0.031)
Observations	3,639	3,376	906	831	1,037	947	1,696	1,598
R^2	0.004	0.266	0.003	0.135	0.002	0.163	0.0003	0.153
Adjusted R^2	0.004	0.263	0.001	0.121	0.001	0.151	-0.0003	0.146
Residual Std. Error	0.974 (df = 3637)	0.836 (df = 3360)	0.850 (df = 904)	0.805 (df = 817)	0.896 (df = 1035)	0.817 (df = 933)	0.930 (df = 1694)	0.860 (df = 1584)
F Statistic	14.454** (df = 1; 3637)	81.337** (df = 15; 3360)	2.314 (df = 1; 904)	9.812** (df = 13; 817)	2.371 (df = 1; 1035)	13.989** (df = 13; 933)	0.475 (df = 1; 1694)	22.061** (df = 13; 1584)
Note:								$^{+}$p<0.1; *p<0.05; **p<0.01

Table 1.8. Partial scalar invariant models: Parameters to be freely estimated

Parameters	**Teacher Math Model**	**Teacher Science Model**	**Student Math Model**	**Teacher Science Model**
Loadings		Teacher Science Factor =~ Teacher Collective Responsibility	Student Engagement =~ Science Math Homework	Student =~ School Engagement
Intercepts	Teacher Group Expectations ~ 1 Teacher Self-Efficacy ~ 1	Teacher Self-Efficacy ~ 1	Student Math Identity ~ 1 Student Math Identity ~ 1 School Belonging ~ 1	Student Science Identity ~ 1 Student School Belonging ~ 1 Student Science Course Interest ~ 1

Table 1.9. Standardized Regression Coefficients from Multigroup SEM Analyses of Math Teacher Factors Predicting Math GPA Across Student Racial/Ethnic Groups

	Hispanic	**Asian**	**Black**
N	1,600	831	953
Math Teacher Factors → Math GPA	0.833	0.695	0.771

Note: Total *N* = 3,384. The variable loadings on the Math Teacher Factors as well as the model covariates were partially fixed to be equal across groups. Fit statistics: CFI = .953, RMSEA = .026, AIC = 32,719, Chi-square (*df* = 133) = 231.52. *p<.05; **p<.01

Table 1.10. Standardized Regression Coefficients from Multigroup SEM Analyses of Student Engagement and Student Science Perceptions Predicting Science GPA Across Student Racial/Ethnic Groups

	Hispanic	**Asian**	**Black**
N	1,598	831	947
Student Science Perceptions → Science GPA	0.026	0.211**	-0.056
Student Engagement → Science GPA	0.363**	0.075	0.387**

Note: Total *N* = 3,639. The variable loadings on the Math Teacher Factors as well as the model covariates were partially fixed to be equal across groups. Fit statistics: CFI = .953, RMSEA = .026, AIC = 32,719, Chi-square (*df* = 133) = 231.52. *p<.05; **p<.01

STUDY 2

Examining Teacher-student Racial/Ethnic Match through the Lens of Math and Science Teachers of Color

Diversifying the STEM high school teacher workforce is a common policy strategy to improve STEM outcomes and increase workforce participation for URM students. Teachers of color can benefit students of color on a variety of levels, including academic benefits (Egalite et al., 2015; Hart, 2020) and higher teacher expectations (Fox, 2016; Gershenson et al., 2018). Hence, increasing the recruitment and retention of high school STEM teachers of color could help reduce racial underrepresentation in STEM, as only 15% of math and science teachers are teachers of color (National Center for Science and Engineering Statistics, 2021). Although the teacher-student racial/ethnic match literature suggests benefits for students of color when their teacher shares their race/ethnicity, there are gaps in understanding the underlying mechanisms by which teachers of color influence their students of color.

Teacher perceptions of their students may represent a key mechanism in improving student outcomes, as positive teacher perceptions can positively influence teacher behavior towards their students (Blanchard & Muller, 2015; Brandmiller et al., 2020). While the positive effects of teacher perceptions on student outcomes are well-established, our understanding of how teacher perceptions are shaped by their racial identity and how these perceptions affect students remains limited. Furthermore, it remains unclear how this phenomenon manifests in the context of STEM teachers of color, who are often trained more on content pedagogy than on cultural competence (Cherry-McDaniel, 2019; Niess, 2005; Philip et al., 2017). Additionally, the extent to which students of color benefit from having a teacher of color, regardless of shared racial/ethnic identity, is not well understood. In particular, it is unclear how teachers of color perceive their teaching and influence on students of color who do not share their race or ethnicity. To address these literature gaps, this study investigated the role of high school math and science teachers of color's racial/ethnic identity in shaping their perceptions of and relationships with students of color, as well as their pedagogical approaches.

Importance and Dilemma around STEM Teachers

While the need for K-12 teachers has remained consistent, the demand for secondary math and science teachers has been particularly pressing. Since the launch of the USSR Sputnik, the United States has recognized the importance of productivity in STEM fields for the nation's economic well-being and global influence. Consequently, policymakers at both the state and federal levels have supported initiatives aimed at improving STEM teacher training, recruitment, and retention. STEM teacher professional learning, as a result, has traditionally emphasized content training and the demonstration of content knowledge through scoring above certain standard certification requirements on statewide math and science tests (Institute for Advanced Study Commission on Mathematics and Science Education, 2009; Monk, 1994; Niess, 2005)

The current emphasis on content training for STEM teachers has created two issues. First, it exacerbates the already limited pool of potential science teachers, as many STEM majors and graduates have more lucrative options than teaching K-12 (Institute for Advanced Study Commission on Mathematics and Science Education, 2009). Thus, increasing content knowledge requirements for math and science teaching may reduce the pool of eligible math and science teachers. Second, many teacher preparation programs sacrifice interpersonal and multicultural education and training aspects to prioritize content knowledge, which may hinder teachers' ability to connect with and understand the diverse student populations they serve (Cherry-McDaniel, 2019; Philip et al., 2017).

As STEM teacher training programs often prioritize content knowledge over multicultural education and implicit bias training, these programs potentially leave STEM teachers lacking in cultural competence and ill-prepared to serve students of color. Hence, recruiting and retaining STEM teachers presents a contradiction. On the one hand, there is a critical need to expeditiously increase their numbers to help address the underrepresentation of URMs in STEM. On the other hand, the need to quickly prepare STEM teachers has led to an emphasis on content training at the expense of multicultural education, which may result in a lack of cultural competence among STEM teachers, leaving them ill-equipped to support URM students.

Therefore, STEM teachers of color hold promise; despite receiving primarily content training in their professional learning, they may be able to compensate for their lack of cultural and interpersonal training by leveraging their cultural wealth and lived experiences to enhance the learning experiences of students of color (Villegas & Irvine, 2010). However, it is unclear how they can effectively bring their cultural experiences into the classroom and in what specific ways they can benefit their students. While some ideas exist on how teachers of color could support students of color, more research is needed to understand the mechanisms through which they can best serve their students, although the literature points to some possible explanations.

Possible Explanations behind Teacher of Color's Benefits for Students of Color

The literature points to three possible pathways that students of color benefit by having a teacher of color. One of the ways teachers of color may benefit students of color is the way they can undermine stereotype threat. Stereotype threat is a psychological phenomenon that occurs when individuals engage in an activity where a negative stereotype about their group is relevant

(Steele & Aronson, 1995). For instance, many URM students may suffer in STEM achievement tests due to feeling stereotyped in performing poorly in STEM related tasks, tests and courses (Corra & Lovaglia, 2012; Totonchi et al., 2021; Woodcock et al., 2012). Teachers of color, who may have previously experienced stereotype threat, may reflect on ways to discuss, and address this concern in the moment to subvert stereotype threat in their classroom.

Teachers of color can also positively influence their students by maintaining high expectations, as they often see greater potential in their students. (Bates & Glick, 2013; Fox, 2016; Gershenson et al., 2018; Ouazad, 2014). For instance, in their analysis of the Education Longitudinal Study of 2002 (ELS), Gershenson et al. (2016) finds that Black teachers of Black students have significantly higher expectations than non-Black teachers of Black students.

Another reason is that teachers of color may better relate with students of color compared to White teachers. Reflecting on their identity and experiences as a person of color in the US, teachers of color are able to better empathize their experiences with their students (Kohli, 2009). For instance, in Kohli's (2009) qualitative study, which explores the Women of Color (i.e., Asian-American, Black, Latina) preservice teachers' reflections on their experiences with race and racism in K-12 schools, she finds that how these teachers were able to connect their personal experiences with racism in schools with the racism that they observed among students of color in the K-12 schools. Kohli also suggests that teacher programs can better leverage the personal knowledge and experiences of teachers of color into the training.

By sharing similar lived experiences with students of color, teachers of color can incorporate that knowledge to make their teaching more culturally responsive. This is another possibility: teachers of color can better enact culturally responsive pedagogy by leveraging their own as well as the students' cultural assets and knowledge into their learning (Borrero et al., 2016; Villegas & Lucas, 2002). For instance, Borrero et al. (2016) explored how teachers of color navigate their schools and communicate with their students, leading to reflection about their own racial identity. By recognizing and addressing microaggressions that affect both themselves and their students, these teachers are able to empathize and incorporate these experiences into their pedagogy (Borrero et al., 2016).

While teacher perceptions could play a role in influencing students, it is unclear whether these general ideas of perceptions apply to STEM teachers of color, given the specific needs, training and concerns that STEM have compared to other teachers. This study explored these nuances.

The Extent of a Racial/Ethnic Match Between Teachers and Students

While there is literature examining how students of color benefit from having a teacher of color, it is less clear how these benefits vary based on the degree of racial/ethnic alignment between teacher and student. This is particularly relevant in cases where a teacher of color teaches a student of color who does not share the same race/ethnicity. Most research has focused on the benefits for students of color who have a direct racial/ethnic match with their teachers (Dee, 2005; Gershenson et al., 2021a). However, there is less understanding of the dynamics when teachers of color instruct students of who do not share their race/ethnicity.

Some literature suggests mixed evidence on this phenomenon (Kokka & Chao, 2020). For instance, Kokka and Chao (2020) found in their qualitative study that Asian American male math teachers identified strongly as people of color and felt a sense of collective responsibility and solidarity with their Latinx and Black students. However, their findings also indicated that these teachers sometimes harbored internalized racism toward their students, suggesting that teachers of color can both benefit and harm students of color. To further explore this issue, this study examines how teachers of color perceive their teaching and interactions with students of color who share the same race/ethnicity, as well as how their perceptions may differ when teaching students of a different race/ethnicity.

School Environment

School environment plays a big role for both teachers and students. For students, the school environment relates to the ways students feel a sense of belonging at school, which can influence their academic performance, especially for students of color (Pena-Shaff et al., 2019; Voight et al., 2015). The literature also cites how school factors, such as the student racial demographics of the school can play a role as well (Parris et al., 2018).

The school environment can also play into teachers of color's working experience. Increasing the number of teachers of color in schools can enhance various outcomes for students of color, including academic achievement, graduation rates, and decreased disciplinary issues (Grissom et al., 2015; Milner, 2006). This is because teachers of color could advocate for students of color (Milner, 2006), which has the potential to not only change teachers' beliefs about their students of color, but also school policies by modifying guidelines that disadvantage students of color, advocating for more conducive curriculum, providing implicit bias training for teachers (Redding, 2019; Warikoo et al., 2016), applying restorative justice approaches to school discipline (Weinstein et al., 2004; Welsh & Little, 2018), and implementing culturally sensitive curriculum (Ladson-Billings, 2014; Ladson-Billings, 1995).

The school climate is also influenced by the school's working conditions. For instance, teachers often suffer with inadequate administrative support and resources to support their students, which impacts teacher morale, leading to teacher turnover and influences student overall learning (Erichsen & Reynolds, 2020; Sutcher et al., 2016). Literature also shows how teachers of color disproportionately leave teaching due to the feelings of isolation (e.g., being the only person of color), lack of autonomy, and tough working conditions (Griffin & Tackie, 2017; Grooms et al., 2021; Kohli, 2018).

The school's governance structure also plays a role. For instance, the lack of autonomy can be a source of job dissatisfaction where many teachers do not have much say regarding school practices and their curriculum, due to the top-down governance structure in which directions are given at the top but are implemented downwards (Worth, 2020). That said, there are schools that provide more egalitarian governance structures, such as community schools. Community schools are viewed as community hubs whereby educators, families, and community partners come together to support their children, youth, as well as their families and communities (Coalition for Community Schools, n.d.). As a result, community schools often act beyond educating the child by providing learning opportunities outside school hours, offering essential social and health supports, and engaging the families and communities as assets in the children's lives (Coalition for Community Schools, n.d.).

Community school teachers are heavily involved in shaping a school culture and policies, arguably more than teachers at traditional public schools. For instance, in the Los Angeles Unified School District, some community schools have an elect to work agreement whereby every year the teachers come together to determine the work agreements with their school (UCLA Community School, 2022). Community schools also have more of a collaborative approach where teachers and community members are involved in many initiatives in the school such as the school's programming, budget, and other facets of the school (Britt et al., 2023; Kang et al., 2021). While there is research about community schools, more research is needed to explore how the community school context provides space for math and science teachers of color to reflect on their racial identity and influence the way they perceive, relate, and teach their students, which this study hopes to shed light on.

Research Goal and Questions

This study explored the processes by which teacher-student racial/ethnic match may influence teachers' perceptions towards high school students of color enrolled in high-minority, low-income urban schools. This study drew upon teacher-interview data from three Los Angeles Unified community schools to explore this specific research question:

1. How does math and science teachers of color's racial/ethnic identity influence their teaching practices and their perceptions of their students?

Statement of Researcher's Positionality

As an Asian American and a previous middle school science teacher, I approach this study with both my racial and teacher identity. As a person of color, through my struggle navigating life in the United States, I realize that the country's purported meritocracy and exceptionalism is built upon the foundations of White supremacy, which permeate every aspect of society. I have come to accept Du Bois's (1903) concept of "double consciousness," which has allowed me to not only understand my own sense of self, but also to recognize the ways in which American society views me. Yet, I have also learned to celebrate the cultural heritage that my family and ethnic identity bring, both for myself and for the broader community.

As I navigated my own racial and ethnic identity in America, I slowly realized that my experiences were not unique to myself and my family but are shared by many marginalized people in the United States and throughout the world. Like Malcom X's (1964) revelations about the global exploitation of people of color by the "Christian trader" White man, I began to see the connections between my experiences of racial microaggressions, whether directly or vicariously through my parents, and those of other people of color in my community and beyond. This awareness informed my approach as a teacher, where I sought to serve as an ally and advocate for the Black and Brown communities I worked with.

Yet, as the only Asian American teacher in my school, I found myself in a unique position. On one hand, I felt a sense of kinship with my fellow students and staff, as we shared common understandings and experiences as people of color. However, I also encountered points of disconnection with some students, as I was entering into communities with different cultural norms and practices than my own. Additionally, due to the lack of Asian American teachers and staff, I sometimes felt unsupported by the administrators. I felt a sense of being both a part of and out of place in my workplace as a teacher.

My background as a teacher of color serving students of color who do not match my racial identity has both advantages and disadvantages for this research. On one hand, since I did not have experience teaching students who look like me in the K-12 school, it may limit my ability to fully comprehend the phenomenon of a teacher-student racial/ethnic match. However, my unique position can serve as a strength in understanding non-direct racial/ethnic matches, which is an emerging area of research, especially given the increasing diversity of US children and the need to recruit more teachers of color, especially in the STEM fields. It is through these experiences of my identity that I perceive and interpret the experiences of teachers and students of color in this study.

Conceptual Framework

This study is guided by the bioecological model (Bronfenbrenner & Morris, 2006), culturally responsive teaching (Gay, 2002b; Ladson-Billings, 1995; Villegas & Lucas, 2002), and intersectionality (Collins, 1999; Crenshaw, 1991, 1997). According to bioecological theory, children's development is heavily influenced by proximal processes, a series of regular and lasting interactions that the child has with individuals such as teachers, parents, and peers (Bronfenbrenner & Morris, 2006). These interactions are iterative, bidirectional, and increase in complexity over time. The nature of the proximal process is influenced by the child's immediate context (e.g., a child's classroom), which is further embedded within a series of larger, interconnected contexts (e.g., a child's school, neighborhood, community).

