Internalizing Achievement Inequality: The Development of Racial/Ethnic Differences in Mathematics Attitudes and Their Implications for Persistence in STEM

by

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Table of Contents

List of Tables

List of Figures

Abstract

Black and Hispanic students have lower achievement than White students due to segregation, discrimination, and poverty. If these disadvantages also lead to negative academic attitudes, Black and Hispanic students may disengage from school, compounding the effects of low achievement and limited opportunities. Therefore, my dissertation is organized around two questions: (1) Do racial/ethnic differences in academic attitudes develop in response to educational inequalities? (2) If so, do differences in attitudes translate into differences in educational behavior and decision-making? I answer these questions using elementary and middle school data on mathematics attitudes from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K). Because STEM (science, technology, engineering, and mathematics) professions are the highest paying, racial/ethnic inequalities in mathematics education are particularly consequential for the reproduction of racial/ethnic income inequality.

My dissertation has two main contributions. First, I show that Black and Hispanic students' mathematics self-competence, or self-assessed mathematics ability, declines as they internalize the limitations placed on their achievement by structural racism. In third grade, Black and Hispanic students have high mathematics self-competence relative to White students with similar achievement because they are segregated into underperforming schools. They compare themselves favorably to their low-achieving peers. However, as they get older, Black and Hispanic students' self-competence falls. By eighth grade, racial/ethnic differences among students with comparable test scores are largely insignificant. Because Black and Hispanic students have lower test scores, on average, this leaves them with lower self-competence overall.

These results extend theories on the classic big-fish-little-pond effect by showing that the effect diminishes with age.

Second, I demonstrate that, compared to mathematics self-competence, mathematics interest is less dependent on school quality but also less consequential for persistence in STEM. In the second chapter, I find that disadvantaged families are able to buttress their children's mathematics interest. As a result, Black and Hispanic students end middle school with high mathematics interest relative to their low self-competence. In the third chapter, I show that high self-competence is associated with enrollment in upper-level mathematics courses, whereas high interest motivates more frequent homework completion. Combined, these two chapters demonstrate that mathematics interest is limited as a source of resilience for Black and Hispanic children. Although interest boosts studiousness, the returns to studiousness are lower in the absence of the self-competence to enroll in advanced mathematics courses.

Overall, this research advances sociological theory on racial/ethnic differences in academic attitudes. Sociologists of education have disproven the claim that Black and Hispanic communities possess an "oppositional culture" that discourages scholastic achievement as a form of "acting White." However, these scholars have not posited an alternate theory on the relationship between racial/ethnic educational inequality and academic attitudes. This dissertation shows that Black and Hispanic students' low achievement leads to negative academic attitudes, not the other way around. Black and Hispanic children enter school with equally positive academic attitudes as White children. Educational disadvantages produce low achievement, which Black and Hispanic students gradually internalize as low self-competence. This low self-competence discourages children from pursuing ambitious academic paths, thereby maintaining racial/ethnic educational inequality.

Chapter 1
Introduction

In the 1980s, Ogbu (Fordham and Ogbu 1986; Ogbu 1987) theorized that Black and Hispanic communities possess an "oppositional culture" that discourages scholastic achievement as a form of "acting White." He attributed Black and Hispanic children's underachievement to negative academic attitudes, downplaying the role of segregation, discrimination, and poverty (Lewis and Diamond 2015; Ochoa 2013; Reardon 2016; Rumberger and Palardy 2005). Since then, multiple quantitative sociologists have used cross-sectional survey data to disprove oppositional culture theory (Ainsworth-Darnell and Downey 1998; Ambriz 2020; Diamond and Huguley 2014; Harris 2006; Matthew 2011; Mickelson 1990). These studies have identified an attitude-achievement paradox: Black and Hispanic students have similar or more positive academic attitudes compared to White students despite having lower achievement.

Sociologists have not been able to explain why Black and Hispanic students have such positive attitudes despite their low achievement. In the absence of an alternate theory on the relationship between racial/ethnic educational inequality and academic attitudes, the "acting White" myth continues to be propagated in popular discourse (McWhorter 2019; Wright 2014). Furthermore, with limited understanding of Black and Hispanic students' academic attitudes, scholars cannot advise practitioners and policymakers on how to best leverage these attitudes to boost achievement and attainment.

This dissertation gains new perspective on the attitude-achievement paradox by examining how racial/ethnic differences in academic attitudes develop with age. I also explore some of the implications of these attitudinal differences for racial/ethnic educational inequality by linking academic attitudes to non-achievement outcomes.

The attitudes I investigate comprise mathematics self-concept, which is a child's perception of themselves as a mathematics student. Mathematics self-concept consists of mathematics interest and mathematics self-competence, or self-assessed mathematics ability (Arens et al. 2011; Pinxten et al. 2014). These attitudes predict grades, test scores, effort, and enrollment in mathematics classes, all of which are necessary for persistence in STEM (science, technology, engineering, and mathematics) education (Chouinard, Karsenti, and Roy 2007; Correll 2001; Köller, Baumert, and Schnabel 2001; Marsh and Yeung 1997; Nagy et al. 2008; Pinxten et al. 2014; Safavian and Conley 2016; Susperreguy et al. 2018; Trautwein, Lüdtke, Kastens, et al. 2006; Trautwein et al. 2009, 2015). I focus on elementary and middle school, the key developmental period for mathematics self-concept (Frenzel et al. 2012; Wigfield et al. 2015).

All three empirical chapters use nationally representative data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K). Chapter Two traces racial/ethnic differences in the development of mathematics self-competence. Because self-competence is sensitive to prior achievement, I hypothesize that the attitude-achievement paradox will disappear (i.e., Black and Hispanic students' self-competence will decline) as children's self-competence normalizes to achievement. Chapter Three examines racial/ethnic differences in the development of mathematics interest. Because mathematics interest is less sensitive to prior achievement, I hypothesize that Black and Hispanic students' mathematics interest will remain relatively high as their mathematics self-competence falls. Chapter Four investigates the effect of mathematics self-competence and mathematics interest on two key outcomes for persistence in STEM: course selection and homework completion. I hypothesize that mathematics self-competence and mathematics interest serve different motivational functions. Self-competence motivates influences decisions closely linked to hierarchical notions of ability (i.e., course selection) such that students choose the option that corresponds best to their idea of what they *can* do. In contrast, interest spurs students to spend more time on activities they like to do (i.e., mathematics homework). Chapter Five summarizes my findings and discusses their implications for racial/ethnic inequality in education.

Chapter 2

Internalizing Achievement Inequality:
The Development of Racial/Ethnic Differences in Mathematics Self-Competence

Abstract

Cross-sectional studies have identified an attitude-achievement paradox: Black and Hispanic students have positive academic attitudes despite their low achievement. Researchers have not yet examined the development of racial/ethnic differences in academic attitudes. Therefore, it is unclear whether Black and Hispanic students sustain such positive attitudes in the face of extensive educational disadvantages. Using third through eighth grade data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99, I examine how and why racial/ethnic differences in mathematics self-competence (i.e., self-assessed mathematics ability) change with age. I find that, at younger ages, Black and Hispanic students have higher mathematics self-competence than White students with identical achievement. This advantage disappears for Black girls and Hispanic children, leaving them with low self-competence to match their low achievement. This disappearing attitude-achievement paradox reflects a weakening big-fish-little-pond effect. Younger Black and Hispanic students judge their achievement favorably relative to the low actual or perceived achievement of peers in segregated schools (i.e., they feel like big fish in little ponds). With age, most students' self-competence normalizes to achievement (with the exception of Black boys), suggesting that Black girls and

Hispanic children come to internalize the limitations placed on their achievement by structural racism.

Keywords: Attitude-achievement paradox, big-fish-little-pond effect, oppositional culture, segregation, race and ethnicity, STEM

2.1 Introduction

Academic attitudes affect future behavior, decisions, and achievement independently of prior achievement. For example, imagine two students with identical mathematics achievement, but different levels of mathematics self-competence, or self-assessed mathematics ability. On average, the student with higher self-competence will go on to have higher mathematics grades and test scores, enroll in higher-level mathematics courses, and continue taking mathematics courses beyond the minimum requirement for high school graduation (Correll 2001; Marsh et al. 2005; Marsh and Yeung 1997; Nagy et al. 2008; Petersen and Hyde 2017; Susperreguy et al. 2018). Therefore, if students of different races/ethnicities have systematically different academic attitudes, these differences can either reproduce or mitigate educational inequalities.

The scholarly consensus as to whether academic attitudes help perpetuate or lessen racial/ethnic educational inequalities has changed over time. In the 1980s, Ogbu argued that Black and Hispanic communities possess an “oppositional culture” that discourages scholastic achievement as a form of “acting White” (Fordham and Ogbu 1986; Ogbu 1987). However, multiple studies have since used nationally representative survey data to disprove oppositional culture theory. These studies have identified an attitude-achievement paradox: despite having lower achievement, Black and Hispanic students have comparable or, in some cases, more positive academic attitudes than White students (Ainsworth-Darnell and Downey 1998; Ambriz

2020; Harris 2006; Matthew 2011; Mickelson 1990). These positive attitudes mitigate racial/ethnic inequalities by motivating Black and Hispanic students to make the most of limited educational opportunities (Goldsmith 2004).

Researchers have focused more on proving the existence of the attitude-achievement paradox rather than investigating how racial/ethnic differences in academic attitudes develop. Because extant studies are cross-sectional, scholars have yet to explore whether Black and Hispanic students can sustain positive academic attitudes over the course of years in a segregated and discriminatory school system. I investigate the development of racial/ethnic differences in academic attitudes, distinguishing between two options. First, Black and Hispanic students may enter school with positive academic attitudes, but lose this advantage as they experience greater discrimination and become more aware of their limited educational opportunities. Second, Black and Hispanic students' positive attitudes may emerge with age as school becomes more challenging and students prove themselves equal to those challenges.

I differentiate between these possibilities using the case of mathematics self-competence, which I chose for two reasons. First, mathematics self-competence is consequential for the reproduction of racial/ethnic income inequality. Students with lower mathematics self-competence are less likely to declare a major in STEM (science, technology, engineering, and mathematics), the degrees with the highest lifetime earnings (Correll 2001; Kim, Tamborini, and Sakamoto 2015; Perez-Felkner, Nix, and Thomas 2017). Second, unlike other academic attitudes, prior research has identified the mechanism underlying Black and Hispanic students' high self-competence: the big-fish-little-pond effect. Black and Hispanic students are segregated into disadvantaged schools and judge their performance positively relative to that of their lower-achieving peers (Crosnoe 2009; Goldsmith 2004, 2011; Marsh 1987). However, children's experience of segregated schools changes with age in ways that could alter how they assess their performance. Racial discrimination by teachers intensifies, schools increasingly highlight performance differences using grades and ability grouping, and students become more aware of achievement and resource inequalities across schools (Benner and Graham 2011; Cimpian 2017; Eccles and Roeser 2009; Shedd 2015). Examining changes in the big-fish-little-pond effect with age may reveal that Black and Hispanic students' positive attitudes are unsustainable as they become conscious of the magnitude of educational inequalities.

Using third through eighth grade data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K), I answer two questions: (1) Do racial/ethnic differences in mathematics self-competence grow or shrink with age, both in the overall population and among students with identical achievement? (2) Is growing/shrinking inequality in self-competence among students with identical achievement associated with changes in the salience of peer comparisons? In other words, do segregated school environments become more/less consequential for students', parents', and teachers' perceptions of academic performance? Although my primary interest is racial/ethnic inequality, all analyses are intersectional by race/ethnicity and gender to account for significant gender disparities in mathematics self-competence (Correll 2001; Else-Quest, Hyde, and Linn 2010; Herbert and Stipek 2005; Jacobs et al. 2002; Marsh et al. 2005; Wigfield and Eccles 1994).

2.2 Background

2.2.1 The Development of Racial/Ethnic Differences in Mathematics Self-Competence

Education scholars have long debated the relationship between academic attitudes and racial/ethnic inequalities in opportunities and achievement. In the 1980s, Ogbu published a series of articles outlining oppositional culture theory. He argued that discrimination in schools stokes distrust and hostility in Black and Hispanic communities (Ogbu 1987). Furthermore, he claimed, these communities see labor market discrimination as so pervasive and intractable as to negate investments in education. Therefore, community members instill students with an "oppositional culture" that discourages scholastic achievement as a form of "acting White" (Fordham and Ogbu 1986). Ogbu (1987) concluded that the resulting low effort yields low achievement, making Black and Hispanic communities "more or less accomplices to their own school success or failure."

Multiple studies have since used cross-sectional, nationally representative survey data to disprove oppositional culture theory. Although Black and Hispanic children are more likely than White children to perceive structural barriers to their academic success (Matthew 2011), they also have similar or more positive attitudes towards their schools, their teachers, and their classes (Ainsworth-Darnell and Downey 1998; Ambriz 2020; Harris 2006; Mickelson 1990). Given that most research finds academic attitudes and achievement to be highly correlated (Denissen, Zarrett, and Eccles 2007; Marsh et al. 2005), Black and Hispanic students' positive attitudes stand in stark contrast with their low achievement. Therefore, education scholars dubbed this trend the attitude-achievement paradox.

The term "attitude-achievement paradox" inherently acknowledges that it may be difficult for Black and Hispanic students to develop and maintain positive academic attitudes. Black and Hispanic students are segregated by race, ethnicity, and socioeconomic status into high-poverty schools with fewer resources, less rigorous academic curricula, and, consequently, lower test scores (Long, Iatarola, and Conger 2009; Morton and Riegle-Crumb 2020; Owens 2018; Reardon 2016; Reardon, Fox, and Townsend 2015; Reardon, Robinson-Cimpian, and Weathers 2015; Rumberger and Palardy 2005). Furthermore, Black and Hispanic students are subject to teachers' racial/ethnic biases, including low expectations for academic performance, lower rates of promotion to advanced courses, and harsher grades and discipline (Downey and Pribesh 2004; Ferguson 2000; Harbatkin 2021; Lewis and Diamond 2015; Ochoa 2013; Owens and McLanahan 2020; Ready and Wright 2011; Skiba et al. 2011; Tenenbaum and Ruck 2007). Limited research explains whether and how Black and Hispanic students' attitudes remain positive with sustained exposure to extensive educational disadvantages.

I address this gap in the literature using the case of mathematics self-competence, or self-perceived mathematics ability. Mathematics self-competence is a psychological resource that motivates children to make the most of available educational opportunities. Children with higher mathematics self-competence earn higher mathematics grades and test scores (Marsh et al. 2005; Petersen and Hyde 2017; Stevens et al. 2004; Susperreguy et al. 2018). They are also more likely to enroll in higher-level mathematics courses, continue taking mathematics courses beyond the minimum requirement for high school graduation, and declare STEM majors (Correll 2001; Marsh and Yeung 1997; Nagy et al. 2008).

I examine the development of racial/ethnic differences in mathematics self-competence for two reasons. First, no studies using nationally representative data have set out to investigate racial/ethnic differences in mathematics self-competence, to my knowledge.[1] Describing these differences contributes to our understanding of how individual-level motivation aggregates to reproduce or mitigate inequalities in achievement and persistence in STEM. Second, longitudinal trends can point towards the process underlying the attitude-achievement paradox. Black and Hispanic students may enter school with high mathematics self-competence, but become

[1] Tables from studies on related topics (e.g., gender inequalities in mathematics self-competence, intersectional disparities in career aspirations) suggest that the attitude-achievement paradox extends to mathematics self-competence (Correll 2001; Riegle-Crumb et al. 2011).

discouraged as they face challenges at school. Alternately, high self-competence may emerge during the schooling years. This takes me to my first question:

> Do racial/ethnic differences in mathematics self-competence grow or shrink with age, both in the overall population and among students with identical achievement?

Although my primary interest is racial/ethnic inequality, all analyses intersect race/ethnicity with gender for two reasons. First, extensive research has identified significant gender disparities in both levels and trajectories of mathematics self-competence (Correll 2001; Else-Quest et al. 2010; Herbert and Stipek 2005; Jacobs et al. 2002; Marsh et al. 2005; Wigfield and Eccles 1994). Second, prior studies of STEM attitudes and experiences more broadly indicate that race/ethnicity and gender sometimes intersect in ways that advantage Black girls relative to White and Hispanic girls. For example, Black girls are more likely to desire a career in mathematics and declare STEM majors than White and Hispanic girls (Riegle-Crumb and King 2010; Riegle-Crumb, Moore, and Ramos-Wada 2011).

2.2.2 Explaining Racial/Ethnic Differences in Mathematics Self-Competence

The Big-Fish-Little-Pond Effect: If mathematics self-competence varies systematically by race/ethnicity among students with identical achievement, this suggests that differences in social context shape how students perceive their performance. Prior research shows that peer performance significantly influences self-assessments through the big-fish-little-pond effect (Marsh 1987; Thijs, Verkuyten, and Helmond 2010). A student has high self-competence when surrounded by lower-achieving peers (i.e., they feel like a big fish in a little pond). That same student has low self-competence when surrounded by higher-achieving peers (i.e., they feel like a little fish in a big pond).

In addition to influencing children directly, the big-fish-little-pond effect operates indirectly through parents and teachers. Parents and teachers also judge student performance relative to peer performance (Irizarry 2015; Lawrence 2015). These perceptions affect the way adults treat children. For example, if they perceive a child to have lower ability, teachers may call on them less or discourage them from taking a difficult class (Wong, Eccles, and Sameroff 2003). Parents, on the other hand, may provide unsolicited homework help more often (Bhanot and Jovanovic 2005). Through these interactions, children discern parents' and teachers' perceptions of their ability, which they incorporate into their self-competence (Bouchey and Harter 2005; Cherng 2017; Gunderson et al. 2012).

The big-fish-little-pond effect emerges in relation to not only peer achievement, but also peer demographic characteristics perceived to be associated with achievement, such as race, ethnicity, and socioeconomic status. For example, Black and Hispanic students have higher educational expectations and aspirations in majority Black and Hispanic schools compared to majority White schools (Goldsmith 2004). Similarly, parents with low socioeconomic status have higher educational expectations for their children in schools with more non-White students (Lawrence 2015). Low-income students are also more likely to have negative self-image in high-income schools compared to low-income schools (Crosnoe 2009).

Whether through peer achievement or peer demographic characteristics, the big-fish-little-pond effect generates systemic racial/ethnic differences in self-competence. Black and Hispanic students are segregated by race, ethnicity, and socioeconomic status into under-resourced schools, leaving them with lower achievement than White students, on average

(Reardon 2016; Reardon, Fox, et al. 2015; Reardon, Robinson-Cimpian, et al. 2015; Rumberger and Palardy 2005). But because they are surrounded by more peers who are Black, Hispanic, poor, and/or low-achieving, Black and Hispanic students have higher self-competence than White students with comparable achievement (Correll 2001; Marsh 1987).

Changes in the Big-Fish-Little-Pond Effect with Age: Prior research examining the effects of schools and neighborhoods on achievement and attainment has found that children's sensitivity to their environments varies by age (Alvarado 2016; Burke and Sass 2013; Langenkamp and Carbonaro 2018; Sharkey et al. 2014; Sorensen, Cook, and Dodge 2017; Wodtke, Harding, and Elwert 2016). However, there is no single age or developmental period when children are most sensitive to all aspects of their surroundings. Whether contextual effects are strongest in early childhood or adolescence depends on the underlying process linking a specific feature of the school or neighborhood to a given academic outcome. Because these studies have not examined academic attitudes, it is unclear when the big-fish-little-pond effect might be strongest.

On one hand, the big-fish-little-pond effect may magnify with age due to changes in either children's cognitive development or their schooling. Developmental psychologists have long found that children have high self-competence at younger ages and diminishing self-competence as they get older (Herbert and Stipek 2005; Jacobs et al. 2002; Wigfield and Eccles 1994). For years, researchers attributed this trend to children's increasingly sophisticated cognitive ability to assess their performance and compare it to that of their peers (Harter 2011). For example, they argued that older children were better able to conceptualize innate capacity, differentiate between their abilities across subjects, take on the perspectives of others, and internalize others' opinions (Marsh, Craven, and Debus 1998; Nicholls 1978; Spinath and

Spinath 2005). However, recent work suggests that assessment processes do not fundamentally change across developmental stages (Muradoglu and Cimpian 2020). Rather, some psychologists theorize that decreasing self-competence reflects changes in the nature of schooling (Cimpian 2017; Eccles and Roeser 2009). At younger ages, children are assessed based on attention and effort. However, as students get older, schools increasingly highlight performance differences and encourage competition between students, for example, by sorting students into ability-differentiated courses. Whether the underlying mechanism is cognitive or structural, both of these explanations for diminishing self-competence assume that social comparison increases with age, which could magnify the big-fish-little-pond effect.

Conversely, structural changes facilitating greater social comparison to students at other schools may diminish the big-fish-little-pond effect. Children begin annual, federally mandated standardized testing in third grade (107th Congress of the United States 2002; 114th Congress of the United States 2015; Koretz 2008, 2017). Score reports compare children's performance to both a fixed standard (e.g., unsatisfactory, proficient, advanced) and the performance of other test-takers state- or nation-wide (e.g., percentile) (Goertz and Duffy 2001; Koretz 2008). These scores may paint a different picture of academic performance than teacher-assigned grades, which are benchmarked or "curved" based on the performance of students in a particular class (Hübner et al. 2020; Marsh 1987; Neumann, Trautwein, and Nagy 2011; Trautwein, Lüdtke, Marsh, et al. 2006). Students may also become aware that achievement and resources differ at other schools through direct contact with students from those schools (Shedd 2015). For example, older children spend more time in extracurricular activities, which often bring together students from multiple schools for competitions or through non-school organizations (Hofferth and Sandberg 2001; White and Gager 2007). With repeated exposure, either standardized test reports or intergroup contact could diminish the big-fish-little-pond effect by decreasing the salience of school-level peers and increasing the salience of a wider group of students. If they judge their own academic performance against the same standard instead of the unique set of peers at their own (segregated) schools, children with similar achievement will have similar self-competence.

The big-fish-little-pond effect may also weaken with age as Black and Hispanic children perceive greater discrimination from their teachers (Benner and Graham 2011). In part, these perceptions may reflect older children's greater cognitive ability to detect and comprehend discrimination when it occurs (Brown 2006; Brown and Bigler 2005; Elenbaas et al. 2016; McKown and Weinstein 2003). But these cognitive developments are accompanied by an actual escalation in discrimination as Black and Hispanic children are increasingly "adultified," or presumed less young and innocent than White children of the same age (Epstein, Blake, and González 2017; Ferguson 2000; Fields 2005; Goff et al. 2014; Lewis and Diamond 2015; Ochoa 2013; Rios 2011). Children who perceive greater racial/ethnic discrimination from teachers have lower self-competence (Eccles, Wong, and Peck 2006; Wong et al. 2003). Therefore, the rise in perceived teacher discrimination may diminish the big-fish-little-pond effect.

This takes me to my second question:

> Is growing/shrinking inequality in self-competence among students with identical achievement associated with changes in the salience of peer comparisons? In other words, do segregated school environments become more/less consequential for students', parents', and teachers' perceptions of academic performance?

If racial/ethnic differences in mathematics self-competence among students with identical achievement grow with age, this may signal that the big-fish-little-pond effect becomes stronger during later stages of schooling or cognitive development. If racial/ethnic differences shrink, this may indicate that the big-fish-little-pond effect weakens with age.