Culturally responsive teaching refers to teachers' ability to teach in culturally appropriate and affirming ways by incorporating students' background and culture (Gay, 2002b; Ladson-Billings, 1995; Villegas & Lucas, 2002). Culturally responsive teaching is composed of culturally responsive practices, which include high expectations, acknowledgement of student's cultural capital, and critical sociocultural/political consciousness, dedication, and passion (Gay, 2002b; Ladson-Billings, 1995). For instance, Villegas and Lucas (2002) argue that culturally responsive teachers have a strong sense of sociocultural consciousness, an affirmative attitude towards students from different cultural groups, the ability to learn about and understand their students' cultural communities, are committed to promoting knowledge construction among their students, and have a variety of instructional strategies to bridge the gap between students' lived experiences and the course content.

Developed first by feminist scholars (Collins, 1999; Crenshaw, 1991, 1997), intersectionality posits that individuals' experiences are not defined solely by one social group membership (e.g., race), but by the intersection of multiple ones (e.g., race, class, gender). These intersecting identities shape experiences of power, oppression, exclusion, and marginalization. Teachers of color, for instance, bring to the classroom a blend of identities including race, class, gender, language, and immigration status, through which they connect with students not only through racial identity but also through this intersection of these various identities.

This study integrates the bioecological model, culturally responsive teaching, and intersectionality to explore how math and science teachers of color's racial/ethnic identity influences their perceptions of their students and teaching practices (see Figure 1.1). When math and science teachers of color teach students of color, they can incorporate culturally responsive teaching practices with their students, which involves reflecting upon their racial/ethnic identity, the intersection of their various other identities (e.g., language, immigration, gender, class), their K-12 schooling experience as a person of color, and their professional learning. This approach allows them to create a classroom environment that affirms and leverages their students' cultural wealth and knowledge, which can lead to closer relationships between teacher and student, greater student responsiveness, foster critical consciousness, and improve the teaching and learning experience for both teacher and students. Additionally, this dialectical relationship between teacher and students (i.e., proximal process) occurs within a series of interconnected contexts, including the classroom, school, and broader neighborhood community.

Methods

This study leveraged both secondary and primary source data from a three-year (i.e., 2021-2024 school years) longitudinal research-practice-partnership study between the UCLA Center for Community Schooling and the Los Angeles Unified School District (LAUSD). The larger study explored how community schools – public schools that center the community and are collaboratively led by family, education, and community leaders as well as provide services to neighborhood families (Benson et al., 2017) – can aid in retaining teachers of color.

During Year 1 (i.e., 2021-2022) of the larger study, teachers of color were interviewed at two LAUSD university assisted community schools (UACs). Teachers were asked about a variety of topics, ranging from the school's working conditions, teachers' commitment to teaching in working-class neighborhoods as members of the community, and how teachers draw upon their contextualized knowledge of identity, culture, community, and activism to develop rigorous, culturally sustaining, and liberatory learning environments for their students. This study used teacher interview data from Year 1 and focused on the subsample of math and science high school teachers.

Primary data used in the present study was collected in year 2 (i.e., 2022-2023). During this year, the larger project expanded to include one elementary and one high school, which were selected from a pool of schools that were participating in LAUSD's Community School Initiative and served as case study sites. The Community School Initiative is a LAUSD policy designed to help support community schools throughout the district. In Year 2, the larger research team interviewed teachers from these two community schools, to which I only incorporated teacher interview data collected from the high school. Overall, this study incorporated teacher interview data from two LAUSD university-assisted community schools and one LAUSD Cohort 1 community high school (see Table 2.1).

Table 2.1. Summary of School Sites

School	Grades	Type	Teacher Demographics (2018-2019)	Student Demographics (2021-2022)
A	K-12	University Assisted Community School	Teachers of Color: 79.6% American Indian or Alaska Native: 1.9% Asian: 26.4% Black or African American: 1.9% Filipino: 0% Hispanic or Latino: 45.3%	Students of Color: 98.1% American Indian or Alaska Native: 0.1% Asian: 7.9% Black or African American: 2.4% Filipino: 4.1% Hispanic or Latino: 83.1%

			Native Hawaiian or Pacific Islander: 0% None Reported: 0% Two or More Races: 1.9% White: 13.3% Female: 75.5% Male: 24.5%	Native Hawaiian or Pacific Islander: 0.1% None Reported: 0.4% Two or More Races: 0.4% White: 1.5% Female: 50.4% Male: 49.6% ELL: 31.5%
B	6-12	University Assisted Community School	Teachers of Color: 84.8% American Indian or Alaska Native: 0% Asian: 15.2% Black or African American: 48.5% Filipino: 3% Hispanic or Latino: 15.2% Native Hawaiian or Pacific Islander: 0% None Reported: 3% Two or More Races: 0% White: 15.2% Female: 72.7% Male: 27.3%	Students of Color: 98.8% American Indian or Alaska Native: 0% Asian: 0% Black or African American: 43.4% Filipino: 0% Hispanic or Latino: 54.1% Native Hawaiian or Pacific Islander: 0% None Reported: 0.4% Two or More Races: 1.3% White: 0.8% Female: 45.7% Male: 54.3% ELL: 25.2%
C	9-12	LAUSD Community School	Teachers of Color: 86.7% American Indian or Alaska Native: 1.7% Asian: 3.3% Black or African American: 6.7% Filipino: 1.7% Hispanic or Latino: 73.3% Native Hawaiian or Pacific Islander: 0% None Reported: 0% Two or More Races: 0% White: 13.3% Female: 58.3%	Students of Color: 99.2% American Indian or Alaska Native: 0.1% Asian: 0.5% Black or African American: 0.6% Filipino: 0.1% Hispanic or Latino: 97.9% Native Hawaiian or Pacific Islander: 0% None Reported: 0% Two or More Races: 0% White: 0.8% Female: 46.7%

	Male: 41.7%	Male: 53.3%
		ELL: 9%

Note: ELL refers to English Language Learner.

Research Team

For the larger study, the research team has evolved through every year of the project. During Year 1, the research team included two university scholars and two teacher-practitioner (fellows) from two different community schools (i.e., one teacher-practitioner for each UACS). This Year 1 research team co-designed this project from preparing this project's IRB approvals from UCLA and LAUSD, as well as creating the larger study's teacher questionnaire and the semi-structured teacher interview protocol.

For Year 2, the research team expanded. As one of the university scholars and the two teacher-practitioners from Year 1 are not directly involved in Year 2 of this larger project, they remained in the research team as consultants for Year 2. I joined the research team in Year 2 as a research assistant, whose role is to help extend this study to LAUSD community schools more broadly. As a result, my role was to assist in building relationships with two LAUSD community schools, adapt our Year 1 study materials for Year 2 schools, recruit and interview participants, and assist in analyzing our data. The research team has recruited two new teacher-practitioners one from each of the case-study schools, and recruited another university scholar. Hence, our new research team consisted of two university researchers, two teacher-practitioners, and our three consultants who were active members of the Year 1 research team.

Recruitment

Participant recruitment for Years 1 and 2 of the larger study occurred in conversation and collaboration with the UCLA Center for Community Schooling (CCS), LAUSD's Community Schools Initiatives (CSI) office, and the respective case study schools. During Year 1 of the larger study, after receiving approval from both the university and school district's IRB offices, interview participants were recruited through flyers distributed by researchers, teacher fellows, and school administrators at both UACS. Interested participants were then asked to complete a questionnaire that asked for their contact information, demographic information, and a few questions to better guide the interview (e.g., intentions for leaving the teaching profession). Following the questionnaire, twenty-five teachers of color were interviewed one-on-one by a university researcher over Zoom, outside school working hours. These interviews lasted 60-75 minutes, were audio-recorded, and transcribed. Participants later received their interview transcripts and were invited to follow-up if they had questions about their transcript. Participants also received a $75 gift card for their time. Only high school math and science teachers from this corpus of interviews were included in this study for a total of nine teacher interviews.

For the 2022-2023 school year, representatives from both CSI and CCS met to discuss potential schools as case study sites. In their deliberation, the 17 potential schools were narrowed down to 11 by removing schools that experienced a principal change since the designation of the community school. Among these 11 schools, CCS independently identified two sites, choosing one elementary and one high school and included metrics, such as school demographics and have demonstrated commitment to the community school approach.

After the CCS research team identified these two schools, school principals at each case study site agreed to participate in the study. The CCS research team sent out recruitment letters, which were distributed to teachers at each site. Interested teachers were asked to complete the consent form; those who returned the signed form were asked to participate in the interview. Those who decided to participate received a $50 gift card. Interviews took place over Zoom, outside of school hours, and lasted at most 90 minutes.

Participants

Participants were 16 high school teachers at three public community schools in the Los Angeles Unified School District (LAUSD). LAUSD is the second largest public school district in the nation and primarily serves students of color. As of the 2019-2020 school year, LAUSD's racial student demographic background was 8.0% were Black, 0.2% American Indian or Alaska Native, 3.6% Asian, 1.9% Filipino, 73.8% Hispanic or Latino, 0.2% Pacific Islander, 10.2% White, 1.6% two or more races, and 0.4% race not reported. Furthermore, 80.2% of students were eligible for and received free and/or reduced-price lunch. As for their teaching workforce, LAUSD has 65% of teachers who are people of color, despite serving a primarily diverse student body. Nonetheless, the district's teacher diversity still surpasses the national average, where less than one in five educators are people of color (de Brey et al., 2019). All participants are high school teachers of color who teach math or science classes. In addition to the already collected nine math and science teachers from Year 1, we recruited seven more teachers, leading to a total of 16 teachers (see Table 2.2 for participant background).

Table 2.2 Background of Each Interview and Participant

Pseudonym	**School**	**Subject**	**Gender**	**Race/Ethnicity**
Elena	C	HS Math	Female	Latina
Camila	C	HS Science	Female	Latina
Diego	C	HS Math	Male	Latino
Sebastian	C	HS Math	Male	Latino
Arnold	C	HS Math	Male	Asian
Gabriel	C	HS Science	Male	Latino
Sofia	C	HS Science	Female	Latina
Shirley	B	HS Science	Female	Asian
Daniel	B	MS Science	Male	Latino
Trisha	B	MS/HS Math	Female	Black
Frank	B	SPED Science	Male	Black
Diya	B	HS Math	Female	Asian
Martin	A	HS Science	Male	Latino
Sara	A	6th Math/Science	Female	Latina
Joy	A	MS Science	Female	Asian

Alice	A	HS Science	Female	Black

Procedures

Teachers of color were interviewed using semi-structured interviews. Semi-structured interviews are a commonly used qualitative interview method in which researchers ask prepared guiding questions and appropriately adapt the interview with follow-up questions (Ravitch & Carl, 2020). For the secondary data (i.e., teacher interview data taken from two UACS), interviews were conducted by a university researcher who was part of the Year 1 research team. For the primary data, I conducted semi-structured teacher interviews during (April to June 2023). All interviews ranged from 60 to 90 minutes and were conducted over Zoom.

Teacher interviews incorporated a semi-structured format borrowed from Seidman's (2019) three-part interview structure. Part one focused on participant background, focusing on their journey in becoming a teacher and their early years in the K-12 teaching profession. Questions in this section include ones that probe the teacher's racial-ethnic identity (i.e., "What role, if any, did your identity as a person of color play in your pathway to becoming a teacher at ________ School?"), affinity (i.e., "Did you have any expectations around how you might connect with students at ______ School along your shared life experiences, identities, or affinities?"), and career decision making (i.e., "Would you tell us if and how your life history motivated you to apply to work at _______ School?").

The second part delves into their current teaching experience, asking them to describe a typical work week as well as satisfying and challenging aspects of their work. Questions are more specific to their everyday experience and include questions about their workload (i.e., "You mentioned in the questionnaire that workload was a challenge; would you tell me more about that?"), responsibilities (i.e., What are some typical tasks in your workday?), pedagogy (i.e.,

“ How do you approach your teaching?”), self-efficacy (i.e., “To what extent does being a classroom teacher, providing instruction for students, spark joy for you?”), and racial identity (i.e., “In what ways does your work at _____ School challenge you as a teacher of color?”).

The final interview section asks participants to reflect on their experience as a teacher of color, the ways they have or have not felt supported by LAUSD and specific school sites, as well as recommendations for how these institutions can better support teachers of color. In this specific section, I asked probing questions that ask the interviewee to reflect on how one’s racial identity shapes their experience with students who share the same race and those who do not (i.e., “Does your racial identity shape your experiences with students who share the same race?”, “How does your racial identity shape your experiences with students who do not share the same racial background?”). See Appendix A for interview protocol.

This three-part interview structure is powerful given that each interview part builds on each other, allowing for a sense of mutual engagement through the cumulative and interactive nature of these interviews (Seidman, 2019). For instance, focusing on a participant's life history for the first part of the interview allows the interviewer and interviewee to build rapport. The first part gives better context to their lived experience, which after describing their current experiences (i.e., part two), provides the best opportunity to reflect on the meaning behind their experiences (i.e., part three).

Analysis

Throughout this study, I analyzed various data: audio/video recordings, interview transcripts, and notes taken during interviews. Prior to coding, I conducted an unstructured data reading of both the Year 1 and Year 2 teacher interviews, to orient myself with the data (Ravitch & Carl, 2020). After conducting an unstructured data reading, I then began precoding by reading and engaging with the data, making notes of themes, patterns, or other significant ideas that appear (Ravitch & Carl, 2020).

From here, I iteratively developed my coding scheme based on my conceptual framework, particularly the principles of culturally responsive teaching (CRT), and initial themes from my unstructured data reading. I conducted two rounds of trial coding, refining codes to address identified patterns and areas of insufficient coverage. Trial coding concluded when saturation was reached, adequately capturing pertinent research patterns and concepts.

After finalizing my codes through trial coding, I proceeded to code my interview transcripts. Throughout this process, I continuously memoed and reflected on emerging patterns and concepts, as well as on how my understanding of the data evolved. Following the completion of this coding phase, I engaged in axial coding and developed a synoptic chart (e.g. code diagram) to enhance my comprehension of the data and its relation to my research question. Subsequently, I iteratively referred to my codes, synoptic chart, excerpts within my code, conceptual framework, and research question to generate my findings. To ensure research validity, teacher research fellows representing each school site reviewed and confirmed a summary of my findings, ensuring alignment with teachers' perspectives. Additionally, selected participants corroborated these views.

Findings

To answer the research question, I used my conceptual model to highlight quotes from math and science teachers of color, revealing their understanding of how their racial/ethnic identity impacts their work with students of color. While teachers acknowledged the significance of racial/ethnic matching with their students, they also emphasized the broader impact of their racialized experiences on these relationships. These experiences also intersect with other aspects of their identity, such as gender, class, language, and generational status. Thus, my primary finding indicates that while racial/ethnic matching is influential, the experiences and intersectional identities of math and science teachers of color also play a great role in their relationships with their students.

Motivation to Teach: "We need people like ourselves in the community."

Teachers of color in our sample expressed how their racial identity drives their motivation to teach in schools where the majority of students are also people of color. "We need people like ourselves in the community," one Latina math teacher who teaches in a school that predominantly serves Latine students exclaimed, emphasizing the need for other teachers of color to return to the "community with degrees" so that the children of color can see them as role models and reimagine their future.

Sara, another Latina math teacher, described her motivation to teach as a community responsibility:

> "I kind of felt like a responsibility. I received all this money to attend college, and now I have a responsibility to pay that back to communities of color. I knew that I wanted to work with communities of color because I think I'm the exception of a first-generation immigrant, because I had all these privileges from my mom's side, of being half-white. But I think, if both of my parents had been immigrants, my life would have been a lot different. I really wanted to work in an immigrant community that I felt connected to in that way, to also explore that side of my identity more."

Sara expressed a desire to give back to communities of color, linking her motivation to her family background, understanding both her immigrant Latino father's struggles as well as her White mother and accompanying racial privilege. This led her to teach in an immigrant community, reflecting a recurring theme in the data where one's various identities as an immigrant and person of color influenced the participant's decision to teach students of color with similar immigrant experiences.

Participants' motivation to serve communities of color often stemmed from their K-12 experiences, particularly whether they were taught by teachers of color. Those who had teachers of color emphasized their "lasting impact" and shared cultural connections, such as through shared language and upbringing. Diego, a Latino math teacher describes the impact that teachers of color had on him:

> "The Chicana, Chicano teachers that I had in high school were the ones who helped really politicize me in terms of understanding my culture and understanding…They're the ones who really help me understand how important it is for us to be conscious about our role in society. They were the ones who brought that enlightenment into me…I [also] had two African American math teachers. Those are the teachers that I think about and aspire to as a math teacher myself, they were the ones that really made math fun and made math meaningful to me."

Diego's comments reflect a tone full of gratitude from her former teachers of color, having been fostered a sense of critical consciousness from his Chicano teachers, as well as his inspiration to pursue math education from his African American teachers.

Similarly, participants not taught by teachers of color were motivated to become teachers and serve as the role models they wished they had in their K-12 education. For example, Elena, a Latina math teacher, reflects on her motivation due to the lack of teacher diversity she experienced: "When I think back on my history as a teacher, like as a student, I don't ever recall. It was always like men and mostly White teachers. … I feel like that's one of the reasons I wanted to go into that because I wanted to support students specifically like my EL [English Language] Learners…I just wanted to change that for myself and for students to see someone that looks like them teaching them."

Despite Elena not experiencing a lasting impact from a teacher of color, the absence of such representation and shared life experiences motivated her to become a teacher and serve in a predominantly ethnic-minority community. Her desire to provide students with an educational experience and connection unlike her own fueled her motivation to teach.

Racial/Ethnic Identity and Culturally Responsive Teaching

Participants often discussed how their racial/ethnic identity shapes their pedagogical approach as teachers. While all aspects of the culturally responsive model were mentioned, notable themes included the use of empathy, high expectations, building student rapport, and incorporating social justice advocacy into their teaching strategies.

Empathy

Participants commonly cited empathy and relating to students' experiences as crucial aspects of their teaching, explaining how their racial/ethnic identity, and the ways their race and ethnicity intersects with their other identities, facilitated empathy with their students. Teachers sharing the same racial/ethnic background as their students noted alignment extending to other points of connection, such as upbringing and language. One participant, Diego, highlighted how his shared racial identity facilitated a connection between student and teacher based on similar experiences:

> "I believe that sharing the same racial identity as my students 100% changes the experience. The reason why is because they're able to relate to that person, or they're able to relate to me with their own experiences. I grew up very similar to how my students are

growing up now, and their experiences are very similar to my experiences. When I talk about that, it just changes kids. I'll talk about when I grew up, and I would go, because I was born here, but every summer I would travel to Mexico and visit family in Mexico and talk about what I did in Mexico when I was younger, and a lot of kids are like 'I do the same thing' or 'I have the same experiences.' That really does help."

Diego emphasizes how his ethnicity intersects with his upbringing and immigrant identity, shaping his empathy for students of the same ethnic background. Citing specific experiences like summer visits to Mexico and the US, he leveraged both his shared racial identity and transnational upbringing, which resonate with his predominantly Mexican American students. Another participant expressed empathy, seeing parallels in language and immigrant experiences between herself and the "parents [of her] students", who were first-generation Americans with Spanish as their first language. This inspired her to support her students, many of whom speak Spanish but struggle with English, by teaching science in Spanish and fostering connections through their shared language.

Teachers of color who did not share the same race as their students, empathized by connecting their racial identity to the broader experience of racism and othering in the US, which thereby informed their pedagogy. For instance, consider Joy, an Asian teacher who primarily teaches Black and Latine students:

"I'm not Black or Brown. As an East Asian person, I also think my experiences of being a person of color is different than many of my students'. But I do think that the commonality of being othered or being told that assimilation is the goal; as I've grown up, I've really been like: That's not the goal, assimilation doesn't set us free…What does it mean to be a person of color in a way that is liberatory but also collective…How do I

> bring other people with me? How do I join people who've been doing this forever? That 100% shapes everything that I do in the classroom, from content, to process, to how I interpret things for students and invite other colleagues to join me in thinking about certain things or shaping things to be more holistic, relevant, too."

Despite Joy having a different racial identity than her students, she connected with them through the shared experience as a people of color in the US, such as experiencing marginalization and the pressure to assimilate, which motivated her to focus her pedagogy on creating a "liberatory" classroom environment.

High Expectations

Many participants, while expressing empathy with their students, emphasized the importance of high expectations. Sebastian, a Latino math teacher, highlighted the need to balance empathy with maintaining high standards:

> "Empathy is what I think of…I try to remind myself of what those experiences are, but yet still not shy away from having high expectations, and not shying away from expecting a lot from them, because, you know, the world is going to expect a lot from them, and if we don't set them up for that success, then it's going to be a lot more challenging for them moving forward."

Sebastian communicated his ability to adeptly balance empathy and high expectations in their culturally responsive teaching. In fact, his high expectations stem partly from his empathy, understanding that "the world is going to expect a lot from them."

Trisha, a Black math teacher, also described demonstrating her high expectations through actions rather than words.

> “There's still this weirdness around the way that students experience me, as a Black person who has gone through a predominantly White system—like UCLA—for so long. The way I talk with them, the way I interact with them, the way I address them; those aren't ways in which they necessarily are familiar…I think also what I sensed was some students—I can't say for all students—but I got the sense that some students were like: Oh, you did that? Okay! Black people can do that? I’m like: Black people can go to college, Black people can go to these different countries, or different stuff like that.

Trisha observed that her mannerisms and interactions as a teacher, which were shaped from her experiences that differed from her students’ (e.g., attending predominantly White institutions), challenged some of her Black students' perspectives, fostering higher expectations and future aspirations, such as attending college.

Establishing Rapport and Relationships

Math and science teachers of color also leveraged their racial/ethnic identity to build rapport, leading to stronger relationships, increased engagement, and responsiveness from their students. For example, in a predominantly Mexican American school, a teacher of Salvadorian and Mexican descent observed that her Central American students, who might feel excluded due to the school's demographics, reached out to her, and felt more included upon discovering their shared heritage. Another participant, a White-passing Mexican American, connected with her students by revealing her non-white identity and limited academic Spanish proficiency, fostering a bond through mutual Spanish learning with her students.

While teachers of color often establish strong relationships with students who share their race, they also built connections with students of different races and ethnicities. Participants bonded over shared interests like "food," "music," and "immigrant struggles." One Latino teacher, for instance, connected with his Asian student from China by sharing his experience as an English learner in high school, fostering a relationship that enabled the teacher to "deliver the content and deliver the knowledge to him."

Social Justice and Advocacy

Participants would discuss race, identity, and teaching, particularly in relation to social justice and advocacy. Some expressed their commitment to social justice through teaching. For instance, a Latino science teacher explained that learning about low graduation rates among Latino students in college motivated him to become a teacher and work against such "statistics." Others advocated improving structures and practices within their school. For instance, a Black teacher addressed her school's issue with anti-Blackness, stressing the necessity that "every classroom or every teacher should be dealing with anti-Blackness." These discussions reflect how teachers of color view race through a lens of social justice and advocacy, driving their motivation to teach and advocate for change within their schools.

Teaching Across Race/Ethnic Lines: Challenges and Successes for Teachers of Color

Participants encountered both challenges and successes in teaching students of color who did not share their race or ethnicity. Regarding successes, many teachers found ways to connect with students through shared experiences (e.g., growing up in the same neighborhood) and other aspects of themselves that was not their racial/ethnic identity (e.g., immigrant identity, language). For example, a Pakistani American teacher connected with his Latine students through his proficiency in Spanish, while a Latino teacher related to his Black students by discussing his similar upbringing and experiences, making it easier for them to open up to "learning the math and what [he] has to teach." Another Latina teacher, working with a recently immigrated Korean student, found connection by showing interest in learning about the student's language and culture, and the student reciprocated by sharing her own culture.

While positive student-teacher connections occurred, teachers of color also encountered challenges. For instance, the teachers of color had heightened cultural sensitivity, recognizing they were outsiders in their students' cultural communities. One Latino science teacher noted, “being from a different culture, different skin tone, different history” than his Black students, compared to his Black colleagues, he noted his interactions with his Black students were more reserved. Another Latina teacher struggled to teach a recently immigrated Chinese student who was an English Language Learner, relying on the school's Mandarin teacher to connect and support the student.

Furthermore, students' perceptions of a teacher's race, as well as accompanying identities, influenced their interactions and engagement. A White-Latina biracial teacher described struggles with her Latine students despite sharing similar racial/ethnic identities:

> “Even though, probably a lot of our experiences are similar, they probably don't see that all of the time. It's interesting because my partner teacher, she is fully White. But she majored in Spanish, her Spanish is much better than mine. So, I wonder—I guess—I don't know how they perceive us to be different, because she is probably in tune with their culture more.”

Despite sharing aspects of her racial/ethnic identity with her Latine students, this participant felt less attuned to their culture due to her background and limited fluency in Spanish. Additionally, the perception of her as White by her students complicated her ability to connect, making her feel less culturally attuned even when compared to her Spanish speaking White colleague.

These examples underscore how teachers of color face challenges connecting with students of color due to mismatches in racial identity and other intersecting factors like language.

The Role of Context

Participants' experiences were significantly shaped by the school and neighborhood contexts. Although similar patterns existed across the three case study sites, variations in environment led participants to describe their experiences differently. Specifically, differences in student demographics and district pressures influenced how teachers interacted with students. In School A, with a high percentage of Asian and Central American newcomer students, but few Black students, teachers of color tailored their discussions on addressing immigrant and language challenges for newcomers while also fostering inclusivity for Black students by confronting instances of anti-Blackness.

For School B, situated in a Los Angeles neighborhood that has a stigma associated with underperforming schools, district pressure and accountability were prominent, leading teachers to prioritize student self-care and mitigate the negative impacts of over testing on students. For School C, situated in a predominantly Mexican-American neighborhood, teachers valued the school's Mexican identity while promoting inclusivity for students from diverse backgrounds, including those from Central America, Asia, and Black communities, and providing more exposure to cultures beyond the local Mexican-American neighborhood.

Despite different school contexts, there were common goals among teachers to create inclusive environments inside and outside the classroom. For example, one Black teacher created an inclusive environment by supporting the school's Black Student Union as a space for Black students to be “unapologetically Black” and to celebrate “Black joy.” In School C, with a majority Mexican-American student demographic, teachers emphasized inclusivity by acknowledging the need to include other cultures in the curriculum and discussed how they would incorporate other cultures beyond the “Latine community.”

Teachers also worked within the classroom to challenge stereotypes and address racist actions against students of color, who may be in the minority at their schools. In School C, where Black students are less represented than Latine students, a Latine teacher emphasized the importance of educating her students in avoiding actions that promote anti-Blackness. Similarly, in School A, contending with anti-Blackness issues, a teacher collaborated on establishing a school-level protocol for addressing instances of anti-Black racism, which included sending students to the office with a referral. In all cases, math and science teachers of color made efforts to promote inclusivity within their schools, considering each sites’ specific context.

STEM Social Justice Pedagogy

Participants also discussed their teaching pedagogy and the ways their racial/ethnic identity played into their teaching. In these discussions, participants demonstrated a deep passion for both STEM content and social justice, viewing teaching as a means to serve their students of color and prepare them for the world. For instance, Gabriel, a Latino math teacher, shared a particularly satisfying experience at his community school. He recounted how his students applied the concept of a Chi-Square test, which he taught in his Biology class, to their AP Psychology class. Gabriel found it exciting to witness his students understand and apply this knowledge, highlighting his dual passion for content mastery and student empowerment.

Another math teacher collaborated with the school’s geography teacher to design an interdisciplinary research course aimed at providing “meaningful and valuable” experiences for students, rather than creating "weeder courses." He aimed to ensure the course added value to students' everyday lives, rather than focusing solely on content knowledge for tests, which he believes “keeps students [of color] from going into STEM further.”

In essence, the motivation for STEM teachers of color to teach students of color stems not only from their passion for service, social justice, and advocacy, but also from their deep love for science and math content. They are driven by a desire to empower their students with this education, merging their commitment to equity with their enthusiasm for the subject matter.

Discussion

In this study, I sought to explore how math and science teachers of color's racial/ethnic identity influences their perceptions of their students and their teaching practices. Math and science teachers of color not only acknowledged the significance of racial/ethnic matching with their students, but also highlighted how their racialized experiences intersect with other aspects of their identity, such as gender, immigration, and class. Teachers also discussed how connecting with their students across their various identities impacted their teaching. Connecting with students across identities boosted empathy, expectations, and rapport with their students. Such connections made it easier for teachers to integrate social justice/advocacy in their curriculum and support students in a holistic, whole child manner. Despite variations in interview content due to different social environments at sites, teachers' overall findings remained consistent across locations.

The teacher’s capacity to relate their multiple identities to students of color of the same race significantly influenced their teaching success. By leveraging the intersection of their identities, teachers connected well with these students, even if they didn’t share the same race or ethnicity. Conversely, teachers of color encountered difficulties when aspects of their identity, such as language, didn't align with their students'.

While this study is only one of a few studies to interview high school math and science teachers of color about their experiences with students of color, the findings align with earlier research. Similar to previous studies, teachers of color demonstrated culturally responsive teaching with students of color, echoing Villegas and Irvine's (2010) arguments about the importance of a diverse teaching workforce in establishing cultural connections. Evidence showed that teachers of color enhanced aspects of their pedagogy, including empathy (Kohli, 2009), increased expectations (Fox, 2016; Gershenson et al., 2018), and providing holistic whole child support for their students (Morse & Allensworth, 2015). In essence, interview data aligned with literature that teachers of color could connect their racial/ethnic identity with students, support their well-being and academic outcomes, and contribute to increasing the number of URM students in STEM professions (Institute for Advanced Study Commission on Mathematics and Science Education, 2009).

What is also noteworthy is how the responses varied based on the distinct school environments at each site. Teachers highlighted varied strategies and challenges in supporting students based on the diverse student demographics and school contexts across sites. In particular, teachers recognized the impact of the school's racial/ethnic composition on students' experiences, particularly if the students were not part of the school's ethnic majority. This aligns with literature emphasizing the significance of school diversity and how it relates to issues of belonging for students of color (Graham et al., 2022; Parris et al., 2018). There's limited literature discussing the impact of STEM teacher-student racial/ethnic matches alongside school diversity (see Banerjee, 2019; Rasheed et al., 2020 for exceptions). Future research should intentionally focus on studying the effects of teacher-student racial/ethnic matches on students, considering the school demographic and general context.

It is also important to note that these findings come from schools where the majority of teachers are people of color. The demographics of these teachers may have influenced the results, as increased teacher diversity within a school can lead to positive outcomes for teachers of color, such as higher morale and better retention rates, especially compared to schools where they are in the minority (Ingersoll et al., 2017). Future research should consider teacher demographics when studying the effects of racial and ethnic matches between teachers and students.

Another significant finding was how teachers applied an intersectional approach, integrating their racial/ethnic identity with other aspects such as language, immigration, gender, and class. This approach differs from the prevailing literature on teacher-student racial/ethnic matches, which primarily focuses on race/ethnicity and its impact. Instead, this evidence highlights another body of literature that underscores the importance of examining how teachers connect with students across multiple identities in an intersectional manner (Pham & Philip, 2021; Warr & Wakefield, 2023).