Family Background: I hypothesize that changes in the big-fish-little-pond effect will account for longitudinal trends in mathematics self-competence, regardless of whether racial/ethnic differences grow or shrink. However, I also test an alternate explanation: changing effects of family background.

Black and Hispanic students may have higher mathematics self-competence than White students because they are more likely to come from low-income families or, for Hispanic students, immigrant families. Low-income families encourage identification with and persistence in STEM to maximize children's future earnings. As a result, students from low-income families have more positive attitudes towards STEM and are more likely to pursue STEM majors (Charles and Bradley 2009; Hanson 2009; Ma 2009). Immigrant families provide identity narratives that counteract negative domestic racial stereotypes pertaining to academic ability, making children less susceptible to stereotype threat (Owens and Lynch 2012).

If racial/ethnic differences in mathematics self-competence grow with age, this may signal that family effects magnify with age. Family effects may simply intensify with increased exposure. Black and Hispanic families may also focus more on bolstering children's mathematics self-competence as school becomes more competitive and consequential for college applications. If racial/ethnic differences in mathematics self-competence shrink with age, this may indicate that family counternarratives become less effective with increased exposure to a segregated and discriminatory school system.

2.3 Data & Methods

2.3.1 The Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K)

The Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K) is a nationally representative, longitudinal survey of over 21,000 kindergarteners enrolled in 1,277 schools during the 1998–99 school year. Samples were drawn using a three-stage design. The United States was divided into primary sampling units (PSUs) consisting of counties or groups of counties. One hundred PSUs were sampled. Schools with kindergarten programs were selected within the PSUs. Kindergarteners were then selected within each school.

Data from parents, teachers, and school administrators were collected in the fall and spring of the 1998–99 school year (kindergarten), the fall and spring of the 1999–2000 school year (first grade), spring 2002 (third grade), spring 2004 (fifth grade), and spring 2007 (eighth grade).[2] Direct cognitive assessments of children occurred in all waves *as part of the study*. Therefore, unlike standardized tests administered by schools in compliance with state and federal regulations, cognitive assessment scores were not shared with students, parents, teachers, or other school officials. Beginning in third grade, students were also surveyed to capture various aspects of academic self-perception. I use data from third, fifth, and eighth grades.

While other national data sets measure mathematics self-competence, the ECLS-K is ideal for examining racial/ethnic and gender differences in the development of mathematics self-competence in three ways. First, because self-competence becomes increasingly calcified in high

[2] I consider grade retention as a potential mediator in footnote 12.

school (Wigfield et al. 2015), data from elementary and middle school are necessary to capture the period of greatest change. Second, the ECLS-K captures a longer time period compared to alternative data sets. For example, the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011) only surveyed students directly from third grade to fifth grade. And third, at least three waves of data are needed to estimate multilevel growth curve models, the method I use to address my first question.

The ECLS-K shares the same limitation of other longitudinal, nationally representative data sets of elementary and middle school students: it does not include standardized test scores or transcript data. However, the cognitive assessments administered to participants as part of the ECLS-K include items adapted from commercially available standardized tests administered by schools to meet federal guidelines (National Center for Education Statistics n.d.). The cognitive assessments differ mainly in that they use students' earlier responses to adjust the difficulty level of later questions, which minimizes floor and ceiling effects. Therefore, the cognitive assessment scores calculated by researchers should be strongly correlated to the standardized test results that students actually see.

Because they are benchmarked against classmates' performance, grades are one of the signals of relative ability that generate the big-fish-little-pond effect (Trautwein, Lüdtke, Marsh, et al. 2006). In other words, grades are not a necessary control to identify the big-fish-little-pond effect, but they likely mediate the big-fish-little-pond effect. The mediators in my analyses encompass the reasons why grades may vary systematically by race, ethnicity, and gender independently of actual performance: teacher perceptions of ability, within-school segregation (captured by classmates' mathematics performance and racial/ethnic composition), and across-school segregation (school demographic and performance composition) (Irizarry 2015;

Kalogrides and Loeb 2013; Ready and Wright 2011). Therefore, these data are sufficient to identify changes in the big-fish-little-pond effect.

2.3.2 Analytic Sample

The analytic sample is based on three inclusion criteria. First, respondents must be members of racial/ethnic groups large enough to support an interaction with gender: non-Hispanic White, non-Hispanic Black, or Hispanic of any race. This excludes approximately 2,570 children of other races/ethnicities. Second, respondents must have participated in all of the final three waves of data collection (third, fifth, and eighth grade). This ensures that the sample sizes for the longitudinal (multilevel growth curve) models for question one match the sample sizes for the cross-sectional (mediation) models for question two. The majority of the approximately 11,030 children excluded by this criterion became ineligible for continued participation in the ECLS-K over the course of the study, usually because they moved out of participating schools. Over half of attrition occurred before third-grade data collection. Third, respondents must have non-missing values on the variables needed to estimate the multilevel growth curve models: mathematics self-competence, race/ethnicity, gender, age, and third grade cognitive assessment scores. This criterion excludes approximately 100 students. Therefore, the sample size for my analyses is approximately 23,120 person-waves for 7,710 students. Consistent with the data user agreement for the restricted ECLS-K data set, all sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.

2.3.3 Measures

Dependent Variable: My dependent variable is a time-varying mathematics self-competence index. Students were asked whether they agreed with a series of statements about themselves, with responses ranging from one, “not at all true,” to four, “very true.” For third and fifth grade, students were given four prompts from the Self Description Questionnaire I, which is designed for preadolescents: “Work in math is easy for me,” “I can do very difficult problems in math,” “I am good at math,” and “I get good grades in math” (Najarian, Pollack, and Sorongon 2009). For eighth grade, students were given two prompts from the Self Description Questionnaire II, which is designed for adolescents: “I get good grades in math” and “Math is one of my best subjects” (Najarian et al. 2009). The mathematics self-competence index for each grade is created by standardizing the average of a student’s non-missing responses.

Independent Variable: My independent variable combines race/ethnicity and gender into six categories: non-Hispanic White boys, non-Hispanic Black boys, Hispanic boys of any race, non-Hispanic White girls, non-Hispanic Black girls, and Hispanic girls of any race. To minimize the standard errors for my estimates, I use the largest group—White boys—as the reference category.

Time Variable: In the multilevel growth curve models, time is operationalized as exact age in years older than age nine, approximately the average age during third grade data collection. This centers the intercept at age nine, which is represented in the data, rather than age zero, which is not.

Controls: I control for cognitive assessment scores in mathematics and reading. I also include an interaction effect to capture how a child’s strength in mathematics relative to reading influences mathematics self-competence (Breda and Napp 2019; Wang, Eccles, and Kenny 2013). Scores are standardized to emphasize children's skill level relative to other children.

In third and fifth grade, cognitive assessments were administered after students answered survey questions measuring mathematics self-competence. In eighth grade, the cognitive assessments preceded these survey questions. During the years separating waves of data collection, both children's development and the content of their mathematics, reading, and language arts courses underwent significant changes (Adams and Hitch 1998; Council of Chief State School Officers and National Governors Association 2019; Geary 1994). Therefore, I do not lag cognitive assessment scores. Rather, I assume students' skills in mathematics and reading were set prior to survey administration, when they reported their self-competence.

Mediators: I test a series of mediators measured in third and eighth grade to investigate whether contextual influences on mathematics self-competence change with age. As with the cognitive assessment scores, I do not lag the mediators due to the long gaps between waves. Given that data were collected in the spring of each school year, for most students, same-wave data reflect classroom and school environments they had been exposed to for many months prior to reporting their mathematics self-competence.

If racial/ethnic differences in mathematics self-competence are generated by the big-fish-little-pond effect, these disparities will be mediated by peers' mathematics performance, peers' demographic composition, and parents' and teachers' perceptions of ability. In third grade, classroom-level mathematics performance is operationalized as two continuous variables: the percent of classmates below grade level and the percent above grade level. In eighth grade, classroom-level performance was no longer measured due to widespread ability grouping (variable described below). School-level (third grade) and grade-level (eighth grade) peer mathematics performance are represented by the percent of students who scored at or above grade level in standardized mathematics tests.

Peer racial/ethnic composition was measured at both the classroom and school levels, with two variables at each level: the percent of students who were Black and the percent who were Hispanic. All variables are continuous except for the eighth-grade school-level variables, which each consist of five categories: less than 1% Black/Hispanic, 1% to less than 5%, 5% to less than 10%, 10% to less than 25%, and 25% or more.

Peer socioeconomic composition was measured at the school level as the percent of students eligible for free lunches in the National School Lunch Program.

Parent perceptions of student ability were measured in third grade only. Parents[3] reported whether they thought their child was performing worse, about the same, a little better, or much better in mathematics than the child's classmates.

Teacher perceptions of student ability are operationalized as the average of how they rated the child on a series of grade-appropriate mathematics skills on a scale from one (not yet) to five (proficient).

Teachers also communicate their perceptions of children's performance via grades and recommendations for course placement. The ECLS-K did not collect school transcripts. However, in eighth grade, parents reported whether their child received mostly A's; mostly B's; or mostly C's, D's, or F's. Similarly, teachers described ability grouping for eighth grade

[3] Over 80% of the adults completing the parent surveys in the third, fifth, and eighth grade waves were mothers (Tourangeau et al. 2004, 2006, 2009). Eight to nine percent were fathers. The remaining parent surveys were completed by other adults, usually grandparents.

mathematics classes in terms of three categories: "Instruction for students performing below grade level in mathematics," "Regular," or "Honors, Enrichment, or Gifted & Talented."

Whereas in third grade, students tend to learn most subjects from a single instructor, in eighth grade, many students move between classes taught by subject specialists. In third grade, each student's regular classroom teacher answered a questionnaire. In eighth grade, students were randomly assigned to have subject-specific teacher questionnaires completed in either mathematics or science. Therefore, only half of students have eighth grade data for classroom racial/ethnic composition, teacher perceptions of mathematics skills, and ability group.

If racial/ethnic disparities in mathematics self-competence originate from differences in family background rather than the big-fish-little-pond effect, significant mediation will be associated with household socioeconomic status (SES) and/or immigration status. Household SES is operationalized as a standardized measure combining mothers' and fathers' education, occupation, and income. Parental immigration status is captured by a dichotomous indicator identifying children with at least one parent born outside of the United States.

2.3.4 Multilevel Growth Curve Models

I use multilevel growth curve models (*mixed* in Stata) to describe racial/ethnic and gender differences in trajectories of mathematics self-competence from third to eighth grade, without and with controlling for cognitive assessment scores (Hoffman 2015).[4] Multilevel growth curve models allow the researcher to estimate differences in average trajectory shape across groups while incorporating within-group heterogeneity in trajectory shape into the model.

[4] Although the ECLS-K data set includes weights, multilevel modeling commands cannot incorporate the complex survey design variables associated with these weights. Therefore, I present unweighted results.

As multilevel growth curve models are limited to time-invariant independent variables (Hoffman 2015), I control for third grade cognitive assessment scores.[5] Children's mathematics and reading performance relative to that of other students is fairly stable between third and eighth grade. Intraclass correlations at the child level show that 83% of the variance in standardized mathematics scores and 78% of the variance in standardized reading scores is across persons (i.e., only 17% and 22% of the total variance, respectively, is the result of changes within children over time). These models do not specify the causal relationship between cognitive assessment scores and self-competence. They simply describe how racial/ethnic and gender gaps in mathematics self-competence change over time before and after accounting for cognitive assessment scores.

The multilevel growth curve models nest person-waves (Level 1) within children (Level 2).[6] The Level 1 equation predicts mathematics self-competence Y_{ti} for person *i* who is *t* years older than age nine as follows:

$$Y_{ti} = \beta_{0i} + \beta_{1i}t + e_{ti} \tag{1}$$

In equation (1), β_{0i} represents a child's predicted mathematics self-competence when $t = 0$, i.e., at age nine. β_{1i} is a child-specific slope for how their mathematics self-competence changes with

[5] Time-varying variables have three sources of variation: average between-person differences in levels, average within-person change over time, and individual-level deviations at each time point (i.e., error). However, there are only two places for independent variables to enter a multilevel growth curve model. If included, coefficients for time-varying independent variables are uninterpretable because they represent a weighted blend of multiple effects (Hoffman 2015).

[6] Although I considered the inclusion of crossed effects that account for time-varying nesting of children in classrooms and schools, I use a two-level model because there is little teacher- or school-level variance in mathematics self-competence relative to child-level variance. Models that include teacher- or school-level error terms do not converge.

age.[7] e_{ti} is a residual term capturing the deviation between a child's observed mathematics self-competence and the self-competence predicted by that child's intercept and slope.

The Level 2 equation for the intercept coefficient predicts a child's mathematics self-competence at age nine as follows:

$$\beta_{0i} = \gamma_{00} + \sum \gamma_{0j} W_{ji} + u_{0i} \tag{2}$$

In equation (2), j indexes the time-invariant independent and control variables: the combined race/ethnicity/gender variable and the third-grade cognitive assessment score variables. γ_{0j} represents the effect of the j^{th} predictor on the intercept. u_{0i} captures the remaining difference between each child's actual intercept and the intercept predicted by the fixed portion of the model.

The Level 2 equation for the slope coefficient predicts how mathematics self-competence changes with age as follows:

$$\beta_{1i} = \gamma_{10} + \sum \gamma_{1j} W_{ji} + u_{1i} \tag{3}$$

In equation (3), γ_{1j} represents the effect of the j^{th} predictor on the slope. u_{1i} captures the emaining difference between each child's actual slope and the slope predicted by the fixed portion of the model. I assume that u_{0i} and u_{1i} have means of zero but make no assumptions about their variances or covariance, which are distinctly estimated by the model.

For ease of interpretation, I show figures of fixed effects predictions calculated by setting standardized cognitive assessment scores to zero.

2.3.5 Natural Effect Models

[7] I cannot formally test for non-linear functional forms with only three time points. However, Figure A.1 in the Appendix shows that the raw means are close to the trajectories predicted by the model. Therefore, linearity is a reasonable approximation.

I conduct separate cross-sectional mediation analyses for third and eighth grade using natural effect models (*medflex* in R) (Lange et al. 2017; Steen et al. 2017). These models identify mediators that account for racial/ethnic (and gender) differences in mathematics self-competence, net of cognitive assessment scores. If racial/ethnic differences in self-competence are generated by the big-fish-little-pond effect, they will be mediated by peer performance, peer demographic composition, and/or parents' and teachers' perceptions of mathematics performance. If racial/ethnic disparities stem from differences in family background, they will be mediated by household SES and/or parental immigration status.

The models are cross-sectional to allow the process shaping mathematics self-competence to differ between third grade and eighth grade. I use natural effect models because—unlike other cross-sectional mediation models—they can accommodate categorical mediators (Steen et al. 2017).[8]

Let Y represent mathematics self-competence, X represent the combined race/ethnicity/gender variable, M represent a given mediator, and C represent the vector of controls (including age, for consistency with the multilevel growth curve models). For each child i with $X_i = x$, we observe a single outcome: $Y_i(x, M_i(x))$. The natural effect model imputes five additional outcomes, one corresponding to each unobserved combination of race/ethnicity/gender x^*, holding the mediator and all control variables constant. For example, for a Hispanic boy, the natural effect model imputes outcomes $Y_i(x^*, M_i(x))$ for counterfactuals where the child is a White boy, Black boy, White girl, Black girl, or Hispanic girl. This allows me to partition the total difference in mathematics self-competence between children of a given race/ethnicity/gender and White boys (the reference group) into two components. The first, the

[8] Like other cross-sectional mediation commands, *medflex* cannot incorporate complex survey design for generalized linear model estimation. Therefore, I present unweighted results.

natural indirect effect, is the portion that is attributable to differences in the level of the mediator: $Y_i\big(x, M_i(x)\big) - Y_i\big(x, M_i(x^*)\big)$. The second, the natural direct effect, is the remainder, which is independent of the mediator: $Y_i\big(x, M_i(x)\big) - Y_i\big(x^*, M_i(x)\big)$. Mediation is significant when the natural indirect effect is significant based on bootstrapped standard errors. For ease of interpretation, I present figures depicting the natural indirect effect and the natural direct effect in terms of percentages.

2.4 Results

2.4.1 Descriptive Statistics

Table 2.1 presents descriptive statistics for the independent variable, dependent variable, controls, and mediators in third grade, both for the overall sample and separately by race/ethnicity and gender. For all controls and mediators, differences across the combined race/ethnicity/gender variable are significant at the .001 level.

The racial/ethnic and gender composition of the sample is 35% non-Hispanic White boys (approximately 2,700 respondents), 6% non-Hispanic Black boys (420), 10% Hispanic boys of any race (730), 35% non-Hispanic White girls (2,690), 6% non-Hispanic Black girls (440), and 9% Hispanic girls of any race (720).

Boys have higher standardized mathematics self-competence than girls. Black boys have slightly higher self-competence than White and Hispanic boys, and Black girls have higher self-competence than White and Hispanic girls.

Standardized cognitive assessment scores are highest for White students, followed by Hispanic students and then Black students. Girls have lower mathematics scores and higher reading scores than boys of the same race/ethnicity.

Differences in peer performance and demographic composition reflect racial/ethnic segregation. Compared to White students, Black and Hispanic students have more peers performing below grade level and fewer peers performing at or above grade level. The average Black student's peers are over 50% Black, compared to less than 10% Black for the average White or Hispanic student. Similarly, the average Hispanic student's peers are approximately 50% Hispanic, versus less than 10% Hispanic for the average White or Black student. The average Black or Hispanic student attends a school where over half of the students qualify for free lunches from the National School Lunch Program, more than twice the proportion of the average White student's school.

Parent and teacher perceptions of mathematics performance vary by students' race/ethnicity. Whereas White and Hispanic parents are more likely to rate their sons (rather than their daughters) as much better at mathematics than their classmates, Black parents are slightly more likely to rate their daughters (rather than their sons) as much better at mathematics. Teachers rate White students as having the highest mathematics performance, followed by Hispanic students and then Black students. Gender differences in teacher-rated mathematics performance among students of the same race/ethnicity are relatively small.

Family background differs significantly by race/ethnicity. The average Black or Hispanic student's household SES is four-tenths of a standard deviation or more below the mean, whereas the average White student's household SES is a quarter of a standard deviation above the mean. Less than 10% of White and Black students have at least one immigrant parent, compared to two-thirds of Hispanic students.

Table 2.2 presents descriptive statistics for eighth grade. For all variables, differences across the combined race/ethnicity/gender variable are significant at the .001 level. Racial/ethnic differences in mathematics self-competence are greater in eighth grade than third grade. Furthermore, patterns of racial/ethnic inequality differ. Among eighth-graders of the same gender, White children have the highest mathematics self-competence, followed by Black children and then Hispanic children. Although boys have higher mathematics self-competence than girls of the same race/ethnicity, gender gaps are narrower for White and Hispanic students compared to third grade.

With regards to the control variables and mediators, racial/ethnic inequalities in teacher ratings of ability are wider compared to third grade despite generally stable disparities in cognitive assessment scores. Teacher-rated mathematics performance is now gendered, such that teachers see girls as better at mathematics than boys of the same race/ethnicity. White eighth-graders have the highest rate of enrollment in honors, enrichment, or gifted and talented mathematics classes, followed by Hispanic students and then Black students. White girls are the most likely to be A-students, followed by White boys, then Hispanic girls, then Black girls, and finally Black and Hispanic boys. Otherwise, patterns of inequality are similar to those in third grade.

2.4.2 Racial/Ethnic and Gender Differences in Mathematics Self-Competence

Table 2.3 presents multilevel growth curve models predicting standardized mathematics self-competence. Model A predicts mathematics self-competence based on race/ethnicity and gender only. Figure 2.1A displays predicted trajectories of average mathematics self-competence by race/ethnicity and gender based on Model A.

At age nine, average mathematics self-competence for boys of all races/ethnicities is higher than average self-competence for girls of all races/ethnicities. There are no significant racial/ethnic differences among boys. Black girls have significantly higher average mathematics self-competence than White and Hispanic girls.

Mathematics self-competence decreases with age for all groups. This pattern is consistent with prior studies finding that mathematics self-competence declines with age for both boys and girls (Herbert and Stipek 2005; Jacobs et al. 2002; Wigfield and Eccles 1994). By intersecting race/ethnicity with gender, I show that Hispanic boys' self-competence declines more sharply than White boys', and Black and Hispanic girls' self-competence drops more steeply than White girls'. By age 14, White students have higher self-competence than Black and Hispanic students of the same gender, although the difference between Black boys and White boys is not significant.[9]

To gauge the substantive significance of differences in mathematics self-competence across groups, consider the largest disparity in mathematics self-competence at age 14, which is between White boys and Hispanic girls. A prior study using data from the Panel Study of Income Dynamics found that mathematics self-competence at ages 11-14 is positively associated with mathematics achievement at ages 16-18 (Susperreguy et al. 2018). Based on those estimates, White boys' .47 standard deviations higher mathematics self-competence at age 14 could translate into .09 standard deviations higher mathematics achievement in high school. This would be sizeable in relation to the Hispanic-White achievement gap in mathematics, which a previous study using ECLS-K data found to be .44 standard deviations in eighth grade (Reardon, Robinson-Cimpian, et al. 2015).

Model B in Table 2.3 adds the control variables: standardized cognitive assessment scores in mathematics and reading and their interaction. Higher mathematics scores are

[9] Analyses with the intercept at age 14 instead of age 9 are available from the author upon request. Results for slope coefficients are identical.

associated with higher mathematics self-competence at age nine and less dramatic declines in self-competence with age. In contrast, higher reading scores are associated with lower mathematics self-competence at age nine. However, the interaction effect indicates that the negative effects of above-average reading scores are smaller for individuals with above-average math scores. These results are consistent with the internal/external frame of reference model: students assess their mathematics abilities in part by comparing their mathematics performance to their performance in other subjects (Breda and Napp 2019; Marsh 1986; Marsh et al. 2014; Wang et al. 2013).

If differences in self-competence by race/ethnicity and gender are purely a reflection of differences in individual-level cognitive assessment scores, the race/ethnicity and gender variable should not have significant effects on the coefficients for the intercept or the slope. This is clearly not the case. However, patterns of racial/ethnic and gender inequality over time differ from Model A.

Figure 2.1B displays predicted trajectories of average mathematics self-competence by race/ethnicity and gender based on Model B. I calculated these trajectories by setting standardized cognitive assessment scores to zero. Unlike in Model A, mathematics self-competence differs by race/ethnicity among nine-year-old boys. Among boys with identical cognitive assessment scores, Black boys have the highest mathematics self-competence, followed by Hispanic boys and then White boys. As in Model A, Black girls have higher mathematics self-competence than White and Hispanic girls at age nine. However, accounting for Black girls' lower cognitive assessment scores shows that Black girls have higher mathematics self-competence than White boys.

The patterns of racial/ethnic differences at age 14 differ from Model A as well. Notably, White and Hispanic boys and Black and White girls are clustered together. In other words, although self-competence at younger ages is racialized and gendered, by age 14, students with identical cognitive assessment scores perceive their own mathematics abilities similarly regardless of race/ethnicity or gender. However, Black boys have significantly higher self-competence than all other groups and Hispanic girls have significantly lower self-competence than all other groups, net of differences in cognitive assessment scores. Mathematics self-competence continues to be racialized and gendered for Black boys and Hispanic girls at age 14.

2.4.3 Mediators of Racial/Ethnic and Gender Differences in Mathematics Self-Competence

Third Grade: Each column of Figure 2.2 represents a separate natural effect model decomposing racial/ethnic and gender differences in mathematics self-competence in third grade (age nine in Figure 2.1B) into two components: the portion that is explained by a given mediator (the indirect effect) and the remainder (the direct effect). These models identify racial/ethnic inequalities in social contexts that lead students with identical cognitive assessment scores to judge that performance differently. The mediators correspond to two possible explanations: school segregation (i.e., the big-fish-little-pond effect) and family background. All models control for standardized cognitive assessment scores in mathematics and reading, the interaction between mathematics and reading scores, and age. Consistent with the multilevel growth curve models, White boys serve as the reference group.

Model B in Table 2.3 indicates that Hispanic boys have significantly higher mathematics self-competence than White boys at age nine. However, this total difference is so small that in the models for classroom peers' mathematics performance and immigrant parentage, both indirect and direct effects for Hispanic boys are not significant. Therefore, I focus on the results for the other groups.

Black boys and girls have significantly higher mathematics self-competence than White boys. In Figure 2.2, the total observed difference in self-competence between one of these groups and White boys corresponds to 100%. Hispanic girls and White girls have significantly lower mathematics self-competence than White boys. The total observed difference in self-competence between one of these groups and White boys is represented by -100%.

Significant mediation can occur in one of two directions. On one hand, inequalities in social contexts may explain a significant proportion of the observed difference in mathematics self-competence between a given group and White boys, as indicated by the dark gray bars. On the other hand, inequalities in social contexts may compensate for other forces driving differences in mathematics self-competence. The black bars illustrate how much greater than observed differences in mathematics self-competence between a given group and White boys would be if both sets of students were in similar school or family environments.

For Black boys, Black girls, and Hispanic girls, mediation is significant for all of the big-fish-little-pond effect variables except for classroom peers' mathematics performance. Black third graders have higher observed mathematics self-competence than White boys with identical cognitive assessment scores in part because they are segregated into schools with more Black, Hispanic, poor, and/or low-achieving peers. Black students, their parents, and their teachers judge their performance positively relative to the low actual performance or perceived ability of their peers. When combined into a single model, the significant peer composition and parent and teacher perception variables explain 48.7% of the observed difference between Black boys and

White boys and 100.0% of the observed difference between Black girls and White boys (not shown in Figure 2.2; analyses available from the author upon request).

Segregation into schools with peers who are more likely to be Black, Hispanic, poor, and/or performing below grade level—as well as positive parent and teacher perceptions, relative to their cognitive assessment scores—also increases self-competence for Hispanic girls. However, Hispanic girls have lower observed mathematics self-competence than White boys with identical cognitive assessment scores. This difference in self-competence would be 47.3% greater than observed in the absence of the big-fish-little-pond effect (as captured by all significant mediators combined).[10]

Mediation is not significant for household SES and parental immigration status. In other words, although racial/ethnic differences in family background are significant, they do not explain racial/ethnic differences in mathematics self-competence.[11]

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[10] Prior research has found that same-race teachers are associated with significantly higher achievement, persistence, aspirations, and expectations, although effects are sometimes small (Atkins, Fertig, and Wilkins 2014; Egalite, Kisida, and Winters 2015; Gershenson et al. 2017; Harbatkin 2021; Price 2010). In sensitivity analyses testing for teacher-student race match effects (available from author upon request), Hispanic girls' greater likelihood of having Hispanic teachers is associated with higher mathematics self-competence in third grade. In the absence of this race matching effect, the difference in mathematics self-competence between Hispanic girls and White boys would be 26.9% greater than observed. Mediation analyses identify no other significant teacher-student race match effects in third or eighth grades. For comparison, effect sizes for Hispanic girls are larger for most of the significant big-fish-little-pond effect variables in third grade.

[11] To explore the extent to which sample restrictions impacted the results, I reran the third grade mediation models to include respondents who participated in the study in third grade but not fifth and/or eighth grades ($n \approx 12{,}450$; analyses available from the author upon request). Results differ for household SES, which is a significant mediator for Black boys, Black girls, and Hispanic girls. Household SES explains 5.8% of the observed difference between Black boys and White boys and 14.9% of the observed difference between Black girls and White boys. In the absence of socioeconomic inequalities, the difference between Hispanic girls and White boys would be 7.4% greater than observed. These results are consistent with low-income Black and Hispanic families promoting high mathematics self-competence and persistence in STEM to maximize children's future earnings. However, the effect sizes for household SES are small relative to the big-fish-little-pond effect.

For White girls, the only significant mediator is parents' perceptions of mathematics performance. White parents' tendency to rate girls' mathematics performance as lower than boys' partially explains White girls' low mathematics self-competence.[12]

Eighth Grade: Each column of Figure 2.3 represents a separate natural effect model decomposing differences in mathematics self-competence between Black boys and White boys with identical cognitive assessment scores in eighth grade (age 14 in Figure 2.1B). Black girls, White girls, and Hispanic boys are excluded from the figure because both the growth curve model and the natural effect models identify no significant differences in mathematics self-competence between these groups and White boys in eighth grade. In other words, for these groups, self-competence is entirely explained by differences in cognitive assessment scores in eighth grade; how they perceive their academic performance does not vary across school or family environments. Recall that, in Figure 2.1B, Hispanic girls have significantly lower mathematics self-competence than White boys with identical cognitive assessment scores at age 14. However, this total difference is so small that in the natural effect model for classroom racial/ethnic composition, neither the indirect effect nor the direct effect for Hispanic girls is significant. Therefore, I focus on the results for Black boys, the greatest outlier at age 14 in Figure 2.1B.

[12] Grade retention also explains gender differences in mathematics self-competence (analyses available from the author upon request). Girls are less likely than boys to be left behind at least one grade, controlling for cognitive assessment scores. Girls with low scores who are promoted to the next grade may have diminished self-competence because they compare themselves to more advanced students. This accounts for 5.5% of the observed difference between White girls and boys and 23.0% of the observed difference between Hispanic girls and White boys. Furthermore, without disproportionate grade promotion dampening Black girls' mathematics self-competence, the difference between Black girls and White boys would be 12.4% greater than observed. These results are consistent with prior work showing that grade retention can benefit self-competence (Lamote et al. 2014).

Socioeconomic segregation is a marginally significant mediator. It explains 9.1% of the difference in mathematics self-competence between Black and White boys with identical cognitive assessment scores. Mediation is not significant for any of the other big-fish-little-pond effect or family background variables.[13]

2.5 Discussion

This study investigated (1) whether racial/ethnic differences in mathematics self-competence grow or shrink with age and (2) whether growing/shrinking inequality reflects segregated school environments' increasing/decreasing influence on ability perceptions. I found that Black and Hispanic third graders have higher mathematics self-competence compared to White third graders with identical test scores. This advantage disappears by eighth grade for Black girls and Hispanic children. Because they have lower test scores than White children, on average, this leaves them with lower mathematics self-competence overall. Racial/ethnic differences in peer composition and parent and teacher perceptions of ability—rather than family background—account for Black and Hispanic students' relatively high mathematics self-competence in third grade.

Together, these results support two general conclusions. First, the attitude-achievement paradox disappears with age for Black girls and Hispanic children. Second, this disappearance is

[13] Prior research has found that racial/ethnic segregation declines during the transition to middle school, when some school districts combine students from multiple, smaller elementary schools into a single middle school (Fiel and Zhang 2018). I conducted decompositions (Gupta 1993; Preston, Heuveline, and Guillot 2001) to test the possibility that decreased segregation (*exposure*)—as opposed to decreased *sensitivity* to peer composition—explains changes in mathematics self-competence between third and eighth grades (available from author upon request). Each model decomposes changes in mathematics self-competence for a given racial/ethnic and gender group into the proportion attributable to changes in exposure (based on the percent of the school that is Black, Hispanic, eligible for free lunches, or at or above grade level in standardized mathematics tests) and the proportion attributable to changes in sensitivity. In each model, changing levels of segregation account for only 0.002%–4.0% of changes in mathematics self-competence between third and eighth grades. These results are consistent with students relying less on comparisons to peers to assess their own mathematics ability with age.

the result of students' mathematics self-competence normalizing to achievement. In third grade, students, teachers, and parents evaluate students' mathematics ability relative to that of their peers, based on either actual performance or perceived ability as a function of race/ethnicity and socioeconomic status. Racial/ethnic segregation concentrates Black and Hispanic children in schools with more students who are Black, Hispanic, poor, and/or performing below grade level in mathematics. Compared to White students with identical test scores, Black and Hispanic students assess their own mathematics performance more highly and receive more positive feedback from parents and teachers. In other words, they feel like big fish in little ponds. But as they get older, students' assessment of their own performance becomes less dependent on peers' actual or perceived achievement. Rather, most students with the same test scores have similar self-competence, with the exception of Black boys.

These results suggest that the negative consequences of segregation magnify as children get older. At younger ages, segregation has opposite effects on achievement and self-competence for Black and Hispanic children. On one hand, prior studies have found that concentrated disadvantage depresses their achievement (Owens 2018; Reardon 2016; Rumberger and Palardy 2005). On the other hand, I posit that isolation gives children an incomplete view of the educational landscape. Black and Hispanic students have high self-competence because they do not know how disadvantaged they are relative to White children. As they age, Black and Hispanic children's exposure to discrimination and resource inequalities increases (Benner and Graham 2011; Shedd 2015). Black girls' and Hispanic students' self-competence then adjusts to limitations placed on their achievement, leaving them with both low achievement and low self-competence.

The process of inequality reproduction I am proposing contrasts with oppositional culture theory, which asserts that Black and Hispanic communities contribute to the achievement gap by instilling negative academic attitudes in children (Fordham and Ogbu 1986; Ogbu 1987). Conversely, I find that Black and Hispanic children have equally high self-competence as White children at younger ages. Educational disadvantages produce low achievement, which Black girls and Hispanic students gradually internalize as low self-competence. Prior studies show that children with such low opinions of their own mathematics abilities are less motivated to work hard in school and make ambitious educational choices (Correll 2001; Marsh et al. 2005; Marsh and Yeung 1997; Nagy et al. 2008; Petersen and Hyde 2017; Susperreguy et al. 2018). Therefore, the internalization of achievement inequality has the potential to perpetuate the cycle of racial/ethnic inequality in education.

Future studies should examine why Black boys are outliers with persistently high self-competence. Prior research has found that poor Black boys have higher aspirations than poor White boys; the steady march of racial progress gives them hope for brighter futures than previous generations (MacLeod 2009). This optimism may extend to other academic attitudes. Another possibility is that Black boys do not trust negative signals of ability handed down by the same teachers and school administrators who subject them to disproportionate discipline (Gregory, Skiba, and Noguera 2010; Morris and Perry 2017). Such an explanation would be consistent with previous work demonstrating that Black students' positive academic attitudes coexist with greater perceived barriers to success (Matthew 2011). Unfortunately, the ECLS-K does not include measures that can pinpoint the mechanisms bolstering Black boys' self-competence.

Similarly, the ECLS-K cannot identify why the big-fish-little-pond effect weakens for other groups. There are two possibilities. First, comparisons to students from other schools may become salient, for example, through standardized test reports or direct interaction (Goertz and Duffy 2001; Hofferth and Sandberg 2001; Koretz 2008; Shedd 2015). If so, children who previously benchmarked their mathematics performance against unique reference groups (i.e., their own, segregated schools) may adopt similar standards. Second, Black girls and Hispanic students may decreasingly feel like big fish in little ponds because teachers increasingly "adultify" and discriminate against them as they age (Epstein et al. 2017; Ferguson 2000; Fields 2005; Goff et al. 2014; Lewis and Diamond 2015; Ochoa 2013; Rios 2011). To tease apart these options, future research should collect more detailed data on how children evaluate their own academic performance.

The present study points toward both the potential and the challenges of school desegregation with respect to promoting racial/ethnic equity in STEM. Under the current regime of segregation, Black girls and Hispanic students have lower self-competence than White eighth-graders overall but similar self-competence to White eighth-graders with identical test scores. This suggests that once the achievement gap completely closes, there may be few racial/ethnic differences in mathematics self-competence in the overall population. However, while the gap is still narrowing, younger Black and Hispanic students would no longer benefit from the big-fish-little-pond effect. Their self-competence might fall before their achievement has had time to improve. This diminished motivation could slow progress in closing the achievement gap. Therefore, desegregation policies should include programs that bolster Black and Hispanic children's self-competence while the achievement gap is still narrowing.

Table 2.1: Descriptive Statistics for Third Grade, by Gender and Race/Ethnicity (n ≈ 7,710 students)

				Boys						Girls					
	Total			White		Black		Hispanic		White		Black		Hispanic	
	Mean	SD	n	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Race/Ethnicity and Gender															
White boys	.35														
Black boys	.06														
Hispanic boys	.10														
White girls	.35														
Black girls	.06														
Hispanic girls	.09														
Dependent Variable															
Standardized mathematics self-competence	.20	(.90)	7,710	.35	(.87)	.39	(.89)	.33	(.83)	.04	(.89)	.19	(.97)	.05	(.91)
Control Variables															
Standardized Cognitive Assessment Scores															
Mathematics	.12	(.97)	7,710	.45	(.92)	-.49	(.91)	-.16	(.96)	.21	(.88)	-.66	(.84)	-.32	(.91)
Reading	.13	(.98)	7,710	.27	(.93)	-.55	(.93)	-.43	(.96)	.42	(.88)	-.40	(.87)	-.22	(.99)
Mediators															
Peer Composition															
Mathematics performance															
Classroom															
% below grade level	.18	(.15)	6,350	.17	(.13)	.24	(.18)	.24	(.20)	.16	(.12)	.24	(.19)	.24	(.19)
% above grade level	.21	(.17)	6,270	.22	(.17)	.18	(.18)	.20	(.18)	.22	(.17)	.17	(.16)	.19	(.18)
All elementary students															
% at or above grade level	.68	(.21)	4,910	.72	(.19)	.57	(.23)	.58	(.24)	.73	(.18)	.56	(.24)	.58	(.23)
Demographics															
Classroom															
% Black	.12	(.23)	6,320	.07	(.13)	.57	(.36)	.08	(.14)	.06	(.13)	.58	(.36)	.10	(.17)
% Hispanic	.13	(.24)	6,320	.05	(.11)	.07	(.13)	.51	(.38)	.06	(.11)	.08	(.15)	.46	(.38)
School															
% Black	.13	(.23)	6,320	.07	(.12)	.58	(.35)	.08	(.13)	.06	(.11)	.59	(.34)	.09	(.15)
% Hispanic	.14	(.25)	6,320	.06	(.10)	.07	(.12)	.51	(.35)	.06	(.11)	.08	(.15)	.49	(.35)
% free lunch eligible	.35	(.28)	6,090	.24	(.19)	.57	(.29)	.55	(.31)	.24	(.19)	.61	(.29)	.55	(.30)
Others' Perceptions of Mathematics Performance															
Parent			7,180												
Worse than classmates	.08			.07		.09		.07		.09		.07		.08	
About the same	.28			.26		.26		.22		.32		.27		.28	
A little better	.29			.29		.29		.29		.29		.26		.31	
Much better	.35			.39		.37		.42		.30		.40		.33	
Teacher (Scale: 1-5)	3.15	(.72)	6,370	3.20	(.73)	2.96	(.73)	3.07	(.75)	3.17	(.70)	2.98	(.72)	3.12	(.73)
Family Background															
SES	.06	(.80)	7,220	.27	(.75)	-.41	(.72)	-.43	(.73)	.25	(.73)	-.47	(.75)	-.45	(.70)
1+ immigrant parents	.18		7,680	.07		.09		.66		.07		.08		.64	
Total	7,710			2,700		420		730		2,690		440		720	

Note: All differences by race/ethnicity and gender are significant at p<0.001 (chi-square tests for parent's perception of ability, grade retention, and parental immigration status; one-way ANOVA for all other variables). Means of standardized variables in the total column are not zero because the variables were standardized before students who were not White, Black, or Hispanic were dropped from the sample. Consistent with the data user agreement for the restricted ECLS-K data set, all unweighted sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Table 2.2: Descriptive Statistics for Eighth Grade, by Gender and Race/Ethnicity (n ≈ 7,710 students)

				Boys						Girls					
	Total			White		Black		Hispanic		White		Black		Hispanic	
	Mean	SD	n	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Dependent Variable															
Standardized mathematics self-competence	-.22	(1.10)	7,710	-.10	(1.09)	-.17	(1.07)	-.35	(1.09)	-.18	(1.08)	-.41	(1.15)	-.54	(1.15)
Control Variables															
Standardized Cognitive Assessment Scores															
Mathematics	.02	(.97)	7,690	.29	(.87)	-.68	(1.03)	-.23	(1.02)	.17	(.84)	-.76	(1.01)	-.36	(1.03)
Reading	.03	(.98)	7,640	.19	(.88)	-.81	(1.09)	-.48	(1.09)	.34	(.78)	-.56	(1.01)	-.32	(1.04)
Mediators															
Peer Composition															
Mathematics performance															
All 8th graders															
% at or above grade level	.65	(.23)	5,550	.70	(.21)	.56	(.23)	.53	(.25)	.69	(.22)	.55	(.23)	.53	(.25)
Demographics															
Classroom															
% Black	.13	(.23)	3,510	.07	(.14)	.51	(.35)	.10	(.16)	.07	(.13)	.55	(.36)	.10	(.17)
% Hispanic	.14	(.24)	3,520	.06	(.12)	.13	(.19)	.48	(.34)	.06	(.12)	.11	(.17)	.46	(.35)
School															
% Black			6,930												
[0%, 1%)	.07			.07		.01		.07		.08		.01		.08	
[1%, 5%)	.49			.56		.03		.42		.57		.04		.43	
[5%, 10%)	.14			.14		.04		.21		.14		.06		.18	
[10%, 25%)	.15			.14		.23		.17		.13		.20		.15	
[25%, 100%]	.16			.09		.69		.13		.09		.69		.17	
% Hispanic			6,940												
[0%, 1%)	.08			.08		.17		<.01		.09		.12		.02	
[1%, 5%)	.45			.55		.33		.10		.55		.36		.11	
[5%, 10%)	.14			.16		.14		.06		.15		.15		.07	
[10%, 25%)	.16			.15		.21		.20		.15		.20		.14	
[25%, 100%]	.18			.06		.16		.65		.07		.18		.66	
% free lunch eligible	.34	(.25)	6,290	.25	(.19)	.53	(.27)	.48	(.27)	.26	(.18)	.52	(.27)	.49	(.28)
Others' Perceptions of Mathematics Performance															
Teacher (Scale: 1-5)	3.09	(.93)	3,650	3.14	(.90)	2.64	(.92)	2.76	(.99)	3.26	(.88)	2.82	(1.01)	2.96	(.96)
Ability group			3,620												
Remedial	.10			.08		.18		.16		.07		.14		.15	
Regular	.63			.62		.70		.66		.63		.68		.64	
Honors, enrichment, or gifted & talented	.27			.30		.13		.18		.31		.18		.21	
Grades			6,790												
Mostly A's	.49			.48		.25		.29		.64		.33		.42	
Mostly B's	.37			.37		.48		.46		.30		.45		.43	
Mostly C's, D's, or F's	.14			.15		.27		.25		.07		.22		.15	
Family Background															
SES	.01	(.80)	7,000	.22	(.73)	-.42	(.71)	-.47	(.75)	.19	(.74)	-.47	(.76)	-.49	(.73)
1+ immigrant parents	.18		7,680	.07		.09		.66		.07		.08		.64	
Total	7,710			2,700		420		730		2,690		440		720	

Note: All differences by race/ethnicity and gender are significant at p<0.001 (chi-square tests for school racial composition, grade retention, ability grouping, grades, and parental immigration status; one-way ANOVA for all other variables). Means of standardized variables in the total column are not zero because the variables were standardized before students who were not White, Black, or Hispanic were dropped from the sample. Consistent with the data user agreement for the restricted ECLS-K data set, all unweighted sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.

Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

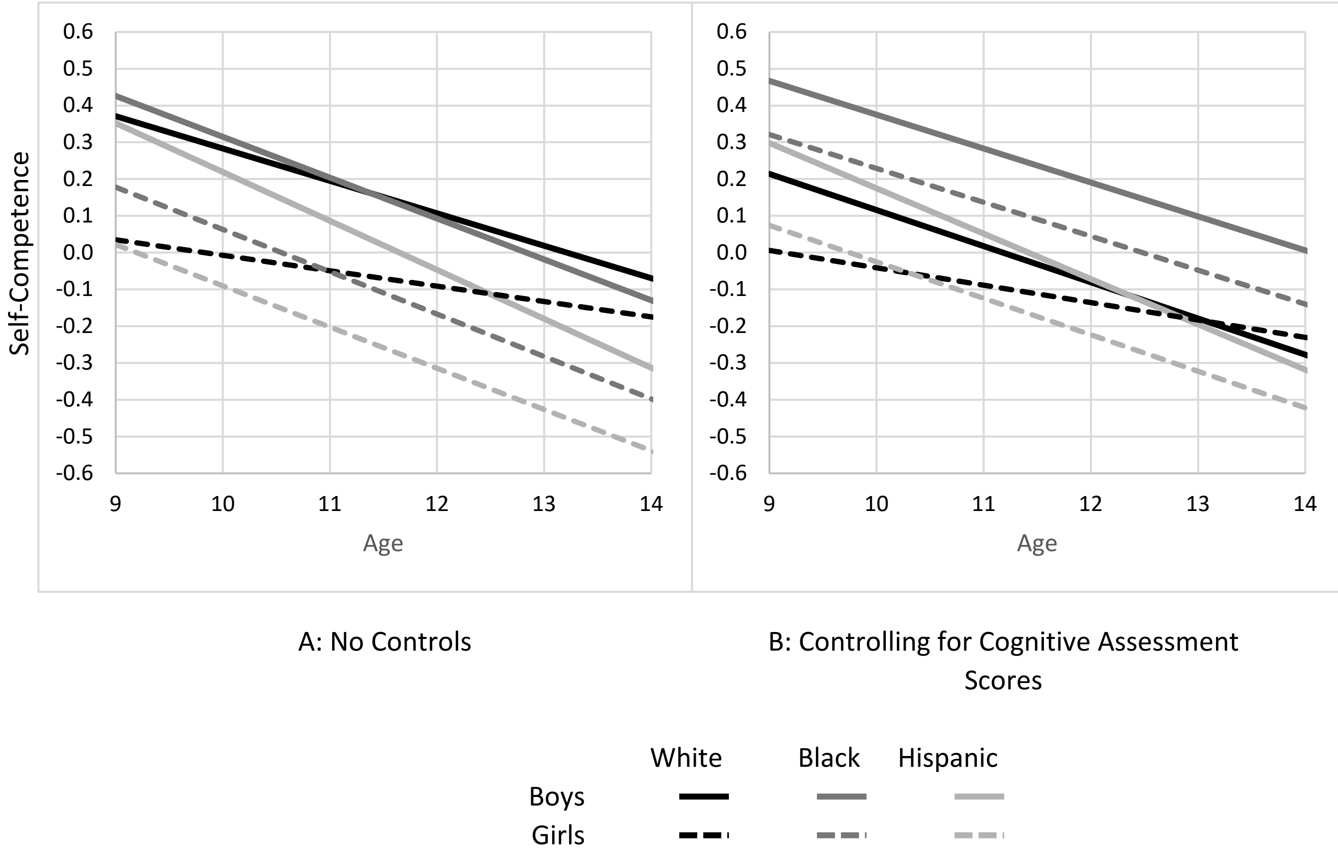
Table 2.3: Multilevel Growth Curve Models Predicting Standardized Mathematics Self-Competence in Grades 3-8 (n ≈ 23,120 person-waves for 7,710 students)

	A: Race/ethnicity and gender only	B: With cognitive assessment scores
	b/se	b/se
Coefficients predicting age 9 level (intercept)		
Constant	.37 **	.19 **
	(.02)	(.02)
Race/ethnicity and gender (ref: White boys)		
Black boys	.06	.25 **
	(.05)	(.05)
Hispanic boys	-.02	.08 *
	(.04)	(.04)
White girls	-.34 **	-.21 **
	(.02)	(.02)
Black girls	-.19 **	.11 *
	(.05)	(.04)
Hispanic girls	-.35 **	-.14 **
	(.04)	(.04)
Standardized cognitive assessment scores		
Mathematics		.39 **
		(.02)
Reading		-.19 **
		(.02)
Mathematics x reading		.08 **
		(.01)
Coefficients predicting slope		
Constant	-.09 **	-.10 **
	(.01)	(.01)
Race/ethnicity and gender (ref: White boys)		
Black boys	-.02 †	.01
	(.01)	(.01)
Hispanic boys	-.05 **	-.03 *
	(.01)	(.01)
White girls	.05 **	.05 **
	(.01)	(.01)
Black girls	-.03 *	.01
	(.01)	(.01)
Hispanic girls	-.02 *	.00
	(.01)	(.01)
Standardized cognitive assessment scores		
Mathematics		.03 **
		(.00)
Reading		.00
		(.00)
Mathematics x reading		.00
		(.00)
Variance components		
$\ln(sd(u_{0i}))$	-1.90 **	-1.91 **
	(.03)	(.03)
$\ln(sd(u_{1i}))$	-.50 **	-.62 **
	(.02)	(.02)
$atanh(corr(U_{0i},U_{1i}))$	-.30 **	-.44 **
	(.03)	(.03)
$\ln(sd(e_{ti}))$	-.37 **	-.37 **
	(.01)	(.01)
chi2	1,269	3,451
p	.00	.00
LL	-30,621	-29,686
AIC	61,273	59,415
BIC	61,402	59,592

Note: † p<0.10, * p<0.05, ** p<0.01. Consistent with the data user agreement for the restricted ECLS-K data set, all unweighted sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.

Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Figure 2.1: Fixed Effects Predictions of Standardized Mathematics Self-Competence by Age, Race/Ethnicity, and Gender

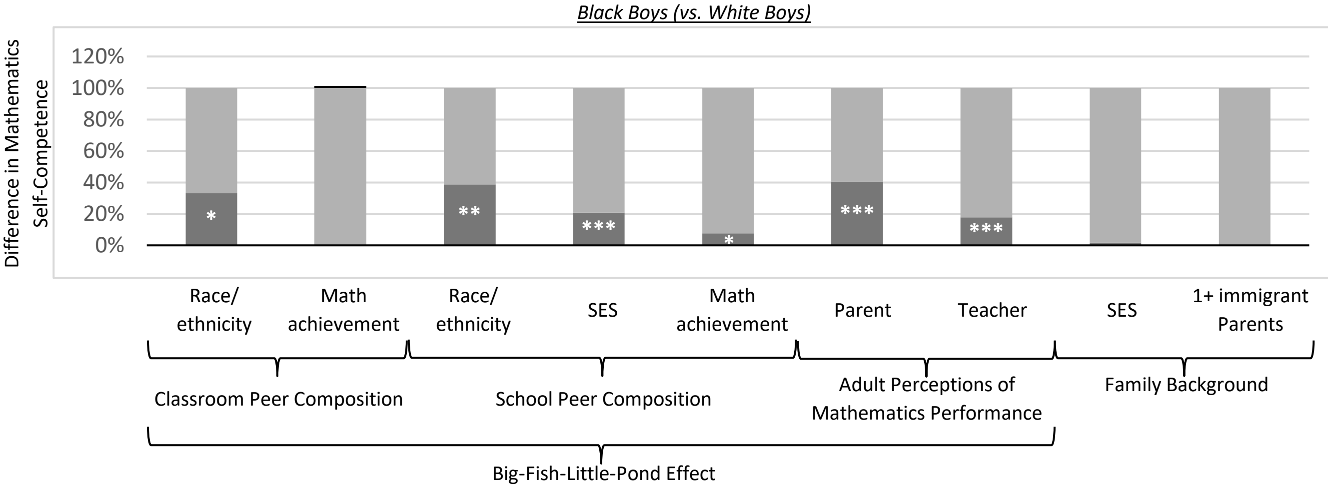


Note: Standardized cognitive assessment scores are set to zero.

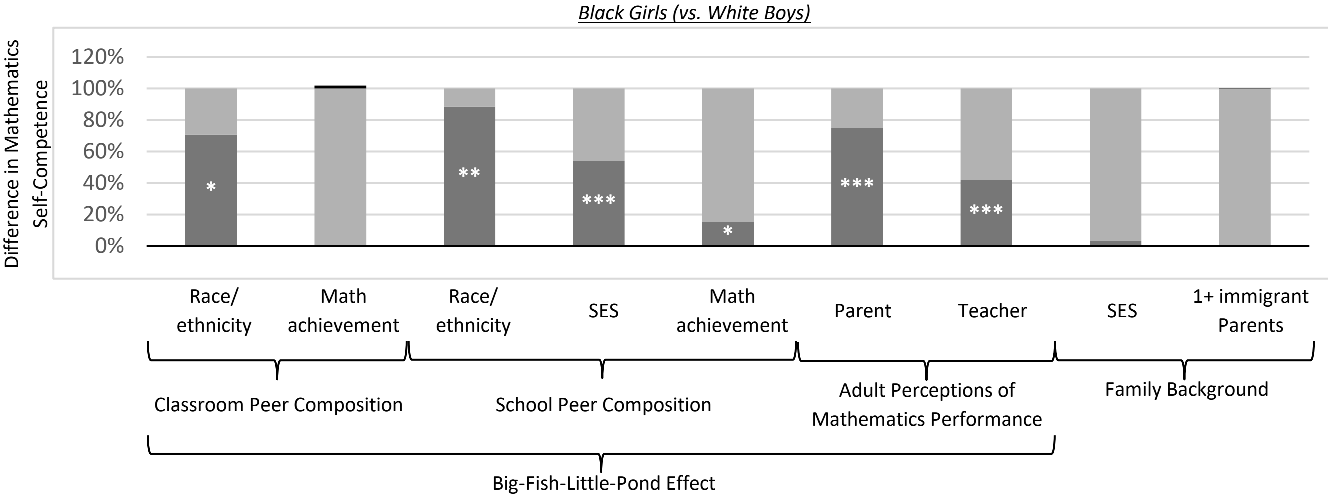
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Figure 2.2: Mediation Models Explaining the Difference in Mathematics Self-Competence between White Boys and Other Groups in Third Grade

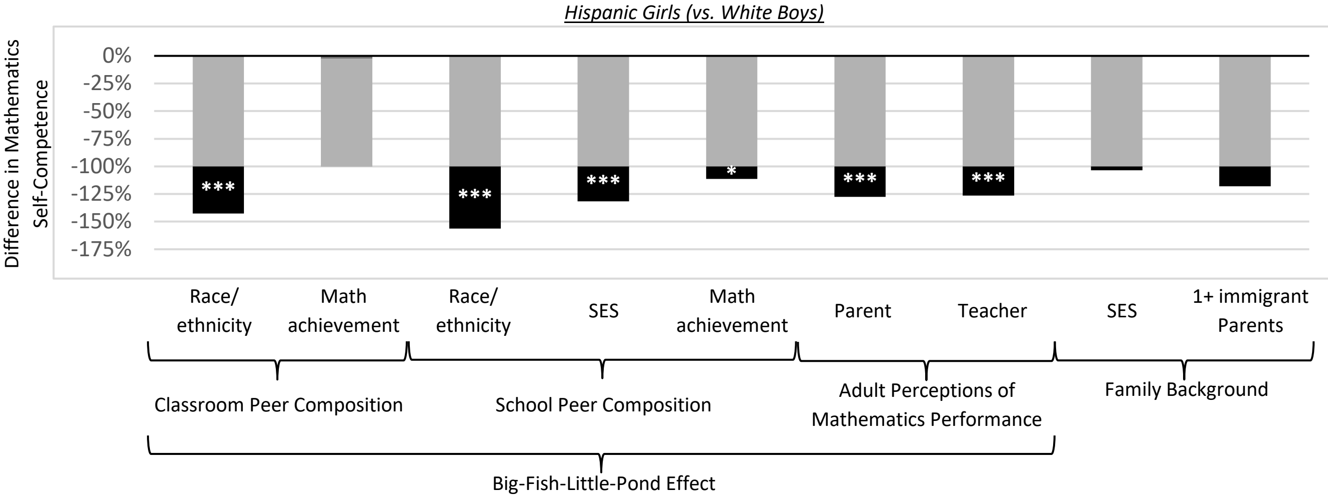
Black Boys (vs. White Boys)



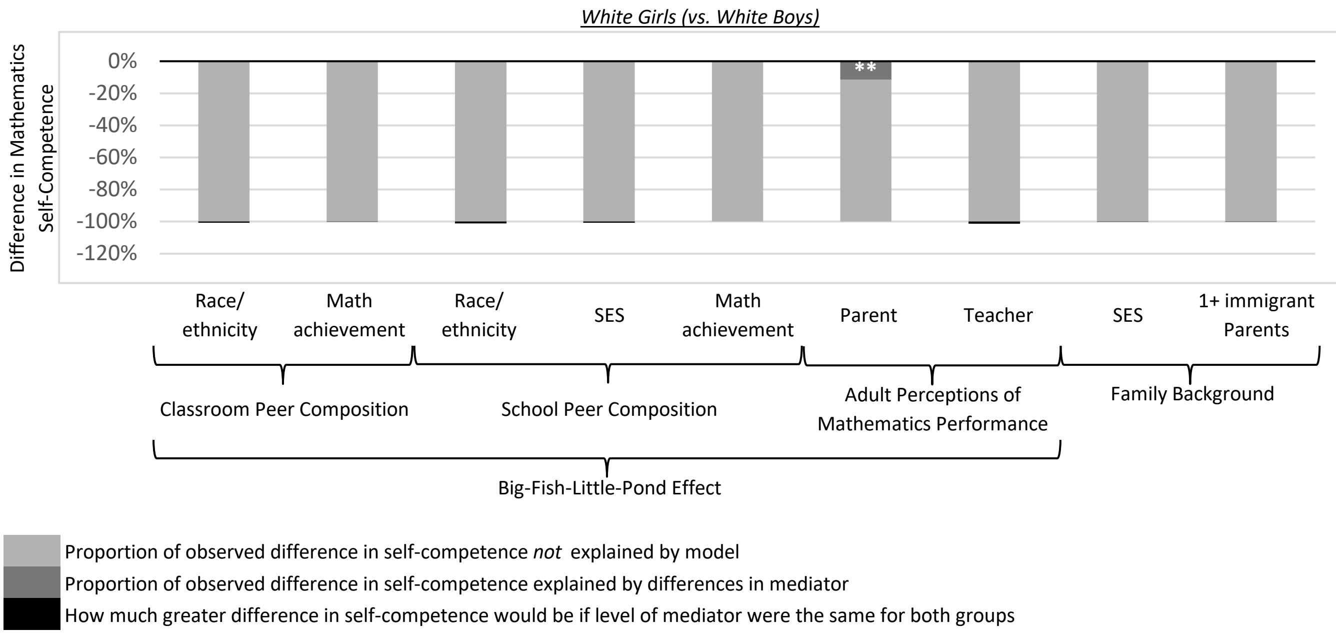
Black Girls (vs. White Boys)



Hispanic Girls (vs. White Boys)



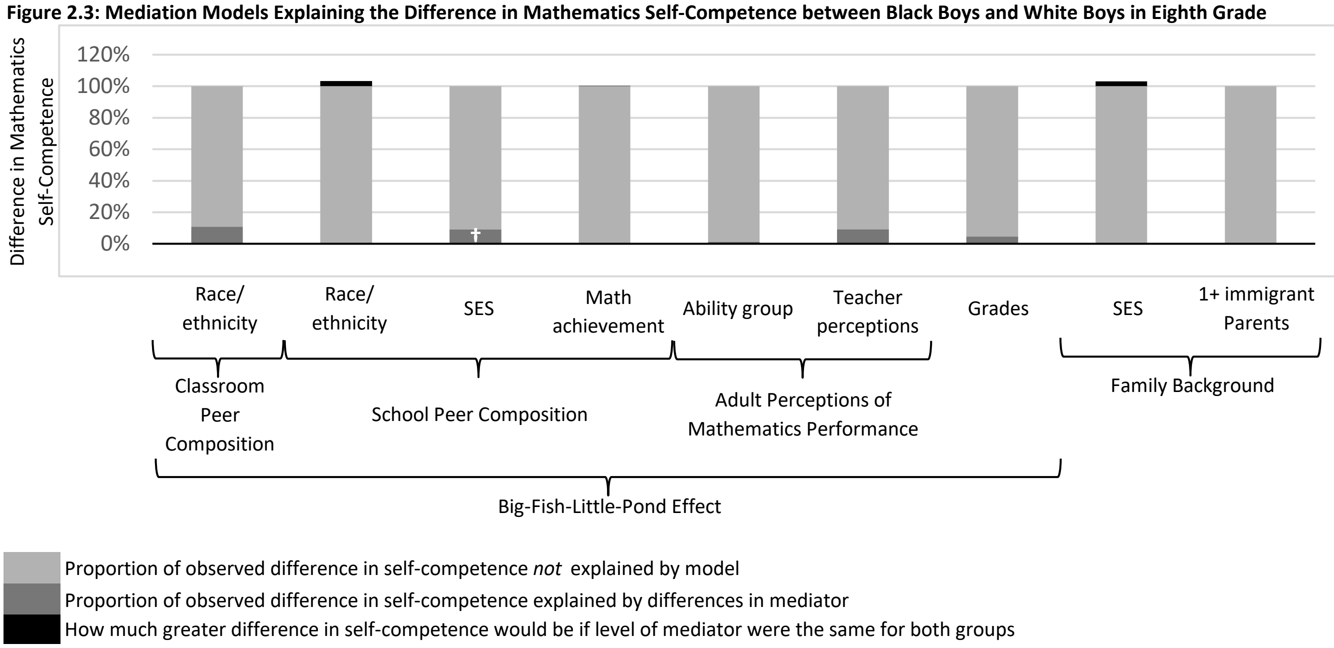
(continued on next page)



Note: † p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Each column represents a separate natural effect model controlling for standardized cognitive assessment scores in mathematics and reading, their interaction, and age.

Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Figure 2.3: Mediation Models Explaining the Difference in Mathematics Self-Competence between Black Boys and White Boys in Eighth Grade



Note: † p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Each column represents a separate natural effect model controlling for standardized cognitive assessment scores in mathematics and reading, their interaction, and age.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Chapter 3

I'm Not Good at Math, but I Still Like It:

Racial/Ethnic Differences in Mathematics Interest and Self-Competence

Abstract

A recent study found that racial/ethnic disparities in mathematics self-competence (i.e., self-assessed mathematics ability) grow with age as self-competence normalizes to achievement, leaving Black and Hispanic students with lower self-competence than White students. Scholars have not examined whether attitudes that are less sensitive to achievement, such as mathematics interest, remain high as Black and Hispanic students' mathematics self-competence declines. Using third through eighth grade data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99, I answer two questions: (1) How does mathematics interest develop relative to mathematics self-competence for students of different races/ethnicities, both in the overall population and among students with identical achievement? (2) Why does the relationship between mathematics interest and mathematics self-competence differ by race/ethnicity in eighth grade? I find that Black and Hispanic students' mathematics interest remains high as their mathematics self-competence falls. Hispanic eighth-graders have high interest and low self-competence in part due to their families' low socioeconomic status, which may increase interest in lucrative fields such as STEM (science, technology, engineering, and mathematics). These findings suggest that some of Black and Hispanic students' attitudes

towards STEM remain positive despite low average achievement. These positive attitudes have the potential to mitigate racial/ethnic inequalities in STEM by motivating persistence.

Key words: race and ethnicity, STEM, attitude-achievement paradox

3.1 Introduction

Studies using cross-sectional survey data have long found an attitude-achievement paradox: Black and Hispanic students have similar or more positive academic attitudes than White students despite having lower achievement (Ainsworth-Darnell and Downey 1998; Ambriz 2020; Diamond and Huguley 2014; Harris 2006; Matthew 2011; Mickelson 1990). These positive attitudes mitigate achievement and attainment inequalities by motivating Black and Hispanic students to make the most of limited opportunities (Ainsworth-Darnell and Downey 1998; Goldsmith 2004; Merolla 2013).

Chapter 2 examined longitudinal trends in mathematics self-competence (i.e., self-assessed mathematics ability) to determine how Black and Hispanic students' positive attitudes develop with age. Instead, she found that Black girls' and Hispanic students' mathematics self-competence falls to match their low achievement. To my knowledge, no studies have investigated racial/ethnic differences in the development of other academic attitudes. It is possible that attitudes less sensitive to achievement remain high among Black and Hispanic students.

The present study addresses this possibility by investigating racial/ethnic differences in the development of the two components of a child's mathematics self-concept, or their perception of themselves as a mathematics student: self-competence and interest. Existing research has established that these components are distinct in their relationship to achievement:

mathematics self-competence is both more dependent on prior achievement and more consequential for future achievement (Arens et al. 2011; Marsh et al. 2005; Petersen and Hyde 2017; Pinxten et al. 2014; Stevens et al. 2004; Susperreguy et al. 2018). In contrast, interest plays a greater role in effort and course selection (Nagy et al. 2008; Pinxten et al. 2014; Safavian and Conley 2016; Trautwein, Lüdtke, Kastens, et al. 2006). The first half of this study investigates whether Black and Hispanic students retain high mathematics interest relative to their declining mathematics self-competence.

If Black and Hispanic students' interest remains high as their self-competence decreases, this would suggest that their interest and self-competence become less tightly linked with age. Such a trend would represent a departure from prior work using majority White samples, which found that interest and self-competence become more correlated with age (Denissen et al. 2007; Wigfield et al. 1997). Therefore, the second half of this study examines four factors that may protect Black and Hispanic students' mathematics interest while their mathematics self-competence falls: family demographic characteristics, limited opportunities to explore alternate interests, school characteristics, and racial socialization.

The present study uses third through eighth grade data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K) to answer two questions: (1) How does mathematics interest develop relative to mathematics self-competence for students of different races/ethnicities, both in the overall population and among students with identical achievement? (2) Why does the relationship between mathematics interest and mathematics self-competence differ by race/ethnicity in eighth grade? Although my primary interest is racial/ethnic inequality, all analyses are intersectional by race/ethnicity and gender to account for significant gender disparities in mathematics interest and self-competence (Ganley and Lubienski

2016; Jacobs et al. 2002; Pinxten et al. 2014). I conclude by discussing the implications of my findings for racial/ethnic inequality in STEM (science, technology, engineering, and mathematics) education.

3.2 Background

3.2.1 The Development of Racial/Ethnic Differences in Mathematics Interest and Self-Competence

Children's mathematics self-concept (i.e., their perception of themselves as a mathematics student) has two components: interest and self-competence, or self-assessed ability (Arens et al. 2011; Pinxten et al. 2014). These constructs are correlated but distinct (Arens et al. 2011; Pinxten et al. 2014). Self-competence is more closely tied to achievement: it is heavily influenced by prior achievement and motivates future achievement (Arens et al. 2011; Marsh et al. 2005; Petersen and Hyde 2017; Pinxten et al. 2014; Stevens et al. 2004; Susperreguy et al. 2018). Interest plays a greater role in determining the courses students choose to take and the amount of effort they put into those courses (Nagy et al. 2008; Pinxten et al. 2014; Safavian and Conley 2016; Trautwein, Lüdtke, Kastens, et al. 2006). Both interest and self-competence change significantly during childhood but become stable during adolescence (Frenzel et al. 2012; Wigfield et al. 2015).

Limited research has examined racial/ethnic differences in mathematics interest and self-competence. Chapter 2 found that Black and Hispanic students have similar or higher mathematics self-competence compared to White students in third grade. However, as they get older, self-competence normalizes to achievement for most children, with the exception of Black boys. Because Black girls and Hispanic children have lower achievement than White students, on average, their self-competence declines more steeply. By the end of eighth grade, they have significantly lower self-competence than White students of the same gender.

No studies using nationally representative data have set out to investigate racial/ethnic differences in mathematics interest, to my knowledge.[14] Because interest is less sensitive than self-competence to achievement (Arens et al. 2011; Marsh et al. 2005; Pinxten et al. 2014), Black and Hispanic students may retain high interest as their self-competence declines. This takes me to my first question:

> How does mathematics interest develop relative to mathematics self-competence for students of different races/ethnicities, both in the overall population and among students with identical achievement?

Although I focus primarily on racial/ethnic inequality, all analyses intersect race/ethnicity with gender for two reasons. First, extensive research has found that boys have more positive mathematics attitudes than girls, with some studies showing that this gender gap diminishes with age (Catsambis 1994; Ganley and Lubienski 2016; Jacobs et al. 2002; Pinxten et al. 2014). Second, prior studies of STEM attitudes and experiences more broadly indicate that race/ethnicity and gender sometimes intersect in ways that advantage Black girls relative to White and Hispanic girls. For example, Black girls are more likely to desire a career in mathematics and declare STEM majors than White and Hispanic girls (Riegle-Crumb and King 2010; Riegle-Crumb et al. 2011).

[14] Tables from cross-sectional studies on related topics (e.g., intersectional disparities in career aspirations, gender differences in mathematics attitudes) suggest that Black and Hispanic students have higher mathematics interest than White students (Catsambis 1994; Riegle-Crumb et al. 2011).

3.2.2 Explaining Racial/Ethnic Differences in Mathematics Interest and Self-Competence

If Black and Hispanic students' mathematics interest remains high as their mathematics self-competence falls, this would suggest that their interest and self-competence become less correlated as they grow older. Such a trend would represent a departure from prior studies using majority White samples, which found that interest and self-competence became more correlated with age (Denissen et al. 2007; Wigfield et al. 1997). This takes me to my second question:

> Why does the relationship between mathematics interest and mathematics self-competence differ by race/ethnicity in eighth grade?

I explore four features of Black and Hispanic students' home and school environments that may lead their interest to stay persistently high. To be clear, I do not hypothesize that changes in home and school environments induce changes in mathematics interest. Rather, I hypothesize that Black and Hispanic students' home and/or school environments maintain their relatively high interest while their self-competence falls, leading to a change in the relationship between interest and self-competence.

First, Black and Hispanic families are more likely than White families to possess demographic characteristics associated with encouraging children in STEM. Black and Hispanic families are more likely to be poor (Shrider et al. 2021). Low-income parents may encourage children's STEM interests to maximize their earning potential (Charles et al. 2014; Charles and Bradley 2009; Hanson 2009; Ma 2009). Hispanic parents are also more likely to be immigrants (U.S. Census Bureau 2020). Immigrant parents may impart a more positive image of STEM than native-born parents because STEM is not derided as “nerdy” in many non-U.S. contexts (Charles et al. 2014; Händel et al. 2014).