Although participants discussed their multiple identities in describing how they taught and related to their students of color, sharing a gender match with their students was not a salient finding. This is notable as it contradicts existing literature that highlights the significance of a gender match, particularly in supporting females in STEM careers (Mau & Li, 2018; Piatek-Jimenez et al., 2018). However, the lack of emphasis on gender in my findings does not mean it was irrelevant. Future research should continue to apply an intersectional approach when exploring teacher-student racial and ethnic matches, particularly examining how gender may influence this phenomenon.

The intersectional ways that teachers of color interacted with students of color challenged a few assumptions behind the importance of a race/ethnic match. For one, it questioned the assumption that teachers of color automatically connect with students of color due to shared race/ethnicity. Teachers of color who did not share the same race/ethnicity as their students still effectively connected through other shared identities like their immigrant background. Conversely, teachers of color who share the same race/ethnicity as their students, may have struggled to connect with their students when they did not align in other areas like sharing the same language. In essence, study findings challenge the assumption of solely focusing on a match based on race/ethnicity and instead suggest that an intersectional approach for understanding how math and science teachers of color support their students.

Contributions and Implications

Study findings have several implications for policymakers and related stakeholders. As findings show the various ways in which teachers of color can support and relate to their students of color, policymakers and stakeholders should continue to prioritize efforts to recruit and support teachers of color.

At the same time, however, findings also suggest a need to move beyond singular race-based policy, but to provide a more intersectional approach to viewing and supporting teachers. For one, study findings challenge the assumption that having the same race/ethnic match between teachers and students is the main solution for increasing URM representation in the STEM professions. Instead, for teachers of color to be effective, they need to be supported through training and guidance; it's unfair to assume that teachers of color do not require support, as they may need to develop foundational teaching skills and address issues such as implicit bias and stereotypes (Eugene et al., 2023). Additionally, while teachers of color bring valuable knowledge and cultural assets, they still need training to effectively leverage these assets and develop culturally responsive teaching practices (Ahmad & Boser, 2014; Gershenson et al., 2021b).

Findings may also underscore a need for teacher programs to better train teachers of color. Teacher preparation programs often lack support for aspiring teachers of color, offering inadequate pedagogical training that fails to leverage their cultural assets and may not provide inclusive learning environments (Gershenson et al., 2021b). These teaching programs often prioritize training for White teachers, which highlights the need to adapt to better prepare teachers of color (Gershenson et al., 2021b).

Lastly, these findings focused on intersectionality may prompt policymakers and stakeholders to reconsider solely diversifying the teaching workforce along racial and ethnic lines. The assumption that teachers of color can automatically relate to students of the same race/ethnicity is unfair; other factors like gender, language, immigrant status, and more should also be considered. An intersectional approach may be more appropriate, as there are cases where individuals of the same race are ineffective due to differences in other factors such as language (Philip et al., 2017). Essentially, schools that focus solely on an intersectional or multiple identities approach to connecting with and serving students, as opposed to focusing mainly on racial/ethnic synchrony, may prove to be a better approach, especially in the long term.

Conclusion

This study explored how math and science teachers of color's racial/ethnic identity influences their perceptions of their students and their teaching practices. While literature often highlights the advantages of teachers sharing the same race as their students (Bates & Glick, 2013; Dee, 2004; Gottfried et al., 2019) my results offer different evidence, suggesting that a more intersectional approach; considering teacher race alongside other factors, rather than prioritizing it above all, may be beneficial. To address STEM racial underrepresentation both in the near future and beyond, adopting an intersectional view of the teacher along with a holistic approach to the school and student peer environment may be most beneficial.

GENERAL DISCUSSION

URM students continue to be underrepresented in STEM careers and academic pathways in the US (National Center for Science and Engineering Statistics, 2023). Part of this inequity can be attributed from the fact that less than 30% of public school teachers are people of color, despite the majority of K-12 children are of color (Villegas & Irvine, 2010). Given research that shows the benefits of a teacher-student racial/ethnic match in improving academic outcomes (Dee, 2005; Egalite et al., 2015; Goldhaber & Hansen, 2010; Yarnell & Bohrnstedt, 2018), policymakers have been exploring efforts to address the lack of diversity in the K-12 teacher workforce by recruiting and retaining teachers color.

Although existing literature provides evidence that a teacher-student racial/ethnic match provides benefits for students of color, it remains unclear how such matches specifically impact high school students of color in STEM outcomes, such as enrollment in STEM courses, math and science GPA, and aspirations for STEM careers. The literature also lacks clarity on both the mechanisms driving the benefits of teacher-student racial/ethnic matches and whether these advantages extend to students of color who do not share the same race/ethnicity as the teacher of color.

Thus, to address these literature gaps, my dissertation explored and investigated the processes by which teacher-student racial/ethnic matching, including partial matches, influences STEM outcomes for high school students of color through two studies. In Study 1, using a nationally representative sample of high school students and math and science teachers, I investigated the pathways by which racial/ethnic teacher-student match is associated with high school students of color's educational engagement and STEM outcomes. Through structural equation modeling, I examined the possible mechanisms by which a teacher-student racial/ethnic match is associated with high school students of color's STEM outcomes. After identifying possible pathways, Study 2 delved into the mechanisms of teacher-student racial/ethnic matches; through a phenomenological analysis of interviews with community school teachers in LAUSD, it explored how teachers' racial/ethnic identity and school context influenced their perceptions and subsequent adjustments to pedagogy and interactions with their students.

My dissertation findings question whether having a racial/ethnic match is the most salient factor to consider in supporting students of color in STEM. In the quantitative study, a nonsignificant or negative association was observed between teacher-student racial/ethnic matches and student outcomes, as well as teacher-led factors and student engagement. However, student engagement and teacher-led factors were significantly associated with student GPA, independent of teacher-student racial/ethnic matches. For the qualitative study, teachers of color spoke to effectively engaging and influencing their students of color when employing an intersectional approach, leveraging not only their racial/ethnic identity but also other identities such as language, gender, immigration status, and socioeconomic class.

Together, these studies suggest that we should consider factors beyond a teacher's race or ethnicity, such as their personal characteristics (e.g., self-efficacy, high expectations) and their ability to connect with students across various identities, including class, gender, language, and immigration status. Teachers of color can leverage these attributes to enrich the lives of all students of color, regardless of whether they share the same racial or ethnic background. This inclusive approach, particularly in STEM education, can help address racial underrepresentation in the field and empower underrepresented minorities to pursue STEM careers.

Implications

Findings from these studies have several short- and long-term implications for teachers of color, policymakers, and stakeholders aiming to support students of color in STEM. In the short term, since my study demonstrates evidence that, regardless of the teacher's race and ethnicity, teacher factors, such as high expectations, self-efficacy, and collective responsibility positively associate with student GPA for students of color, policymakers and stakeholders should continue to invest and support the existing teaching workforce. This could involve supporting initiatives that enhance teachers' cultural responsiveness, foster positive mindsets to elevate expectations, and empower teachers to cultivate a stronger sense of collective responsibility, as these are all actionable ways to support teachers in assisting students.

Alongside providing teacher support, dissertation findings also underscore the significance of enhancing the school environment to benefit both teachers and students of color. In my qualitative study, teachers of color, mindful of school demographics, consistently sought ways to foster inclusivity in their classroom and school overall. Hence, improving school settings can facilitate effective teaching and enhance student engagement, thereby improving student outcomes (Wang & Degol, 2016). Examples include granting teachers more autonomy to integrate their cultural knowledge into teaching practices and working towards more inclusive environments for all students.

Another example would be to promote progressive education models like community schools, which uniquely enhance the school environment by focusing on the whole child and providing teachers with autonomy and collaborative opportunities (Benson et al., 2017; Kang et al., 2021). Community schools also emphasize community-focused philosophies, fostering a strong sense of collective responsibility among teachers for both the school and its students, thereby positively influencing student outcomes (Benson et al., 2017).

As for long-term implications, research highlights limitations in solely prioritizing race in recruiting and retaining teachers of color. Instead, a shift toward a holistic and intersectional approach, considering aspects beyond race like gender, class, language, and immigration in teacher recruitment could be better. My qualitative findings indicate that teachers of color effectively connect with students not only through racial/ethnic identity but also shared backgrounds, language, and experiences. Thus, broadening recruitment and retention strategies to include connections based on various identities, such as language and gender, could better support students and address racial underrepresentation in STEM fields.

Limitations and Future Directions

There were several limitations in my dissertation that raised important directions for future research. While my dissertation focused on the teacher-student relationship with less emphasis on broader classroom and school contexts, it's recognized that these contexts significantly influence this relationship (Graham et al., 2022; Wang & Degol, 2016). Future studies on teacher-student racial/ethnic matches should more deliberately integrate school and classroom contexts for a comprehensive understanding.

My studies also do not enable causal inference due to the qualitative design of the second study and the correlational design of the first study. Future research should employ study designs that allow for causal interpretations, such as randomized control trials or quasi-experimental designs, to explore teacher-student racial/ethnic matches more thoroughly.

There's also a need for teacher-student racial/ethnic match research that incorporates more nuance, particularly regarding intersectionality. While both studies focused on teacher-student racial/ethnic match, they revealed limitations in primarily studying teacher race/ethnicity. Additionally, my studies did not highly investigate the effect of a gender match, as well as more complex cases, such as white passing students of color and multiracial students, which can complicate the influence of racial/ethnic matches on these subgroups. Future studies should adopt a more intersectional perspective and examine these specific racial/ethnic groups to provide further nuance and better understand how teachers of color support their students of color.

Conclusion

Diversifying the K-12 STEM teacher workforce is crucial for supporting students of color, particularly URM students, in pursuing STEM careers and addressing racial disparities in the STEM workforce. However, solely focusing on racial/ethnic diversity among teachers may be insufficient. My dissertation's findings emphasize the importance of nuance, suggesting that improving STEM outcomes for students of color requires consideration of multiple factors beyond race. These include enhancing the school environment, improving teacher dispositions and practices, and connecting with students of color through shared identities such as race, as well as other identities like gender, language, and immigration status. Recognizing this complexity may be essential for effectively supporting students of color and reducing racial underrepresentation in STEM fields in both the short and long term.

APPENDIX

Appendix A: Community Schooling & Teacher Retention Study Interview Protocol

My name is [Jeffrey or insert name] and I am a researcher at UCLA's Center for Community Schooling. Thank you for agreeing to participate in our project. Through your workplace experiences and observations, and in conversations with your colleagues at [insert school], we aim to better understand what motivates teachers in community schools and how to better support community school teachers' to stay and grow in the profession.

There are three parts to this interview: basically, we will cover your past, present, and future in chronological order. First, we will invite you to tell us about yourself, about how you came to be a teacher at _____ School. Then, we'll ask about your current observations as a community school teacher. In the last section, we'll have you explain how the contexts of your life and personal experiences influence your observations and ask what's in store for you in your future.

Before we get started, I want to take a moment to acknowledge how extraordinary these current times are for school employees. As I ask you about your experiences at _____ School, I encourage you to speak freely about how the ongoing pandemics shift the nature of your work.

This interview will take approximately 45-60 minutes. Please know that all of your responses will remain anonymous and confidential, and will only be reviewed by the researchers. We will assign pseudonyms to all information that is attributable to an individual. Do you have any questions before we get started? (pause)

Please feel free to stop me at any time if you have any questions or if you would like to discontinue participation. With your permission, I would like to record the interview. Do you consent to participate and to be recorded?

A. Focused Life History

Your responses to this first set of questions will help us understand who you are, your values and experiences, everything that led you to your current position.

1. Thinking back to when you first considered becoming a teacher: What two or three factors drove your career decisions back then?
    a. REWORD: You indicated in the questionnaire that you became interested in teaching as a career in _____ (ex. when you were in high school). What are some of the important aspects of your identity or life history that influenced your career options then?
    b. **PROBE**: Were you ever taught by any teacher(s) of color?
        i. If "Yes": Is there anything that you recall or stands out about being taught by a teacher of color? How did the teacher's racial/ethnic identity influence your classroom experience (if at all)?
        ii. If "No": Did you ever think about the fact that you were not taught by a teacher of color? How do you think it would have influenced your classroom experience?

2. Once you decided to become a teacher, how did you end up teaching at _____ School? Would you briefly narrate your decision-making processes back then and your pathway to your current position?
    a. REWORD: In the questionnaire, you indicated that ______ and ______ (ex. location, the hiring manager) were among the reasons that you chose to apply to work there. Would you talk us through your thoughts and plans at the time?
    b. **PROBE** (ethno-racial identity): What role, if any, did your identity as a person of color play in your pathway to becoming a teacher at ________ School?
    c. **PROBE** (identity/affinity): Did you have any expectations around how you might connect with students at ______ School along your shared life experiences, identities, or affinities? If so, what were some of those qualities in common that crossed your mind back then?
    d. **PROBE** (org. identity): Back then, how did you define *community school*? When you first started teaching at _____ School, what features made it a community school?
    e. **PROBE** (ideology): How important was it for you to serve a community school?
    f. PROBE (career decision-making): Would you tell us if and how your life history motivated you to apply to work at _______ School?
    g. PROBE (professional preparation/experience): In the questionnaire, you indicated that you held teaching positions at other schools. What prompted your move to ________ School?
3. Thinking back to when you were first hired at _____ School: What were some of your earliest observations of the school and your roles and responsibilities as a teacher there?
    a. REWORD: How well did your prior experiences prepare you for teaching at _____ School?
    b. **PROBE** (professional preparation/experience): How well prepared were you for the job? OR: What is one valuable thing you learned in your teacher education program or during student-teaching that prepared you for working in a community school?
    c. PROBE (professional preparation/experience): What did you encounter at _____ School that was new to you or surprising?
    d. PROBE (sense of belonging): In general, how strong was your sense of belonging within the school community when you first began working there? Did you feel accepted and welcomed as you are?
    e. PROBE (relationships): When you first started teaching at your school, who were your go-to people? Which members of the school community did you most easily connect with in those early days, and why?

B. The Details of Experience

In this next set of questions, we would like you to describe what you're currently experiencing at work. Before transition, I want to remind you that everything you say in this interview will be de-identified immediately, meaning, no one outside of this interview will be able to associate what you say, with your name, your school, your title, or any information that would identify who made those statements. Also, we know that this has been a particularly difficult year for many teachers. You are welcome to share as much or as little as you'd like about your experiences, in answering the questions about what's happening currently. As you respond, it would be helpful if you would tell us if your current experiences are very different from previous years, and why.

4. What are some of the roles that you take on as a member of the school community and why? How do you describe your work? What tasks take up the most of your time? What is it like to be a teacher at your school and a member of a community school community?
    a. PROBE (responsibilities): What are some typical tasks in your workday? Which of them take up the most of your time?
    b. PROBE (roles/responsibilities): What are the roles that you take on as a member of the school community and why?
    c. PROBE (workload): What is the workload at the community school like, how do you manage it? OR: You mentioned in the questionnaire that workload was a challenge; would you tell me more about that?
    d. PROBE (relationships): How do you typically interact with different members of the school community? Would you briefly describe your relationships with various stakeholders, on or off-campus?
    e. PROBE (org. structure): In what ways do you participate in school leadership and contribute to decisions that affect the whole campus?
    f. PROBE (pedagogy): How do you approach your teaching? What is most important to you in lesson-planning for your students?
    g. PROBE (collaboration): What are your experiences with teacher collaboration?
5. What aspects of working in a community school are most satisfying to you?
    a. REWORD: What do you find most enjoyable or rewarding about working at ______ School?
    b. **PROBE** (racial identity): In what ways do you feel supported as a person of color teaching at a community school?
    c. PROBE (values): Which aspects of the work align with your personal or professional values? For example, you mentioned in the questionnaire that your school community frequently takes action on the social issues that you most care about. Would you tell us more about that?
    d. PROBE (org structure): Community schools aim to distribute leadership and decision-making. What are your thoughts on how you participate in those aspects of your community school?
    e. PROBE (impact): In what ways do you feel that your knowledge and expertise are valued? Do you feel that you can share your knowledge and expertise to make a difference in the school community?
    f. PROBE (relationships): Who are the people that you go to for support and camaraderie at your community school?
    g. PROBE (relationships): Who relies on you for support?
    h. PROBE (self-efficacy): To what extent does being a classroom teacher, providing instruction for students, spark joy for you?
    i. PROBE (self-efficacy): Do you feel like you're making a difference with students? In what ways?
6. What aspects of your work at the community school do you find most challenging or dissatisfying?
    a. REWORD: You mentioned in the questionnaire that you struggle with ______; would you talk to me more about that?
    b. **PROBE** (racial identity): In what ways does your work at _____ School challenge you as a teacher of color?

c. **PROBE** (teacher growth): Which challenging aspects of your work require you to grow as an educator? OR: Which conditions, circumstances, or relationships in your workplace require extra patience on your part?
d. PROBE (ideology): Which aspects of the work at your community school challenge your personal values as an educator?
e. PROBE (relationships): You mentioned in the questionnaire that you don't collaborate as often with ______ stakeholders; would you talk to me more about that?
f. PROBE (relationships): Who hinders your work?
g. **PROBE** (org change): What can your community school do to alleviate those challenges? OR: What supports at the school level would make your job easier?
h. **PROBE** (ethno-racial identity): What <u>changes</u> would help you feel better nurtured and sustained professionally at ______ School, particularly as an educator of color?

C. Reflection on the Meaning

In this last section, we ask you to reflect on your past and your present, and tell us about your plans for the future. We'll also ask you to reflect on and interpret some "big picture" questions for us.

7. You just told me what it's like to teach at _____ School. To what extent do you think your experiences at the community school are shaped in any way by your identity as a teacher of color?
    a. REWORD (ethno-racial identity): In what ways do your experiences at ______ School reflect your identity and perspective as a teacher of color?
    b. **PROBE** (ethno-racial identity): Does your racial identity shape your experiences with students who share the same race? Do you perceive that this makes a difference with those students who do share the same racial identity? Would you provide some examples of this?
        i. **FURTHER PROBE** (ethno-racial identity): In what ways does knowing your students' racial identity influence your expectations, teaching, and beliefs about your students?
    c. **PROBE** (ethno-racial identity): How does your racial identity shape your experiences with students who do not share the same racial background? In what ways do you think this matters for students with a different racial background? Would you provide some examples of this?
        i. **FURTHER PROBE** (ethno-racial identity): In what ways does knowing your students' racial identity influence your expectations, teaching, and beliefs about your students?
    d. **PROBE** (ethno-racial identity): What conditions would enable you to connect better with students of all racial backgrounds? How can those conditions be cultivated and sustained?
8. We know that _______ School has a whole-child approach to serving students. In what ways does your community school environment recognize you and nurture your development as a whole person, as a "whole teacher"? Would you give us some concrete examples?
    a. REWORD (teacher & org identity): What specific aspects of community schooling help you feel accepted and appreciated for who you are, so that you can reach your fullest potential?
    b. PROBE (PD): What conditions at the school enable you to develop <u>as a teacher</u>?

c. PROBE (PD): In what ways does the school help you grow in your role as a member of the school community?
d. PROBE (retention): What would help you feel more nurtured and appreciated at your community school as a teacher of color?

9. Do you see yourself teaching or serving in some other capacity at ______ School for the foreseeable future or long term? Why or why not?
    a. **PROBE** (identity): How does your identity, however you define that, contribute to your plans to continue serving your community school? Specifically, to what extent are your future career plans shaped by your identity as a teacher of color?
    b. PROBE (values): How do the values you hold today and the experiential knowledge that you have now, shape your plans to continue serving your community school or to remain in the profession?
    c. PROBE (efficacy): How confident are you that your efforts to respond to students' assets and needs are effective and sustainable at ______ School?
    d. PROBE (values): We asked about the factors that drove your career decisions when you first entered the profession. Have those changed? What's most salient now, in considering whether you will stay or leave your job?
    e. PROBE (career decision-making): You responded in the questionnaire that you were seriously planning to leave your job. Would you please tell us more about that?
    f. PROBE (career decision-making): You responded in the questionnaire that you were seriously planning to leave teaching altogether. Would you please tell us more about that and where you see yourself landing after your career transition?
    g. PROBE (org change): What changes at the school level would boost your longevity as a teacher at ______ School? And what would help improve your sustainability and enable you to remain in the teaching profession for the foreseeable future?
10. This is our last question. As you probably know, LAUSD is exponentially expanding its network of community schools throughout the district. If you were to advise the District on how to build community schools that better support and retain teachers of color—from your perspective as a teacher of color who serves a community school—what suggestions would you make?
    a. PROBE (org change): In your opinion, what can the District do to make a difference to teachers of color at community schools?
    b. PROBE (org identity/ideology): From your vantage point, what makes community schools different from other schools?
    c. PROBE (org identity/ideology): In the ideal world, what role would a community school play in the community? How can community schools better serve all of their stakeholders?
11. Is there anything else that pertains to BIPOC teacher retention at community schools that we didn't ask about?
12. Do you have any questions for us?

Thank you so much for your time and for sharing your personal insights with us. In our next steps, we will be in touch a couple more times by email to send you a copy of the transcript from today's interview, just to make sure everything you said was accurately recorded. Just so you know, all data will be anonymized and the transcript will be stripped of any identifiable information, including your name, your role, your school, etc. If you have concerns about anything you shared with us today or if you want to *redact any of the information, please contact me or my supervisor Dr. Marisa Saunders at any time in the future, and we will immediately address your requests. We will also reach out again by email to send you the token of our gratitude for your participation in our study. Thanks again for talking with me today!*

Appendix B: Correlation Matrix

Table B1. Correlation Matrix

Num	Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	MO																							
2	SO	0.82																						
3	TM1	0.12	0.11																					
4	TM2	0.14	0.12	0.25																				
5	TM3	0.08	0.06	0.57	0.21																			
6	TS1	0.08	0.09	0.16	0.04	0.10																		
7	TS2	0.09	0.10	0.08	0.13	0.09	0.16																	
8	TS3	0.10	0.12	0.17	0.08	0.13	0.52	0.15																
9	SMP1	0.37	0.30	0.05	0.06	*0.03*	0.05	0.04	0.05															
10	SMP2	*0.03*	*-0.01*	*-0.01*	0.05	*0.01*	*-0.01*	*0.04*	*-0.01*	0.25														
11	SMP3	0.32	0.24	0.07	0.08	0.07	0.05	0.07	0.09	0.54	0.34													
12	SMP4	0.24	0.17	*0.03*	0.08	*0.04*	*0.03*	*0.03*	0.06	0.50	0.39	0.49												
13	SSP1	0.21	0.25	*0.02*	*0.03*	*0.03*	*0.00*	0.04	*0.02*	0.29	0.09	0.18	0.10											
14	SSP2	0.09	0.13	*0.04*	0.08	0.05	*0.03*	0.10	0.05	0.19	0.40	0.22	0.22	0.41										
15	SSP3	0.18	0.26	*0.03*	0.05	*0.04*	*0.03*	0.07	0.07	0.22	0.16	0.39	0.15	0.50	0.40									
16	SSP4	0.12	0.18	*0.02*	*0.01*	0.05	*0.04*	0.07	*0.03*	0.12	0.18	0.15	0.19	0.46	0.49	0.52								
17	SE1	0.21	0.20	0.08	0.08	0.10	0.05	0.08	0.10	0.24	0.30	0.30	0.35	0.22	0.32	0.28	0.32							
18	SE2	0.29	0.29	0.06	0.05	*0.02*	0.07	0.05	0.10	0.18	0.07	0.18	0.20	0.16	0.14	0.19	0.16	0.26						
19	SE3S	0.06	0.06	*0.02*	*0.02*	*0.02*	*0.01*	*0.03*	*0.02*	0.07	0.05	0.05	0.07	0.13	0.10	0.11	0.11	0.14	0.13					
20	SE3M	0.10	0.10	0.05	*0.02*	0.05	*0.02*	0.05	*0.04*	0.09	*0.04*	0.07	0.07	0.19	0.14	0.11	0.16	0.17	0.15	0.60				
21	SES	0.37	0.39	0.12	0.11	0.09	0.09	0.08	0.11	0.17	-0.05	0.16	0.05	0.22	0.07	0.19	0.10	0.15	0.17	0.06	0.09			
22	AGE	-0.19	-0.22	*-0.03*	-0.07	*-0.03*	*-0.02*	-0.04	*-0.01*	-0.08	*0.01*	-0.08	-0.05	-0.08	*-0.02*	-0.07	*-0.03*	-0.09	-0.06	*-0.03*	-0.05	-0.15		
23	MTYRS	0.10	0.10	0.13	0.10	0.12	0.04	*0.03*	0.06	0.07	*-0.01*	0.05	*-0.01*	0.09	0.05	0.05	0.05	0.09	0.10	*0.02*	*0.02*	0.15	-0.04	
24	STYRS	0.08	0.07	0.06	0.04	*0.02*	0.15	*0.00*	0.11	*0.02*	*-0.01*	*0.02*	*-0.00*	0.07	*0.01*	*0.01*	*0.02*	0.04	0.06	*0.01*	0.07	0.08	*-0.01*	0.14

Note: Correlations for each pair of columns were computed using vectors formed by omitting rows with missing values on a pairwise basis. Correlations that are italicized were not significant at p<.05 SD.

Correlation matrix shows the intercorrelations upon which the analyses below are based. Basic relations among these variables are clear, with 78% of the 276 correlations achieving significance. As the large sample size means that even small correlations achieve significance, I am cautious not to overemphasize these relations; however, the relations are nontrivial, with an average r(276) = .11 among all of the variables and an average r(190) = .14 among our substantive variables of interest.

Appendix C: Summary Information for Item Scales

Table C1. Summary Information for Item Scales

Item	Scale	Variable Names	Chronbach's Alpha
SM1	X1MTHID: Mathematics Identity	S1MPERSON1: 9th grader sees himself/herself as a math person	0.72+
		S1MPERSON2: Others see 9th grader as a math person	
SM2	X1MTHUTI: Mathematics utility	S1MUSELIFE: 9th grader thinks fall 2009 math course is useful for everyday life	0.78
		S1MUSECLG: 9th grader thinks fall 2009 math course will be useful for college	
		S1MUSEJOB: 9th grader thinks fall 2009 math course is useful for future career	
SM3	X1MTHEFF: Mathematics self-efficacy	S1MTESTS: 9th grader confident can do excellent job on fall 2009 math tests	0.90
		S1MTEXTBOOK: 9th grader certain can understand fall 2009 math textbook	
		S1MSKILLS: 9th grader certain can master skills in fall 2009 math course	
		S1MASSEXCL: 9th grader confident can do excellent job on fall 2009 math assignments	
SM4	X1MTHINT: Mathematics course interest	S1FAVSUBJ*: 9th grader's favorite school subject	0.75
		S1LEASTSUBJ*: 9th grader's least favorite school subject	
		S1MENJOYING: 9th grader is enjoying fall 2009 math course very much	
		S1MENJOYS*: 9th grader is taking fall 2009 math b/c he/she really enjoys math	
		S1MWASTE: 9th grader thinks fall 2009 math course is a waste of time	
		S1MBORING: 9th grader thinks fall 2009 math course is boring	
SS1	X1SCIID: Science identity	S1SPERSON1: 9th grader sees himself/herself as a science person	0.72+
		S1SPERSON2: Others see 9th grader as a science person	
SS2	X1SCIUTI: Science utility	S1SUSELIFE: 9th grader thinks fall 2009 science course is useful for everyday life	0.75
		S1SUSECLG: 9th grader thinks fall 2009 science course will be useful for college	
		S1SUSEJOB: 9th grader thinks fall 2009 science course is useful for future career	
SS3	X1SCIEFF:	S1STESTS: 9th grader confident can do excellent job on fall 2009 science tests	0.88
		S1STEXTBOOK: 9th grader certain can understand fall 2009 science textbook	

	Science self-efficacy	S1SSKILLS: 9th grader certain can master skills in fall 2009 science course	
		S1SASSEXCL: 9th grader confident can do excellent job on fall 09 science assignments	
SS4	X1SCIINT: Science course interest	S1FAVSUBJ*: 9th grader's favorite school subject	0.73
		S1LEASTSUBJ*: 9th grader's least favorite school subject	
		S1SENJOYING: 9th grader is enjoying fall 2009 science course very much	
		S1SWASTE: 9th grader thinks fall 2009 science course is a waste of time	
		S1SBORING: 9th grader thinks fall 2009 science course is boring	
		S1SENJOYS*: 9th grader is taking fall 2009 science b/c he/she really enjoys science	
SE1	X1SCHOOLBEL: School belonging	S1SAFE: 9th grader feels safe at school	0.72
		S1PROUD: 9th grader is proud to be part of his/her school	
		S1TALKPROB: 9th grader has teacher/adult in school he/she can talk to about problems	
		S1SCHWASTE: 9th grader feels that school is often a waste of time	
		S1GOODGRADES: Getting good grades is important to 9th grader	
SE2	X1SCHOOLENG: School engagement	S1NOHWDN: How often 9th grader goes to class without their homework done	0.67
		S1NOPAPER: How often 9th grader goes to class without pencil or paper	
		S1NOBOOKS: How often 9th grader goes to class without books	
		S1LATE: How often 9th grader goes to class late	
SE3	X1TMEXP: Mathematics teacher’s perceptions of teacher expectations	M1TEACHING: Math teachers in this school set high standards for teaching	0.86
		M1LEARNING: Math teachers in the school set high standards for students' learning	
		M1BELIEVE: Math teachers in this school believe all students can do well	
		M1CLEARGOALS: Math teachers in this school make goals clear to students	
		M1GIVEUP: Math teachers in this school have given up on some students	
		M1CARE: Math teachers in this school care only about smart students	
		M1EXPECT: Math teachers in this school expect very little from students	
		M1WORKHARD: Math teachers in the school work hard to make sure all students learn	
SE4	X1TMEFF:	M1FAMILY: Amount a student can learn is primarily related to family background	0.71
		M1DISCIPLINE: Students not disciplined at home not likely to accept school discipline	

	Mathematics teacher self-efficacy	M1STUACHIEVE: Teachers are limited b/c home environment influences student achievement	
		M1PARENT: If parents would do more for children teacher could do more for students	
		M1RETAIN: Knows how to increase student retention of info from lesson to lesson	
		M1REDIRECT: Knows techniques to redirect disruptive students quickly	
		M1GETTHRU: Can get through to even the most difficult or unmotivated students	
		M1HOMEFX: Cannot do much b/c student motivation/performance depends on home	
MT1	X1TMRESP: Mathematics teacher's perceptions of collective responsibility	M1TSCHDISC: Teachers at this school help maintain discipline in the entire school	0.89
		M1TIMPROVE: Teachers at this school take responsibility for improving the school	
		M1TSETSTDS: Teachers at this school set high standards for themselves	
		M1TSELFDEV: Teachers at school feel responsible for developing student self-control	
		M1THELPBEST: Teachers at school feel responsible for helping each other do their best	
		M1TALLLEARN: Teachers at this school feel responsible that all students learn	
		M1TFAIL: Teachers at school feel responsible when students in this school fail	
MT2	X1TSEXP: Science teacher's perceptions of teacher expectations	N1TEACHING: Science teachers in this school set high standards for teaching	0.86
		N1LEARNING: Science teachers in the school set high standards for students' learning	
		N1BELIEVE: Science teachers in this school believe all students can do well	
		N1CLEARGOALS: Science teachers in this school make goals clear to students	
		N1GIVEUP: Science teachers in this school have given up on some students	
		N1CARE: Science teachers in this school care only about smart students	
		N1EXPECT: Science teachers in this school expect very little from students	
		N1WORKHARD: Science teachers in the school work hard to make sure all students learn	
MT3	X1TSEFF: Science teacher self-efficacy	N1FAMILY: Amount a student can learn is primarily related to family background	0.68
		N1DISCIPLINE: Students not disciplined at home not likely to accept school discipline	
		N1STUACHIEVE: Teachers are limited b/c home environment influences student achievement	
		N1PARENT: If parents would do more for children teacher could do more for students	

		N1RETAIN: Knows how to increase student retention of info from lesson to lesson	
		N1REDIRECT: Knows techniques to redirect disruptive students quickly	
		N1GETTHRU: Can get through to even the most difficult or unmotivated students	
		N1HOMEFX: Cannot do much b/c student motivation/performance depends on home	
ST1	X1TSRESP: Science teacher's perceptions of collective responsibility	N1TSCHDISC: Teachers at this school help maintain discipline in the entire school	0.89
		N1TIMPROVE: Teachers at this school take responsibility for improving the school	
		N1TSETSTDS: Teachers at this school set high standards for themselves	
		N1TSELFDEV: Teachers at school feel responsible for developing student self-control	
		N1THELPBEST: Teachers at school feel responsible for helping each other do their best	
		N1TALLLEARN: Teachers at this school feel responsible that all students learn	
		N1TFAIL: Teachers at school feel responsible when students in this school fail	

Note: *Items that are that are not a 4-point Likert-type scale. S1FAVSUBJ and S1LEASTSUBJ are both categorical items. S1MENJOYS and S1SENJOYS both binary (Yes/No) items. $^{+}$Inter-item correlation is presented here given the variable is composed of two items.