Second, Black and Hispanic children may sustain high mathematics interest because, compared to White children, they have fewer opportunities to explore alternative interests, whether at home or through extracurricular activities (Bottia et al. 2018).

Third, Black and Hispanic children are segregated into under-resourced schools (Reardon 2016; Rumberger and Palardy 2005). These schools may represent another environment in which college and career advice tailored to low-income students and/or lack of opportunity to explore alternate interests bolster mathematics interest.[15]

Finally, the vast majority of Black and Hispanic families engage in two key forms of racial socialization: cultural socialization, which instills racial knowledge and pride, and preparation for bias (Harris-Britt et al. 2007; Hughes 2003; Hughes and Chen 1997). Racial socialization protects Black and Hispanic children’s self-esteem and academic self-competence (Banerjee, Byrd, and Rowley 2018; Harris-Britt et al. 2007; Wang et al. 2020). Its benefits may extend to mathematics interest as well. Although the ECLS-K does not include questions on preparation for bias, cultural socialization was measured in kindergarten (Brown et al. 2007) and tends to remain stable throughout elementary and middle school (Hughes and Chen 1997).

3.3 Data & Methods

3.3.1 The Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K)

[15] There is limited evidence that teacher-student race-matching in segregated schools reinforces Black and Hispanic students’ mathematics interest. Scholars have found that Black teachers increase Black students’ persistence in STEM courses (Klopfenstein 2005; Price 2010). However, the only study that has investigated the effect of teacher-student race-matching on academic attitudes directly found that same-race teachers do not increase interest in or enjoyment of coursework, although they benefit other academic attitudes (Egalite and Kisida 2018). In sensitivity analyses (available from author upon request), teacher-student race-matching does not explain racial/ethnic differences in the relationship between mathematics interest and mathematics self-competence in eighth grade.

The Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K) is a nationally representative, longitudinal survey of over 21,000 kindergarteners enrolled in 1,277 schools during the 1998–99 school year. Samples were drawn using a three-stage design. The United States was divided into primary sampling units (PSUs) consisting of counties or groups of counties. One hundred PSUs were sampled. Schools with kindergarten programs were selected within the PSUs. Kindergarteners were then selected within each school.

Data from parents, teachers, and school administrators were collected in the fall and spring of the 1998–99 school year (kindergarten), the fall and spring of the 1999–2000 school year (first grade), spring 2002 (third grade), spring 2004 (fifth grade), and spring 2007 (eighth grade). Direct cognitive assessments of children occurred in all waves. Beginning in third grade, students were also surveyed to capture various aspects of academic self-perception. I use data from third, fifth, and eighth grades.

While other national data sets measure mathematics interest and self-competence, the ECLS-K is ideal for examining the development of mathematics interest and self-competence in three ways. First, because self-competence becomes increasingly calcified in high school (Wigfield et al. 2015), data from elementary and middle school are necessary to capture the period of greatest change. Second, the ECLS-K captures a longer time period compared to alternative data sets. For example, the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011) only surveyed students directly from third grade to fifth grade. And third, at least three waves of data are needed to estimate multilevel growth curve models, the method I use to trace the development of mathematics interest and self-competence.

3.3.2 Analytic Sample

The analytic sample is based on three inclusion criteria. First, respondents must be members of racial/ethnic groups large enough to support an interaction with gender: non-Hispanic White, non-Hispanic Black, or Hispanic of any race. This excludes approximately 2,570 children of other races/ethnicities. Second, respondents must have participated in all of the final three waves of data collection (third, fifth, and eighth grades). This ensures that the sample sizes for the longitudinal (multilevel growth curve) models match the sample sizes for the cross-sectional (mediation) models. The majority of the approximately 11,030 children excluded by this criterion became ineligible for continued participation in the ECLS-K over the course of the study, usually because they moved out of participating schools. Over half of attrition occurred before third-grade data collection. Third, respondents must have non-missing values on the variables needed to estimate the multilevel growth curve models. This criterion excludes approximately 110 students. Therefore, the sample size for my analyses is approximately 23,100 person-waves for 7,700 students. Consistent with the data user agreement for the restricted ECLS-K data set, all sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.

3.3.3 Measures

Dependent Variables: My first two dependent variables are time-varying indices for mathematics interest and mathematics self-competence. Students were asked whether they agreed with a series of statements about themselves, with responses ranging from one, "not at all true," to four, "very true." The indices for each grade are created by standardizing the average of a student's non-missing responses.

For third and fifth grade, students were given prompts from the Self Description Questionnaire I, which is designed for preadolescents (Najarian et al. 2009). For eighth grade, students were given prompts from the Self Description Questionnaire II, which is designed for adolescents. Statements assessing interest included “I like math” and “I enjoy doing work in math.” Items measuring self-competence included “Work in math is easy for me” and “I get good grades in math.”

My third dependent variable is the difference between the first two dependent variables, calculated by subtracting standardized mathematics self-competence from standardized mathematics interest.

Independent Variable: My independent variable combines race/ethnicity and gender into six categories: non-Hispanic White boys, non-Hispanic Black boys, Hispanic boys of any race, non-Hispanic White girls, non-Hispanic Black girls, and Hispanic girls of any race. I use White boys as the reference category for two reasons. First, this minimizes the standard errors for my estimates, as White boys are the largest group. Second, as the group whose attitudes undergo the least change, White boys provide the most stable baseline for comparison.

Time Variable: In the multilevel growth curve models, time is operationalized as exact age in years older than age nine, approximately the average age during third grade data collection. This centers the intercept at age nine, which is represented in the data, rather than age zero, which is not.

Controls: I control for cognitive assessment scores in mathematics and reading, as well as an interaction effect to capture how a child’s strength in mathematics relative to reading influences their mathematics attitudes (Breda and Napp 2019; Wang, Eccles, and Kenny 2013). Scores are standardized to emphasize children's skill level relative to other children.

In third and fifth grade, cognitive assessments were administered after students answered survey questions measuring their mathematics attitudes. In eighth grade, the cognitive assessments preceded these survey questions. During the years separating waves of data collection, both children's development and the content of their mathematics, reading, and language arts courses underwent significant changes (Adams and Hitch 1998; Council of Chief State School Officers and National Governors Association 2019; Geary 1994). Therefore, I do not lag cognitive assessment scores. Rather, I assume students' skills in mathematics and reading were set prior to survey administration, when they reported their mathematics attitudes.

When predicting the trajectory of the difference between mathematics interest and mathematics self-competence, I also control for mathematics interest in third grade, which constrains both the intercept and the slope of the trajectory. For example, individuals with the highest possible value for mathematics interest cannot have a negative value for the difference between mathematics interest and mathematics self-competence in third grade. Because their intercept cannot be negative, their slope cannot be extremely positive.

Mediators: I test a series of mediators measured in eighth grade (with the exception of cultural socialization) to investigate why the discrepancy between mathematics interest and mathematics self-competence is greater for Black and Hispanic students than White students. As with the cognitive assessment scores, I do not lag the mediators due to the long gaps between waves. Given that data were collected in the spring of each school year, for most children, same-wave data reflect family and school environments they had been exposed to for many months prior to reporting their mathematics interest and mathematics self-competence.

The first set of mediators represents family demographic characteristics. Household socioeconomic status (SES) is operationalized as a standardized measure combining mothers' and fathers' education, occupation, and income. College savings are captured by a dichotomous indicator of whether the child's family had "done anything specific in order to have some money for [the child's] education after high school." Parents' nativity is measured by a dichotomous indicator identifying children with at least one parent born outside of the United States.

The second set of mediators captures opportunities to explore interests: a three-category measure of whether the child never or rarely, sometimes, or frequently works on a hobby or plays sports with an adult family member; a dichotomous indicator of whether the child participates in an athletic extracurricular activity; and a dichotomous indicator of whether the child participates in a non-athletic extracurricular activity.

The third set of mediators corresponds to school characteristics. A dichotomous indicator is set to one for students who attend private school. Peer racial/ethnic composition is captured by two variables—percent Black and percent Hispanic—each consisting of five categories: less than 1% Black/Hispanic, 1% to less than 5%, 5% to less than 10%, 10% to less than 25%, and 25% or more. Peer socioeconomic composition is measured by the percent of students eligible for free lunches in the National School Lunch Program. Peer performance composition is represented by the percent of eighth graders scoring at or above grade level in standardized mathematics tests. Mathematics teacher qualifications are measured using years of teaching experience and a three-category variable of educational attainment: four-year college degree or less, some graduate school, and graduate degree.

The final mediator captures cultural socialization in kindergarten, the only wave when racial socialization was measured. Parents reported whether their family discussed their racial/ethnic heritage with their child "never," "almost never," "several times a year," "several times a month," or "several times a week or more."

3.3.4 Multilevel Growth Curve Models

I use multilevel growth curve models (*mixed* in Stata) to describe racial/ethnic and gender differences in trajectories of mathematics attitudes from third to eighth grade (Hoffman 2015).[16] Multilevel growth curve models allow the researcher to estimate differences in average trajectory shape across groups while incorporating within-group heterogeneity in trajectory shape into the model.

As multilevel growth curve models are limited to time-invariant independent variables (Hoffman 2015), I control for third-grade cognitive assessment scores.[17] Children's mathematics and reading performance relative to that of other students is fairly stable between third and eighth grade. Intraclass correlations at the child level show that 83% of the variance in standardized mathematics scores and 78% of the variance in standardized reading scores is across persons (i.e., only 17% and 22% of the total variance, respectively, is the result of changes within children over time). These models do not specify the causal relationship between cognitive assessment scores and mathematics attitudes. They simply describe how racial/ethnic

[16] Although the ECLS-K data set includes weights, multilevel modeling commands cannot incorporate the complex survey design variables associated with these weights. Therefore, I present unweighted results.
[17] Time-varying variables have three sources of variation: average between-person differences in levels, average within-person change over time, and individual-level deviations at each time point (i.e., error). However, there are only two places for independent variables to enter a multilevel growth curve model. If included, coefficients for time-varying independent variables are uninterpretable because they represent a weighted blend of multiple effects (Hoffman 2015).

and gender gaps in mathematics attitudes change over time before and after accounting for cognitive assessment scores.

The multilevel growth curve models nest person-waves (Level 1) within children (Level 2).[18] The Level 1 equation predicts mathematics attitude Y_{ti} for person i who is t years older than age nine as follows:

$$Y_{ti} = \beta_{0i} + \beta_{1i}t + e_{ti} \quad (1)$$

In equation (1), β_{0i} represents a child's predicted mathematics attitude when $t = 0$, i.e., at age nine. β_{1i} is a child-specific slope for how their mathematics attitude changes with age.[19] e_{ti} is a residual term capturing the deviation between a child's observed mathematics attitude and the level of the attitude predicted by that child's intercept and slope.

The Level 2 equation for the intercept coefficient predicts a child's mathematics attitude at age nine as follows:

$$\beta_{0i} = \gamma_{00} + \sum \gamma_{0j} W_{ji} + u_{0i} \quad (2)$$

In equation (2), j indexes the time-invariant independent and control variables. γ_{0j} represents the effect of the j[th] predictor on the intercept. u_{0i} captures the remaining difference between each child's actual intercept and the intercept predicted by the fixed portion of the model.

The Level 2 equation for the slope coefficient predicts how the given mathematics attitude changes with age as follows:

[18] Although I considered the inclusion of crossed effects that account for time-varying nesting of children in classrooms and schools, I use a two-level model because there is little teacher- or school-level variance in mathematics attitudes relative to child-level variance. Models that include teacher- or school-level error terms do not converge.
[19] I cannot formally test for non-linear functional forms with only three time points. Figure 3.1 and Appendix Figure A.2 plot both the raw means and the trajectories predicted by the models using race/ethnicity and gender only. For most of the trajectories, the raw means are close to the model predictions; linearity is a reasonable approximation. However, Hispanic girls' self-competence (and therefore the difference between interest and self-competence) may be slightly curvilinear.

$$\beta_{1i} = \gamma_{10} + \sum \gamma_{1j} W_{ji} + u_{1i} \tag{3}$$

In equation (3), γ_{1j} represents the effect of the j^{th} predictor on the slope. u_{1i} captures the remaining difference between each child's actual slope and the slope predicted by the fixed portion of the model. I assume that u_{0i} and u_{1i} have means of zero but make no assumptions about their variances or covariance, which are distinctly estimated by the model.

For ease of interpretation, I show figures of fixed effects predictions calculated by setting the standardized control variables to zero.

3.3.5 Natural Effect Models

I conduct cross-sectional mediation analyses for eighth grade using natural effect models (*medflex* in R) (Lange et al. 2017; Steen et al. 2017). These models identify mediators that account for racial/ethnic (and gender) differences in the relationship between mathematics interest and mathematics self-competence in eighth grade, net of cognitive assessment scores. I use natural effect models because—unlike other cross-sectional mediation models—they can accommodate categorical mediators (Steen et al. 2017).[20]

Let Y represent the difference between mathematics interest and mathematics self-competence, X represent the combined race/ethnicity/gender variable, M represent a given mediator, and C represent the vector of controls (including age, for consistency with the multilevel growth curve models). For each child i with $X_i = x$, we observe a single outcome: $Y_i(x, M_i(x))$. The natural effect model imputes five additional outcomes, one corresponding to each unobserved combination of race/ethnicity/gender x^*, holding the mediator and all control variables constant. For example, for a Hispanic boy, the natural effect model imputes outcomes

[20] Like other cross-sectional mediation commands, *medflex* cannot incorporate complex survey design for generalized linear model estimation. Therefore, I present unweighted results.

$Y_i(x^*, M_i(x))$ for counterfactuals where the child is a White boy, Black boy, White girl, Black girl, or Hispanic girl. This allows me to partition the total difference in mathematics attitudes between children of a given race/ethnicity/gender and White boys (the reference group) into two components. The first, the natural indirect effect, is the portion that is attributable to differences in the level of the mediator: $Y_i\big(x, M_i(x)\big) - Y_i\big(x, M_i(x^*)\big)$. The second, the natural direct effect, is the remainder, which is independent of the mediator: $Y_i\big(x, M_i(x)\big) - Y_i\big(x^*, M_i(x)\big)$. Mediation is significant when the natural indirect effect is significant based on bootstrapped standard errors. For ease of interpretation, I present figures depicting the natural indirect effect and the natural direct effect in terms of percentages.

3.4 Results

3.4.1 The Development of Racial/Ethnic Differences in Mathematics Interest and Self-Competence

Descriptive Statistics: Table 3.1 presents descriptive statistics for demographic composition, standardized cognitive assessment scores, and standardized mathematics attitudes in third and eighth grades.

The racial/ethnic and gender composition of the sample is 35% non-Hispanic White boys (approximately 2,700 respondents), 6% non-Hispanic Black boys (420), 10% Hispanic boys of any race (730), 35% non-Hispanic White girls (2,690), 6% non-Hispanic Black girls (440), and 9% Hispanic girls of any race (720).

Standardized cognitive assessment scores are highest for White students, followed by Hispanic students and then Black students. Boys have higher mathematics scores and lower reading scores than girls of the same race/ethnicity.

Boys have higher standardized mathematics interest than girls of the same race/ethnicity, on average. Among third-graders of the same gender, interest is highest for Black students, followed by Hispanic students and then White students. In eighth grade, the same pattern holds for boys. However, Hispanic girls have the lowest interest of all groups.

Boys have higher standardized mathematics self-competence than girls of the same race/ethnicity, on average. Among third-grade boys, self-competence is highest for Black students, followed by White students and then Hispanic students. Among third-grade girls, self-competence is highest for Black girls, followed by Hispanic girls and then White girls. In eighth grade, White students have higher self-competence than other students of the same gender.

To gauge the substantive significance of differences in mathematics attitudes across groups, consider the largest disparities at age 14, which are between Black boys and Hispanic girls for standardized mathematics interest and between White boys and Hispanic girls for standardized mathematics self-competence. Based on estimates from prior studies, Black boys' .37 standard deviations higher mathematics interest could translate into 20% greater odds of enrolling in an advanced mathematics course as opposed to a regular mathematics course (Nagy et al. 2008) and .18 standard deviations greater effort put into mathematics homework (Trautwein, Lüdtke, Kastens, et al. 2006). Similarly, White boys' .40 standard deviations higher mathematics self-competence could lead to .08 standard deviations higher mathematics achievement in high school (Susperreguy et al. 2018). This would be sizeable in relation to the Hispanic-White achievement gap in mathematics, which a previous study using ECLS-K data found to be .44 standard deviations in eighth grade (Reardon, Robinson-Cimpian, et al. 2015).

Separate Trajectories for Interest and Self-Competence: Table 3.2 presents multilevel growth curve models predicting mathematics attitudes. Models A and B predict standardized mathematics interest and standardized mathematics self-competence, respectively, based on race/ethnicity and gender only. Figure 3.1 displays predicted trajectories of average interest and self-competence by race/ethnicity and gender based on Models A and B. The figure also includes raw means for each wave of data collection.

White boys' mathematics interest is marginally lower than average and stable throughout the study. Their mathematics self-competence is higher than average, but becomes closer to average with age.

Black boys have above-average interest and self-competence at age nine. Their interest is stable, whereas their self-competence declines as they grow older. By age 14, their self-competence is statistically indistinguishable from average.

Hispanic boys have above-average interest and self-competence at age nine, but both attitudes decrease. In fact, Hispanic boys experience the steepest decline in self-competence of all groups. By age 14, their interest is approximately average and their self-competence is below average.

Hispanic girls have above-average interest at age nine, but experience the steepest decline of all groups. By age 14, their interest is below average. Their self-competence is below average at age nine and significantly decreases with age.

Black girls have above-average interest at age nine. The slope for their interest is negative, but not statistically significant. Nonetheless, by age 14, their interest is not statistically distinguishable from average.

Black girls have average self-competence at age nine, but experience significant decreases. By age 14, their self-competence is below average.

White girls are the only group to experience significant increases in standardized interest and self-competence. At age nine, their interest and self-competence are below average. By age 14, their interest is higher but still below average, and their self-competence is roughly average.

Recall that these models present standardized values to emphasize changes in relative interest and self-competence. As with all other groups in this study, White girls' raw mathematics interest and mathematics self-competence decrease with age (tables available from author upon request). This pattern is consistent with prior studies finding that mathematics interest and mathematics self-competence decline with age (Ganley and Lubienski 2016; Jacobs et al. 2002; Pinxten et al. 2014).

Trajectories of the Difference between Interest and Self-Competence: Models C and D in Table 3.2 present multilevel growth curve models predicting the difference between standardized mathematics interest and standardized mathematics self-competence. Model C predicts this difference based on race/ethnicity and gender only. Figure 3.2C displays predicted trajectories of the average difference between interest and self-competence by race/ethnicity and gender based on Model C.

When the difference between standardized mathematics interest and standardized mathematics self-competence is zero, interest is equal to self-competence. When the difference is greater than zero, interest exceeds self-competence. When the difference is less than zero, self-competence exceeds interest.

At age nine, Black and Hispanic girls' interest is greater than their self-competence. White girls, Black boys, and Hispanic boys have roughly equal interest and self-competence. White boys' self-competence exceeds their interest.

Between the ages of nine and 14, the difference between interest and self-competence becomes more positive for boys of all races/ethnicities, as well as Black girls, because their self-competence declines faster than their interest. The difference between interest and self-competence decreases for Hispanic girls because their interest declines more steeply than their self-competence. The difference between interest and self-competence becomes more negative for White girls because their self-competence increases more dramatically than their interest (although, as noted in the prior section, only the standardized values increase; the raw values decrease).

By age 14, interest exceeds self-competence for all Black and Hispanic students. Differences between these groups are no longer significant. In contrast, White students' self-competence is greater than their interest.

Model D in Table 3.2 adds the third-grade control variables: standardized mathematics interest, standardized cognitive assessment scores in mathematics and reading, and the interaction between mathematics and reading scores. Unsurprisingly, the higher students' mathematics interest in third grade, the more likely their interest exceeds their self-competence at age nine. These students also experience more dramatic declines in the difference between interest and self-competence because their interest decreases faster than their self-competence. Quite simply, their interest has nowhere else to go but down.

High mathematics scores are associated with high mathematics self-competence relative to mathematics interest at age nine. The interaction effect for the intercept indicates that the effect of high mathematics scores is even more pronounced for students with high reading scores. In other words, students who are overall high-performing academically have particularly high self-competence relative to interest at age nine. High mathematics scores are also associated with less dramatic declines in interest relative to self-competence. High mathematics scores are protective for both interest and self-competence; this protective effect is simply stronger for interest.

High reading scores have no effect on relative levels of mathematics interest versus mathematics self-competence at age nine. However, high reading scores are associated with more dramatic declines in interest than self-competence. The interaction effect for the slope indicates that this negative effect is tempered for students with high mathematics scores.

If differences in mathematics attitudes by race/ethnicity and gender are purely a reflection of differences in individual-level cognitive assessment scores, the race/ethnicity and gender variable should not have significant effects on the coefficients for the intercept or the slope. This is clearly not the case. However, patterns of racial/ethnic and gender inequality over time differ from Model C.

Figure 3.2D displays predicted trajectories of the average difference between standardized mathematics interest and standardized mathematics self-competence by race/ethnicity and gender based on Model D. I calculated these trajectories by setting the control variables to zero.

As in Figure 3.2C, at age nine, girls have interest equal to or greater than self-competence and boys have self-competence equal to or greater than interest. However, patterns of within-gender racial/ethnic inequality differ after accounting for racial/ethnic differences in cognitive assessment scores. In the overall population (Figure 3.2C), White students have the highest self-competence relative to their interest, followed by Black students and then Hispanic students. White students' high cognitive assessment scores explain their relatively high self-competence. Among students with identical cognitive assessment scores (Figure 3.2D), Black students have the highest self-competence relative to their interest.

For most groups, the level and direction of change in mathematics attitudes between the ages of nine and 14 are similar before and after accounting for cognitive assessment scores. However, high scores explain why White boys' interest declines less dramatically than their self-competence. Therefore, the difference between interest and self-competence is relatively stable for White boys in Figure 3.2D.

In both the overall population (Figure 3.2C) and among students with identical cognitive assessment scores (Figure 3.2D), Black and Hispanic students converge on interest exceeding self-competence by age 14. In contrast, accounting for White students' high cognitive assessment scores shows that their interest and self-competence become increasingly similar, although the difference between the two attitudes remains significantly different from zero at age 14.

3.4.2 Explaining Racial/Ethnic Differences in Mathematics Interest and Self-Competence

Descriptive Statistics: Table 3.3 presents descriptive statistics for racial/ethnic differences in home and school environments that may explain racial/ethnic differences in the relationship between mathematics interest and mathematics self-competence in eighth grade.

The average White student's family's socioeconomic status (SES) is one-fifth of a standard deviation above the mean, whereas the average Black or Hispanic student's family's SES is two-fifth's to one-half of a standard deviation below the mean. Over 60% of White students' families are preparing to help them pay for college, compared to only 40% of Black and Hispanic students' families. Less than 10% of White and Black students have at least one immigrant parent, as opposed to over 60% of Hispanic students.

Opportunities to explore interests are both racialized and gendered. Boys are more likely to work on a hobby or play a sport with an adult family member than girls of the same race/ethnicity, and White students are more likely to have these opportunities than Black or Hispanic students. Boys are more likely to participate in athletic extracurricular activities and less likely to participate in non-athletic extracurricular activities than girls of the same race/ethnicity. White and Black boys are more likely to engage in non-athletic extracurricular activities than Hispanic boys. White girls are more likely to participate in both athletic and non-athletic extracurricular activities than Black and Hispanic girls.

Differences in school characteristics reflect racial/ethnic segregation. White students are more likely to attend private schools than Black and Hispanic students. White students' schools have fewer Black and Hispanic students, half as many students who are eligible for free lunches through the National School Lunch Program, and more students performing at or above grade level in mathematics on standardized tests. White students' mathematics teachers are also more educated and more experienced than Black and Hispanic students' mathematics teachers, on average.

Most White students' families never or almost never discuss their racial/ethnic heritage, whereas most Black and Hispanic students' families discuss their racial/ethnic heritage several times a year or more.

Mediation: Each column of Figure 3.3 represents a separate natural effect model decomposing racial/ethnic and gender differences in the relationship between interest and self-competence in eighth grade (age 14 in Figure 3.2D) into two components: the portion that is explained by a given mediator (the indirect effect) and the remainder (the direct effect). These models identify racial/ethnic inequalities in social contexts that lead students with identical cognitive assessment scores to hold different mathematics attitudes. Consistent with Model D in Table 3.2, all natural effect models control for age in eighth grade and third-grade values for standardized cognitive assessment scores in mathematics and reading, the interaction between mathematics and reading scores, and standardized mathematics interest. White boys serve as the reference group.

Figure 3.2D shows both Black and Hispanic students converging on interest exceeding self-competence by age 14, whereas White students' interest increasingly matches their self-competence. However, in some of the natural effect models, neither the indirect effect nor the direct effect for Black students is significant. Black students are the smallest racial/ethnic group in the analytical sample. This sample size is too small for the natural effect models to consistently identify significant differences between Black students and White boys. Therefore, I focus on the results for Hispanic students.

In Figure 3.3, 100% represents the total observed difference in the relationship between mathematics interest and mathematics self-competence between White boys and either Hispanic boys or girls. Significant mediation can occur in one of two directions. The dark gray bars depict the extent to which inequalities in social contexts explain why, compared to White boys, Hispanic students have such high interest relative to their self-competence. It is also possible that, in the absence of inequalities in social contexts, the difference between Hispanic students' interest and self-competence would be even greater. The black bars illustrate how much greater the difference between their interest and self-competence would be if Hispanic students had the same experiences at home or at school as White boys.

Hispanic students have high interest relative to self-competence in part because of their families' low SES, as evidenced by not only the model for household SES, but also the models for college savings and school socioeconomic composition. Combined, these mediators explain 33.1% of the observed difference between Hispanic boys and White boys and 42.4% of the observed difference between Hispanic girls and White boys.

Hispanic girls also have high interest relative to self-competence because they have less opportunity to explore alternate interests at home compared to White boys (and Hispanic boys). This may reflect Hispanic families prioritizing boys when allocating limited resources, or Hispanic boys opting for activities that are cheaper or otherwise easier for their families to support. Hispanic girls' more limited opportunities to explore interests at home account for 7.9% of the observed difference between Hispanic girls and White boys.[21]

Neither school characteristics (other than socioeconomic composition) nor cultural socialization explain racial/ethnic differences in the relationship between mathematics interest and mathematics self-competence.

3.5 Discussion

This study (1) described racial/ethnic differences in the development of mathematics interest relative to mathematics self-competence during elementary and middle school and (2) investigated why the relationship between interest and self-competence differs by race/ethnicity in eighth grade. I found that, in third grade, the relationship between interest and self-competence is primarily gendered: girls' interest is greater than or equal to their self-competence, whereas boys' self-competence is greater than or equal to their interest. However, by eighth

[21] I cannot combine opportunities to explore interests at home with the SES variables in a single natural effect model because there are not enough respondents within each race/ethnicity/gender group with all possible combinations of the mediator values.

grade, the relationship between interest and self-competence is a function of race/ethnicity: Black and Hispanic students converge on interest exceeding self-competence, whereas White students converge on self-competence exceeding interest. After controlling for cognitive assessment scores, White students' interest nearly matches their self-competence.

For Black students and Hispanic boys, the difference between interest and self-competence increases with age because their interest remains high as their self-competence falls (for Hispanic girls, interest declines but remains significantly higher than self-competence). Hispanic families' low SES plays a significant role in keeping Hispanic eighth-graders' mathematics interest high despite their low mathematics self-competence. Hispanic girls also have relatively high mathematics interest because they have limited opportunities to explore alternative interests at home. Due to small sample size, I could not explain why Black eighth-graders have high interest and low self-competence as well.

These results extend longstanding cross-sectional research finding an attitude-achievement paradox, where Black and Hispanic students have similar or more positive academic attitudes compared to White students despite their lower average achievement (Ainsworth-Darnell and Downey 1998; Ambriz 2020; Diamond and Huguley 2014; Harris 2006; Matthew 2011; Mickelson 1990). The longitudinal trends I present suggest that one key determinant of whether Black and Hispanic students' academic attitudes remain high throughout childhood is the relationship of the given attitude to achievement. Mathematics self-competence, which is heavily influenced by prior achievement (Arens et al. 2011; Marsh et al. 2005; Pinxten et al. 2014), falls to match Black and Hispanic students' relatively low average achievement. Mathematics interest, which is less dependent on achievement (Arens et al. 2011; Marsh et al. 2005; Pinxten et al. 2014), remains high in comparison. Hispanic students' mathematics interest is further bolstered by their families, who may encourage children in STEM in the hopes of upward socioeconomic mobility (Charles et al. 2014; Charles and Bradley 2009; Hanson 2009; Ma 2009).

Resilient mathematics interest may mitigate Black and Hispanic underrepresentation in STEM by motivating persistence, even when students have lower achievement. Prior studies have found that high mathematics interest is associated with enrollment in more advanced mathematics courses and greater effort spent on coursework (Nagy et al. 2008; Pinxten et al. 2014; Safavian and Conley 2016; Trautwein, Lüdtke, Kastens, et al. 2006). By encouraging them to earn the prerequisites, high mathematics interest may help keep more Black and Hispanic students on track for advanced STEM coursework in high school and college.

Although my analyses identified some drivers of Hispanic eighth graders' mathematics attitudes, a significant portion of racial/ethnic differences in the relationship between mathematics interest and mathematics self-competence in eighth grade remains unexplained. The ECLS-K is limited in its ability to capture racial socialization: cultural socialization (in terms of discussing racial/ethnic heritage) was measured in kindergarten only, and no wave included questions about preparing children for racial/ethnic bias. Future studies should further explore whether racial socialization in Black and Hispanic families helps children develop and maintain interest in mathematics. Scholars should also investigate why the relationship between interest and self-competence switches from a largely gendered process in third grade to an almost entirely racialized process in eighth grade.

Table 3.1: Descriptive Statistics for Independent, Dependent, and Control Variables by Gender and Race/Ethnicity (n ≈ 7,700 students)

				Boys						Girls					
	Total			White		Black		Hispanic		White		Black		Hispanic	
	Mean	SD	n	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Race/Ethnicity and Gender															
White boys	.35														
Black boys	.06														
Hispanic boys	.10														
White girls	.35														
Black girls	.06														
Hispanic girls	.09														
Standardized Mathematics Attitudes															
Interest															
Third grade	-.03	(1.01)	7700	-.02	(1.01)	.19	(.95)	.17	(.89)	-.18	(1.05)	.15	(.97)	.07	(.95)
Eighth grade	-.02	(1.00)	7700	-.02	(.99)	.21	(1.03)	.04	(.99)	-.04	(.99)	.06	(1.08)	-.16	(1.00)
Self-competence															
Third grade	.01	(.99)	7700	.17	(.96)	.22	(.98)	.14	(.91)	-.18	(.98)	.00	(1.07)	-.16	(1.01)
Eighth grade	.00	(1.00)	7700	.10	(.99)	.04	(.98)	-.13	(.99)	.03	(.98)	-.18	(1.05)	-.30	(1.05)
Standardized Cognitive Assessment Scores															
Mathematics															
Third grade	.12	(.97)	7,700	.45	(.92)	-.48	(.91)	-.15	(.95)	.21	(.88)	-.66	(.84)	-.32	(.91)
Eighth grade	.02	(.97)	7,680	.29	(.87)	-.67	(1.03)	-.23	(1.02)	.17	(.84)	-.76	(1.01)	-.36	(1.03)
Reading															
Third grade	.13	(.98)	7,700	.27	(.93)	-.54	(.92)	-.43	(.96)	.42	(.88)	-.40	(.87)	-.22	(.99)
Eighth grade	.03	(.98)	7,630	.19	(.88)	-.80	(1.09)	-.48	(1.09)	.34	(.78)	-.56	(1.01)	-.32	(1.04)
Total	7,700			2,700		420		730		2,690		440		720	

Note: For all standardized mathematics attitudes and standardized cognitive assessment score variables, differences across the combined race/ethnicity/gender variable are significant at p<0.001. Means of standardized variables in the total column are not zero because the variables were standardized before students who were not White, Black, or Hispanic were dropped from the sample. Consistent with the data user agreement for the restricted ECLS-K data set, all unweighted sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Table 3.2: Multilevel Growth Curve Models Predicting Mathematics Attitudes in Grades 3-8 (n ≈ 23,100 person-waves for 7,700 students)

	Standardized Mathematics Interest	Standardized Mathematics Self-competence	Difference between Standardized Mathematics Interest and Standardized Mathematics Self-Competence	
	A	B	C	D
	b/se	b/se	b/se	b/se
Coefficients predicting age 9 level (intercept)				
Constant	-.03 †	.19 **	-.22 **	-.07 **
	(.02)	(.02)	(.02)	(.01)
Race/ethnicity and gender (ref: White boys)				
Black boys	.24 **	.07	.17 **	-.07 *
	(.05)	(.05)	(.04)	(.04)
Hispanic boys	.22 **	-.02	.24 **	.06 *
	(.04)	(.04)	(.03)	(.03)
White girls	-.14 **	-.36 **	.23 **	.22 **
	(.03)	(.03)	(.02)	(.02)
Black girls	.15 **	-.21 **	.36 **	.08 *
	(.05)	(.05)	(.04)	(.04)
Hispanic girls	.11 **	-.38 **	.49 **	.31 **
	(.04)	(.04)	(.03)	(.03)
Control variables (3rd grade)				
Mathematics interest				.32 **
				(.01)
Standardized cognitive assessment scores				
Mathematics				-.21 **
				(.01)
Reading				.00
				(.01)
Mathematics x reading				-.08 **
				(.01)
Coefficients predicting slope				
Constant	.00	-.01 **	.02 **	.01
	(.01)	(.01)	(.00)	(.00)
Race/ethnicity and gender (ref: White boys)				
Black boys	.00	-.02 †	.02 *	.04 **
	(.01)	(.01)	(.01)	(.01)
Hispanic boys	-.03 **	-.04 **	.01	.02 *
	(.01)	(.01)	(.01)	(.01)
White girls	.03 **	.05 **	-.03 **	-.03 **
	(.01)	(.01)	(.01)	(.01)
Black girls	-.02	-.02	.00	.02 *
	(.01)	(.01)	(.01)	(.01)
Hispanic girls	-.05 **	-.01	-.04 **	-.03 **
	(.01)	(.01)	(.01)	(.01)
Control variables (3rd grade)				
Mathematics interest				-.06 **
				(.00)
Standardized cognitive assessment scores				
Mathematics				.02 **
				(.00)
Reading				-.02 **
				(.00)

Mathematics x reading				.01 **
				(.0)
Variance components				
ln(sd(u_{0i}))	-2.04 **	-2.08 **	-2.33 **	-2.52 **
	(.04)	(.04)	(.04)	(.06)
ln(sd(u_{1i}))	-.35 **	-.37 **	-.74 **	-1.15 **
	(.02)	(.02)	(.02)	(.04)
atanh(corr(U_{0i},U_{1i}))	-.56 **	-.49 **	-.81 **	-.60 **
	(.03)	(.03)	(.03)	(.05)
ln(sd(e_{ti}))	-.30 **	-.32 **	-.47 **	-.47 **
	(.01)	(.01)	(.01)	(.01)
chi2	170	393	586	3,744
p	.00	.00	.00	.00
LL	-31,467	-30,995	-25,702	-24,398
AIC	62,965	62,022	51,435	48,844
BIC	63,094	62,151	51,564	49,037

Note: † p<0.10, * p<0.05, ** p<0.01. Consistent with the data user agreement for the restricted ECLS-K data set, all unweighted sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

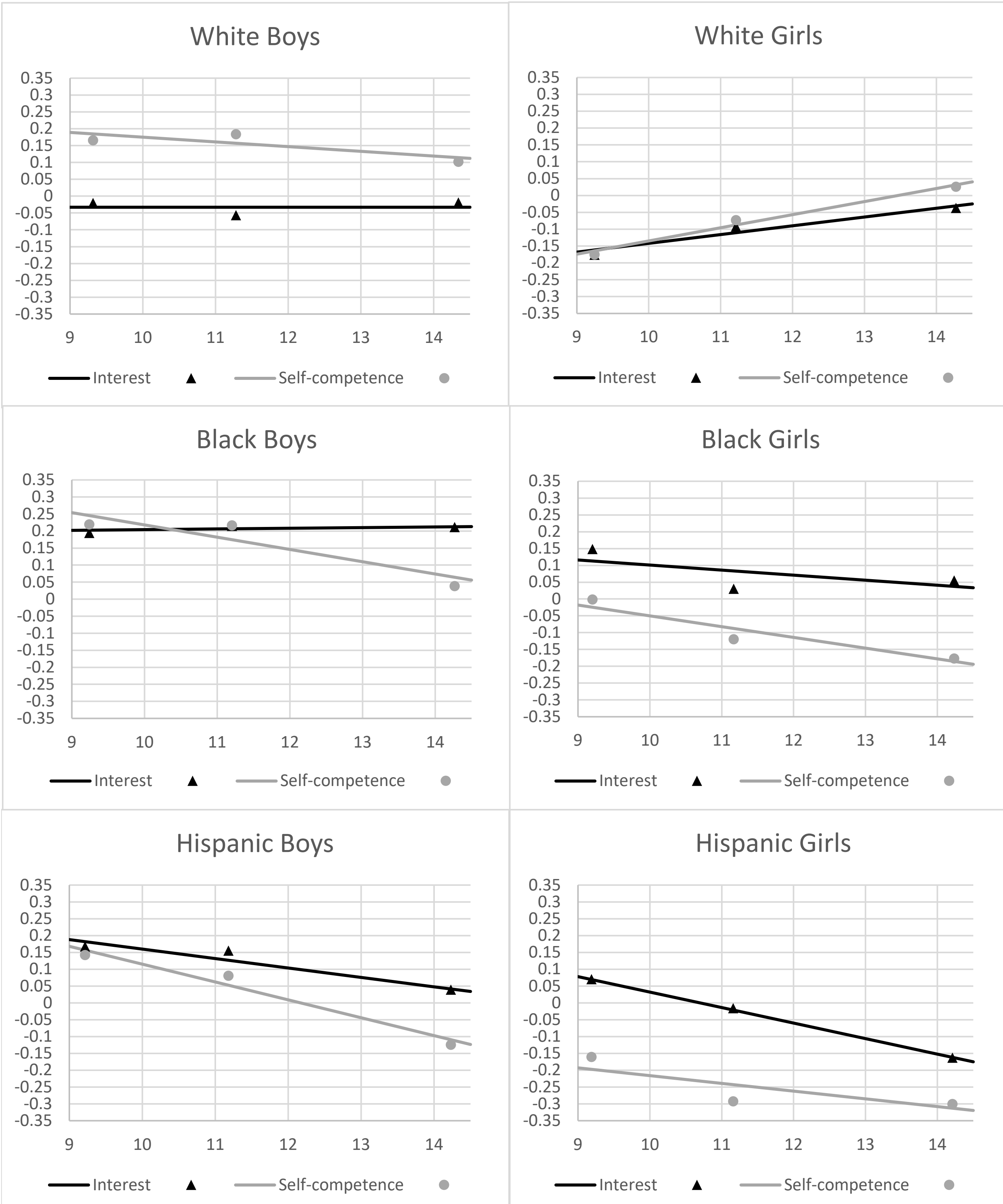
Table 3.3: Descriptive Statistics for Eighth-Grade Mediators, by Gender and Race/Ethnicity (n ≈ 7,700 students)

				Boys						Girls						
	Total			White		Black		Hispanic		White		Black		Hispanic		
	Mean	SD	n	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Family Characteristics																
SES	.01	(.79)	7,000	.22	(.73)	-.42	(.71)	-.47	(.75)	.19	(.74)	-.47	(.76)	-.49	(.73)	
Preparing to help pay for child's postsecondary education	.57		6,860	.64		.42		.39		.63		.39		.40		
1+ immigrant parents	.18		7,670	.07		.09		.66		.07		.08		.64		
Opportunities to Explore Interests																
Hobbies and sports at home			6,940													
Never/rarely	.14			.09		.18		.24		.11		.29		.28		
Sometimes	.39			.36		.41		.37		.40		.45		.43		
Frequently	.47			.56		.41		.39		.49		.26		.30		
Extracurriculars																
Sports	.85		7,670	.88		.92		.85		.85		.73		.71		
Non-sports	.73		7,660	.66		.65		.56		.86		.75		.70		
School Characteristics																
Private school	.18		7,660	.22		.04		.12		.21		.08		.12		
School segregation																
% Black			6,920													
[0%, 1%)	.07			.07		.01		.07		.08		.01		.08		
[1%, 5%)	.49			.56		.03		.42		.57		.04		.43		
[5%, 10%)	.14			.14		.04		.21		.14		.06		.18		
[10%, 25%)	.15			.14		.23		.17		.13		.20		.15		
[25%, 100%]	.16			.09		.69		.13		.09		.69		.17		
% Hispanic			6,930													
[0%, 1%)	.08			.08		.17		.00		.09		.12		.02		
[1%, 5%)	.45			.55		.33		.10		.55		.36		.11		
[5%, 10%)	.14			.16		.14		.06		.15		.15		.07		
[10%, 25%)	.16			.15		.21		.20		.15		.20		.14		
[25%, 100%]	.18			.06		.16		.65		.07		.18		.66		
% free lunch eligible	.34	(.25)	6,280	.25	(.19)	.53	(.27)	.48	(.27)	.26	(.18)	.52	(.27)	.49	(.28)	
% at or above grade level in mathematics	.65	(.23)	5,540	.70	(.21)	.56	(.23)	.53	(.25)	.69	(.22)	.55	(.23)	.53	(.25)	
Mathematics Teacher Qualifications																
Educational attainment			3,670													
4-year college degree or less	.23			.21		.30		.27		.21		.28		.25		
Some graduate school	.27			.25		.30		.36		.25		.33		.35		
Graduate degree	.50			.54		.41		.37		.54		.39		.40		
Years of teaching experience	14.03	(10.38)	3,660	14.59	(10.54)	11.29	(8.87)	12.62	(10.07)	14.92	(10.57)	11.53	(9.43)	12.77	(9.94)	
Racial Socialization																
Family discusses racial/ethnic heritage			7,370													
Never	.23			.29		.14		.13		.26		.13		.12		
Almost never	.25			.29		.16		.15		.29		.14		.14		
Several times a year	.29			.30		.28		.26		.31		.26		.26		
Several times a month	.15			.09		.26		.28		.11		.30		.30		
Several times a week or more	.08			.03		.17		.18		.04		.18		.19		
Total	7,700			2,700		420		730		2,690		440		720		

Note: For all mediators, differences across the combined race/ethnicity/gender variable are significant at p<0.001. Means of standardized variables in the total column are not zero because the variables were standardized before students who were not White, Black, or Hispanic were dropped from the sample. Consistent with the data user agreement for the restricted ECLS-K data set, all unweighted sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.

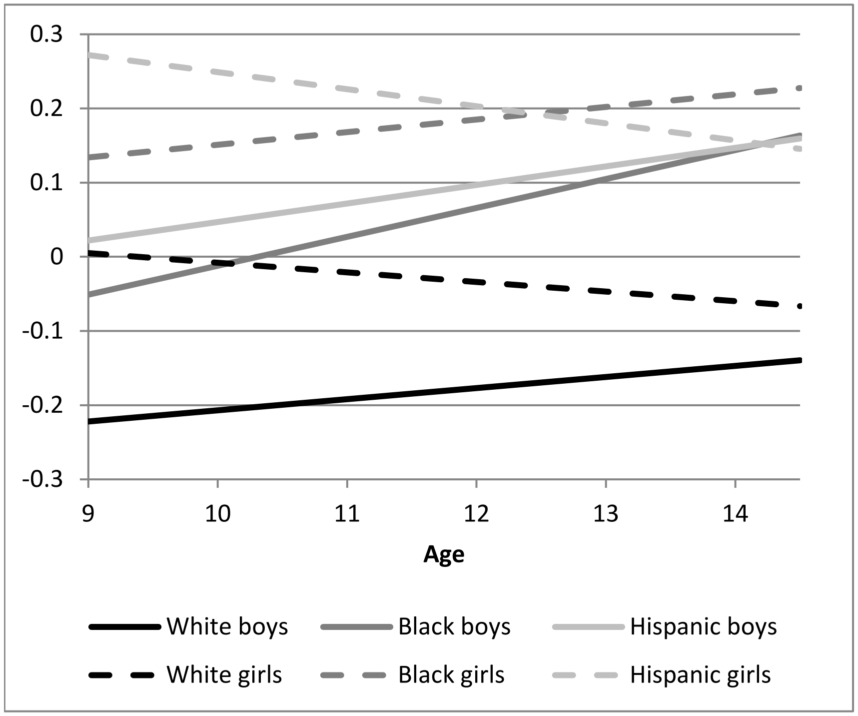
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Figure 3.1: Fixed Effects Predictions of Standardized Mathematics Interest and Standardized Mathematics Self-Competence by Age, Race/Ethnicity, and Gender

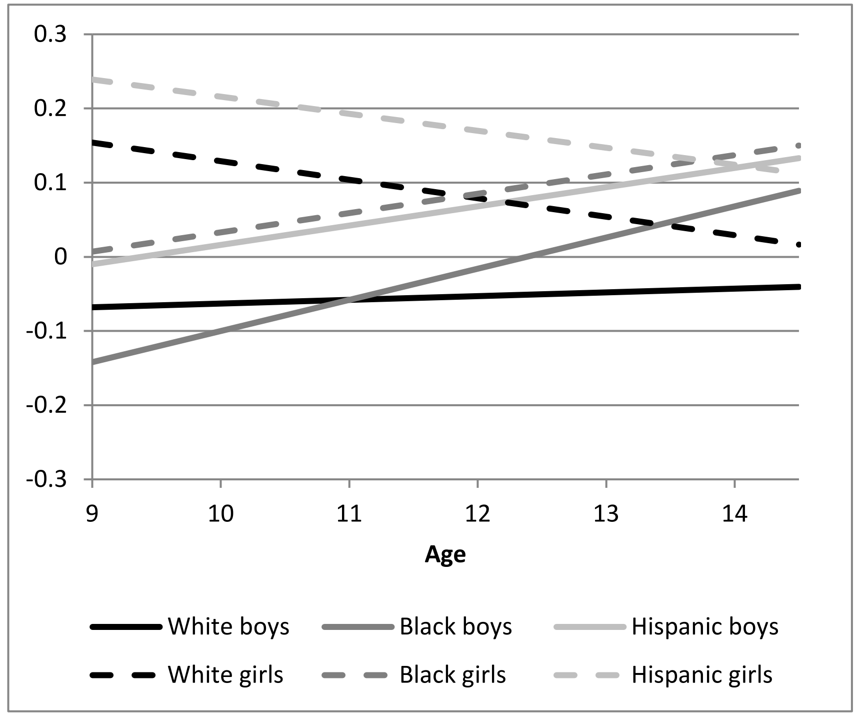


Note: Lines represent fixed effects predictions from multilevel growth curve models. Dots represent raw means for each wave of data collection.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Figure 3.2: Fixed Effects Predictions of the Difference between Standardized Mathematics Interest and Standardized Mathematics Self-Competence by Age, Race/Ethnicity, and Gender