Appendix D: Teacher Math Structural Equation Model Coefficients

Table D1. Teacher Math Structural Equation Model Coefficients

			B	**SE**	***β***	**p**
Latent Variables						
Math teacher factor	=~	Math teacher expectations	1	0	0.19	
Math teacher factors	=~	Math teacher self-efficacy	1.22	0.19	0.23	0
Math teacher factors	=~	Math teacher collective responsibility	0.81	0.13	0.14	0
Regressions						
Math GPA	~	Teacher-Student Match	-0.29	0.14	-0.08	0.03
Math GPA	~	Student Sex (Female)	0.05	0.01	0.03	0
Math GPA	~	First Language: Not English	0.09	0.02	0.04	0
Math GPA	~	First Language: English & Another Language	0.07	0.01	0.03	0
Math GPA	~	Student Age	-0.04	0.01	-0.03	0
Math GPA	~	Suburb	0	0.01	0	0.75
Math GPA	~	Town	0	0.01	0	0.88
Math GPA	~	Rural	0.02	0.01	0.01	0.12
Math GPA	~	Teacher Sex (Female)	0.02	0.01	0.01	0.01
Math GPA	~	Teacher Highest Degree	0.01	0.01	0.01	0.07
Math GPA	~	Teacher is Certified	-0.04	0.02	-0.01	0.02
Math GPA	~	Years Teaching	0	0	0.02	0
Math GPA	~	Child SES	0.11	0.02	0.09	0
Math teacher factors	~	Teacher-Student Match	0.04	0.05	0.05	0.45
Math teacher factors	~	Student Sex (Female)	0.05	0.01	0.14	0
Math teacher factors	~	First Language: Not English	0.09	0.02	0.22	0
Math teacher factors	~	First Language: English & Another Language	0.07	0.01	0.14	0
Math teacher factors	~	Student Age	-0.04	0.01	-0.18	0
Math teacher factors	~	Suburb	0	0.01	-0.01	0.75
Math teacher factors	~	Town	0	0.01	0	0.88
Math teacher factors	~	Rural	0.02	0.01	0.04	0.12
Math teacher factors	~	Teacher Sex (Female)	0.02	0.01	0.06	0.01
Math teacher factors	~	Teacher Highest Degree	0.01	0.01	0.04	0.07

Math teacher factors	~	Teacher is Certified	-0.04	0.02	-0.06	0.02
Math teacher factors	~	Years Teaching	0	0	0.09	0
Math teacher factors	~	Child SES	0.11	0.02	0.5	0
Math GPA	~	Math teacher factors	2.8	0.57	0.52	0
Covariances						
Math teacher expectations	~~	Math teacher collective responsibility	0.56	0.02	0.56	0
Math teacher self-efficacy	~~	Math teacher collective responsibility	0.18	0.02	0.18	0
Math teacher expectations	~~	Math teacher self-efficacy	0.19	0.02	0.2	0
Math teacher expectations	~~	Math teacher expectations	0.94	0.02	0.97	0
Math teacher self-efficacy	~~	Math teacher self-efficacy	0.9	0.02	0.95	0
Math teacher collective responsibility	~~	Math teacher collective responsibility	1.06	0.03	0.98	0
Math GPA	~~	Math GPA	0.63	0.04	0.64	0
Math teacher factors	~~	Math teacher factors	0.02	0.01	0.6	0
Teacher-Student Match	~~	Teacher-Student Match	0.08	0	1	
Teacher-Student Match	~~	Student Sex (Female)	0	0	0.02	
Teacher-Student Match	~~	First Language: Not English	0	0	-0.04	
Teacher-Student Match	~~	First Language: English & Another Language	0	0	-0.03	
Teacher-Student Match	~~	Student Age	0	0	-0.02	
Teacher-Student Match	~~	Suburb	0	0	0.03	
Teacher-Student Match	~~	Town	0	0	-0.05	
Teacher-Student Match	~~	Rural	0	0	-0.02	
Teacher-Student Match	~~	Teacher Sex (Female)	0	0	0.02	
Teacher-Student Match	~~	Teacher Highest Degree	-0.01	0	-0.05	
Teacher-Student Match	~~	Teacher is Certified	0	0	0.03	
Teacher-Student Match	~~	Years Teaching	-0.24	0	-0.1	
Teacher-Student Match	~~	Child SES	-0.01	0	-0.05	
Student Sex (Female)	~~	Student Sex (Female)	0.25	0	1	
Student Sex (Female)	~~	First Language: Not English	0	0	0.01	
Student Sex (Female)	~~	First Language: English & Another Language	0.01	0	0.04	
Student Sex (Female)	~~	Student Age	-0.04	0	-0.09	
Student Sex (Female)	~~	Suburb	0	0	0	

Student Sex (Female)	~~	Town	0	0	0
Student Sex (Female)	~~	Rural	0	0	-0.02
Student Sex (Female)	~~	Teacher Sex (Female)	0.01	0	0.03
Student Sex (Female)	~~	Teacher Highest Degree	0.01	0	0.02
Student Sex (Female)	~~	Teacher is Certified	0	0	-0.01
Student Sex (Female)	~~	Years Teaching	0.03	0	0.01
Student Sex (Female)	~~	Child SES	0.01	0	0.01
First Language: Not English	~~	First Language: Not English	0.19	0	1
First Language: Not English	~~	First Language: English & Another Language	-0.04	0	-0.24
First Language: Not English	~~	Student Age	0.01	0	0.03
First Language: Not English	~~	Suburb	0	0	0.02
First Language: Not English	~~	Town	0	0	-0.03
First Language: Not English	~~	Rural	0	0	0.01
First Language: Not English	~~	Teacher Sex (Female)	0	0	0.01
First Language: Not English	~~	Teacher Highest Degree	0	0	-0.01
First Language: Not English	~~	Teacher is Certified	0	0	0.03
First Language: Not English	~~	Years Teaching	-0.05	0	-0.01
First Language: Not English	~~	Child SES	-0.05	0	-0.13
First Language: English & Another Language	~~	First Language: English & Another Language	0.13	0	1
First Language: English & Another Language	~~	Student Age	-0.01	0	-0.03
First Language: English & Another Language	~~	Suburb	0	0	-0.02
First Language: English & Another Language	~~	Town	0	0	0.01
First Language: English & Another Language	~~	Rural	0	0	0
First Language: English & Another Language	~~	Teacher Sex (Female)	0	0	0
First Language: English & Another Language	~~	Teacher Highest Degree	0.01	0	0.03
First Language: English & Another Language	~~	Teacher is Certified	0	0	0.02
First Language: English & Another Language	~~	Years Teaching	0.05	0	0.02
First Language: English & Another Language	~~	Child SES	0	0	0.01
Student Age	~~	Student Age	0.68	0	1
Student Age	~~	Suburb	-0.02	0	-0.06
Student Age	~~	Town	0.01	0	0.03

Student Age	~~	Rural	0.01	0	0.02
Student Age	~~	Teacher Sex (Female)	0	0	-0.01
Student Age	~~	Teacher Highest Degree	-0.03	0	-0.07
Student Age	~~	Teacher is Certified	0	0	0.01
Student Age	~~	Years Teaching	-0.32	0	-0.05
Student Age	~~	Child SES	-0.11	0	-0.16
Suburb	~~	Suburb	0.23	0	1
Suburb	~~	Town	-0.04	0	-0.26
Suburb	~~	Rural	-0.09	0	-0.43
Suburb	~~	Teacher Sex (Female)	0.01	0	0.03
Suburb	~~	Teacher Highest Degree	0.01	0	0.03
Suburb	~~	Teacher is Certified	0	0	0.03
Suburb	~~	Years Teaching	0.08	0	0.02
Suburb	~~	Child SES	0.02	0	0.05
Town	~~	Town	0.1	0	1
Town	~~	Rural	-0.03	0	-0.2
Town	~~	Teacher Sex (Female)	0	0	-0.02
Town	~~	Teacher Highest Degree	0	0	0.01
Town	~~	Teacher is Certified	0	0	0
Town	~~	Years Teaching	-0.02	0	-0.01
Town	~~	Child SES	-0.02	0	-0.08
Rural	~~	Rural	0.19	0	1
Rural	~~	Teacher Sex (Female)	0	0	-0.01
Rural	~~	Teacher Highest Degree	-0.01	0	-0.06
Rural	~~	Teacher is Certified	0.01	0	0.1
Rural	~~	Years Teaching	-0.14	0	-0.04
Rural	~~	Child SES	-0.02	0	-0.04
Teacher Sex (Female)	~~	Teacher Sex (Female)	0.24	0	1
Teacher Sex (Female)	~~	Teacher Highest Degree	0.01	0	0.05
Teacher Sex (Female)	~~	Teacher is Certified	0	0	-0.01
Teacher Sex (Female)	~~	Years Teaching	-0.24	0	-0.06

Teacher Sex (Female)	~~	Child SES	0.02	0	0.04	
Teacher Highest Degree	~~	Teacher Highest Degree	0.29	0	1	
Teacher Highest Degree	~~	Teacher is Certified	0.01	0	0.07	
Teacher Highest Degree	~~	Years Teaching	0.91	0	0.2	
Teacher Highest Degree	~~	Child SES	0.03	0	0.08	
Teacher is Certified	~~	Teacher is Certified	0.07	0	1	
Teacher is Certified	~~	Years Teaching	0.15	0	0.07	
Teacher is Certified	~~	Child SES	-0.03	0	-0.12	
Years Teaching	~~	Years Teaching	71.6	0	1	
Years Teaching	~~	Child SES	1.03	0	0.15	
Child SES	~~	Child SES	0.7	0	1	
Intercepts						
Math teacher expectations	~1		0.62	0.11	0.63	0
Math teacher self-efficacy	~1		0.75	0.12	0.77	0
Math teacher collective responsibility	~1		0.54	0.1	0.52	0
Math GPA	~1		4.29	0.29	4.31	0
Teacher-Student Match	~1		0.08	0	0.3	
Student Sex (Female)	~1		0.49	0	0.98	
First Language: Not English	~1		0.25	0	0.57	
First Language: English & Another Language	~1		0.15	0	0.42	
Student Age	~1		15.03	0	18.25	
Suburb	~1		0.37	0	0.76	
Town	~1		0.11	0	0.35	
Rural	~1		0.25	0	0.57	
Teacher Sex (Female)	~1		0.61	0	1.25	
Teacher Highest Degree	~1		0.52	0	0.95	
Teacher is Certified	~1		0.92	0	3.36	
Years Teaching	~1		10.09	0	1.19	
Child SES	~1		-0.09	0	-0.11	
Math teacher factors	~1		0	0	0	

Note: Total N = 3,384. Fit statistics: CFI = .923, RMSEA = .039, SRMR = .022.

Appendix E: Teacher Science Structural Equation Model Coefficients

Table E1. Teacher Science Structural Equation Model Coefficients

			B	**SE**	***β***	**p**
Latent Variables						
Science teacher factors	=~	Science teacher expectations	1	0	0.15	
Science teacher factors	=~	Science teacher self-efficacy	1.04	0.24	0.15	0
Science teacher factors	=~	Science teacher collective responsibility	1.16	0.18	0.18	0
Regressions						
Science GPA	~	Teacher-Student Match	-0.24	0.16	-0.07	0.13
Science GPA	~	Student Sex (Female)	0.05	0.01	0.02	0
Science GPA	~	First Language: Not English	0.05	0.01	0.02	0
Science GPA	~	First Language: English & Another Language	0.06	0.01	0.02	0
Science GPA	~	Student Age	-0.04	0.01	-0.03	0
Science GPA	~	Suburb	-0.01	0.01	0	0.32
Science GPA	~	Town	0.01	0.01	0	0.45
Science GPA	~	Rural	0	0.01	0	0.64
Science GPA	~	Teacher Sex (Female)	0.03	0.01	0.02	0
Science GPA	~	Teacher Highest Degree	0.02	0.01	0.01	0.02
Science GPA	~	Teacher is Certified	-0.05	0.02	-0.01	0
Science GPA	~	Years Teaching	0	0	0.01	0.02
Science GPA	~	Child SES	0.09	0.02	0.08	0
Science teacher factors	~	Teacher-Student Match	0.03	0.05	0.05	0.58
Science teacher factors	~	Student Sex (Female)	0.05	0.01	0.16	0
Science teacher factors	~	First Language: Not English	0.05	0.01	0.15	0
Science teacher factors	~	First Language: English & Another Language	0.06	0.01	0.14	0
Science teacher factors	~	Student Age	-0.04	0.01	-0.2	0
Science teacher factors	~	Suburb	-0.01	0.01	-0.03	0.32
Science teacher factors	~	Town	0.01	0.01	0.02	0.45
Science teacher factors	~	Rural	0	0.01	0.01	0.64
Science teacher factors	~	Teacher Sex (Female)	0.03	0.01	0.1	0
Science teacher factors	~	Teacher Highest Degree	0.02	0.01	0.06	0.02

Science teacher factors	~	Teacher is Certified	-0.05	0.02	-0.08	0
Science teacher factors	~	Years Teaching	0	0	0.07	0.02
Science teacher factors	~	Child SES	0.09	0.02	0.52	0
Science GPA	~	Science teacher factors	3.45	0.84	0.54	0
Covariances						
Science teacher expectations	~~	Science teacher collective responsibility	0.48	0.02	0.5	0
Science teacher expectations	~~	Science teacher self-efficacy	0.13	0.02	0.13	0
Science teacher self-efficacy	~~	Science teacher collective responsibility	0.12	0.02	0.12	0
Science teacher expectations	~~	Science teacher expectations	1	0.03	0.98	0
Science teacher self-efficacy	~~	Science teacher self-efficacy	1.03	0.03	0.98	0
Science teacher collective responsibility	~~	Science teacher collective responsibility	0.91	0.02	0.97	0
Science GPA	~~	Science GPA	0.59	0.05	0.62	0
Science teacher factors	~~	Science teacher factors	0.01	0.01	0.57	0.01
Teacher-Student Match	~~	Teacher-Student Match	0.08	0	1	
Teacher-Student Match	~~	Student Sex (Female)	0	0	0.01	
Teacher-Student Match	~~	First Language: Not English	0	0	-0.03	
Teacher-Student Match	~~	First Language: English & Another Language	0	0	-0.04	
Teacher-Student Match	~~	Student Age	0	0	0	
Teacher-Student Match	~~	Suburb	0	0	0.03	
Teacher-Student Match	~~	Town	0	0	-0.01	
Teacher-Student Match	~~	Rural	0	0	-0.03	
Teacher-Student Match	~~	Teacher Sex (Female)	0	0	0.03	
Teacher-Student Match	~~	Teacher Highest Degree	-0.01	0	-0.04	
Teacher-Student Match	~~	Teacher is Certified	0	0	-0.06	
Teacher-Student Match	~~	Years Teaching	0.07	0	0.03	
Teacher-Student Match	~~	Child SES	-0.01	0	-0.06	
Student Sex (Female)	~~	Student Sex (Female)	0.25	0	1	
Student Sex (Female)	~~	First Language: Not English	0	0	0	
Student Sex (Female)	~~	First Language: English & Another Language	0.01	0	0.03	
Student Sex (Female)	~~	Student Age	-0.04	0	-0.09	
Student Sex (Female)	~~	Suburb	0	0	0.01	