C: Without Controls

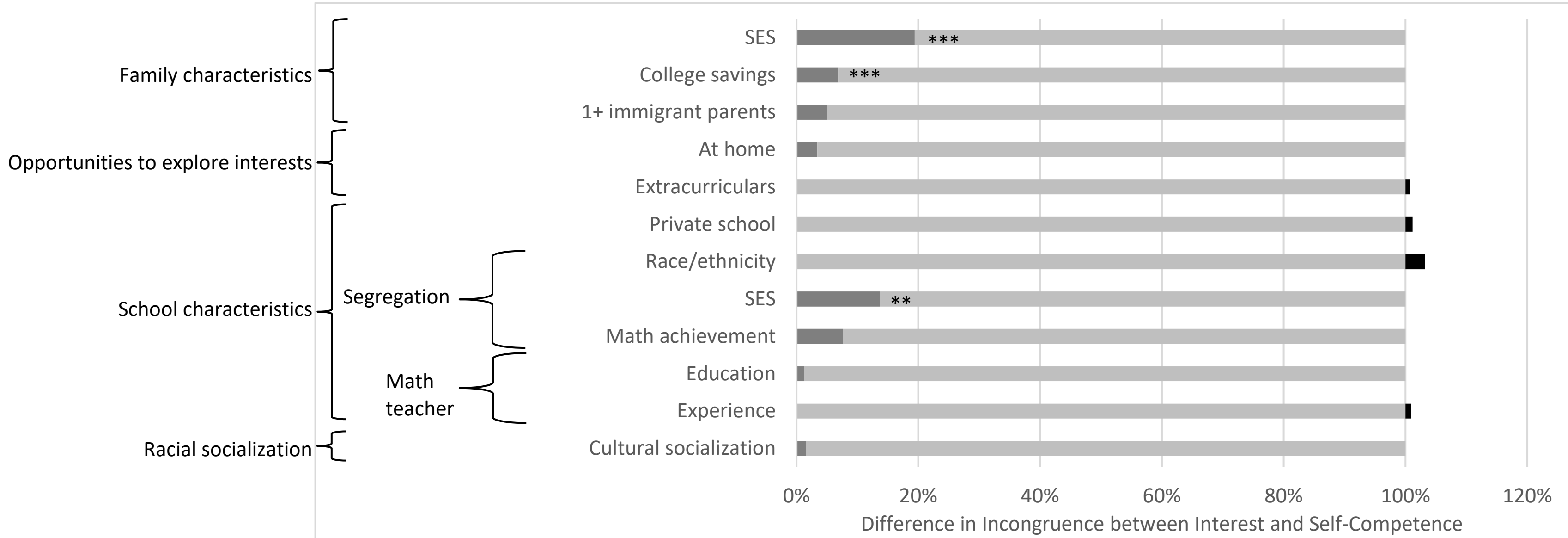


D: With Controls

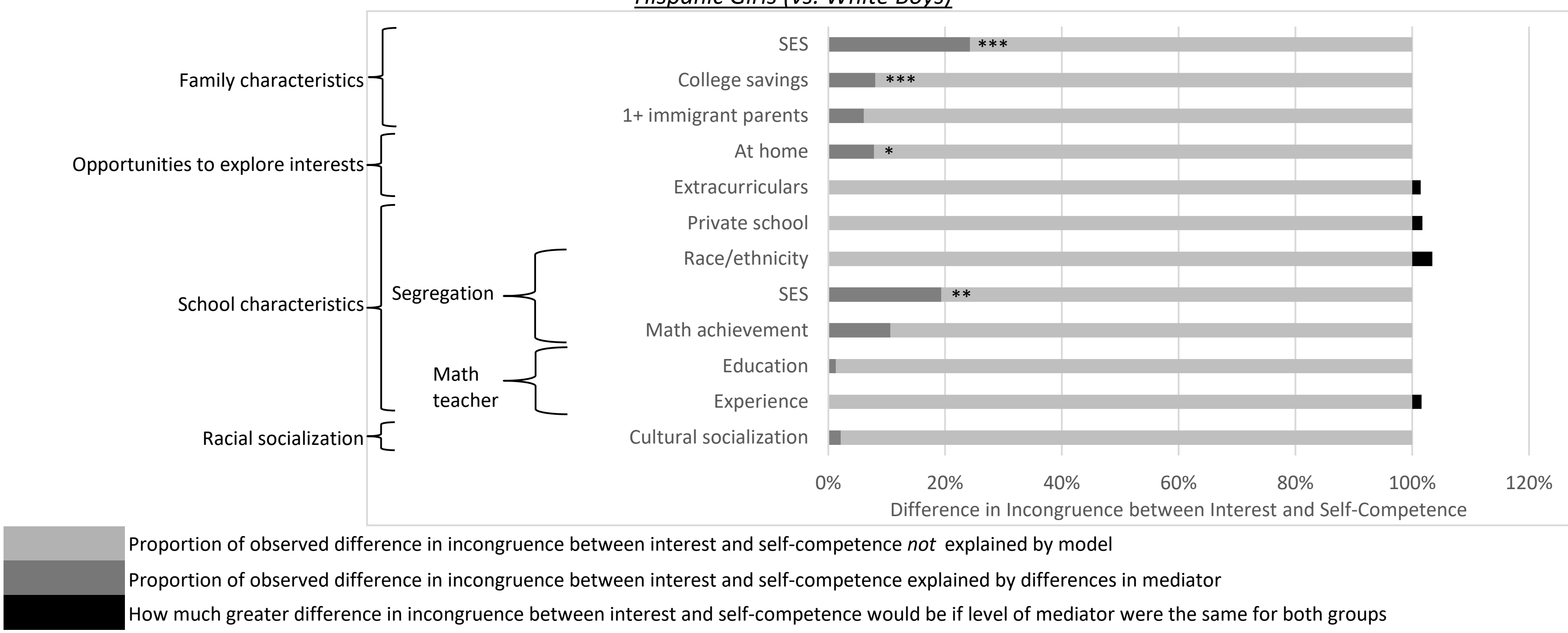
Note: All controls are standardized and set to zero.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Figure 3.3: Mediation Models Explaining Why the Relationship between Mathematics Interest and Mathematics Self-Competence Differs between Hispanic Students and White Boys in Eighth Grade

Hispanic Boys (vs. White Boys)



Hispanic Girls (vs. White Boys)



Note: † p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Each row represents a separate natural effect model controlling for age in eighth grade and standardized cognitive assessment scores in mathematics and reading, their interaction, and standardized mathematics interest in third grade.

Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Chapter 4

Mathematics Interest and Mathematics Self-Competence Affect Different Behaviors and Decisions

Abstract

Although the effect of mathematics interest and mathematics self-competence (i.e., self-assessed mathematics ability) on achievement is well-established, their impact on non-achievement outcomes is poorly understood. Using nationally representative data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K), I use mathematics interest and mathematics self-competence in fifth grade to predict mathematics course enrollment and frequency of mathematics homework completion in eighth grade, both for all students and separately by gender. I find that self-competence influences decisions closely linked to hierarchical notions of ability (i.e., mathematics track), whereas interest spurs students to spend more time on activities they enjoy (i.e., mathematics homework). The effect of self-competence is stronger for boys, while the effect of interest is stronger for girls.

Key words: race/ethnicity, self-concept, mathematics, secondary data analysis

4.1 Introduction

Multiple theories of academic motivation highlight mathematics interest and mathematics self-competence, or self-assessed mathematics ability, as key to achievement and persistence in mathematics. For example, interest and self-competence are the two primary components of mathematics self-concept, or children's perception of themselves as a mathematics student (Arens et al. 2011; Marsh, Craven, and Debus 1999; Pinxten et al. 2014). Self-competence and interest are also integral to expectancies for success and subjective task values, respectively, in Eccles et al.'s expectancy-value model of achievement-related choices (Eccles and Wigfield 2020; Wigfield and Eccles 2000).

These theories posit that self-competence is a stronger predictor of achievement, whereas interest is a greater motivator for non-achievement outcomes. However, most empirical studies have examined the effect of either interest or self-competence on academic performance and persistence, rather than including both in the same model. Interest and self-competence become increasingly correlated with age (e.g., r increases from 0.23 in first grade to 0.71 in tenth grade in the Michigan Childhood and Beyond Study) (Denissen et al. 2007; Simpkins, Davis-Kean, and Eccles 2006; Wigfield et al. 1997). Therefore, studies that examine these attitudes separately have linked both to a wide range of outcomes, including grades, test scores, course enrollment, and effort (Chouinard et al. 2007; Correll 2001; Gaspard et al. 2020; Köller et al. 2001; Marsh and Yeung 1997; Simpkins et al. 2006; Susperreguy et al. 2018; Trautwein et al. 2009, 2015). Models that include both attitudes simultaneously have indeed shown that self-competence is more consequential for future achievement (Arens et al. 2011; Marsh et al. 2005; Petersen and Hyde 2017).

In contrast, few studies have compared the effect of interest versus self-competence on non-achievement outcomes such as course selection and homework completion, which are crucial to persistence in STEM (science, technology, engineering, or mathematics) education. Existing research has found slightly more evidence in favor of interest motivating persistence, but results have been inconsistent for two reasons (Nagy et al. 2008; Pinxten et al. 2014;

Safavian and Conley 2016; Trautwein, Lüdtke, Kastens, et al. 2006; Yonezawa, Wells, and Serna 2002). First, this work uses regional samples with limited measures, which cannot capture the complicated process linking attitudes to academic engagement and decision-making. Second, most studies do not account for potential gender differences in the relationship between attitudes and non-achievement outcomes. Boys are stereotyped as naturally more gifted at mathematics than girls (Cvencek, Meltzoff, and Greenwald 2011; Nosek, Banaji, and Greenwald 2002). This gender stereotype may create greater barriers to girls pursuing STEM compared to boys with identical attitudes (Riegle-Crumb and Morton 2017). Prior studies examining the effect of mathematics interest and mathematics self-competence on non-achievement outcomes may have had conflicting results because they averaged significant effects for boys with non-significant effects for girls.

The present study addresses these data and modeling issues while investigating the possibility that self-competence plays a greater role in persistence than previously understood. Specifically, I hypothesize that interest and self-competence serve different motivational functions with regards to non-achievement outcomes. Self-competence influences decisions closely linked to achievement, such as mathematics track. Students choose the option that corresponds best to their idea of what they *can* do. In contrast, interest spurs students to spend more time on activities they *like* to do, such as mathematics homework. I further hypothesize that mathematics self-competence and interest are stronger predictors of course selection and homework completion, respectively, for boys than girls.

I test these hypotheses using nationally representative data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K). I use mathematics interest and self-competence in fifth grade to predict mathematics course enrollment and homework completion in eighth grade, both for all students and separately for boys and girls. I focus on eighth-grade outcomes because advanced mathematics classes in eighth grade are the gateway to advanced mathematics courses in high school (Irizarry 2021). I conclude by discussing the implications of my findings for gender inequality in mathematics education.

4.2 Background

4.2.1 Mathematics Course Level

Ability-differentiated mathematics courses begin in middle school and continue through high school. Advanced course-taking has a wide range of benefits. Students who take advanced mathematics courses have higher test scores and educational expectations and are more likely to graduate high school, attend college, declare a STEM major, and graduate college (Andersen 2018; Chen and Weko 2009; Gamoran and Hannigan 2000; Karlson 2015; Long, Conger, and Iatarola 2012; Schneider, Swanson, and Riegle-Crumb 1998; Wang 2013).

While the strongest predictor of mathematics track is achievement (Kelly 2009; Morton and Riegle-Crumb 2019), students influence course level as well. Studies examining either mathematics interest or mathematics self-competence have linked both to enrollment in higher-level mathematics courses (Correll 2001; Gaspard et al. 2020; Köller et al. 2001; Marsh and Yeung 1997).

Two quantitative studies have examined interest and self-competence simultaneously. This work has used regional samples to show that interest, but not self-competence, influences mathematics course level (Nagy et al. 2008; Safavian and Conley 2016). This result stands in stark contrast with qualitative research finding that students choose between tracks by matching their self-assessed ability to their perceptions of hierarchical ability groups (Yonezawa et al. 2002).

The discrepancy between the quantitative and qualitative findings may stem from differences in research focus or modeling strategies. Safavian and Conley (2016) predicted whether low-achieving seventh-graders enrolled in grade-level or below-grade-level algebra in eighth grade. In contrast, Yonezawa et al.'s (2002) interviews focused on whether students enrolled in advanced classes. It is possible that self-competence matters more when choosing between advanced and regular courses than between regular and remedial courses.

Nagy et al. (2008) predicted students' high school mathematics track without controlling for prior course enrollment. Most high-school students either continue their middle-school course sequences or drop to a lower-level class (Irizarry 2021; Lucas and Good 2001). It is possible that self-competence determines initial course enrollment in middle school but (lack of) interest motivates attrition in high school, and Nagy et al. captured the latter process.

Unlike prior quantitative research, the present study uses a nationally representative sample to examine the full range of mathematics courses available in eighth grade. Therefore,

Hypothesis 1: I hypothesize that mathematics self-competence, but not mathematics interest, affects mathematics course level.

4.2.2 Homework Completion

Once a student is in a higher-level mathematics course, they must do their homework to earn high grades (Cooper et al. 1998; Kelly 2008). Homework completion also improves standardized test scores (Cooper et al. 1998; Green et al. 2012).

To my knowledge, no studies have examined the effect of interest and self-competence on homework completion. However, researchers have investigated a related outcome: effort. Both on its own and in models including self-competence, high interest increases effort expended on classwork and homework (Pinxten et al. 2014; Trautwein, Lüdtke, Kastens, et al. 2006; Trautwein et al. 2015). In contrast, results have been more mixed for self-competence (Chouinard et al. 2007; Marsh et al. 2016; Pinxten et al. 2014; Trautwein, Lüdtke, Kastens, et al. 2006; Trautwein et al. 2009) because effort reinforces existing self-competence (Marsh et al. 2016). Low-performing students must exert more effort to keep up with their schoolwork, which directly undermines their self-competence. High-performing students may exert additional effort to maintain their high performance, bolstering their high self-competence.

I examine homework completion because, compared to effort, completion is less dependent on ability and more predictive of grades and standardized test scores (Cooper et al. 1998; Green et al. 2012; Kelly 2008; Marsh et al. 2016). Given that homework completion is less dependent on ability,

Hypothesis 2: I hypothesize that mathematics interest, but not mathematics self-competence, predicts mathematics homework completion.

4.2.3 Gendered Returns to Attitudes

Longstanding research has established that boys have higher mathematics interest and mathematics self-competence than girls (Breda and Napp 2019; Catsambis 1994; Correll 2001; Else-Quest et al. 2010). These attitudinal differences help explain the gender gap in advanced mathematics course-taking and STEM major declaration (Correll 2001; Nagy et al. 2008). Therefore, many interventions seek to address the underrepresentation of women and girls in STEM education by improving girls' attitudes towards mathematics (Casad et al. 2018).

To my knowledge, prior studies have not examined whether boys and girls are equally likely to act on high mathematics interest and mathematics self-competence. As early as second grade, children are aware that boys are considered naturally more gifted at mathematics (Cvencek et al. 2011; Nosek et al. 2002). If girls assume they will face greater resistance when pursuing advanced mathematics education, they may be less likely to make decisions and engage in behaviors that are consistent with their positive mathematics attitudes. Therefore,

> *Hypothesis 3: I hypothesize that the effects of mathematics self-competence and mathematics interest on mathematics course level and mathematics homework completion, respectively, are stronger for boys than girls.*

4.3 Data & Methods

4.3.1 The Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K)

The Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K) is a nationally representative, longitudinal survey of over 21,000 students who were followed from the 1998–99 school year (kindergarten) to spring 2007 (eighth grade). The ECLS-K is the only nationally representative data set that connects eighth-grade outcomes to data from previous grades. I use data from the last two waves, or fifth and eighth grades.

The ECLS-K randomly assigned eighth graders to have questionnaires completed by either their mathematics teacher or their science teacher. Approximately half of students were assigned to the mathematics condition. My analytic sample consists of the approximately 2,270 non-Hispanic White, non-Hispanic Black, and Hispanic students with non-missing data for all fifth- and eighth-grade predictors and eighth-grade mathematics course outcomes.[22]

[22] Most students who were excluded from the analytic sample were assigned to the science condition in eighth grade or became ineligible for continued participation in the ECLS-K earlier in the study, usually because they moved out of participating schools.

All estimates account for the ECLS-K's three-stage sampling design using jackknife replication weights from the data provider. Consistent with the data user agreement for the restricted ECLS-K data set, all sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.

4.3.2 Measures

My two dependent variables are drawn from eighth-grade mathematics teachers' questionnaires. Teachers described students' mathematics course level using one of three response options: "instruction for students performing below grade level in mathematics," "regular," or "honors, enrichment, or gifted & talented." Teacher reports of homework completion fell into three categories: "never," "rarely," or "some of the time;" "most of the time;" and "all of the time."

I predict eighth-grade outcomes using mathematics attitudes and student-level control variables measured in fifth grade to maintain temporal priority. I also control for eighth-grade school-level characteristics that affect the number of mathematics tracks offered and competition for spots in advanced courses.

My independent variables are standardized indices for mathematics interest and mathematics self-competence in fifth grade. Students were asked whether they agreed with a series of statements about themselves from the Self Description Questionnaire 1, with response options ranging from one, "not at all true," to four, "very true." Statements assessing interest included "I like math" and "I enjoy doing work in math." Items measuring self-competence included "Work in math is easy for me" and "I get good grades in math." The indices are created by standardizing the average of a student's non-missing responses.

I control for performance and perceived ability in fifth grade: standardized cognitive assessment scores in mathematics and reading, the interaction between mathematics and reading scores, a dichotomous indicator of whether the child is behind one or more grades[23], and their teacher's perception of their mathematics ability. The latter variable is operationalized as the average of a teacher's ratings for a series of grade-appropriate mathematics skills, which could range from one (not yet) to five (proficient).

In the full sample, I control for student race/ethnicity and gender using a single variable with six categories: non-Hispanic White boys, non-Hispanic Black boys, Hispanic boys of any race, non-Hispanic White girls, non-Hispanic Black girls, and Hispanic girls of any race. In the models stratified by gender, I control for race/ethnicity only: non-Hispanic White, non-Hispanic Black, and Hispanic of any race.

I also control for a series of fifth-grade family characteristics. Parental nativity is captured by a dichotomous indicator identifying children with at least one parent born outside of the United States. Household SES is operationalized as a standardized measure combining mothers' and fathers' education, occupation, and income. Parental educational expectations fall into three categories: less than a four-year college degree, a four-year college degree, or a graduate degree.

I also control for school characteristics in eighth grade. School size is measured using total eighth grade enrollment, which consists of three categories: 0-60 students, 61-180 students, or 181 or more students. Peer performance composition is represented by the percent of eighth graders scoring at or above grade level in standardized mathematics tests. Peer racial/ethnic

[23] Most students who were not in fifth grade in the second-to-last wave of the study were not in eighth grade during the final wave. However, I include them in the analysis because they advanced to grades that sort students into remedial, regular, and honors mathematics courses. For the sake of simplicity, I refer to students in each wave based on the grade most students attended during that wave.

composition is captured by two variables—percent Black and percent Hispanic—each consisting of five categories: less than 1% Black/Hispanic, 1% to less than 5%, 5% to less than 10%, 10% to less than 25%, and 25% or more. I also include a dichotomous indicator of whether the school is private.

Finally, when predicting homework completion, I control for mathematics course level.

Table 4.1 presents descriptive statistics, both for the overall sample and separately by gender. Girls are more likely to take advanced mathematics courses and complete their mathematics homework than boys. Although the gender difference in mathematics interest is not statistically significant, boys have significantly higher mathematics self-competence than girls. Boys have higher cognitive assessment scores in mathematics and lower scores in reading than girls. Boys are also twice as likely to be one or more grades behind than girls. Parents have slightly higher educational expectations for girls than boys. Otherwise, there are few significant gender differences in family or school environments.

4.4 Results

4.4.1 Mathematics Course Level

Table 4.2 presents multinomial logistic regression models predicting the log-odds of mathematics course level (with regular classes as the reference category), both for the overall sample and separately by gender. In the full sample, mathematics interest does not predict mathematics course level. Mathematics self-competence does not predict whether students enroll in remedial as opposed to regular mathematics classes. However, one standard deviation higher self-competence is associated with over 60% greater odds ($e^{0.494} = 1.639$) of enrolling in an honors, enrichment, or gifted and talented mathematics class as opposed to a regular mathematics class. These results are consistent with Hypothesis 1.

In the stratified models, mathematics interest does not predict mathematics course level for boys or girls. Among boys, one standard deviation higher mathematics self-competence is associated with more than double the odds ($e^{0.809} = 2.246$) of enrolling in an advanced mathematics class as opposed to a regular mathematics class. Among girls, mathematics self-competence does not predict mathematics course level. Mathematics cognitive assessment scores are a stronger predictor of mathematics course level for girls than boys. These results are consistent with Hypothesis 3.

4.4.2 Homework Completion

Table 4.3 presents ordered logistic regression models predicting the log-odds of homework completion, both for the overall sample and separately by gender. In the full sample, students with greater mathematics interest complete their mathematics homework more frequently. For example, one standard deviation higher interest is associated with over 20% greater odds ($e^{0.200} = 1.221$) of a student completing their mathematics homework all of the time as opposed to less frequently. In contrast, mathematics self-competence does not predict how often a student completes their mathematics homework. These results are consistent with Hypothesis 2.

Among boys, mathematics interest does not predict mathematics homework completion. Among girls, students with greater mathematics interest complete their mathematics homework more frequently. For example, one standard deviation higher interest is associated with 30% greater odds ($e^{0.266} = 1.305$) of a girl completing her homework all of the time as opposed to less frequently. Mathematics self-competence does not predict homework completion for boys or girls. These results are inconsistent with Hypothesis 3.

Few of the control variables are significant for girls. In contrast, high cognitive assessment scores, positive teacher perceptions of mathematics performance, enrollment in an advanced mathematics course, and attendance at a private school are associated with more frequent mathematics homework completion among boys.

4.5 Discussion

This study investigated how mathematics interest and self-competence influence mathematics course type and homework completion, both for students overall and separately for boys and girls. I found that interest and self-competence motivate different behaviors and decisions. Students with higher mathematics self-competence are more likely to enroll in an honors, enrichment, or gifted and talented mathematics class as opposed to a regular mathematics class. Students with higher interest more consistently complete their mathematics homework. Stratified models showed that the effect of self-competence on mathematics course level was significant for boys but not girls, and the effect of interest on homework completion was significant for girls but not boys.

These findings suggest that interest and self-competence serve distinct functions in the motivation of non-achievement outcomes. Self-competence motivates decisions closely linked to hierarchical notions of ability, such as mathematics track. Students choose the option that corresponds best to their idea of what they *can* do. In contrast, interest motivates students to spend more time on activities they *like* to do, such as mathematics homework. Both high self-competence and high interest are necessary for students to enroll and excel in advanced mathematics courses.

Furthermore, boys and girls have unequal opportunity to leverage these psychological resources. In particular, high mathematics self-competence is more likely to lead to advanced mathematics course-taking for boys but not girls, suggesting that girls face greater barriers to making decisions that are consistent with their attitudes.

Although I hypothesized that the effects of both mathematics interest and mathematics self-competence would be stronger for boys than girls, I found that interest is a stronger predictor of homework completion for girls. In contrast, high achievement, positive teacher perceptions, and competitive classroom and school environments are stronger predictors of homework completion for boys. These results suggest that mathematics engagement is more extrinsically motivated for boys and intrinsically motivated for girls.

The present study shows that self-competence plays a greater role in persistence in mathematics than previously understood. Theories of academic motivation posit that self-competence predicts achievement while interest predicts non-achievement outcomes (Arens et al. 2011; Eccles and Wigfield 2020; Pinxten et al. 2014; Wigfield and Eccles 2000). However, I show that self-competence motivates decisions closely tied to perceptions of performance, such as course selection. Therefore, self-competence affects not only whether students meet prerequisites for advanced mathematics coursework, but also whether they seize opportunities to enroll in those courses.

My findings also have implications for policymakers and practitioners seeking to redress gender inequalities in STEM. Many interventions focus on boosting girls' persistence in STEM coursework by increasing their mathematics interest and mathematics self-competence (Casad et al. 2018). However, self-competence does not predict girls' decisions the way it does for boys. This suggests that improving girls' mathematics attitudes is not enough. Children's family and school environments need to change so that girls with positive mathematics attitudes feel just as supported as boys in the pursuit of advanced mathematics education.

Table 4.1: Descriptive Statistics by Gender

	All Students		Boys		Girls		
	Mean	SD	Mean	SD	Mean	SD	p
Mathematics Course Outcomes (8th Grade)							
Course level							**
Remedial	.099		.122		.074		
Regular	.660		.681		.638		
Honors, Enrichment, or Gifted & Talented	.241		.197		.288		
How often student completes homework							**
Never, rarely, or some of the time	.288		.348		.224		
Most of the time	.385		.427		.340		
All of the time	.327		.225		.435		
Standardized Mathematics Attitudes (5th Grade)							
Interest	.011	(.982)	.050	(.973)	-.030	(.989)	
Self-Competence	.043	(.982)	.178	(.933)	-.100	(1.013)	**
Performance and Perceived Ability (5th Grade)							
Standardized Cognitive Assessment Scores							
Mathematics	.015	(.971)	.090	(.923)	-.064	(1.013)	*
Reading	-.001	(.959)	-.107	(.967)	.112	(.937)	**
Perceived Ability							
Teacher perception of mathematics performance (scale: 1-5)	3.423	(.676)	3.412	(.707)	3.434	(.643)	
Left behind 1+ grades	.108		.145		.070		**
Student Race/Ethnicity and Gender							
White boys	.340		.660				
Black boys	.074		.144				
Hispanic boys	.101		.196				
White girls	.308				.635		
Black girls	.080				.165		
Hispanic girls	.097				.200		
Family Characteristics (5th Grade)							
1+ immigrant parents	.193		.200		.186		
Household socioeconomic status	-.064	(.762)	-.057	(.745)	-.072	(.779)	
Parent's educational expectations							*
Less than a college degree	.264		.300		.226		
4-year college degree	.509		.490		.529		
Graduate degree	.227		.210		.244		
School Characteristics (8th Grade)							
Total 8th grade enrollment							
0-60 students	.090		.101		.079		
61-180 students	.234		.228		.240		
181+ students	.676		.671		.681		
% of 8th graders scoring at or above grade level in mathematics	.650	(.220)	.665	(.209)	.634	(.231)	*
% Black							
[0%, 1%)	.044		.040		.047		
[1%, 5%)	.455		.475		.434		
[5%, 10%)	.131		.125		.139		
[10%, 25%)	.176		.167		.184		
[25%, 100%]	.194		.193		.196		
% Hispanic							
[0%, 1%)	.060		.058		.061		
[1%, 5%)	.394		.398		.389		
[5%, 10%)	.159		.139		.181		
[10%, 25%)	.189		.200		.177		
[25%, 100%]	.198		.204		.192		
Private	.034		.036		.033		
Total	2,260		1,130		1,130		

Note: † p<0.10, * p<0.05, ** p<0.01 (chi-square tests for categorical variables, bivariate regressions for continuous variables). Means of standardized values may differ from zero because the variables were standardized before students who were not White, Black, or Hispanic were dropped from the sample. Consistent with the data user agreement for the restricted ECLS-K data set, all unweighted sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Table 4.2: Multinomial Logistic Regressions Predicting Mathematics Course Level in 8th Grade

Sample:	All Students		Boys		Girls	
Model:	A		B		C	
Course Level (ref: Regular)	Remedial	Honors, Enrichment, or Gifted & Talented	Remedial	Honors, Enrichment, or Gifted & Talented	Remedial	Honors, Enrichment, or Gifted & Talented
	b/se	b/se	b/se	b/se	b/se	b/se
Standardized Mathematics Attitudes (5th Grade)						
Interest	.340	.002	.378	-.082	.370	.064
	(.260)	(.136)	(.359)	(.157)	(.388)	(.217)
Self-competence	-.297	.494 **	-.277	.809 **	-.317	.269
	(.214)	(.158)	(.351)	(.219)	(.304)	(.196)
Performance and Perceived Ability (5th Grade)						
Standardized Cognitive Assessment Scores						
Mathematics	-.838 **	.455 *	-.805 †	.295	-1.047 **	.681 *
	(.289)	(.211)	(.475)	(.249)	(.280)	(.314)
Reading	-.231	.441 **	-.251	.474 *	-.161	.356
	(.228)	(.156)	(.303)	(.199)	(.328)	(.285)
Mathematics x reading	.281 †	.165	.514 *	.244	.065	.096
	(.150)	(.129)	(.214)	(.168)	(.203)	(.258)
Perceived Ability						
Teacher perception of mathematics performance	-.162	.602 **	.221	.732 **	-.581 †	.482 *
(scale: 1-5)	(.228)	(.208)	(.290)	(.256)	(.311)	(.228)
Left behind 1+ grades	-.400	-2.294 **	-.383	-2.816 *	-.330	-1.479 †
	(.272)	(.600)	(.451)	(1.139)	(.499)	(.881)
Student Race/Ethnicity and Gender (ref: White Boys)						
Black boys	-.348	-1.196 †	-.634	-1.355 *		
	(.522)	(.651)	(.599)	(.566)		
Hispanic boys	.779	.450	.802	.438		
	(.593)	(.373)	(.765)	(.382)		
White girls	-.713 *	.546 **				
	(.331)	(.185)				
Black girls	-.957	.760			.095	.329
	(.597)	(.693)			(.549)	(.703)
Hispanic girls	-.326	.653			.616	-.061
	(.677)	(.428)			(.611)	(.423)
Family Characteristics (5th Grade)						
1+ immigrant parents	-.533	.005	-.560	.026	-.517	.110
	(.477)	(.284)	(.704)	(.412)	(.484)	(.484)
Household socioeconomic status	.006	.515 **	.088	.469 **	-.031	.640 **
	(.239)	(.140)	(.347)	(.167)	(.281)	(.220)
Parent's educational expectations (ref: less than a college degree)						
4-year college degree	-.359	.063	-.933 *	.098	.318	.123
	(.281)	(.238)	(.427)	(.328)	(.372)	(.356)
Graduate degree	-.325	-.050	-.642	-.328	.050	.199
	(.421)	(.307)	(.562)	(.431)	(.576)	(.423)
School Characteristics (8th Grade)						
Total 8th grade enrollment (ref: 0-60 students)						
61-180	1.247 *	.592	1.160	.651	1.246 *	.764
	(.521)	(.535)	(.757)	(.873)	(.572)	(.468)
181+	1.597 **	.142	1.70 **	.174	1.443 *	.303
	(.463)	(.507)	(.610)	(.849)	(.656)	(.494)
% of 8th graders scoring at or above grade level in	-.066	-.022	-.095	-.108	-.030	.046
mathematics (in tens)	(.066)	(.050)	(.088)	(.072)	(.079)	(.064)
% Black (ref: [0%, 1%))						
[1%,5%)	.185	-.371	-.391	-.103	.885	-.801
	(.582)	(.632)	(.774)	(.659)	(.790)	(1.197)
[5%,10%)	-.199	.141	-1.490 †	.347	1.163	-.193
	(.667)	(.707)	(.818)	(.842)	(.804)	(1.293)

[10%,25%)	-.319	-.112	-.777	-.516	.301	-.052
	(.635)	(.637)	(.906)	(.778)	(.848)	(1.244)
[25%, 100%]	-.444	.787	-1.150	1.022	.023	.400
	(.615)	(.712)	(.754)	(.785)	(1.030)	(1.282)
% Hispanic (ref: [0%, 1%))						
[1%,5%)	-.166	.551	.039	.088	-.326	1.026 †
	(.582)	(.601)	(.823)	(.699)	(.782)	(.545)
[5%,10%)	-.062	.860	.783	.047	-1.010	1.550 †
	(.652)	(.696)	(.857)	(.683)	(.903)	(.844)
[10%,25%)	.263	.144	.899	-.054	-.824	.318
	(.568)	(.563)	(.666)	(.698)	(.869)	(.597)
[25%, 100%]	-.562	.365	-.200	-.283	-.863	1.187 †
	(.705)	(.575)	(.817)	(.713)	(1.034)	(.598)
Private school	.404	-.467	-.157	-.273	.561	-.452
	(1.167)	(.561)	(1.854)	(.739)	(.976)	(.676)
Constant	-2.452 *	-4.497 **	-3.171 *	-4.125 *	-2.747 †	-4.425 **
	(1.052)	(1.170)	(1.319)	(1.679)	(1.514)	(1.411)
p	.000		.000		.000	
N	2,260		1,130		1,130	

Note: † p<0.10, * p<0.05, ** p<0.01. Coefficients are additive effects on log-odds. Consistent with the data user agreement for the restricted ECLS-K data set, all unweighted sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.
Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Table 4.3: Ordered Logistic Regressions Predicting How Often Students Complete Mathematics Homework in 8th Grade

Sample:	All Students	Boys	Girls
Model:	A	B	C
	b/se	b/se	b/se
Standardized Mathematics Attitudes (5th Grade)			
Interest	.200 *	.168	.266 *
	(.090)	(.120)	(.128)
Self-competence	-.001	-.131	.062
	(.101)	(.150)	(.135)
Performance and Perceived Ability (5th Grade)			
Standardized Cognitive Assessment Scores			
Mathematics	.194	.440 *	.074
	(.120)	(.173)	(.175)
Reading	-.127	-.333 *	.026
	(.093)	(.138)	(.132)
Mathematics x reading	.037	.188 *	-.114
	(.080)	(.090)	(.120)
Perceived Ability			
Teacher perception of mathematics performance (scale: 1-5)	.355 *	.403 *	.299
	(.135)	(.172)	(.218)
Left behind 1+ grades	-.167	-.481	.579
	(.265)	(.351)	(.594)
Student Race/Ethnicity and Gender (ref: White Boys)			
Black boys	-.144	-.117	
	(.309)	(.364)	
Hispanic boys	-.557 †	-.809 *	
	(.302)	(.377)	
White girls	.966 **		
	(.167)		
Black girls	.470		-.355
	(.380)		(.381)
Hispanic girls	.578 *		-.222
	(.250)		(.233)
Family Characteristics (5th Grade)			
1+ immigrant parents	-.108	-.003	-.164
	(.175)	(.266)	(.298)
Household socioeconomic status	.370 **	.360 *	.464 *
	(.128)	(.159)	(.184)
Parent's educational expectations (ref: less than a college degree)			
4-year college degree	.072	.056	.042
	(.226)	(.314)	(.315)
Graduate degree	.225	.360	.155
	(.30)	(.396)	(.345)
Mathematics Course Level (ref: Regular)			
Remedial	-.012	.158	-.494
	(.221)	(.275)	(.365)
Honors, enrichment, or gifted & talented	.707 **	1.016 **	.447
	(.188)	(.220)	(.309)
School Characteristics (8th Grade)			
Total 8th grade enrollment (ref: 0-60 students)			
61-180	-.258	-.277	-.264
	(.271)	(.352)	(.432)
181+	-.351	.005	-.753 †
	(.234)	(.345)	(.412)
% of 8th graders scoring at or above grade level in mathematics (in tens)	.019	-.025	.062
	(.032)	(.048)	(.053)
% Black (ref: [0%, 1%))			
[1%,5%)	-.241	.001	-.533
	(.322)	(.362)	(.510)
[5%,10%)	-.352	-.304	-.438
	(.334)	(.376)	(.563)

[10%,25%)	-.651	-.373	-.974
	(.407)	(.435)	(.592)
[25%, 100%]	-.706 †	-.864 †	-.682
	(.380)	(.436)	(.580)
% Hispanic (ref: [0%, 1%))			
[1%,5%)	-.005	-.636	.746
	(.347)	(.389)	(.555)
[5%,10%)	.029	-.532	.633
	(.362)	(.433)	(.569)
[10%,25%)	-.058	-.484	.325
	(.348)	(.382)	(.629)
[25%, 100%]	-.131	-.828 †	.752
	(.380)	(.428)	(.631)
Private school	.724 *	1.151 *	.456
	(.344)	(.573)	(.638)
Cutpoints			
1	.053	-.217	-.694
	(.609)	(.697)	(1.017)
2	2.055 **	2.085 **	1.129
	(.610)	(.707)	(1.009)
p	.000	.000	.000
N	2,260	1,130	1,130

Note: † p<0.10, * p<0.05, ** p<0.01. Coefficients are additive effects on log-odds. Consistent with the data user agreement for the restricted ECLS-K data set, all unweighted sample sizes are rounded to the nearest tenths place to protect respondent confidentiality.

Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Chapter 5
Conclusion

This dissertation provides new insight into a longstanding puzzle in the sociology of education literature: the attitude-achievement paradox. Cross-sectional studies have found that Black and Hispanic students have similar or more positive academic attitudes than White students despite having lower achievement, and education scholars have not been able to explain why (Ainsworth-Darnell and Downey 1998; Ambriz 2020; Diamond and Huguley 2014; Harris 2006; Matthew 2011; Mickelson 1990). Using data from the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K), I described how racial/ethnic differences in mathematics self-competence and mathematics interest develop. I then linked these attitudes to non-achievement outcomes key to persistence in STEM (science, technology, engineering, and mathematics) education. This chapter summarizes key findings from these studies.

The first empirical chapter (Chapter Two) traced racial/ethnic differences in the development of mathematics self-competence. I showed that in third grade, Black and Hispanic students have higher mathematics self-competence than White students with identical achievement. Due to segregation, Black and Hispanic students feel like big fish in little ponds: they judge their own mathematics abilities positively in comparison to that of their peers. However, as students grow older, their self-competence normalizes to achievement. By eighth grade, there are few racial/ethnic differences in self-competence among students with identical achievement. Because Black and Hispanic students have lower achievement, on average, they end eighth grade with lower self-competence overall (with the exception of Black boys, whose self-competence remains comparable to that of White boys).

The second empirical chapter (Chapter Three) described racial/ethnic differences in the development of mathematics interest. I showed that as their self-competence falls, Black and Hispanic students' interest remains high, in part due to their families' relatively low socioeconomic status (SES). This finding is consistent with prior research suggesting that low-SES families encourage their children to pursue STEM in the hopes of upward socioeconomic mobility (Charles et al. 2014; Charles and Bradley 2009; Hanson 2009; Ma 2009).

The third empirical chapter (Chapter Four) compared the effect of mathematics self-competence and mathematics interest on two key outcomes for persistence in STEM: course selection and homework completion. I showed that interest and self-competence serve different motivational functions. Self-competence influences decisions closely linked to hierarchical notions of ability, such as mathematics track. Students choose the option that corresponds best to their idea of what they *can* do. In contrast, interest spurs students to spend more time on activities they *like* to do, such as mathematics homework.

Altogether, findings from these three empirical chapters show that the attitude-achievement paradox disappears for mathematics self-competence, which is very sensitive to achievement inequalities. Meanwhile, Black and Hispanic students' mathematics interest remains high because interest is less dependent on achievement. Rather, encouragement from families effectively bolsters interest. Although high interest increases studiousness, this advantage is limited in the absence of the high self-competence necessary to enroll in advanced mathematics courses.

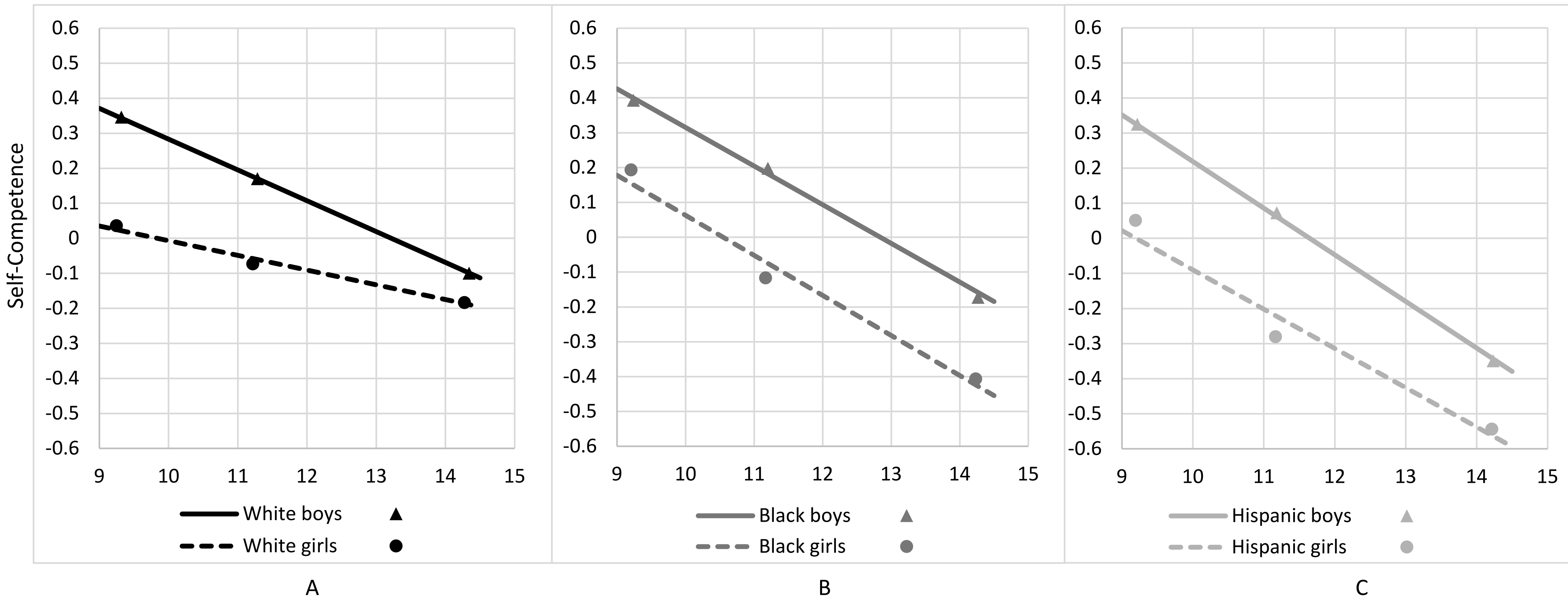
These results contribute to the attitude-achievement paradox literature by providing further evidence rebutting oppositional culture theory. The core argument of oppositional culture theory is that Black and Hispanic communities instill children with negative academic attitudes, which decrease their achievement (Ogbu 1987). This dissertation demonstrates that low achievement diminishes (some) academic attitudes, not the other way around.

This research suggests that policies designed to redress racial/ethnic achievement inequalities should also decrease racial/ethnic differences in mathematics self-competence. Closing racial/ethnic achievement gaps would provide all students with equal access to the three ingredients necessary to persist in STEM education: the achievement to meet prerequisites for advanced courses, the self-competence to enroll in those courses, and the interest to work hard in them. Currently, most Black and Hispanic students only have high interest. This high interest motivates them to make the most of limited opportunities, but does not expand the opportunities available to them. If policymakers can clear the structural barriers to Black and Hispanic students' achievement, it will have downstream effects as they progress through the STEM pipeline.

Appendix

Supplementary Figures

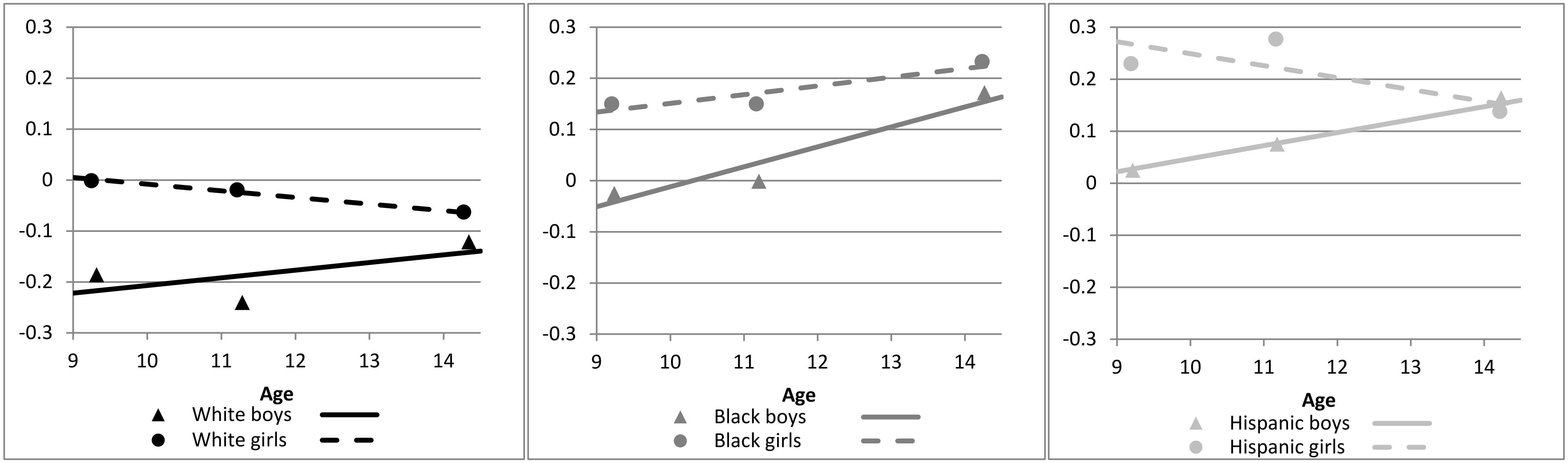
Figure A.1: Fixed Effects Predictions and Observed Means of Mathematics Self-Competence by Age, Race/Ethnicity, and Gender



Note: Lines represent fixed effects predictions from multilevel growth curve models. Dots represent raw means for each wave of data collection.

Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

Figure A.2: Fixed Effects Predictions and Observed Means of the Difference between Standardized Mathematics Interest and Standardized Mathematics Self-Competence by Age, Race/Ethnicity, and Gender



Note: Lines represent fixed effects predictions from multilevel growth curve models. Dots represent raw means for each wave of data collection.

Source: U.S. Department of Education, National Center for Education Statistics, Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

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