Student Sex (Female)	~~	Town	0	0	0
Student Sex (Female)	~~	Rural	0	0	-0.02
Student Sex (Female)	~~	Teacher Sex (Female)	0.01	0	0.03
Student Sex (Female)	~~	Teacher Highest Degree	-0.01	0	-0.03
Student Sex (Female)	~~	Teacher is Certified	0	0	0
Student Sex (Female)	~~	Years Teaching	0.13	0	0.03
Student Sex (Female)	~~	Child SES	0.01	0	0.02
First Language: Not English	~~	First Language: Not English	0.19	0	1
First Language: Not English	~~	First Language: English & Another Language	-0.04	0	-0.24
First Language: Not English	~~	Student Age	0.01	0	0.04
First Language: Not English	~~	Suburb	0	0	0.02
First Language: Not English	~~	Town	0	0	-0.03
First Language: Not English	~~	Rural	0	0	0.01
First Language: Not English	~~	Teacher Sex (Female)	0	0	-0.02
First Language: Not English	~~	Teacher Highest Degree	0	0	0.01
First Language: Not English	~~	Teacher is Certified	0	0	0.02
First Language: Not English	~~	Years Teaching	0.07	0	0.02
First Language: Not English	~~	Child SES	-0.05	0	-0.14
First Language: English & Another Language	~~	First Language: English & Another Language	0.13	0	1
First Language: English & Another Language	~~	Student Age	-0.01	0	-0.03
First Language: English & Another Language	~~	Suburb	0	0	-0.02
First Language: English & Another Language	~~	Town	0	0	0.01
First Language: English & Another Language	~~	Rural	0	0	0
First Language: English & Another Language	~~	Teacher Sex (Female)	0	0	0
First Language: English & Another Language	~~	Teacher Highest Degree	0	0	-0.02
First Language: English & Another Language	~~	Teacher is Certified	0	0	0
First Language: English & Another Language	~~	Years Teaching	0.13	0	0.05
First Language: English & Another Language	~~	Child SES	0	0	0.01
Student Age	~~	Student Age	0.68	0	1
Student Age	~~	Suburb	-0.02	0	-0.06
Student Age	~~	Town	0.01	0	0.02

Student Age	~~	Rural	0.01	0	0.02
Student Age	~~	Teacher Sex (Female)	0.01	0	0.01
Student Age	~~	Teacher Highest Degree	-0.02	0	-0.04
Student Age	~~	Teacher is Certified	0	0	0.02
Student Age	~~	Years Teaching	-0.1	0	-0.02
Student Age	~~	Child SES	-0.11	0	-0.16
Suburb	~~	Suburb	0.23	0	1
Suburb	~~	Town	-0.04	0	-0.27
Suburb	~~	Rural	-0.09	0	-0.44
Suburb	~~	Teacher Sex (Female)	0	0	0.02
Suburb	~~	Teacher Highest Degree	0.02	0	0.09
Suburb	~~	Teacher is Certified	-0.01	0	-0.04
Suburb	~~	Years Teaching	0.07	0	0.02
Suburb	~~	Child SES	0.02	0	0.05
Town	~~	Town	0.1	0	1
Town	~~	Rural	-0.03	0	-0.2
Town	~~	Teacher Sex (Female)	-0.01	0	-0.03
Town	~~	Teacher Highest Degree	-0.01	0	-0.03
Town	~~	Teacher is Certified	0.01	0	0.07
Town	~~	Years Teaching	0.14	0	0.06
Town	~~	Child SES	-0.02	0	-0.08
Rural	~~	Rural	0.19	0	1
Rural	~~	Teacher Sex (Female)	0.01	0	0.04
Rural	~~	Teacher Highest Degree	-0.02	0	-0.06
Rural	~~	Teacher is Certified	0.01	0	0.07
Rural	~~	Years Teaching	-0.15	0	-0.04
Rural	~~	Child SES	-0.02	0	-0.04
Teacher Sex (Female)	~~	Teacher Sex (Female)	0.24	0	1
Teacher Sex (Female)	~~	Teacher Highest Degree	-0.02	0	-0.06
Teacher Sex (Female)	~~	Teacher is Certified	0.01	0	0.05
Teacher Sex (Female)	~~	Years Teaching	-0.57	0	-0.15

Teacher Sex (Female)	~~	Child SES	0.01	0	0.02	
Teacher Highest Degree	~~	Teacher Highest Degree	0.31	0	1	
Teacher Highest Degree	~~	Teacher is Certified	0.01	0	0.08	
Teacher Highest Degree	~~	Years Teaching	0.55	0	0.13	
Teacher Highest Degree	~~	Child SES	0.03	0	0.06	
Teacher is Certified	~~	Teacher is Certified	0.07	0	1	
Teacher is Certified	~~	Years Teaching	-0.02	0	-0.01	
Teacher is Certified	~~	Child SES	-0.02	0	-0.11	
Years Teaching	~~	Years Teaching	61.6	0	1	
Years Teaching	~~	Child SES	0.52	0	0.08	
Child SES	~~	Child SES	0.71	0	1	
Intercepts						
Science teacher expectations	~1		0.63	0.11	0.63	0
Science teacher self-efficacy	~1		0.65	0.12	0.63	0
Science teacher collective responsibility	~1		0.65	0.12	0.67	0
Science GPA	~1		4.71	0.28	4.83	0
Teacher-Student Match	~1		0.09	0	0.32	
Student Sex (Female)	~1		0.49	0	0.98	
First Language: Not English	~1		0.25	0	0.57	
First Language: English & Another Language	~1		0.15	0	0.43	
Student Age	~1		15.02	0	18.28	
Suburb	~1		0.37	0	0.76	
Town	~1		0.11	0	0.35	
Rural	~1		0.25	0	0.57	
Teacher Sex (Female)	~1		0.58	0	1.17	
Teacher Highest Degree	~1		0.58	0	1.04	
Teacher is Certified	~1		0.92	0	3.47	
Years Teaching	~1		10.26	0	1.31	
Child SES	~1		-0.09	0	-0.1	
Science teacher factors	~1		0	0	0	

Note: Total *N* = 3,376. Fit statistics: CFI = .907, RMSEA = .039, SRMR = .022.

Appendix F: Student Math Structural Equation Model Coefficients

Table F1. Student Math Structural Equation Model Coefficients

			B	SE	*β*	p
Latent Variables						
Student math perceptions	=~	Student math identity	1	0	0.75	
Student math perceptions	=~	Student math utility	0.42	0.03	0.32	0
Student math perceptions	=~	Student math self-efficacy	0.95	0.03	0.74	0
Student math perceptions	=~	Student math course interest	0.88	0.03	0.68	0
Student engagement	=~	School belonging	1	0	0.4	
Student engagement	=~	School engagement	0.95	0.07	0.37	0
Student engagement	=~	Math homework hours	0.21	0.05	0.1	0
Regressions						
Math GPA	~	Teacher-Student Match	-0.04	0.11	-0.01	0.69
Math GPA	~	Student Sex (Female)	0.09	0.01	0.04	0
Math GPA	~	First Language: Not English	0.14	0.02	0.06	0
Math GPA	~	First Language: English & Another Language	0.11	0.02	0.04	0
Math GPA	~	Student Age	-0.06	0.01	-0.05	0
Math GPA	~	Suburb	-0.01	0.01	0	0.68
Math GPA	~	Town	0	0.02	0	0.87
Math GPA	~	Rural	0.02	0.02	0.01	0.24
Math GPA	~	Teacher Sex (Female)	0.02	0.01	0.01	0.09
Math GPA	~	Teacher Highest Degree	0.02	0.01	0.01	0.12
Math GPA	~	Teacher is Certified	-0.03	0.02	-0.01	0.15
Math GPA	~	Years Teaching	0	0	0.02	0
Math GPA	~	Child SES	0.16	0.01	0.13	0
Student math perceptions	~	Teacher-Student Match	-0.03	0.05	-0.01	0.61
Student math perceptions	~	Student Sex (Female)	0.09	0.01	0.06	0
Student math perceptions	~	First Language: Not English	0.14	0.02	0.08	0
Student math perceptions	~	First Language: English & Another Language	0.11	0.02	0.05	0
Student math perceptions	~	Student Age	-0.06	0.01	-0.06	0
Student math perceptions	~	Suburb	-0.01	0.01	0	0.68

Student math perceptions	~	Town	0	0.02	0	0.87
Student math perceptions	~	Rural	0.02	0.02	0.01	0.24
Student math perceptions	~	Teacher Sex (Female)	0.02	0.01	0.01	0.09
Student math perceptions	~	Teacher Highest Degree	0.02	0.01	0.01	0.12
Student math perceptions	~	Teacher is Certified	-0.03	0.02	-0.01	0.15
Student math perceptions	~	Years Teaching	0	0	0.03	0
Student math perceptions	~	Child SES	0.16	0.01	0.18	0
Student engagement	~	Teacher-Student Match	-0.08	0.05	-0.06	0.1
Student engagement	~	Student Sex (Female)	0.09	0.01	0.12	0
Student engagement	~	First Language: Not English	0.14	0.02	0.15	0
Student engagement	~	First Language: English & Another Language	0.11	0.02	0.1	0
Student engagement	~	Student Age	-0.06	0.01	-0.12	0
Student engagement	~	Suburb	-0.01	0.01	-0.01	0.68
Student engagement	~	Town	0	0.02	0	0.87
Student engagement	~	Rural	0.02	0.02	0.02	0.24
Student engagement	~	Teacher Sex (Female)	0.02	0.01	0.03	0.09
Student engagement	~	Teacher Highest Degree	0.02	0.01	0.02	0.12
Student engagement	~	Teacher is Certified	-0.03	0.02	-0.02	0.15
Student engagement	~	Years Teaching	0	0	0.05	0
Student engagement	~	Child SES	0.16	0.01	0.34	0
Math GPA	~	Student math perceptions	-0.35	0.17	-0.26	0.04
Math GPA	~	Student engagement	2.02	0.33	0.78	0
Covariances						
Student math perceptions	~~	Student engagement	0.22	0.02	0.89	0
Student math utility	~~	Student math course interest	0.16	0.02	0.25	0
Student math utility	~~	Student math self-efficacy	0.09	0.01	0.16	0
School belonging	~~	Math homework hours	0.08	0.01	0.11	0
School belonging	~~	School engagement	0.1	0.02	0.13	0
School engagement	~~	Math homework hours	0.08	0.02	0.1	0
Student math identity	~~	Student math identity	0.43	0.02	0.44	0
Student math utility	~~	Student math utility	0.85	0.02	0.9	0

Student math self-efficacy	~~	Student math self-efficacy	0.43	0.02	0.46	0
Student math course interest	~~	Student math course interest	0.5	0.02	0.54	0
School belonging	~~	School belonging	0.81	0.02	0.84	0
School engagement	~~	School engagement	0.87	0.02	0.86	0
Math homework hours	~~	Math homework hours	0.69	0.02	0.99	0
Math GPA	~~	Math GPA	0.55	0.03	0.55	0
Student math perceptions	~~	Student math perceptions	0.53	0.02	0.95	0
Student engagement	~~	Student engagement	0.12	0.01	0.8	0
Teacher-Student Match	~~	Teacher-Student Match	0.08	0	1	
Teacher-Student Match	~~	Student Sex (Female)	0	0	0.02	
Teacher-Student Match	~~	First Language: Not English	0	0	-0.04	
Teacher-Student Match	~~	First Language: English & Another Language	0	0	-0.03	
Teacher-Student Match	~~	Student Age	0	0	-0.02	
Teacher-Student Match	~~	Suburb	0	0	0.03	
Teacher-Student Match	~~	Town	0	0	-0.05	
Teacher-Student Match	~~	Rural	0	0	-0.02	
Teacher-Student Match	~~	Teacher Sex (Female)	0	0	0.02	
Teacher-Student Match	~~	Teacher Highest Degree	-0.01	0	-0.05	
Teacher-Student Match	~~	Teacher is Certified	0	0	0.03	
Teacher-Student Match	~~	Years Teaching	-0.24	0	-0.1	
Teacher-Student Match	~~	Child SES	-0.01	0	-0.05	
Student Sex (Female)	~~	Student Sex (Female)	0.25	0	1	
Student Sex (Female)	~~	First Language: Not English	0	0	0.01	
Student Sex (Female)	~~	First Language: English & Another Language	0.01	0	0.04	
Student Sex (Female)	~~	Student Age	-0.04	0	-0.09	
Student Sex (Female)	~~	Suburb	0	0	0	
Student Sex (Female)	~~	Town	0	0	0	
Student Sex (Female)	~~	Rural	0	0	-0.02	
Student Sex (Female)	~~	Teacher Sex (Female)	0.01	0	0.03	
Student Sex (Female)	~~	Teacher Highest Degree	0.01	0	0.02	
Student Sex (Female)	~~	Teacher is Certified	0	0	-0.01	

Student Sex (Female)	~~	Years Teaching	0.03	0	0.01
Student Sex (Female)	~~	Child SES	0.01	0	0.01
First Language: Not English	~~	First Language: Not English	0.19	0	1
First Language: Not English	~~	First Language: English & Another Language	-0.04	0	-0.24
First Language: Not English	~~	Student Age	0.01	0	0.03
First Language: Not English	~~	Suburb	0	0	0.02
First Language: Not English	~~	Town	0	0	-0.03
First Language: Not English	~~	Rural	0	0	0.01
First Language: Not English	~~	Teacher Sex (Female)	0	0	0.01
First Language: Not English	~~	Teacher Highest Degree	0	0	-0.01
First Language: Not English	~~	Teacher is Certified	0	0	0.03
First Language: Not English	~~	Years Teaching	-0.05	0	-0.01
First Language: Not English	~~	Child SES	-0.05	0	-0.13
First Language: English & Another Language	~~	First Language: English & Another Language	0.13	0	1
First Language: English & Another Language	~~	Student Age	-0.01	0	-0.03
First Language: English & Another Language	~~	Suburb	0	0	-0.02
First Language: English & Another Language	~~	Town	0	0	0.01
First Language: English & Another Language	~~	Rural	0	0	0
First Language: English & Another Language	~~	Teacher Sex (Female)	0	0	0
First Language: English & Another Language	~~	Teacher Highest Degree	0.01	0	0.03
First Language: English & Another Language	~~	Teacher is Certified	0	0	0.02
First Language: English & Another Language	~~	Years Teaching	0.05	0	0.02
First Language: English & Another Language	~~	Child SES	0	0	0.01
Student Age	~~	Student Age	0.68	0	1
Student Age	~~	Suburb	-0.02	0	-0.06
Student Age	~~	Town	0.01	0	0.03
Student Age	~~	Rural	0.01	0	0.02
Student Age	~~	Teacher Sex (Female)	0	0	-0.01
Student Age	~~	Teacher Highest Degree	-0.03	0	-0.07
Student Age	~~	Teacher is Certified	0	0	0.01
Student Age	~~	Years Teaching	-0.32	0	-0.05

Student Age	~~	Child SES	-0.11	0	-0.16
Suburb	~~	Suburb	0.23	0	1
Suburb	~~	Town	-0.04	0	-0.26
Suburb	~~	Rural	-0.09	0	-0.43
Suburb	~~	Teacher Sex (Female)	0.01	0	0.03
Suburb	~~	Teacher Highest Degree	0.01	0	0.03
Suburb	~~	Teacher is Certified	0	0	0.03
Suburb	~~	Years Teaching	0.08	0	0.02
Suburb	~~	Child SES	0.02	0	0.05
Town	~~	Town	0.1	0	1
Town	~~	Rural	-0.03	0	-0.2
Town	~~	Teacher Sex (Female)	0	0	-0.02
Town	~~	Teacher Highest Degree	0	0	0.01
Town	~~	Teacher is Certified	0	0	0
Town	~~	Years Teaching	-0.02	0	-0.01
Town	~~	Child SES	-0.02	0	-0.08
Rural	~~	Rural	0.19	0	1
Rural	~~	Teacher Sex (Female)	0	0	-0.01
Rural	~~	Teacher Highest Degree	-0.01	0	-0.06
Rural	~~	Teacher is Certified	0.01	0	0.1
Rural	~~	Years Teaching	-0.14	0	-0.04
Rural	~~	Child SES	-0.02	0	-0.04
Teacher Sex (Female)	~~	Teacher Sex (Female)	0.24	0	1
Teacher Sex (Female)	~~	Teacher Highest Degree	0.01	0	0.05
Teacher Sex (Female)	~~	Teacher is Certified	0	0	-0.01
Teacher Sex (Female)	~~	Years Teaching	-0.24	0	-0.06
Teacher Sex (Female)	~~	Child SES	0.02	0	0.04
Teacher Highest Degree	~~	Teacher Highest Degree	0.29	0	1
Teacher Highest Degree	~~	Teacher is Certified	0.01	0	0.07
Teacher Highest Degree	~~	Years Teaching	0.91	0	0.2
Teacher Highest Degree	~~	Child SES	0.03	0	0.08

Teacher is Certified	~~	Teacher is Certified	0.07	0	1	
Teacher is Certified	~~	Years Teaching	0.15	0	0.07	
Teacher is Certified	~~	Child SES	-0.03	0	-0.12	
Years Teaching	~~	Years Teaching	71.6	0	1	
Years Teaching	~~	Child SES	1.03	0	0.15	
Child SES	~~	Child SES	0.7	0	1	
Intercepts						
Student math identity	~1		0.86	0.12	0.87	0
Student math utility	~1		0.47	0.06	0.48	0
Student math self-efficacy	~1		0.82	0.12	0.85	0
Student math course interest	~1		0.81	0.11	0.84	0
School belonging	~1		0.86	0.12	0.88	0
School engagement	~1		0.76	0.12	0.76	0
Math homework hours	~1		0.74	0.05	0.89	0
Math GPA	~1		4.28	0.29	4.29	0
Teacher-Student Match	~1		0.08	0	0.3	
Student Sex (Female)	~1		0.49	0	0.98	
First Language: Not English	~1		0.25	0	0.57	
First Language: English & Another Language	~1		0.15	0	0.42	
Student Age	~1		15.03	0	18.25	
Suburb	~1		0.37	0	0.76	
Town	~1		0.11	0	0.35	
Rural	~1		0.25	0	0.57	
Teacher Sex (Female)	~1		0.61	0	1.25	
Teacher Highest Degree	~1		0.52	0	0.95	
Teacher is Certified	~1		0.92	0	3.36	
Years Teaching	~1		10.09	0	1.19	
Child SES	~1		-0.09	0	-0.11	
Student math perceptions	~1		0	0	0	
Student engagement	~1		0	0	0	

Note: Total N = 3,384. Fit statistics: CFI = .883, RMSEA = .044, SRMR = .030.

Appendix G: Student Science Structural Equation Model Coefficients

Table G1. Student Science Structural Equation Model Coefficients

			B	**SE**	***β***	**p**
Latent Variables						
Student science perceptions	=~	Student science identity	1	0	0.7	
Student science perceptions	=~	Student science utility	0.79	0.03	0.58	0
Student science perceptions	=~	Student science self-efficacy	1.01	0.03	0.73	0
Student science perceptions	=~	Student science course interest	0.94	0.03	0.69	0
Student engagement	=~	School belonging	1	0	0.49	
Student engagement	=~	School engagement	0.99	0.06	0.48	0
Student engagement	=~	Science homework hours	0.51	0.04	0.3	0
Regressions						
Science GPA	~	Teacher-Student Match	-0.2	0.06	-0.06	0
Science GPA	~	Student Sex (Female)	0.09	0.02	0.05	0
Science GPA	~	First Language: Not English	0.11	0.02	0.05	0
Science GPA	~	First Language: English & Another Language	0.13	0.02	0.05	0
Science GPA	~	Student Age	-0.08	0.01	-0.07	0
Science GPA	~	Suburb	-0.02	0.02	-0.01	0.26
Science GPA	~	Town	-0.02	0.03	-0.01	0.54
Science GPA	~	Rural	-0.02	0.02	-0.01	0.27
Science GPA	~	Teacher Sex (Female)	0.05	0.01	0.02	0
Science GPA	~	Teacher Highest Degree	0.04	0.01	0.02	0.01
Science GPA	~	Teacher is Certified	-0.09	0.03	-0.02	0
Science GPA	~	Years Teaching	0	0	0.02	0.01
Science GPA	~	Child SES	0.21	0.01	0.18	0
Student science perceptions	~	Teacher-Student Match	0.04	0.05	0.02	0.43
Student science perceptions	~	Student Sex (Female)	0.09	0.02	0.06	0
Student science perceptions	~	First Language: Not English	0.11	0.02	0.06	0
Student science perceptions	~	First Language: English & Another Language	0.13	0.02	0.06	0
Student science perceptions	~	Student Age	-0.08	0.01	-0.09	0
Student science perceptions	~	Suburb	-0.02	0.02	-0.01	0.26

Student science perceptions	~	Town	-0.02	0.03	-0.01	0.54
Student science perceptions	~	Rural	-0.02	0.02	-0.01	0.27
Student science perceptions	~	Teacher Sex (Female)	0.05	0.01	0.03	0
Student science perceptions	~	Teacher Highest Degree	0.04	0.01	0.03	0.01
Student science perceptions	~	Teacher is Certified	-0.09	0.03	-0.03	0
Student science perceptions	~	Years Teaching	0	0	0.03	0.01
Student science perceptions	~	Child SES	0.21	0.01	0.24	0
Student engagement	~	Teacher-Student Match	0.04	0.04	0.03	0.34
Student engagement	~	Student Sex (Female)	0.09	0.02	0.1	0
Student engagement	~	First Language: Not English	0.11	0.02	0.1	0
Student engagement	~	First Language: English & Another Language	0.13	0.02	0.09	0
Student engagement	~	Student Age	-0.08	0.01	-0.14	0
Student engagement	~	Suburb	-0.02	0.02	-0.02	0.26
Student engagement	~	Town	-0.02	0.03	-0.01	0.54
Student engagement	~	Rural	-0.02	0.02	-0.02	0.27
Student engagement	~	Teacher Sex (Female)	0.05	0.01	0.05	0
Student engagement	~	Teacher Highest Degree	0.04	0.01	0.04	0.01
Student engagement	~	Teacher is Certified	-0.09	0.03	-0.05	0
Student engagement	~	Years Teaching	0	0	0.04	0.01
Student engagement	~	Child SES	0.21	0.01	0.36	0
Science GPA	~	Student science perceptions	-0.09	0.08	-0.07	0.25
Science GPA	~	Student engagement	0.99	0.16	0.5	0
Covariances						
Student science perceptions	~~	Student engagement	0.2	0.01	0.68	0
Student science utility	~~	Student science course interest	0.09	0.02	0.16	0
Student science identity	~~	Student science identity	0.54	0.02	0.5	0
Student science utility	~~	Student science utility	0.67	0.02	0.67	0
Student science self-efficacy	~~	Student science self-efficacy	0.46	0.02	0.46	0
Student science course interest	~~	Student science course interest	0.5	0.02	0.52	0
School belonging	~~	School belonging	0.73	0.03	0.76	0
School engagement	~~	School engagement	0.78	0.03	0.77	0

Science homework hours	~~	Science homework hours	0.62	0.02	0.91	0
Science GPA	~~	Science GPA	0.61	0.02	0.65	0
Student science perceptions	~~	Student science perceptions	0.48	0.02	0.91	0
Student engagement	~~	Student engagement	0.19	0.02	0.8	0
Teacher-Student Match	~~	Teacher-Student Match	0.08	0	1	
Teacher-Student Match	~~	Student Sex (Female)	0	0	0.01	
Teacher-Student Match	~~	First Language: Not English	0	0	-0.03	
Teacher-Student Match	~~	First Language: English & Another Language	0	0	-0.04	
Teacher-Student Match	~~	Student Age	0	0	0	
Teacher-Student Match	~~	Suburb	0	0	0.03	
Teacher-Student Match	~~	Town	0	0	-0.01	
Teacher-Student Match	~~	Rural	0	0	-0.03	
Teacher-Student Match	~~	Teacher Sex (Female)	0	0	0.03	
Teacher-Student Match	~~	Teacher Highest Degree	-0.01	0	-0.04	
Teacher-Student Match	~~	Teacher is Certified	0	0	-0.06	
Teacher-Student Match	~~	Years Teaching	0.07	0	0.03	
Teacher-Student Match	~~	Child SES	-0.01	0	-0.06	
Student Sex (Female)	~~	Student Sex (Female)	0.25	0	1	
Student Sex (Female)	~~	First Language: Not English	0	0	0	
Student Sex (Female)	~~	First Language: English & Another Language	0.01	0	0.03	
Student Sex (Female)	~~	Student Age	-0.04	0	-0.09	
Student Sex (Female)	~~	Suburb	0	0	0.01	
Student Sex (Female)	~~	Town	0	0	0	
Student Sex (Female)	~~	Rural	0	0	-0.02	
Student Sex (Female)	~~	Teacher Sex (Female)	0.01	0	0.03	
Student Sex (Female)	~~	Teacher Highest Degree	-0.01	0	-0.03	
Student Sex (Female)	~~	Teacher is Certified	0	0	0	
Student Sex (Female)	~~	Years Teaching	0.13	0	0.03	
Student Sex (Female)	~~	Child SES	0.01	0	0.02	
First Language: Not English	~~	First Language: Not English	0.19	0	1	
First Language: Not English	~~	First Language: English & Another Language	-0.04	0	-0.24	

First Language: Not English	~~	Student Age	0.01	0	0.04
First Language: Not English	~~	Suburb	0	0	0.02
First Language: Not English	~~	Town	0	0	-0.03
First Language: Not English	~~	Rural	0	0	0.01
First Language: Not English	~~	Teacher Sex (Female)	0	0	-0.02
First Language: Not English	~~	Teacher Highest Degree	0	0	0.01
First Language: Not English	~~	Teacher is Certified	0	0	0.02
First Language: Not English	~~	Years Teaching	0.07	0	0.02
First Language: Not English	~~	Child SES	-0.05	0	-0.14
First Language: English & Another Language	~~	First Language: English & Another Language	0.13	0	1
First Language: English & Another Language	~~	Student Age	-0.01	0	-0.03
First Language: English & Another Language	~~	Suburb	0	0	-0.02
First Language: English & Another Language	~~	Town	0	0	0.01
First Language: English & Another Language	~~	Rural	0	0	0
First Language: English & Another Language	~~	Teacher Sex (Female)	0	0	0
First Language: English & Another Language	~~	Teacher Highest Degree	0	0	-0.02
First Language: English & Another Language	~~	Teacher is Certified	0	0	0
First Language: English & Another Language	~~	Years Teaching	0.13	0	0.05
First Language: English & Another Language	~~	Child SES	0	0	0.01
Student Age	~~	Student Age	0.68	0	1
Student Age	~~	Suburb	-0.02	0	-0.06
Student Age	~~	Town	0.01	0	0.02
Student Age	~~	Rural	0.01	0	0.02
Student Age	~~	Teacher Sex (Female)	0.01	0	0.01
Student Age	~~	Teacher Highest Degree	-0.02	0	-0.04
Student Age	~~	Teacher is Certified	0	0	0.02
Student Age	~~	Years Teaching	-0.1	0	-0.02
Student Age	~~	Child SES	-0.11	0	-0.16
Suburb	~~	Suburb	0.23	0	1
Suburb	~~	Town	-0.04	0	-0.27
Suburb	~~	Rural	-0.09	0	-0.44

Suburb	~~	Teacher Sex (Female)	0	0	0.02
Suburb	~~	Teacher Highest Degree	0.02	0	0.09
Suburb	~~	Teacher is Certified	-0.01	0	-0.04
Suburb	~~	Years Teaching	0.07	0	0.02
Suburb	~~	Child SES	0.02	0	0.05
Town	~~	Town	0.1	0	1
Town	~~	Rural	-0.03	0	-0.2
Town	~~	Teacher Sex (Female)	-0.01	0	-0.03
Town	~~	Teacher Highest Degree	-0.01	0	-0.03
Town	~~	Teacher is Certified	0.01	0	0.07
Town	~~	Years Teaching	0.14	0	0.06
Town	~~	Child SES	-0.02	0	-0.08
Rural	~~	Rural	0.19	0	1
Rural	~~	Teacher Sex (Female)	0.01	0	0.04
Rural	~~	Teacher Highest Degree	-0.02	0	-0.06
Rural	~~	Teacher is Certified	0.01	0	0.07
Rural	~~	Years Teaching	-0.15	0	-0.04
Rural	~~	Child SES	-0.02	0	-0.04
Teacher Sex (Female)	~~	Teacher Sex (Female)	0.24	0	1
Teacher Sex (Female)	~~	Teacher Highest Degree	-0.02	0	-0.06
Teacher Sex (Female)	~~	Teacher is Certified	0.01	0	0.05
Teacher Sex (Female)	~~	Years Teaching	-0.57	0	-0.15
Teacher Sex (Female)	~~	Child SES	0.01	0	0.02
Teacher Highest Degree	~~	Teacher Highest Degree	0.31	0	1
Teacher Highest Degree	~~	Teacher is Certified	0.01	0	0.08
Teacher Highest Degree	~~	Years Teaching	0.55	0	0.13
Teacher Highest Degree	~~	Child SES	0.03	0	0.06
Teacher is Certified	~~	Teacher is Certified	0.07	0	1
Teacher is Certified	~~	Years Teaching	-0.02	0	-0.01
Teacher is Certified	~~	Child SES	-0.02	0	-0.11
Years Teaching	~~	Years Teaching	61.6	0	1

Years Teaching	~~	Child SES	0.52	0	0.08	
Child SES	~~	Child SES	0.71	0	1	
Intercepts						
Student science identity	~1		1.15	0.15	1.11	0
Student science utility	~1		1.02	0.12	1.02	0
Student science self-efficacy	~1		1.19	0.15	1.19	0
Student science course interest	~1		1.14	0.14	1.16	0
School belonging	~1		1.26	0.15	1.28	0
School engagement	~1		1.18	0.15	1.17	0
Science homework hours	~1		1.19	0.09	1.44	0
Science GPA	~1		4.53	0.27	4.67	0
Teacher-Student Match	~1		0.09	0	0.32	
Student Sex (Female)	~1		0.49	0	0.98	
First Language: Not English	~1		0.25	0	0.57	
First Language: English & Another Language	~1		0.15	0	0.43	
Student Age	~1		15.02	0	18.28	
Suburb	~1		0.37	0	0.76	
Town	~1		0.11	0	0.35	
Rural	~1		0.25	0	0.57	
Teacher Sex (Female)	~1		0.58	0	1.17	
Teacher Highest Degree	~1		0.58	0	1.04	
Teacher is Certified	~1		0.92	0	3.47	
Years Teaching	~1		10.26	0	1.31	
Child SES	~1		-0.09	0	-0.1	
Student science perceptions	~1		0	0	0	
Student engagement	~1		0	0	0	

Note: Total *N* = 3,379. Fit statistics: CFI = .887, RMSEA = .042, SRMR = .030.

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